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ΕΙΣΑΓΩΓΙΚΟ ΣΗΜΕΙΩΜΑ ΕΛΕΒΙΤ

Αγαπητοί Σύνεδροι και Μέλη της ΕΛΕΒΙΤ,

Με ιδιαίτερη χαρά σας καλωσορίζουμε στο 11° Πανελλήνιο Συνέδριο της Ελληνικής Εταιρείας Βιοϊατρικής Τεχνολογίας (ΕΛΕΒΙΤ)!
Όταν τη δεκαετία του 70 ιδρυόταν η εταιρεία ίσως δεν θα μπορούσε κανείς να φανταστεί πόση μεγάλη ιστορία θα μπορούσε ίσως να γράψει και το ρόλο που θα μπορούσε να διαδραματίσει στα επιστημονικά, επαγγελματικά και τεχνολογικά δρώμενα του χώρου της βιοϊατρικής τεχνολογίας και βιοϊατρικής/κλινικής μηχανικής – τομείς που τον καιρό εκείνο είχαν αρχίσει να «δείχνουν το πρόσωπό τους» αλλά και τη σημασία τους για το χώρο της υγείας. Όταν πάλι την περίοδο 2008-2010 η ΕΛΕΒΙΤ ξεκινούσε να επαναδραστηριοποιείται επίσημα μετά από ολιγόχρονη παύση δραστηριοτήτων, πάλι κανείς δε φανταζόταν τον όγκο της δουλειάς και την ένταση που θα απαιτούνταν για να καθιερωθεί ως μια σταθερή και σημαίνουσα αξία στο χώρο, με τη διοργάνωση σε σταθερή διετή βάση του Πανελλήνιου Συνεδρίου της αλλά και πλήθος επιστημονικών και εκπαιδευτικών εκδηλώσεων με επίκεντρο θέματα του χώρου της Βιοϊατρικής Τεχνολογίας και της Κλινικής Μηχανικής.
Η ΕΛΕΒΙΤ, ως το κατεξοχήν επιστημονικό σωματείο και ως ο φορέας του χώρου της Βιοϊατρικής Τεχνολογίας αποσκοπεί στην ενίσχυση της έρευνας, την προώθηση της εκπαίδευσης και τη βελτίωση του επιστημονικού και επαγγελματικού τοπίου στο χώρο της Τεχνολογίας της Υγείας, της Βιοϊατρικής και Κλινικής Μηχανικής και των συναφών πεδίων. Πριν 4 χρόνια η ΕΛΕΒΙΤ ίδρυσε Τμήμα Κλινικής Μηχανικής (Clinical Engineering Chapter) στους κόλπους της για να παρακολουθεί και να εμπλέκεται πιο αποτελεσματικά στα θέματα του πεδίου αυτού. Σταθερά πλέον, η ΕΛΕΒΙΤ συνεχίζει να έχει διεθνή εμβέλεια ως μέλος της European Alliance for Medical and Biological Engineering & Sciences (EAMBES), της International Federation of Medical and Biological Engineering (IFMBE) με ενεργό εμπλοκή στα Clinical Engineering και Healthcare Technology Assessment τμήματά της, και ως ιδρυτικό μέλος της Global Clinical Engineering Alliance (GCEA) της πιο σημαντικής διεθνούς πρωτοβουλίας για το συντονισμό και την προώθηση της Κλινικής Μηχανικής ως ξεχωριστό και ιδιαίτερο τομέα της Βιοϊατρικής Τεχνολογίας.
Το φετινό 11° Πανελλήνιο Συνέδριο της ΕΛΕΒΙΤ έχει μια εξέχουσα και σημειολογική αξία: γίνεται παράλληλα με το 2° Πανελλήνιο Συνέδριο Φυσικών Επιστημών στην Υγεία της Ελληνικής Εταιρείας Νανοϊατρικής στις Επιστήμες Υγείας (ΕΛΕΝΕΠΥ) που έχει ως στόχο να αναδείξει τις καινοτομίες, τις νέες τάσεις και τις προοπτικές των επιστημονικών εξελίξεων και εφαρμογών των Φυσικών Επιστημών στον χώρο της Υγείας.
Η συνδιοργάνωση των δύο συνεδρίων φέρει επίσης για πρώτη φορά και την αιγίδα και υποστήριξη της Εταιρίας Φυσικών Ιατρικής Ελλάδας (ΕΦΙΕ) αλλά και του Υπουργείου Υγείας. Το γεγονός αυτό από μόνο του αποτιμάται ως μια πολύ σημαντική συνεργασία επιστημόνων από συναφή πεδία, ενισχύοντας το διάλογος και την ανταλλαγή γνώσεων, που ανοίγει ο δρόμος για ακόμα μεγαλύτερες και διεθνείς επιστημονικές διοργανώσεις.
Μια τέτοια λοιπόν μακροπρόθεσμη συνεργασία και στοχοθεσία επιδιώκεται: η ΕΛΕΒΙΤ από κοινού μαζί με την ΕΦΙΕ (αλλά και την ΕΛΕΝΕΠΥ) διεκδικούν για πρώτη φορά να φέρουν στην Ελλάδα το 2031 το Παγκόσμιο Συνέδριο Ιατρικής Φυσικής και Βιοϊατρικής Μηχανικής (IUPESM World Congress for Medical Physics and Biomedical Engineering) της Διεθνούς Ένωσης Εταιρειών Ιατρικής Φυσικής και Βιοϊατρικής Μηχανικής (IUPESM). Πρόκειται για το World Congress on Medical Physics & Biomedical Engineering (WC2031) την διοργάνωση του οποίου διεκδικεί η Ελλάδα απέναντι στην αντίστοιχη Ιαπωνική.

ΜΗΝΥΜΑ ΤΗΣ ΟΡΓΑΝΩΤΙΚΗΣ ΕΠΙΤΡΟΠΗΣ ΤΟΥ ΣΥΝΕΔΡΙΟΥ
ΕΙΣΑΓΩΓΙΚΟ ΣΗΜΕΙΩΜΑ ΕΛΕΒΙΤ

Με επίγνωση λοιπόν των προβλημάτων του παρόντος χρόνου, αλλά με το βλέμμα στο μέλλον και με στόχο να αναδειχθεί ο ρόλος της Ελλάδας στην έρευνα και την καινοτομία στον τομέα της Υγείας σας χαιρετίζουμε στη φετινή διοργάνωση, της οποίας το πρόγραμμα είναι πλούσιο, η δε έκθεση και συμμετοχή των εταιρειών του χώρου είναι η μεγαλύτερη όλων των ετών! Πέρα από την προσπάθεια για παραγωγή Πρακτικών του Συνεδρίου υψηλής επιστημονικής ποιότητας και έκδοσή τους με ISBN, το οποίο έχουμε καταφέρει να το κάνουμε θεσμό, στο Συνέδριο αυτό προωθούμε την ακαδημαϊκή άμιλλα των νέων ερευνητών τρέχοντας το Διαγωνισμό Καλύτερης Φοιτητικής Εργασίας (Student Paper Competition). Επιπλέον έχει υπάρξει μέριμνα για τη δημοσίευση των περιλήψεων σε Ειδικό Τεύχος (special issue) του Health Informatics Journal.

Κλείνοντας αυτό το Εισαγωγικό Σημείωμα θα θέλαμε να ευχαριστήσουμε όλους του συμμετέχοντες, καθώς και όλη την οικογένεια των χορηγών εκθετών και υποστηρικτών της ΕΛΕΒΙΤ για τη διαρκή και έμπρακτη συμπαράστασή τους σε όλες τις συνθήκες που έχουμε αντιμετωπίσει. Να ευχαριστήσουμε τα μέλη της Επιστημονικής και Τοπικής Τεχνικής Επιτροπής για το ζήλο που επέδειξαν ώστε να διοργανωθεί αυτό το υψηλού επιπέδου συνέδριο. Ευχόμαστε καλή απόλαυση και ας είναι «αυτό το Συνέδριο το καλύτερο συνέδριο που έχουμε διοργανώσει… ως το επόμενο!»

Εκ μέρους της Οργανωτικής Επιτροπής του 11^{ου} Πανελληνίου Συνεδρίου και του ΔΣ της ΕΛΕΒΙΤ,
Παναγιώτης Μπαμίδης
Αλκίνοος Αθανασίου
Βασιλική Ζηλίδου

ΜΗΝΥΜΑ ΤΗΣ ΟΡΓΑΝΩΤΙΚΗΣ ΕΠΙΤΡΟΠΗΣ ΤΟΥ ΣΥΝΕΔΡΙΟΥ
ΕΙΣΑΓΩΓΙΚΟ ΣΗΜΕΙΩΜΑ ΕΛΕΝΕΠΥ

Η Ελληνική Εταιρεία Νανοϊατρικής στις Επιστήμες Υγείας (**ΕΛΕΝΕΠΥ**) είναι μια διεπιστημονική επιστημονική εταιρεία που ιδρύθηκε το 2016 με σκοπό την προώθηση της Νανοτεχνολογίας στις Επιστήμες Υγείας.

Στους στόχους της ΕΛΕΝΕΠΥ περιλαμβάνονται:

- Η προώθηση της γνώσης σχετικά με την Νανοτεχνολογία στις Επιστήμες Υγείας.
- Η ανάδειξη και προβολή ερευνητικών, εκπαιδευτικών, και επιχειρηματικών δραστηριοτήτων των μελών της εταιρείας σε εθνικό και διεθνές επίπεδο.
- Η προώθηση της συνεργασίας, ανάπτυξης συνεργιών και συμπληρωματικότητας μεταξύ των μελών της εταιρείας.
- Η ενίσχυση συνεργασιών μεταξύ ελληνικών και αλλοδαπών φορέων που δραστηριοποιούνται στον τομέα της Νανοτεχνολογίας στις Επιστήμες Υγείας.
- Η προώθηση επίλυσης θεμάτων που αφορούν το νομικό πλαίσιο που σχετίζεται με δραστηριότητες έρευνας και ανάπτυξης καθώς και επιχειρηματικές δραστηριότητες, στον τομέα της Νανοτεχνολογίας στις Επιστήμες Υγείας.

Στο πλαίσιο αυτών των δράσεων, η ΕΛΕΝΕΠΥ διοργανώνει το **2ο Πανελλήνιο Συνέδριο Φυσικών Επιστημών στην Υγεία** που έχει ως στόχο να αναδείξει τις καινοτομίες, τις νέες τάσεις και τις προοπτικές των επιστημονικών εξελίξεων και εφαρμογών των Φυσικών Επιστημών στον χώρο της Υγείας φέρνοντας σε επαφή ανθρώπους από τον ακαδημαϊκό χώρο, τα νοσοκομεία και τη βιομηχανία. Απώτεροι στόχοι είναι η διάχυση της γνώσης και της έρευνας αιχμής, με εστίαση στις καινοτομίες που αναπτύσσονται από το χώρο των Φυσικών Επιστημών στο πεδίο της Υγείας, η ενίσχυση των συνεργασιών στο ευρύτερο και ταχέως εξελισσόμενο πεδίο των εφαρμογών των Φυσικών Επιστημών στην Υγεία καθώς και η αλληλεπίδραση όλων των επιστημόνων της χώρας με συναφή γνωστικά αντικείμενα εντός του πεδίου των Φυσικών Επιστημών, τόσο μεταξύ τους, όσο και με τους ιατρούς και τους λοιπούς επιστήμονες υγείας. Ασφαλώς, κορυφαία επιδίωξη είναι η ενεργός συμμετοχή των νέων επιστημόνων και η αλληλεπίδρασή τους σε ένα υψηλού επιπέδου επιστημονικό γεγονός.

Η φετινή συνδιοργάνωση του 2ου Πανελλήνιου Συνεδρίου Φυσικών Επιστημών στην Υγεία με το **11ο Συνέδριο Βιοϊατρικής Τεχνολογίας της ΕΛΕΒΙΤ** είναι μια σημαντική συνεργασία που φέρνει κοντά επιστήμονες από συναφή πεδία, όπως η φυσική, η μηχανική, η βιοϊατρική τεχνολογία και η ιατρική. Μέσα από αυτή τη συνάντηση ενισχύεται ο διάλογος και η ανταλλαγή γνώσεων, ενώ ανοίγει ο δρόμος για ακόμα μεγαλύτερες και διεθνείς επιστημονικές διοργανώσεις στο μέλλον, με στόχο να αναδειχθεί ο ρόλος της Ελλάδας στην έρευνα και την καινοτομία στον τομέα της Υγείας.

Ο Πρόεδρος της ΕΛΕΝΕΠΥ
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Θωμάς Αποστόλου	Νίκη Πανδριά	Thomas Apostolou	Niki Pandria
Αλέξανδρος Αστάρας	Θεόδωρος Παπαϊωάννου	Alexander Astaras	Theodoros Papaioannou
Emil Valchinov	Εμμανουήλ Παπαναστασίου	Emil Valchinov	Emmanouil Papanastasiou
Ελευθερία Βελλίδου	Ευάγγελος Παρασκευόπουλος	Eleftheria Vellidou	Evangelos Paraskevopoulos
Βασίλειος Γκέργκης	Αναστασία Ροντίνα-Θεοχαράκη	Vasileios Gkergkis	Anastassia Rodina-Theoharaki
Άρης Δερμιτζάκης	Παύλος Σαράφης	Aris Dermitzakis	Pavlos Sarafis
Στάθης Ευσταθόπουλος	Αναστάσιος Σιούντας	Stathis Efstathopoulos	Anastasios Siountas
Μιχαήλ Ζερβάκης	Στεργιανή Σπύρου	Michalis Zervakis	Stergiani Spyrou
Βασιλική Ζηλίδου	Καλλιρρόη Σταυριανού	Vasiliki Zilidou	Kalliroi Stavrianou
Δήμητρα Ηλιοπούλου	Χάρης Στυλιάδης	Dimitra Iliopoulou	Haris Styliadis
Ελένη Καλδούδη	Δημήτριος Τσαλικάκης	Eleni Kaldoudi	Dimitrios Tsalikakis
Ανέστης Κάλφας	Μάρκος Τσίπουρας	Anestis Kalfas	Markos Trsipouras
Γεώργιος Καραγιάννης	Δημήτριος Φωτιάδης	Georgios Karagiannis	Dimitrios Fotiadis
Παντελής Καραΐσκος	Δημήτρης Φωτιάδης	Pantelis Karaiskos	Dimitris Fotiadis
Δημήτριος Κουτσούρης	Λεόντιος Χατζηλεοντιάδης	Dimitrios Koutsouris	Leontios Hadjileontiadis
Ευδόκιμος Κωνσταντινίδης	Μαρία Χατζηνικολάου	Evdokimos Konstantinidis	Maria Hadjinicolaou
Χρήστος Μανόπουλος	Ιωάννα Χουβαρδά	Christos Manopoulous	Ioanna Chouvarda
Γεώργιος Ματσόπουλος	Σπύρος Νικολόπουλος	Georgios Matsopoulos	Spyros Nikolopoulos

ΕΠΙΣΤΗΜΟΝΙΚΗ ΕΠΙΤΡΟΠΗ | SCIENTIFIC COMMITTEE

Ιωάννης Αντωνάκος	Ioannis Antonakos
Μαρία Γαζούλη	Maria Gazouli
Κωνσταντίνος Δεμέτζος	Constantinos Demetzos
Κυβέλη Ζουράρη	Kyveli Zourari
Ευστράτιος Καραβασίλης	Efstratios Karavasilis
Παντελής Καραΐσκος	Pantelis Karaiskos
Νίκος Κόλλαρος	Nikos Kollaros
Νεφέλη Λαγοπάτη	Nefeli Lagopati
Γιώργος Μανιός	George Manios
Εμμανουήλ Παπαναστασίου	Emmanouel Papanastasiou
Ελευθέριος Παππάς	Eleftherios Pappas
Γιώργος Πατατούκας	George Patatoukas
Νατάσσα Πίππα	Natassa Pippa
Καλλιόπη (Πόλα) Πλατώνη	Kalliopi (Pola) Platoni
Ιωάννης Σεΐμένης	Ioannis Seimenis
Μαρίνα Χαλκιά	Marina Chalkia

ΕΠΙΤΡΟΠΗ ΒΡΑΒΕΙΩΝ | AWARDS COMMITTEE

Σάββας Αναστασιάδης	Savvas Anastasiadis
Αλέξανδρος Αστάρας	Alexander Astaras
Ελευθερία Βελλίδου	Eleftheria Vellidou
Άρης Δερμιτζάκης	Aris Dermitzakis
Ευαγγελία Μιχαλοπούλου	Evaggelia Mihalopoulou
Ιωάννης Τσούγκος	Ioannis Tsougkos
Γεώργιος Παναγιωτάκης	George Panagiotakis

ΤΟΠΙΚΗ ΤΕΧΝΙΚΗ ΕΠΙΤΡΟΠΗ | LOCAL TECHNICAL COMMITTEE

Αννίτα Βαρέλλα	Δημήτριος Μπαμίδης	Annita Varella	Dimitrios Bamidis
Άλκηστη Βασιλικά-Πατσαρασλή	Αλέξανδρος Μωραϊτόπουλος	Alkisti Vasilika-Patsarasli	Alexandros Moraitopoulos
Αναστασία Γκαρτζώνη	Γεώργιος Νομικός	Anastasia Gkartzoni	George Nomikos
Αλίκη Ζηλίδου	Νίκη Πανδριά	Aliki Zilidou	Niki Pandria
Απόλλων Ζωηρός	Ευαγγελία Ρωμανοπούλου	Apollon Zoiros	Evangelia Romanopoulou
Σμαράντα Κετσερίδου	Θεόδωρος Σαββίδης	Smaranda Ketseridou	Theodoros Savvidis
Βασιλική Μαντιού	Κωνσταντίνος Ταγάρας	Vasiliki Mantiou	Konstantinos Tagaras
Δέσποινα Μάρκογλου	Βασίλειος Τριανταφυλλίδης	Despoina Markoglou	Vasilios Triantafyllidis
Ηλίας Μαχαιράς	Ελένη Τρώντσιου	Ilias Machairas	Eleni Trontsiou
Κωνσταντίνος Μητσόπουλος	Βασιλική Φίσκα	Konstantinos Mitsopoulos	Vasiliki Fiska

ΕΠΙΣΤΗΜΟΝΙΚΟ ΠΡΟΓΡΑΜΜΑ
21-23 ΜΑΙΟΥ 2025

SCIENTIFIC PROGRAMME
21-23 MAY 2025

ΕΠΙΣΤΗΜΟΝΙΚΟ ΠΡΟΓΡΑΜΜΑ | SCIENTIFIC PROGRAMME

ΤΕΤΑΡΤΗ, 21 ΜΑΙΟΥ 2025 | WEDNESDAY, 21 MAY 2025

16.30 - 17:00
Γραμματεία

Προσέλευση - Εγγραφές

17:00 - 18:30
"Αθηνά"

Ακτινοθεραπεία (Debate)

Συντονιστές: Κυριακή Θεοδώρου, Παντελής Καραΐσκος

Κυβέλη Ζουράρη, *Φυσικός Ιατρικής, Ακτινοφυσικός, Μονάδα Ιατρικής Φυσικής, Β' Εργαστήριο Ακτινολογίας, ΠΓΝ "Αττικόν"*

Βλαστού Ε., *Ακτινοφυσικός, Παίδων Αγ. Κυριακού*

"Η αναλυτική βαθμονόμηση των σύγχρονων τεχνικών ακτινοθεραπείας καθιστά περιττό τον έλεγχο του πλάνου για κάθε ασθενή (Patient Specific Quality Assurance, PSQA)"

Παλληκαρώνα Τ., *Ακτινοφυσικός, 401 ΓΝΑ,*

Στρουμπινής Θ., *Ακτινοφυσικός, Mediterraneo Hospital*

"Η ανάγκη για αυστηρή τοποθέτηση και ακινητοποίηση στην ακτινοθεραπεία έχει ξεπεραστεί"

Μάριος Μυρωνάκης, *Επίκουρος Καθηγητής Ιατρικής Φυσικής, Παν/μιο Θεσσαλίας,*

Ελευθέριος Παππάς, *Επίκουρος Καθηγητής Ιατρικής Φυσικής, Ιατρική Σχολή, ΕΚΠΑ*

"Ο έλεγχος ποιότητας της τεχνικής IMRT στην Ακτινοθεραπεία μέσω αρχείων καταγραφής (log files) είναι καλύτερος από τον έλεγχο μέσω μετρήσεων"

17:00 - 18:30
"ΉΡΑ"

Creating a Common Language: Applying Systems Engineering to Healthcare Innovation *(Workshop)*

Συντονιστές: Κωνσταντίνος Μητσόπουλος, Βασιλική Μαντιού

Ομιλητές – Εκπαιδευτές:

Κωνσταντίνος Μητσόπουλος, *MEng, MSc / Lab of Medical Physics and Digital Innovation School of Medicine, Aristotle University of Thessaloniki*

Βασιλική Μαντιού, *Electronic's Engineer, Lab of Medical Physics and Digital Innovation, School of Medicine, Aristotle University of Thessaloniki*

18:30 - 20:00
"Αθηνά"

Το μέλλον της ΤΝ στην Υγεία

Συντονιστές: Παναγιώτης Μπαμίδης, Αλέξης Κελέκης

Ομιλητές:

Σπύρος Βλαχόπουλος, *Καθηγητής, Νομική Σχολή, ΕΚΠΑ*
"Νομικές Προκλήσεις για την Τεχνητή Νοημοσύνη στην Υγεία"

Αρίσταρχος Γκρέκας, *Αν. Καθηγητής, Τμήμα Θεολογίας, ΕΚΠΑ*
"Ηθικά Διλήμματα και Βιοηθικές Προεκτάσεις της Τεχνητής Νοημοσύνης στην Υγεία"

Ευστάθιος Ευσταθόπουλος, *Καθηγητής Ιατρικής Φυσικής, Ιατρική Σχολή, ΕΚΠΑ*
"Ποιες αλλαγές φέρνει η Τεχνητή Νοημοσύνη στην Υγεία"

18:30 - 20:00
"Ήρα"

Ρόλος Μηχανικού Βιοϊατρικής Τεχνολογίας *(Round Table)*

Συντονιστές: Χρήστος Χ. Μιχαήλ

Ομιλητές:

Ιωάννης Καλατζής, *Καθηγητής, Πρόεδρος Τμήματος Μηχανικών Βιοϊατρικής, ΠΑΔΑ*
"Η Ακαδημαϊκή Θεμελίωση του Ρόλου του Μηχανικού Βιοϊατρικής Τεχνολογίας στις Σύγχρονες Προκλήσεις"

Δρ. Χρήστος Χ. Μιχαήλ, *Εθνική Κεντρική Αρχή Προμηθειών Υγείας (Ε.Κ.Α.Π.Υ.)*
"Ο Μηχανικός Βιοϊατρικής Τεχνολογίας στην Ελλάδα και Διεθνώς: Δείκτες, Συγκρίσεις και Προοπτικές"

Νικόλαος Κραβαρίτης, *Πανεπιστημιακό Γενικό Νοσοκομείο "ΑΤΤΙΚΟΝ" (Π.Γ.Ν. "ΑΤΤΙΚΟΝ")*
"Ο ρόλος και η θέση του Μηχανικού Βιοϊατρικής Τεχνολογίας: Η μελέτη περίπτωσης ενός Γενικού Πανεπιστημιακού Νοσοκομείου - Γ.Π.Ν. «ΑΤΤΙΚΟΝ»"

Ιωάννης Οικονόμου, *Ιωάννης Οικονόμου, Γενικό Νοσοκομείο Αθηνών "Γ. Γεννηματάς" (Γ.Ν.Α. "Γ. Γεννηματάς")*
"Ο ρόλος και η θέση του Μηχανικού Βιοϊατρικής Τεχνολογίας: Η μελέτη περίπτωσης ενός Γενικού Νοσοκομείου - Γ.Ν.Α. «Γ. Γεννηματάς»"

Γεώργιος Χαλούτσος, *Ωνάσειο Καρδιοχειρουργικό Κέντρο (Ω.Κ.Κ.)*
"Ο μηχανικός Βιοϊατρικής Τεχνολογίας και η Αξιολόγηση Ιατρικού Εξοπλισμού (HTA): Το Παράδειγμα του Ωνασείου Καρδιοχειρουργικού Κέντρου (Ω.Κ.Κ.)"

18:30 - 20:00
"Syndicate 6"

Digital Intervention in the Management of Balance Disorders *(Round Table)*

Συντονιστές: Δημήτρης Κικίδης, Χρήστος Νικήτας, Ελευθερία Βελλίδου

Ομιλητές:

Χρήστος Νικήτας, *Φυσικοθεραπευτής, Α' Ω.Ρ.Λ. Πανεπιστημιακή Κλινική, Εθνικό και Καποδιστριακό Πανεπιστήμιο Αθηνών, Γ.Ν.Α. «Ιπποκράτειο»*

"HOLOBalance: Κλινικά αποτελέσματα εφαρμογής ολογραμμάτων την αποκατάσταση της Ισορροπίας"

Ελευθερία Ηλιάδου, *Επίκ. Καθηγήτρια, Πανεπιστήμιο Πελοποννήσου, Τμήμα Λογοθεραπείας*

"Smart Bear: Ποια τα διδάγματα της εφαρμογής της πλατφόρμας ;"

Δημήτρης Κικίδης, *Επίκ. Καθηγητής, Α' Ω.Ρ.Λ. Πανεπιστημιακή Κλινική, Εθνικό και Καποδιστριακό Πανεπιστήμιο Αθηνών, Γ.Ν.Α. «Ιπποκράτειο»*

"Telerehab DSS: Παρουσίαση Κλινικού Πρωτοκόλλου"

Θεόδωρος Παναγιώτης Βαγενάς, *ΣΗΜΜΥ, ΕΜΠ, Εργαστήριο Βιοϊατρικής Τεχνολογίας*
"Ανασκόπηση ψηφιακών παρεμβάσεων από την διεθνή βιβλιογραφία"

20:00 - 21:00 Τελετή Έναρξης - Opening Ceremony

20:00 - 20:30 **Χαιρετισμοί**

Παναγιώτης Μπαμίδης, ***Πρόεδρος ΕΛΕΒΙΤ***

Ευστάθιος Ευσταθόπουλος, ***Πρόεδρος ΕΛΕΝΕΠΥ***

Καλλιόπη (Πόλα) Πλατώνη, ***Πρόεδρος ΕΦΙΕ***

Αναστάσιος Γαϊτάνης, ***Γενικός Γραμματέας Έρευνας και Καινοτομίας***

Νίκος Παπαϊωάννου, ***Υφυπουργός Παιδείας Θρησκευμάτων και Αθλητισμού, Υφυπουργός αρμόδιος για την τριτοβάθμια εκπαίδευση***

20:30 - 21:00 **Συντονιστής:** Παναγιώτης Μπαμίδης

Keynote Speaker

Giuseppe Fico, ***President of EAMBES***

"Transforming Healthcare in the Digital Era: Biomedical Engineers Driving Innovation and Impact"

21:00 - 22:00 Welcome Reception

ΕΠΙΣΤΗΜΟΝΙΚΟ ΠΡΟΓΡΑΜΜΑ | SCIENTIFIC PROGRAMME

ΠΕΜΠΤΗ, 22 ΜΑΙΟΥ 2025 | THURSDAY, 22 MAY 2025

9:00 – 10:30
"Αθηνά"

MRI

Συντονιστές: Νίκη Λάμα, Ιωάννης Σεϊμένης

Ομιλητές:

Γεώργιος Μπρούμπουλης, *Ακτινοφυσικός, Εργαστήριο Εφαρμοσμένης Ιατρικής Φυσικής, Ιατρική Σχολή, ΕΚΠΑ*

"Παραμετροποίηση απεικονιστικών τεχνικών Μαγνητικού Συντονισμού και βελτιστοποίηση της ποιότητας εικόνας"

Ευστράτιος Καραβασίλης, *Επ. Καθηγητής Ιατρικής Φυσικής, Ιατρική Σχολή, ΔΠΘ*

"Προηγμένες τεχνικές απεικόνισης Μαγνητικού Συντονισμού"

Ελίνα Σταματελάτου, *RadboudUMC, Nijmegen, the Netherlands*

"Προηγμένες MR τεχνικές στον προστάτη: Από την φασματοσκοπία στην αυτοματοποιημένη διάγνωση"

9:00 – 10:30
"ΗΡΑ"

Προφορικές Ανακοινώσεις 1 - Oral presentations 1

Συντονιστές: Χριστίνα Αρμπιλιά, Γιώργος Πατατούκας

1. *Theano-Marina Axakali, Maria-Anthi Kouri, Emmanouil Ioannidis, Konstantinos Manousopoulos, Ioannis Papadopoulos, Panagiotis Varelas, Konstantinos Fillipou, Panagiota Manwlakou, Ioannis Karalis, Ioannis Tsiafoutis, Evaggelia Kounadi, Nektarios Kalyvas and Giorgos Fountos*

   "Optimizing Radiation Safety in Chronic Total Occlusion (CTO) Procedures: Dosimetric Assessment With and Without the Implementation of Egg Nest Radioprotective Shielding"
2. *Maria Giannopoulou, Theodoros Stroubinis, Despoina Stasinou, Michalis Psarras, Anna Zygogianni, Maria Protopapa, Vasileios Kouloulias and Kalliopi Platoni*

   "Volumetric Modulated Arc Therapy (VMAT) Versus Optimized Dynamic Conformal Arc (OptDCA) Techniques for Linac-Based Stereotactic Radiotherapy of Single Brain Metastases"
3. *Angeliki Tsantiri, Sophia Zisiadi, Stauros Vorrias, Zisis Tsouris, Agapi Ploussi and Efstathios Efstathopoulos*

   "Nanoparticles in Medical Imaging: Advantages and Challenges
4. *Vasiliki Margaroni, Pantelis Karaiskos and Eleftherios Pappas*

   "Dosimetry in Non-Standard Fields of 1.5t MR-Linacs: Correction Factors for Two Commercially Available OSL Dosimeters"
5. *Matina Patsioti, Agapi Ploussi, George Christopoulos and Efstathios Efstathopoulos*

   "Evaluation of a Deep Learning Image Reconstruction Algorithm on Radiation Dose and Image Quality in CT Examinations."
6. *Michaila Akathi Pantelaiou, Dimitrios Vagenas and Stergios Pispas*

"Aggregation-Induced Emmision of Anticancer Natural Substances: Nanoformulation With Random Copolymers and Physicochemical Studies"

7. *Emmanouil Anousis, Georgios Patatoukas, Marina Chalkia, Nikolaos Kollaros, Kyveli Zourari, Nikolaos Trogkanis, Dimitra Michaletou and Kalliopi Platoni*

   "Assesing the Dosimetric Effect of Golden Beam Data and Machine Equivalence in VMAT and IMRT Treatment Plans"

8. *Charalampia Ganou, Aristotelis Ganos, Spiridon Papatheodorou, Vasileios Metaxas, Christos Dimitroukas and George Panayiotakis*

   "Software Solutions for Shielding Calculations in Radiotherapy Rooms"

9. *Dimitrios Samaras, Georgios Agrotis, Alexandros Vamavakas, Maria Vakalopoulou, Marianna Vlychou, Aikaterini Vassiou, Vasileios Tzortzis and Ioannis Tsougos*

   "Investigating the Stability of Radiomic Features Across Different MRI Field Strengths and the Impact of Harmonization Techniques"

10. *Konstantinos Outsikas, George Patatoukas, Marina Chalkia, Kyveli Zourari, Nikolaos Kolaros, Efrosyni Kypraiou and Kalliopi Platoni*

    "Low Gamma Passing Rate Analysis for VMAT And IMRT Treatment Plans"

11. *Andreas Stratis*

    "The Theranostics Era: From Treating What You See to Seeing What You Treat"

12. *Kalliopi Natalia Tzaneti, Dimitris Zantzas, Efstathios Sidiropoulos, Konstantinos Zisis, Anestis Kalfas and Kyriaki Papadopoulou Pappas*

    "Hemodynamic and Anatomic Effects of the Anterior Cerebral Artery in Aneurysm Formation"

9:00 - 11:00
"Syndicate 6"

9:00 - 10:00

HEROES Final Meeting & Open Workshop *(Symposium)*

Συντονιστές: Αλκίνοος Αθανασίου, Παναγιώτης Μπαμίδης

Ομιλητές:

Αλκίνοος Αθανασίου, *Assistant Professor of Neurosurgery School of Medicine, Faculty of Health Sciences, Aristotle University of Thessaloniki, Vice-President ELEVIT*

"A decade of BERD development for neural rehabilitation"

Κωνσταντίνος Μητσόπουλος, *MEng, MSc / Lab of Medical Physics and Digital Innovation,School of Medicine, Aristotle University of Thessaloniki*

"The NeuroSuitUp platform of wearable robotics, interfaces and serious gaming"

Παναγιώτης Ε. Αντωνίου, *Μεταδιδακτορικός Ερευνητής και Διδάσκων, Εργαστήριο Ιατρικής Φυσικής και Ψηφιακής Καινοτομίας, Τμήμα Ιατρικής, Αριστοτέλειο Πανεπιστήμιο Θεσσαλονίκης*

Κωνσταντίνος Ταγάρας, *Research Associate, Lab of Medical Physics and Digital Innovation, Aristotle University of Thessaloniki*

"Serious gaming for neural rehabilitation: lessons learned during development"

Βασιλική Φίσκα, *Βοηθός Ερευνητή, BHV Group ΙΠΤΗΛ, ΕΚΕΤΑ – ΥΠ. ΔΙΔ. Πανεπιστήμιο Δυτ. Μακεδονίας*

"Integration and validation of soft robotic gloves: HEROES pilots"

10:00 - 11:00

ThessRoboGlove Forum: TRG2025 Symposium

Συντονιστές: Βασιλική Φίσκα, Κωνσταντίνος Μητσόπουλος

Ομιλητές:

Παναγίωτης Βαρθολομαίος (online), *Assistant Professor of Robotics, Department of Computer Science and Biomedical Informatics, University of Thessaly & Institute of Robotics, "Athena" Research Center*

"Ερευνητικές Κατευθύνσεις στην Ιατρική Ρομποτική: Ελάχιστα Επεμβατική Ρομποτική Χειρουργική και Ρομποτικά Συστήματα Αποκατάστασης - Research Directions in Medical Robotics: Minimally Invasive Robotic Surgery and Rehabilitation Robotics"

Παναγιώτης Πολυγερινός, *Αν. Καθηγητής, Soft Robotics, Τμήμα Μηχανολόγων Μηχανικών, Ελληνικό Μεσογειακό Πανεπιστήμιο (ΕΛΜΕΠΑ)*

"Soft Wearable Robotic Garments: The EU SWAG project"

Ελευθερία Βελλίδου, *Senior Researcher, Εργαστήριο Βιοϊατρικής Τεχνολογίας, ΣΗΜΜΥ, ΕΜΠ*

"Exoskeletons in balance disorders & the Rehabotics"

Μάρκος Τσίπουρας (online), *Καθηγητής, Τμήμα Ηλεκτρολόγων Μηχανικών και Μηχανικών Η/Υ, Παν. Δυτ. Μακεδονίας*

"Ανάλυση ΗΕΓ για Νευρολογικές Διαταραχές και ανάπτυξη Διεπαφών Εγκεφάλου-Υπολογιστή."

Αλέξανδρος Αστάρας, *Επίκουρος Καθηγητής Πληροφορικής, Αμερικανικό Κολέγιο Θεσσαλονίκης*

"Results from the online workshop on wearable robotics questionnaires"

Σπύρος Νικολόπουλος, *Senior Researcher, Multimedia Knowledge and Social Media Analytics Lab, Information Technologies Institute*, *CERTH,*

Βασιλική Φίσκα *Βοηθός Ερευνητή, BHV Group ΙΠΤΗΛ, ΕΚΕΤΑ – ΥΠ. ΔΙΔ. Πανεπιστήμιο Δυτ. Μακεδονίας*

(Hybrid) ***"Collaborations and search for future funding for TRG forum project proposals and actions"***

Παναγιώτης Μπαμίδης, *Καθηγητής Ιατρικής Φυσικής, Πληροφορικής Και Ιατρικής Εκπαίδευσης, Δ/ντης Εργαστηρίου Ιατρικής Φυσικής και Ψηφιακής Καινοτομίας, Τμήμα Ιατρικής, ΑΠΘ, Προέδρος ΔΣ ΕΛΕΒΙΤ*

Closing Remarks

Discussion

ΕΠΙΣΤΗΜΟΝΙΚΟ ΠΡΟΓΡΑΜΜΑ | SCIENTIFIC PROGRAMME

ΠΕΜΠΤΗ, 22 ΜΑΙΟΥ 2025 | THURSDAY, 22 MAY 2025

10.30 - 11.00 **Industry Session**

"Αθηνά"

Συντονιστές: Βίκυ Ζηλίδου, Σάββας Αναστασιάδης

ANTISEL SA

"From Data to Decisions: How Mindray IoT Brings Biomedical Teams, IT, and Clinicians Together. A deep dive into cross-functional collaboration enabled by real-time device connectivity, centralized monitoring, and remote diagnostics."

Ομιλητής:

Serban Necula, *Healthcare Informatics Specialist at Mindray*

10.30 - 11.00 **Προφορικές Ανακοινώσεις 2 - Oral presentations 2**

"Ήρα"

Συντονιστές: Χρήστος Μανόπουλος, Μάριος Αντωνακάκης

1. *Grigorios Kotoulas, Vasileios Loukas, Georgia Karanasiou, Christos Katsouras and Dimitrios Fotiadis*

   "Angioplasty Balloon Deployment in 3D Reconstructed Arteries"

2. *Konstantina-Helen Tsarapatsani, Antonis Sakellarios, Vassilis Tsakanikas, Henrik Rudolf, Hans J. Trampisch, Marcus Kleber, Winfried Maerz and Dimitrios Fotiadis*

   "Machine Learning Models for Long-Term Cardiovascular and Related Events Prediction: A Multi-Study Comparative Analysis"

3. *Dimitrios Petrolekas, Anastasios Raptis, Efstratios Karavasilis, Konstantinos Moulakakis, Ioannis Kakisis and Christos Manopoulos*

   "4D Flow MRI-Enabled Patient-Specific Computational Hemodynamics of Thoracic Aorta: CFD Predictions Vs. In Vivo Imaging Data"

4. *Eleni Papanikolaou, Dimitrios Sokolis, Dimitrios Iliopoulos and Christos Manopoulos*

   "Dissection Mechanics of Tissue Components in Human Aorta"

5. *Platon Sarantides, Anastasios Raptis and Christos Manopoulos*

   "Structural Modelling and Simulation of Abdominal Aortic Aneurysms Accounting for Intraluminal Thrombus and Calcifications"

11.00 - 11.30 **Διάλειμμα - Καφές**

Poster Presentation to Award Committee

Award Committee: Anastasiadis Savvas, Astaras Alexander, Vellidou Eleftheria, Dermitzakis Aris, Tsougkos Ioannis, Panagiotakis George, Mihalopoulou Evaggelia (Lia)

1. *Christina Plomariti, Antonis Billis, Paraskevas Lagakis,Despoina Mantziari, Anastasia Barboudi, Maria Bigaki, Stergiani Spyrou, Dimitrios Tsalikakis and Panagiotis Bamidis*

   "Application of telehealth in cancer care: Experiences from the Greek pilot of the eCAN project"

2. *Antonios Panagakis, Vasiliki Fiska, Vasiliki Mantiou, Konstantinos Mitsopoulos,*

Alexandros Moraitopoulos, Konstantinos Tagaras, Panagiotis Antoniou, Panagiotis Bamidis and Alkinoos Athanasiou

"Structural and functional optimization of pneumatics-based soft robotics glove using Finite & Boundary Element Analysis"

3. *Andreas Belavgenis, Spyros Skiadopoulos, Anna Karahaliou, Christos Dimitroukas, Basilis Metaxas, Fotios Efthymiou, Panagiotis Megas and George Panayiotakis*

   "Monitoring Scattered Radiation for Optimizing Staff Positioning in Fluoroscopically-Guided Hip Interventions"

4. *Ioannis Anagnostopoulos, Eleftherios Pappas and Pantelis Karaiskos*

   "Automated Algorithm and User Interface for Spatial Distortion Detection in MR Images Used for Target Localization in Stereotactic Radiosurgery"

5. *Ilektra Makridou, Despoina Petsani, Konstantina Tsimpita, David Gaburici, Panagiotis Bamidis and Evdokimos Konstantinidis*

   "Understanding Barriers and Enablers of Innovation in Transitional Care: A Mixed-Methods Study"

6. *Ekaterini Bei, Konstantinos Politof, Konstantia Moirogiorgou, Marios Antonakakis and Michalis Zervakis*

   "Morphological Analysis of Intraluminal Thrombus of Abdominal Aortic Aneurysm"

7. *Georgios Parisis, Parmenion Tsitsopoulos, Panagiotis Bamidis and Alkinoos Athanasiou*

   "Source-Level EEG Functional Connectivity Analysis in Schizophrenia Patients"

8. *George M A Papanikitas, Konstantinos Mitsopoulos,Panagioths Antoniou, Konstantinos Tagaras, Alkinoos Athanasiou and Panagioths Bamidis*

   "Eye Tracking in Serious Games and Its Rehabilitation Applications"

9. *Vyacheslav Skopintsev, Haridimos Kondylakis, Georgios Dimitrakopoulos and Alkinoos Athanasiou*

   "Brain Network Biomarkers in Psychiatric Diagnosis"

10. *Evangelia Maneni, Anna Karahaliou, Spyridon Skiadopoulos and George Panayiotakis*

    "A Phantom-Based Study for Optimization of Image Quality and Radiation Dose in Pediatric CT"

11. *Nikos Merkos*

    "Study of the Self-Absorption Effect in the Gamma Spectroscopic Analysis of Environmental Samples"

12. *Emmanouil Spyrou, Parmenion Tsitsopoulos, Alkinoos Athanasiou and Panagiotis Bamidis*

    "Study of Event-Related Potentials in EEG Data in Major Depressive Disorder"

13. *Νικόλαος Γκαντσινικούδης, Σάββας Κολτσακίδης, Παναγιώτης Προδρόμου, Ελένη Αγγελίδου, Στυλιανός Καπετανάκης, Ελευθέριος Τσιρίδης, Ιωάννης Μάγρας, Ειρήνη Σαρπεκίδου, Γεώργιος Καζάκος, Δημήτριος Τζέτζης and Αριστείδης Κριτής*

    "Εργαστηριακη Εμβιομηχανικη Αξιολογηση Ιστομηχανικα Ανεπτυγμενων Εμφυτευματων Μεσοσπονδυλιου Δισκου"

14. *Georgios Sotiroudis, Panagiotis Bamidis and Alkinoos Athanasiou*

    "Wayfinding In Hospitals - A Narrative Review of Existing Solutions and Upcoming Technological Advancements"

15. *Kyriakos Kokkinogoulis, Michalis Psarras, Despoina Stasinou, Theodoros Stroubinis,*

Kyveli Zourari and Kalliopi Platoni

"Dosimetric Verification of the Virtual Cone Technique for Stereotactic Radiosurgery"

16. *Athina Tsagkalidou and Sophia Koukouraki*

    "SPECT/CT Whole-Body Scintigraphy With 131 Iodine in the Assessment of Recurrence of Patients With Differentiated Thyroid Cancer"

17. *Dimitris zi, Evdokimos Konstantinidis and Nikos Athanasopoulos*

    "Blockchain-Enabled Federated Learning Models for Secure and Open Medical Data Sharing: A Comparative Review"

18. *Matina Patsioti, Ioannis Antonakos, Maria-Eleni Zachou, George Christopoulos and Efstathios P. Efstathopoulos*

    "Estimation of Dose in Neonates Under 1kg in Incubator from Chest X-RAYS"

19. *Ηλιάνα Σωτηροπούλου, Ιωάννης Τσίχλης, Μαρία Τσακίρη and Κώστας Δεμέτζος*

    "Λιποσώματα DPPC:Cholesterol και DPPC:Pluronic F-127 με Ενσωματωμένη Κερκετίνη: Συγκριτική Μελέτη Φυσικοχημικών Και θερμοτροπικών Ιδιοτήτων"

11.30 - 12.15 **"Αθηνά"**

Invited Session: Special BME topics

Συντονιστές: Γιώργος Ματσόπουλος, Αντώνης Μπίλλης

Ομιλητές:

Αμαλία Αγγελή, ***Aristotle University of Thessaloniki***

"In situ tissue regeneration via in-vivo tissue engineering"

Σωκράτης Παπαγεωργίου, ***Ιατρική Σχολή ΕΚΠΑ***

«Τηλεϊατρική και Ψυχική Υγεία»

11.30 - 12.15 **"Ήρα"**

Προφορικές Ανακοινώσεις (Συνέχεια) - Oral presentations (Cont.)

Συντονιστές: Παναγιώτης Αντωνίου

1. *Michail Athanasiou, Anastasios Raptis and Christos Manopoulos*

   "Exploring State-Of-The-Art Deep Learning Architectures for Blood Flow Prediction in Pathological Vessels"

2. *Andreas Stratis, Kostas Dimos and Stathis Despotopoulos*

   "Is AI Ending the Compromise Between Dose and Image Quality? The Lung CT Paradigm"

3. *Ourania Ntousi, Panagiotis Siogkas and Dimitrios Fotiadis*

   "Modeling of Three-Dimensional Scaffolds for Bone Regeneration using CFD Analysis"

4. *Dimitrios Arampatzis, Emmanouil Athanasiadis, Eleftherios Kontopodis, Ilias Theodorakopoulos, Ioannis Theocharakis, Spyridon Kostopoulos, Dimitrios Glotsos, Panteleimon Asvestas, Anastasios Raptis, Christos Manopoulos, Konstantinos Moulakakis, John Kakisis and Ioannis Kalatzis*

   "A Preliminary Comparison of Unsupervised and Deep Learning Approaches for

Automatic Abdominal Aortic Aneurysm Segmentation on CT Images"

5. *Meriem Abadi, Toubakh Houari, Billal Benarabi, Noureddine Zerhouni, Michalis Zervakis and Marios Antonakakis*

   "Vision Transformer for Thyroid Ultrasound Image Classification"

6. *George Mavrovounis, Martina Samiotaki, Ioannis Kakkos, Vassilis Aidinis, George Stranjalis and Theodosis Kalamatianos*

   "The Hematoma Fluid and Serum Proteomes of Chronic Subdural Hematoma Patients"

7. *Sosanna-Anastasia Fragaki, Aikaterini Skouroliakou and Ioannis Kalatzis*

   "Glucose Control in Artificial Pancreas Scheme with Pid and Pso-Optimized PID Controllers"

11.30 - 12.45
"Syndicate 6"

The role of computational models and artificial intelligence for digital twins in non-invasive diagnosis of brain and heart diseases *(Round Table)*

Συντονιστές: Χρήστος Μανόπουλος, Μάριος Αντωνακάκης

Ομιλητές:

Χρήστος Μανόπουλος, *Αναπληρωτής Καθηγητής, Εργαστήριο Βιορευστομηχανικής & Βιοϊατρικής Τεχνολογίας, ΕΜΠ*

"SAFE-AORTA: An overview of a CDSS for Abdominal Aortic Aneurysm Disease Based on Artificial Intelligence Models"

Δρ. Μάριος Αντωνακάκης, *Εργαστήριο Ψηφιακής Επεξεργασίας Εικόνας και Σήματος, Σχολή Ηλεκτρολόγων Μηχανικών και Μηχανικών Υπολογιστών Πολυτεχνείο Κρήτης*

"Non-invasive diagnosis of brain and heart disorders with computational and AI modeling"

Γιώργος Σταυρουλάκης, *Καθηγητής, Εργαστήριο Υπολογιστικής Μηχανικής και Βελτιστοποίησης, Σχολή Μηχανικών Παραγωγής και Διοίκησης, Πολυτεχνείο Κρήτης*

"Computational mechanics tools for biomechanics and artificial intelligent reduced order modelling for digital twins and virtual sensors"

Νίκος Διαγγελάκης, *Επίκ. Καθηγητής, Δυναμική, Βελτιστοποίηση και Ρύθμιση Διεργασιών, Σχολή Χημικών Μηχανικών και Μηχανικών Περιβάλλοντος, Πολυτεχνείο Κρήτης*

"Complexity reduction of hemodynamics modelling of infrarenal aortas via machine learning"

12.15 - 14.00
"Αθηνά"

Industry Session

Συντονιστές: Βίκυ Ζηλίδου, Αικατερίνη Σκουρολιάκου

1. **Siemens Healthineers Ελλάς ΑΕ**

   "Applications training in the digital era"

   Ομιλητής:

   Ιωάννης Κατσίκης, *Application Specialist in Advanced Therapies*

2. **GE HealthCare AE**

   "360° solutions to improve your facility workflow"

   Ομιλητής:

   Michal Kolanowski, *Digital Adoption Leader Eastern Europe, GE HealthCare*

3. **Philips Hellas Single Member SA**

   "CathLab Dose awareness and Fusion Imaging approach"

   Ομιλητής:

   Βασίλης Διακομανώλης, *Application Specialist iGT, Philips Hellas Single Member SA*

4. **Agfa - Gevaert AEBE**

   "AGFA DR portfolio & SmartXR (AI) Technology"

   Ομιλητές:

   Αθανάσιος Τσέγκος, *Sales Manager Greece | Rad Sol Sales Europe NSE Greece/Cyprus*

   Φώτης Βαγλάς, *Key Account Manager | Rad Sol Sales Europe*

   Κωνσταντίνος Κωνσταντόπουλος, *Key Account Manager |Rad Sol Sales Europe NSE Greece/Cyprus*

5. **ICON DYNAMICS**

   "VISION SUPPORT in the Radiography Workflow"

   Ομιλητής:

   Siniša Kardum, *Regional Sales Manager*

12.15 - 14.00
"Ήρα"

Προφορικές Ανακοινώσεις 3 - Oral presentations

Συντονιστές: Άρης Δερμιτζάκης, Παναγιώτης Αντωνίου

1. *Anastasia Daskalaki, Spilios Zisimopoulos and Aris Dermitzakis*

   "Structured Data Entry Workflow for Medical Equipment Inventory Management"
2. *Spilios Zisimopoulos, Anastasia Daskalaki and Aristeidis Dermitzakis*

   "Creating a Unified Medical Equipment Inventory in Greece"
3. *Giorgos Papadoulis, Damianos Dumi-Sigalas, Christos Sintoris and Aris Dermitzakis*

   "Advancing Universal Accessibility in Healthcare"
4. *Konstantinos Diamantis and Panagiotis Bamidis*

   "Εμπειρίες από τη Χρήση Εργαλείων Τεχνητής Νοημοσύνης στην Μεταπτυχιακή Εκπαίδευση για τον Ψηφιακό Μετασχηματισμό της Υγείας"
5. *Panagiotis Antoniou, Niki Pandria, Anastassia Rodina Theocharaki, Stathis Th.*

Konstantinidis and Panagiotis Bamidis

"Mapping Digital Soft Skills for Implementation of Digital Scenario Based Learning Educational Resources"

6. *Vasiliki Pappa, Efstathios Sidiropoulos, Evangelos Paraskevopoulos and Panagiotis Bamidis*

   "Brain Tumor Digital Twin with Deep Learning"

7. *Apollon Zoiros, Giorgos Petridis, Brigilda Merkaj, Antonis Billis and Panagiotis Bamidis*

   "Modeling Late-Age Adverse Effects of Breast Cancer Survivors from Real-World EHR Data"

8. *Vasiliki Fiska, Anna-Maria Krooupa, Spiros Nikolopoulos and Ioannis Kompatsiaris*

   "AI-Powered Personalised Lifestyle Coaching for Nutrition & Physical Activity in Breast Cancer"

9. *Smaranda Ketseridou, Christina Plomariti, Christos Frantzidis, Eleni Feleki, Marianthi Kermenidou, Ilias Machairas, Georgia Kioselaki, Anthoula Chatzimpaloglou, Spyros Karakitsios, Dimosthenis Sarigiannis and Panagiotis Bamidis*

   "Exploring the Impact of Age and Weight on Sleep Quality: Insights from the URBANOME Project"

10. *Efterpi Karapintzou, Vassilis Tsakanikas, Brooke Nairn, Marousa Pavlou, Doris Eva Bamiou, Themis Exarchos and Dimitrios Fotiadis*

    "AI-Enhanced Tele-Rehabilitation: Research-Oriented Modeling for Fall Risk, Treatment Effectiveness, and Adverse Events in Balance Disorders"

11. *Michail Kalogeropoulos, Petros Papachristou and Alexandra Athanasiou*

    "Swarm Learning with Weak Supervision for Automatic Breast Cancer Detection in MRI"

12. *Veatriki Nikoudi, Eleftherios Kontopodis, Ioannis Kalatzis, Erricos Ventouras and Aikaterini Skouroliakou*

    "A Functional Near Infrared Spectroscopy Acquisiton Protocol"

13. *Konstantinos Chaitas, Menelaos Karamichalis and Alexander Astaras*

    "A Novel Wearable Navigation Assistance Device Using Intuitive Tactile Feedback for People with Visual Impairments (Navisense)"

14. *Filip Ivanis, Georgia Beleli, Vasiliki Fiska and Alexander Astaras*

    "A Novel Soft-Robotic Glove for Physical Rehabilitation Featuring Adjustable Agonist/Antagonist Muscle Assistance"

15. *Arsenios Arsenidis, Nikoletta Papazisimou, Alkinoos Athanasiou, Panagiotis Bamidis, Petros Stefaneas and Alexander Astaras*

    "Development of a functional electrical stimulation prototype device with novel optimization methodology for neurorehabilitation (OptiPulse)"

12.45 - 14.00
"Syndicate 6"

Digital health services to facilitate non-invasive diagnostics of brain diseases
(Workshop)

Empowering digital health in public and private sector: The case of smartHEALTH

Συντονιστές: Μάριος Αντωνακάκης

Ομιλητές:

Κώστας Καραμάνης, *Κέντρο Εφαρμογών και Υπηρεσιών Ηλεκτρονικής Υγείας, Ινστιτούτο Πληροφορικής, Ίδρυμα Τεχνολογίας και Έρευνας (ΙΤΕ)*
"The smartHEALTH EDIH"

Δρ. Μάριος Αντωνακάκης, *Εργαστήριο Ψηφιακής Επεξεργασίας Εικόνας και Σήματος, Σχολή Ηλεκτρολόγων Μηχανικών και Μηχανικών Υπολογιστών Πολυτεχνείο Κρήτης*

"A sample of smartHEALTH services"

Δρ. Γιάννης Γκουζιώνης, *CEO Aisthesis Medical*

"smartHEALTH experience - Aisthesis Medical"

Δρ. Γιώργος Λούντος, *CEO Bioemtech*
"smartHEALTH experience: Bioemtech"

14.00-15:00 **Διάλειμμα - Γεύμα**

Poster Presentation to Award Committee

Award Committee: Anastasiadis Savvas, Astaras Alexander, Vellidou Eleftheria, Dermitzakis Aris, Tsougkos Ioannis, Panagiotakis George, Mihalopoulou Evaggelia (Lia)

1. *Despoina Markoglou and Konstantinos Ampountolas*

   "Reinforcement Learning for Walking Assistance Control of a Lower Limb Exoskeleton"

2. *Vasileios Triantafyllidis, Konstantinos Mitsopoulos, Vasiliki Fiska, Georgios Stamboulis, Vasiliki Mantiou, Alexandros Moraitopoulos, Leontios J Hadjileontiadis, Dimitrios Kugiumtzis, Panagiotis Bamidis and Alkinoos Athanasiou*

   "Designing a Wearable Lower Body Distributed Sensor System Using Data Fusion from SEMG and MARG"

3. *Kyriakos Birmpas, Konstantinos Baldoukas, Aristeidis Dermitzakis and Konstantinos Moustakas*

   "Energy Harvesting Systems for Self-Powered Prostheses"

4. *Christina Plomariti, Panagiotis Emmanouil Kartsidis, Georgia Kioselaki, Ilias Machairas, Chrysoula Kourtidou-Papadeli and Panagiotis Bamidis*

   "Literature Review of Short-Arm Human Centrifuge Rehabilitation Protocols"

5. *Panagiotis Antoniou, Konstantinos Tagaras, Alkinoos Athanasiou and Panagiotis Bamidis*

   "Linking semantic medical vocabularies to 3d assets for a chatgpt powered, virtual reality based, medical education environment"

6. *Vasiliki Margaroni, Eleftherios Pappas, Alexandra Drakopoulou and Pantelis Karaiskos*

   "Monte Carlo Determination of Correction Factors for Beo-Based Optically Stimulated Luminescence Detectors in Gamma Knife Radiosurgery Small Fields"

7. *Konstantina Tsimpita and Ilektra Makridou*

   "Agile Methodology for User Requirements Elicitation in The Raise Platform"

8. *Maria-Eleni Zachou, Ellas Spyratou, Nefeli Lagopati, Kalliopi Platoni and Efstathios P. Efstathopoulos*

   "Πρόσφατες Εξελίξεις στη Νανοϊατρική για τη Συνδυαστική Αντικαρκινική Θεραπεία με Ακτινοθεραπεία και Φωτοθερμία"

9. *Fotini Spanou, Spyros Skiadopoulos, Anna Karahaliou and George Panayiotakis*

   "The Impact of Computed Tomography Iterative Reconstruction in Radiation Dose Reduction"

10. *Κωνσταντίνος Πέτρου, Αγάπη Πλουσή, Ευστράτιος Καραβασίλης, Ιωάννης Σεϊμένης, Γιώργος Βελονάκης and Ευστάθιος Ευσταθόπουλος*

    "Η Ραδιομική ως βασικό εργαλείο για την πρόβλεψη και την διάγνωση νέων εστιών Σκλήρυνσης κατά Πλάκας"

11. *Vasileios Rangos, Athanasia Adamopoulou, Georgios Chatzikostas, Constantinos Koumenis, Athanasios Koutsostathis and Alexandros G. Georgakilas*

    "A Review of the Technological Advancements and Technical Challenges of Flash Radiation Therapy"

12. *Vassiliki Potsika, Nikolaos Tachos, Georgios Papagiannis, Athanasios Triantafyllou, Dimitrios Fotiadis and Vassilis Tsakanikas*

    "REHABOTICS: An Integrated Rehabilitation System for Assessing and Treating Upper Limb Spasticity after Stroke"

13. *Evanthia Rouka, Vasiliki Fiska, Vasiliki Mantiou, Konstantinos Mitsopoulos, Panagiotis Bamidis and Alkinoos Athanasiou*

    "CPR Assist: A Wearable and Mobile App System for Real-Time CPR Feedback and Training"

14. *Konstantinos Baldoukas, Kyriakos Birmpas, Konstantinos Risvas and Konstantinos Moustakas*

    "Searching for Biomarkers in Cerebral Palsy: An In-Silico Analysis"

15. *Konstantina Zeimpeki, Aris Vrahatis and Alkinoos Athanasiou*

    "Study of Spinal Muscular Atrophy Using Graph Theory"

16. *Margarita Tsoplaktsoglou, Ellas Spyratou and Estathios P Efstahopoulos*

    "Light-based nanomedicine approaches in ocular cancer management: Future perspectives"

17. *Emmanouil Kenanoglou, Ioannis Magras and Alkinoos Athanasiou*

    "Reviewing Clinical Use of Fluorophores in Endoscope Assisted Resection of Intraparenchymal Brain Tumors"

18. *Konstantinos Michailidis, Marina Chalkia, Kyveli Zourari, Nikolaos Kollaros, Georgios Patatoukas, Andromachi Kougioumtzopoulou, Vasilios Kouloulias, Dimitris Emfietzoglou and Kalliopi Platoni*

    "Knowledge-Based Treatment Planning Models in Radiotherapy for Prostate Patients"

19. *Anna Papacharisi, Maria Anthi Kouri, Theano Marina Axakali, Panagiotis Georgakis, Virginia Tanou, Eugenia Bournaki, Evangelia, Kounadi, Christos Michail, Ioannis Valais and George Fountos*

    "Personalized Real-Time Dosimetry for Anaesthesiologists: Assessing Radiation Exposure Across Fluoroscopic Guided Surgical Procedures"

ΕΠΙΣΤΗΜΟΝΙΚΟ ΠΡΟΓΡΑΜΜΑ | SCIENTIFIC PROGRAMME
ΠΕΜΠΤΗ, 22 ΜΑΙΟΥ 2025 | THURSDAY, 22 MAY 2025

15.00 - 16.30
"Αθηνά"

Industry Session

Συντονιστές: Βίκυ Ζηλίδου, Σάββας Αναστασιάδης

1. **TELMACO SA, BARCO, VIROO**

   "Τεχνολογίες Εμβύθισης και Εικονικής Πραγματικότητας στην Ιατρική Εκπαίδευση: Αμφιθέατρα και Χειρουργεία σε Διάλογο."

   Ομιλητής:

   Αλέξανδρος Ψήτος *MSC in Data Communication, AVS Systems Sales Manager*

2. **ΠΑΠΑΠΟΣΤΟΛΟΥ Ν.ΑΕ**

   "Σύστημα μαγνητικής τομογραφίας 1.5T με τεχνητή νοημοσύνη (AI)"

   Ομιλητής:

   Απόστολος Γεωργάκης, *Τεχνολόγος Ακτινολόγος*

3. **Elekta Hellas EPE**

   "Online adaptive curative bladder cancer treatment on a CBCT-linac"

   Ομιλητής:

   Λαέρτης Παπασπύρου, *Medical Physicists Manager*

4. **ΚΑΡΒΩΝΗΣ ΑΝΤ. & ΣΙΑ ΕΕ**

   "Νέες τάσεις και εργαλεία στην εκπαίδευση. Το παράδειγμα των Τεχνολόγων Ακτινοθεραπείας - Ακτινολογίας"

   Ομιλητής:

   Ιωάννης Γεννιτσάριος , *MSc TAA*

15.00 - 16.30
"Ήρα"

Ακτινοδιαγνωστική

Συντονιστές: Ιωάννης Αντωνάκος, Νικόλαος Κολλάρος

Ομιλητές:

Ιωάννης Σεϊμένης, *Καθηγητής Ιατρικής Φυσικής, Ιατρική Σχολή, ΕΚΠΑ*

"Βασικές αρχές λειτουργίας, πλεονεκτήματα και προκλήσεις Υπολογιστικής Τομογραφίας Καταμέτρησης Φωτονίων (Photon-Counting CT)"

Στυλιανός Αργέντος, *Ακτινολόγος, Β' Εργαστήριο Ακτινολογίας, ΠΓΝ "Αττικόν"*

"Η Υπολογιστική Τομογραφία με Καταμέτρηση Φωτονίων στην Καρδιαγγειακή Απεικόνιση"

Νικόλαος Βορδός, *Αν. Καθηγητής, Τμήμα Φυσικής, ΔΠΘ*

"μ-CT: Από τη Βιοϊατρική στην τεχνολογία μη-καταστροφικού ελέγχου"

ΕΠΙΣΤΗΜΟΝΙΚΟ ΠΡΟΓΡΑΜΜΑ
ΠΕΜΠΤΗ, 22 ΜΑΙΟΥ 2025

SCIENTIFIC PROGRAMME
THURSDAY, 22 MAY 2025

15.00 - 16.30
"Syndicate 6"

Ολοκληρωμένος έλεγχος απινιδωτών *(Workshop)*

Συντονιστής: Εμμανουήλ Πραματευτάκης -BIOTECH

Ομιλητής: Εμμανουήλ Πραματευτάκης

Εισαγωγή στον έλεγχο απινιδωτών &
Εφαρμογή με αναλυτές της κατασκευάστριας Rigel Medical:
- Σύνδεση συσκευής υπό έλεγχο στον αναλυτή
- Έλεγχος λειτουργικών παραμέτρων απινιδωτή
- Έλεγχος ηλεκτρικής ασφάλειας
- Δημιουργία φύλλου μετρήσεων, με γραφικές παραστάσεις παλμών απινίδωσης

16.30 - 18.00
"Αθηνά"

"Εκπαίδευση στην Ιατρική Φυσική και Βιοϊατρική Μηχανική: ευκαιρίες και απορρόφηση αποφοίτων"

Συντονιστές: Άρης Δερμιτζάκης, Καλλιόπη (Πόλα) Πλατώνη, Ευαγγελία Μιχαλοπούλου

Ομιλητές:

Ιωάννης Δαμηλάκης, *Πρόεδρος IOMP, Καθηγητής Ιατρικής Φυσικής, Πανεπιστήμιο Κρήτης*

Ευστάθιος Ευσταθόπουλος, *Πρόεδρος ΕΛΕΝΕΠΥ, Διευθυντής ΠΜΣ Νανοϊατρική, Καθηγητής Ιατρικής Φυσικής, ΕΚΠΑ*

Παντελής Καραϊσκος, *Διευθυντής ΔΔΠΜΣ Ιατρικής Φυσική-Ακτινοφυσικής, Καθηγητής Ιατρικής Φυσικής, ΕΚΠΑ*

Ιωάννης Τσούγκος, *Διευθυντής ΠΜΣ Φυσικές Αρχές Βιοϊατρικής Απεικόνισης και Ακτινοπροστασίας, Καθηγητής Ιατρικής Φυσικής, Πανεπιστήμιο Θεσσαλίας*

Παναγιώτης Μπαμίδης, *Καθηγητής, Πρόεδρος ΕΛΕΒΙΤ, Διευθυντής ΔΠΜΣ Βιοϊατρικής Μηχανικής, Αριστοτέλειο Πανεπιστήμιο Θεσσαλονίκης*

Δημήτριος Γκλώτσος, *Καθηγητής, Συντονιστής Μεταπτυχιακού Προγράμματος Σπουδών «Biomedical Engineering & Technology», Τμήμα Μηχανικών Βιοϊατρικής, ΠΑΔΑ*

Ιωάννης Καλατζής, *Καθηγητής, Πρόεδρος Τμήματος Μηχανικών Βιοϊατρικής, ΠΑΔΑ*

Μαρία Χατζηνικολάου, *Καθηγήτρια, Διευθύντρια του Μεταπτυχιακού Προγράμματος «Βιοπληροφορική και Νευροπληροφορική», Ελληνικό Ανοικτό Πανεπιστήμιο*

Κωνσταντίνος Μουστάκας, *Καθηγητής, Διευθυντής Μεταπτυχιακού Προγράμματος*

Σπουδών «Biomedical Engineering», Πανεπιστήμιο Πατρών

Κρίστη Καντώρου, *Υπεύθυνη Ανθρώπινου Δυναμικού, ΠΑΠΑΠΟΣΤΟΛΟΥ Ν.ΑΕ*

Μάριος Χανδρής, *Customer Service and Operations Manager, ΦΙΛΙΠΣ ΕΛΛΑΣ ΜΟΝΟΠΡΟΣΩΠΗ Α.Ε.Β.Ε.*

Ελένη Μπόλη, *HR Manager South Eastern Europe, GE HealthCare Greece*

Θεόδωρος Γιαννακάς, *Clinical Sales Manager, Robotic Surgery, Sofmedica*

16.30 - 18.00
"Syndicate 6"

Biomechanics of Spine *(Round Table)*

Συντονιστές: Θωμάς Αποστόλου, Ιωάννης Μάγρας

Ομιλητές:

Παρμενίων Τσιτσόπουλος, *Καθηγητής Νευροχειρουργικής, Β' Νευροχειρουργική Κλινική ΑΠΘ, Γ.Ν.Θ. Ιπποκράτειο*
"Basic principles of biomechanics of spine"

Dr. Δήμος Μπουράμας, *Διευθυντής Νευροχειρουργικής Κλινικής, Βιοκλινική Αθηνών*
"Upper spine biomechanics"

Θωμάς Αποστόλου, *Καθηγητής Τμήματος Φυσικοθεραπείας, Δι.Πα.Ε*
"Advanced spine biomechanics & instrumentations"

Σάββας Γρηγοριάδης, *Αν. Καθηγητής Νευροχειρουργικής, Ιατρική Σχολή ΑΠΘ*
"Innovations in materials in spine"

Dr. Νίκος Γκαντσινικούδης, *Ιατρός, Εργαστήριο Φυσιολογίας, Τμήμα Ιατρικής ΑΠΘ*
"Modelling of intravetrebral disc"

18.00 - 18.30 **Διάλειμμα - Καφές**

18.30 - 19.00

Συντονιστής: Ευδόκιμος Κωνσταντινίδης
Keynote Speaker
Arnold Pompos
Professor of Physics, Associate Vice Chair for Strategic Initiatives and Capital Investments, The University of Texas, Southwestern Harold C. Simmons Comprehensive Cancer Centre, USA
"Emerging Radiation Therapy Technologies in AI assisted ultra-personalized cancer care"

ΕΠΙΣΤΗΜΟΝΙΚΟ ΠΡΟΓΡΑΜΜΑ
ΠΕΜΠΤΗ, 22 ΜΑΙΟΥ 2025

SCIENTIFIC PROGRAMME
THURSDAY, 22 MAY 2025

19.00 – 21.00
"Αθηνά"

Ακτινοθεραπεία με Πρωτόνια

Συντονιστές: Καλλιόπη Πλατώνη, Ευστάθιος Ευσταθόπουλος

Ομιλητές:

Γιώργος Πατατούκας, *Ακτινοφυσικός, Εργαστήριο Εφαρμοσμένης Ιατρικής Φυσικής, Ιατρική Σχολή, ΕΚΠΑ*
"Θεραπεία με Πρωτόνια. Φυσικές αρχές και πλεονεκτήματα"

Βασίλειος Κουλουλίας, *Καθηγητής Ακτινοθεραπευτικής Ογκολογίας, Ιατρική Σχολή, ΕΚΠΑ*
"Κλινική Αποτελεσματικότητα. Ποιοι Ασθενείς Επωφελούνται;"

Δημήτριος Κουρούκλης, *PhD, Visiting Fellow, Office of Health Economics, UK*
"Οικονομική Ανάλυση & Βιωσιμότητα μιας Επένδυσης στη Θεραπεία με πρωτόνια: Υπερβολικό Κόστος ή Στρατηγική Ανάπτυξης;"

Πανταλός Ι., *Ακτινοφυσικός, Cyprus Pharmaceutical Organisation "Costas Papaellinas"*
"Η Ελλάδα στο Παγκόσμιο Τοπίο της Θεραπείας με Πρωτόνια: Επιστημονικές, Τεχνολογικές και Εκπαιδευτικές Προοπτικές"

19.00 - 21.00
"Ήρα"

Γενική Συνέλευση Ελληνικής Εταιρείας Βιοϊατρικής Τεχνολογίας ΕΛΕΒΙΤ + Εκλογές Σωματείου

19.00 - 21.00
"Syndicate 6"

Νανοϊατρική

Συντονιστές: Μαρία Γαζούλη, Ελλάς Σπυράτου

Ομιλητές:

Κωνσταντίνος Δεμέτζος, , *Καθηγητής Φαρμακευτικής Νανο-Τεχνολογίας, Τμήμα Φαρμακευτικής, ΕΚΠΑ*
"Η εφαρμογή της εντροπίας Tsallis στη μελέτη της πολυπλοκότητας νανοσυστημάτων για μεταφορά φαρμακομορίων"

Νεφέλη Λαγοπάτη, *Επ. Καθηγήτρια Βιολογίας-Νανοϊατρικής, Ιατρική Σχολή, ΕΚΠΑ*
"Ανάλυση εκπνεόμενων σωματιδίων με χρήση νανοαισθητήρων"

Νατάσσα Πίππα, *Επ. Καθηγήτρια, Τμήμα Φαρμακευτικής, ΕΚΠΑ*
"Η Χρήση Νανοϋλικών Άνθρακα στη Μεταφορά Φαρμάκων και στη Φαρμακευτική Βιομηχανία"

Ευάγγελος Καραλής, *Αν. Καθηγητής, Τμήμα Φαρμακευτικής, ΕΚΠΑ*
"Κλινικές μελέτες με χρήση τεχνητής νοημοσύνης και υπολογιστικές μεθόδους"

ΕΠΙΣΤΗΜΟΝΙΚΟ ΠΡΟΓΡΑΜΜΑ
ΠΑΡΑΣΚΕΥΗ, 23 ΜΑΙΟΥ 2025

SCIENTIFIC PROGRAMME
FRIDAY, 23 MAY 2025

9:00 - 11:00
"Αθηνά"

Ψηφιακός μετασχηματισμός της υγείας (Panel)

Συντονιστής: Παναγιώτης Μπαμίδης

Ομιλητές:

Ελπίδα Φωτιάδου, ΗΔΙΚΑ

Γεώργιος Δαφούλας, Υπουργείο Ψηφιακής Διακυβέρνησης

Κωστής Καγγελίδης, ΓΝΩΜΩΝ Πληροφορική

Χάρης Καρανίκας, Πανεπιστήμιο Θεσσαλίας

Παρασκευή Μιχαλοπούλου, ΕΛΛΟΚ

Νίκος Κυριακουλάκος, Netcompany, HL7 Hellas

9:00 - 11:00
"ΗΡΑ"

The Role of AI and Multivariate Data in Enhancing Transitional Care *(Round Table)*

Συντονιστές: Ευδόκιμος Κωνσταντινίδης, Δέσποινα Πετσάνη

Ομιλητές:

Ευδόκιμος Κωνσταντινίδης, *PostDoctoral Researcher at Medical Physics and Digital Innovation Laboratory, School of Medicine, Aristotle University of Thessaloniki*

"From Sharing to Access: Leveraging Secondary Data in Transitional Care"

Δέσποινα Πετσάνη, *Research Associate, Medical Physics and Digital Innovation Laboratory, School of Medicine, Aristotle University of Thessaloniki*

"Living Labs as a Catalyst for Data Collection in Transitional Care"

Olga Galanets, *IT Project Manager, International Data Spaces Association*

"European Health Data Space: Legislative framework"

Ναταλία Μανωλά, *CEO at OpenAIRE AMKE, Non-profit pan European e-Infrastructure*

"Open Science, AI, and Data Interoperability: Unlocking the Potential of Multivariate Data in Healthcare"

11.00 - 11.30 **Διάλειμμα - Καφές**

11.30 - 13:00
"Αθηνά"

Student Competition

Συντονιστές: Μιχάλης Ζερβάκης, Αλέξανδρος Αστάρας

1. *Charalampos Tsemekidis, Athanasios Arvanitidis, Christoforos Gravalidis, Panagiotis Bamidis and Alkinoos Athanasiou*

   "Machine Learning Algorithmic Classification of Surface Electromyography (SEMG) of Biceps & Triceps Agonist/Antagonist Activity"

2. *Charalampos Drakos, Athanasios Arvanitidis, Panagiotis Antoniou and Alkinoos Athanasiou*

   "Development of a Non-Relational Database and Front-End Interface for Extended Reality in Healthcare"

3. *Andreas Kalogeris, Adam Adamopoulos, Maria Hadjinicolaou and Alkinoos Athanasiou*

   "Comparative Analysis of Machine Learning Models of Depression Detection Using EEG Data"

4. *Aliki Zilidou, Alexandros Moraitopoulos, Vasiliki Zilidou and Panagiotis Bamidis*

   "Development of an Exergames Platform for Physical Assessment Using Depth Sensors and Unity: A Gamified Approach to Human Motion Analysis"

5. *Maria Michailidou, Vicky Fiska, Vasiliki Mantiou, Panagiotis Bamidis and Alkinoos Athanasiou*

   "Iterative Development, Testing, Validation and Benchmarking of Custom EEG, FNIRS and SEMG Sensors"

6. *Stelina Naka, Marios Antonakakis and Michalis Zervakis*

   "ViTSeg - A Whole Heart Image Segmentation Model using Vision Transformers"

11.30 - 13:00 **Μη Ιοντίζουσες Ακτινοβολίες**

"Ηρα"

Συντονιστές: Ασπασία Πετρή, Δημήτρης Κουτουνίδης

Ομιλητές:

Σπυρέττα Γολεμάτη, *Αν. Καθηγήτρια Βιοϊατρικής Τεχνολογίας, Ιατρική Σχολή, ΕΚΠΑ*

"Η θεραπευτική χρήση των εστιασμένων υπερήχων"

Γιάννης Τσιλίκας, *Επιστημονικός Συνεργάτης, ΠΑ.Δ.Α, Π. Α.*

"Time stretched imaging flow cytometry: Μια νέα εφαρμογή των femtosecond laser στην κυτταρομετρία ροής και στην μορφολογική ταξινόμηση κυττάρων."

Κιουβρέκης Γ., *Επ. Καθηγητής, Τμήμα Δημόσιας και Ενιαίας Υγείας, Πανεπιστήμιο Θεσσαλίας*

"Μοντέλα μηχανικής μάθησης για την εκτίμηση της έκθεσης σε ηλεκτρομαγνητική ακτινοβολία στην περιοχή των ραδιοσυχνοτήτων"

11.30 - 13:00 **Φασματοσκοπία** *(Workshop)*

"Syndicate 6"

Σπυράτου Ελλάς, *Επιστημονικός Συνεργάτης, Εργαστήριο Εφαρμοσμένης Ιατρικής Φυσικής, Ιατρική Σχολή, ΕΚΠΑ*

ΕΠΙΣΤΗΜΟΝΙΚΟ ΠΡΟΓΡΑΜΜΑ | SCIENTIFIC PROGRAMME

ΠΑΡΑΣΚΕΥΗ, 23 ΜΑΙΟΥ 2025 | FRIDAY, 23 MAY 2025

13:00 - 14:30 **Student Competition**

"Αθηνά"

Συντονιστές: Ιωάννης Τσούγγος, Μαρία Χατζηνικολάου

Συντονιστές: Αλκίνοος Αθανασίου, Παναγιώτης Μπαμίδης

1. *Magdalini Anastasiadou, Vicky Fiska, Konstantinos Mitsopoulos, Panagiotis Bamidis and Alkinoos Athanasiou*

   "Background and Development Protocol for Sensor Data Fusion Gesture Classification Using a Soft Robotic Glove"

2. *Konstantinos Siatos, Maria Hadjinikolaou, Adam Adamopoulos and Alkinoos Athanasiou*

   "An investigation into the use of convolutional neural networks for classifying neurodegenerative diseases using resting-state EEG"

3. *Ioannis Pappas and Alkinoos Athanasiou*

   "Orthotropic Approaches of Human Jawbone in Finite Element Method"

4. *Alexandros Moraitopoulos, Niki Pandria, Konstantinos Mitsopoulos, Panagiotis Bamidis and Alkinoos Athanasiou*

   "Enhancing Household Objects into Smart Health Monitoring Devices: An Unobtrusive Remote Health Monitoring System to Assist Healthy Aging"

5. *Dimitrios Samaras, Georgios Agrotis, Maria Vakalopoulou, Dimitra Tsivaka and Ioannis Tsougos*

   "AI-Driven Radiomics for Prostate Cancer Diagnosis: Integrating Automated Clinical Decision Support with Harmonized Machine Learning Models"

13:00 - 14:30 **Πυρηνική Ιατρική**

"Ήρα"

Συντονιστές: Γεωργία Λυμπεροπούλου, Γιώργος Μανιός

Ομιλητές:

Γιώργος Λούντος, *CEO BIOEMTECH*

"Οι προοπτικές της χρήσης σωματίων α και β στη θεραπεία του καρκίνου και οι τεχνολογικές προκλήσεις για την απεικόνισή τους"

Παναγιώτης Παπαδημητρούλας, *Αναπλ. Καθηγητής Βιοϊατρικής Πληροφορικής, Πανεπιστήμιο Θεσσαλίας*

"Υπολογιστική δοσιμετρία και Τεχνητή Νοημοσύνη στην Πυρηνική Ιατρική: Από την κλασική προσέγγιση στην εξατομικευμένη θεραπεία"

Ιωάννης Τσούγκος, *Καθηγητής Ιατρικής Φυσικής, Πανεπιστήμιο Θεσσαλίας*

"Υβριδικές Απεικονιστικές Τεχνικές στην Πυρηνική Ιατρική: Σύγχρονες Εφαρμογές και Μελλοντικές Προοπτικές με τη Συμβολή της Τεχνητής Νοημοσύνης."

14.30 - 15.30 **Διάλειμμα - Γεύμα**

ΕΠΙΣΤΗΜΟΝΙΚΟ ΠΡΟΓΡΑΜΜΑ | SCIENTIFIC PROGRAMME

ΠΑΡΑΣΚΕΥΗ, 23 ΜΑΙΟΥ 2025 | FRIDAY, 23 MAY 2025

15.30 - 16.00 **Συντονιστής: Νικόλαος Παλληκαράκης**

Keynote Speaker

Yota Foka, GSI/CERN

"From Physics to Clinics"

16.00 - 17.00 "Αθηνά" **Η επανάσταση των DRGs στο Ελληνικό Σύστημα Υγείας**

Συντονιστής: Παντελής Αγγελίδης, *Παν Δυτ. Μακεδονίας*

Ομιλητές:

Παντελής Μεσσαρόπουλος, *ΔΣ ΚΕΤΕΚΝΥ*
"DRG: Ψηφιακός Μετασχηματισμός ενίσχυσης της ποιότητας των υπηρεσιών του ΕΣΥ"

Δημήτρης Τσαλικάκης, *Διοικητής 3ης ΥΠΕ*
"Η αξία των κωδικοποιήσεων στη διοίκηση"

Νικόλαος Τεντολούρης, *Δ/ντης Διαβητολογικής, ΕΚΠΑ/Λαϊκό Νοσοκομείο*
"Κλινική Πρακτική Εφαρμογής των DRGs"

Δημήτρης Πάνου, *OneSys*
"Ψηφιακές Υποδομές DRG"

Ελένη Κωφού, *VIDAVO*
"Σύστημα Ελέγχου Ορθότητας Κωδικοποίησης DRG"

Η συνεδρία οργανώνεται με την υποστήριξη του Ευρωπαϊκού Κόμβου Ψηφιακής Καινοτομίας για την Ευφυή Υγεία smartHEALTH και της εταιρείας ψηφιακών τεχνολογιών υγείας VIDAVO

16.00 - 17.00 "Ήρα" **Η Πυρηνική Τεχνολογία για την παραγωγή ηλεκτρικής ενέργειας**

Συντονιστής: Ελευθερία Καρίνου, Ίων Σταματελάτος

Ομιλητές:

Θεόδωρος Μερτζιμέκης, *Αν. Καθηγητής Πυρηνικής Φυσικής, Τμήμα Φυσικής, ΕΚΠΑ*
"Η φυσική παραγωγής ενέργειας από σχάση πυρήνων"

Ευστάθιος Στυλιάρης, *Καθηγητής, Τμήμα Φυσικής, ΕΚΠΑ*
"Μικροί Αρθρωτοί Αντιδραστήρες (Small Modular Reactors-SMRs)"

Κωνσταντίνος Αβραμίδης, *Αν. Καθηγητής, Τμήμα Φυσικής, ΕΚΠΑ*
"Fusion. Θα λύσει το ενεργειακό πρόβλημα της ανθρωπότητας;"

Ευστάθιος Ευσταθόπουλος, *Καθηγητής Ιατρικής Φυσικής, Ιατρική Σχολή, ΕΚΠΑ*
"Πόσο ασφαλής είναι η παραγωγή ηλεκτρικής ενέργειας από πυρηνικούς αντιδραστήρες;"

17.00 - 17.30 **Λήξη - Συμπεράσματα - Βραβεύσεις**
Closing Remarks - Awards

Ευρετήριο άρθρων

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ΕΠΙΣΤΗΜΟΝΙΚΟ ΠΡΟΓΡΑΜΜΑ

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Στρογγυλή τράπεζα / Round Table

Τίτλος θεματικής στρογγυλής τράπεζας / Round table title

Ψηφιακές Παρεμβάσεις Στην Διαχείριση Διαταραχών Ισορροπίας / Digital Intervention in the Management of Balance Disorders

Οργανωτές / Organisers

Καθ. Δ. Κουτσούρης και καθ. Γ. Ματσόπουλος | Prof. D. Koutsouris and Prof. G. Matsopoulos
| *ΣΗΜΜΥ ΕΜΠ – Εργαστήριο Βιοίατρικης Τεχνολογίας*

Περιγραφή αντικειμένου / Abstract

Οι ψηφιακές παρεμβάσεις των διαταραχών ισορροπίας, περιλαμβάνουν τη χρήση προηγμένων τεχνολογιών για την αξιολόγηση παρακολούθηση και θεραπεία. Αποτελούν την αιχμή του δώρατος στην αντιμετώπιση τέτοιου είδους παθολογιών, δίνοντας σημαντικό κλινικό πλεονέκτημα. Συμβάλλουν τόσο στη λήψη αντικειμενικών μετρήσεων που υποβοηθούν τον κλινικό στη λήψη αποφάσεων, όσο και στην εξ αποστάσεως συστηματική παρακολούθηση της πορείας αποκατάστασης. Στην συγκεκριμένη στρογγυλή τράπεζα θα παρουσιαστούν προγράμματα χρηματοδοτούμενα στο πλαίσιο του ορίζοντα 2020, τα οποία αφορούν την εξ αποστάσεως παρακολούθηση ατόμων τρίτης ηλικίας με συννοσηρότητες καθώς και την εφαρμογή αποκατάσταση στις ισορροπίας σε συνθήκες επαυξημένης πραγματικότητας, υπό την επίβλεψη ολογραφιών με τεχνητή ευφυία.

Digital interventions for balance disorders include using advanced technologies for assessment, monitoring, and treatment. They represent the cutting-edge treating such pathologies, giving a significant clinical advantage. They contribute both to obtaining objective measurements to assist the clinician in decision-making, and to remotely and systematically monitoring the progress of rehabilitation. This roundtable will present projects funded under Horizon 2020 which concern the remote monitoring of elderly people with comorbidities and the application of balance rehabilitation in augmented reality, under the supervision of holographic artificial intelligence.

Λίστα ομιλητών-εισηγητών / List of speakers

- **Εισήγηση 1** (Talk 1)

HOLOBalance: Κλινικά αποτελέσματα εφαρμογής ολογραμμάτων την αποκατάσταση της Ισορροπίας.

Χρήστος Νικήτας, *Φυσικοθεραπευτής, Α Ω.Ρ.Λ. Πανεπιστημιακή Κλινική, Εθνικό και Καποδιστριακό Πανεπιστήμιο Αθηνών, Γ.Ν.Α. «Ιπποκράτειο»*

- **Εισήγηση 2** (Talk 2)

Smart Bear: Ποια τα διδάγματα της εφαρμογής της πλατφόρμας;

Ελευθερια Ηλιάδου, *Επικουρη Καθηγήτρια, Πανεπιστήμιο Πελοποννήσου, Τμήμα Λογοθεραπείας*

- **Εισήγηση 3** (Talk 3)

Telerehab DSS: Παρουσίαση Κλινικού Πρωτοκόλλου.

Δημήτρης Κικίδης, *Επίκουρος Καθηγητής, Α Ω.Ρ.Λ. Πανεπιστημιακή Κλινική, Εθνικό και Καποδιστριακό Πανεπιστήμιο Αθηνών, Γ.Ν.Α. «Ιπποκράτειο».*

- **Εισήγηση 4** (Talk 4)

Ανασκόπηση ψηφιακών παρεμβασεων από την διεθνή βιβλιογραφία

Ανδρέας Βεζάκης, *ΣΗΜΜΥ, ΕΜΠ, Εργαστήριο Βιοιατρικής Τεχνολογίας*

Στρογγυλή τράπεζα / Round Table

Τίτλος θεματικής στρογγυλής τράπεζας / Round table title

The role of computational models and artificial intelligence for digital twins in non-invasive diagnosis of brain and heart diseases

Οργανωτής / Organiser

Δρ. Μάριος Αντωνακάκης | *Συνεργάτης Ερευνητής,*
Εργαστήριο Ψηφιακής Επεξεργασίας Εικόνας και Σήματος, Σχολή Ηλεκτρολόγων Μηχανικών και Μηχανικών Υπολογιστών Πολυτεχνείο Κρήτης, Πολυτεχνειούπολη, Χανιά 73100, Ελλάδα

Περιγραφή αντικειμένου / Abstract

The integration of **Computational models** for **Digital Twins** and **Artificial Intelligence (AI)** is revolutionizing the non-invasive diagnosis of **brain and heart diseases**, offering unprecedented precision and personalized healthcare solutions. This panel will explore how **Computational modeling constructs digital twins for** enabling simulation and disease detection, enhancing early treatment planning. Experts will also discuss the role of computational and **AI-driven models**, including **machine learning and deep learning**, in analyzing medical imaging, physiological signals, and patient-specific data to improve diagnostic accuracy. The session will highlight current advancements, and challenges in adopting these technologies for clinical applications. Attendees will gain insights into how computational modeling, AI and digital twins are shaping the future of non-invasive diagnostics, driving innovation, and improving patient outcomes.

Λίστα ομιλητών-εισηγητών / List of speakers

- **Εισήγηση 1** (Talk 1)

SAFE-AORTA: An overview of a CDSS for Abdominal Aortic Aneurysm Disease Based on Artificial Intelligence Models

Επικ. Καθ. Χρήστος Μανόπουλος, *Εργαστηρίο Βιορευστομηχανικής & Βιοϊατρικής Τεχνολογίας, Σχολή Μηχανολόγων Μηχανικών, Εθνικό Μετσόβιο Πολυτεχνείο,*
Ηρώων Πολυτεχνείου 9, 15780 ΖΩΓΡΑΦΟΣ - ΑΘΗΝΑ

- **Εισήγηση 2** (Talk 2)

Non-invasive diagnosis of brain and heart disorders with computational and AI modeling

Δρ. Μάριος Αντωνακάκης, *Εργαστήριο Ψηφιακής Επεξεργασίας Εικόνας και Σήματος Σχολή Ηλεκτρολόγων Μηχανικών και Μηχανικών Υπολογιστών Πολυτεχνείο Κρήτης, Πολυτεχνειούπολη, Χανιά 73100, Ελλάδα*

- **Εισήγηση 3** (Talk 3)

Computational mechanics tools for biomechanics and artificial intelligent reduced order modelling for digital twins and virtual sensors

Καθ. Σταυρουλάκης Γιώργος, *Εργαστήριο Υπολογιστικής Μηχανικής και Βελτιστοποίησης, Σχολή Μηχανικών Παραγωγής και Διοίκησης, Πολυτεχνειούπολη, Χανιά 73100, Ελλάδα*

- **Εισήγηση 4** (Talk 4)

Complexity reduction of hemodynamics modelling of infrarenal aortas via machine learning

Επικ. Καθ. Διαγγελάκης Νίκος, *Δυναμική, Βελτιστοποίηση και Ρύθμιση Διεργασιών, Σχολή Χημικών Μηχανικών και Μηχανικών Περιβάλλοντος, Πολυτεχνειούπολη, Χανιά 73100, Ελλάδα*

Στρογγυλή τράπεζα / Round Table

Τίτλος θεματικής στρογγυλής τράπεζας / Round table title

Digital health services to facilitate non-invasive diagnostics of brain diseases. Empowering digital health in public and private sector: The case of smartHEALTH

Οργανωτής / Organiser

Δρ. Μάριος Αντωνακάκης | *Συνεργάτης Ερευνητής, Εργαστήριο Ψηφιακής Επεξεργασίας Εικόνας και Σήματος Σχολή Ηλεκτρολόγων Μηχανικών και Μηχανικών Υπολογιστών Πολυτεχνείο Κρήτης, Πολυτεχνειούπολη, Χανιά 73100, Ελλάδα*

Περιγραφή αντικειμένου / Abstract

European Digital Innovation Hubs (EDIH) Network is the driving force behind Europe's Digitalisation. With the support of the European Commission, the EDIH Network is a community of tech experts that work together to help and assist Europe's businesses and organizations on their path toward Digital Transformation and Innovation. smartHEALTH is an EDIH dedicated to accelerating Greek entities in the healthcare sector. This panel discussion will provide a comprehensive overview of the smartHEALTH role. It will highlight its mission to support SMEs, startups, mid-caps, and public sector entities in enhancing their processes, products, and services through digital technology. A key component of this initiative is the "Test Before Invest" services, which allow organizations to assess and experiment with digital solutions before full-scale implementation, thereby mitigating risks and fostering informed decision-making. Notably, within its first 20 months of operation, smartHEALTH provides "Test Before Invest" services to 78 beneficiaries, earning a badge of excellence in recognition of this achievement. The panel will also present recent results and success stories, demonstrating the tangible impact of smartHEALTH's contribution to the Digital Transformation of healthcare companies & organizations. Attendees will gain insights into how smartHEALTH and its partners are driving the Digitalisation of Healthcare Ecosystem.

Λίστα ομιλητών-εισηγητών / List of speakers

- **Εισήγηση 1** (Talk 1)

The smartHEALTH EDIH

Κώστας Καραμάνης, *Κέντρο Εφαρμογών και Υπηρεσιών Ηλεκτρονικής Υγείας, Ινστιτούτο Πληροφορικής, Ίδρυμα Τεχνολογίας και Έρευνας (ΙΤΕ), Ν.Πλαστήρα 100, Βασιλικά Βουτών, 70013 Ηράκλειο, Κρήτη*

- **Εισήγηση 2** (Talk 2)

A sample of smartHEALTH services

Δρ. Μάριος Αντωνακάκης, *Εργαστήριο Ψηφιακής Επεξεργασίας Εικόνας και Σήματος Σχολή Ηλεκτρολόγων Μηχανικών και Μηχανικών Υπολογιστών Πολυτεχνείο Κρήτης, Πολυτεχνειούπολη, 73100 Χανιά, Κρήτη*

- **Εισήγηση 3** (Talk 3)

smartHEALTH experience - Aisthesis Medical

Δρ. Γιάννης Γκουζιώνης, *CEO Aisthesis Medical, Βαλτετσίου & Τριπόλεως, 41336 Λάρισα*

- **Εισήγηση 4** (Talk 4)

smartHEALTH experience: Bioemtech

Δρ. Γιώργος Λούντος, *CEO Bioemtech, Γέρακας, 15344 Αθήνα*

Στρογγυλή τράπεζα / Round Table

Τίτλος θεματικής στρογγυλής τράπεζας / Round table title

The Role of AI and Multivariate Data in Enhancing Transitional Care

Οργανωτές / Organisers

Evdokimos Konstantinidis | *PostDoctoral Researcher at Medical Physics and Digital Innovation Laboratory, School of Medicine, Aristotle University of Thessaloniki*

Despoina Petsani | *Research Associate, Medical Physics and Digital Innovation Laboratory, School of Medicine, Aristotle University of Thessaloniki*

Περιγραφή αντικειμένου / Abstract

This panel explores the critical role of multivariate data in transitional care and its impact on decision making, quality of care and patient outcomes. From data storage, access and sharing to interoperability and compliance, the discussion will highlight practical examples, challenges, and emerging frameworks. With the rise of AI, new opportunities are emerging to enhance data-driven decision-making, ultimately leading to better health outcomes. This evolving landscape presents a valuable opportunity for innovators and entrepreneurs to leverage data effectively in support of their healthcare innovations.

This session is supported by three HE projects, RAISE (https://raise-science.eu/), EVOLVE2CARE (https://evolve2care.eu/) and DataPACT (https://datapact.eu/)

Λίστα ομιλητών-εισηγητών / List of speakers

- **Εισήγηση 1** (Talk 1)

From Sharing to Access: Leveraging Secondary Data in Transitional Care

Evdokimos Konstantinidis, *PostDoctoral Researcher at Medical Physics and Digital Innovation Laboratory, School of Medicine, Aristotle University of Thessaloniki*

- **Εισήγηση 2** (Talk 2)

Living Labs as a Catalyst for Data Collection in Transitional Care

Despoina Petsani, *Research Associate, Medical Physics and Digital Innovation Laboratory, School of Medicine, Aristotle University of Thessaloniki*

- **Εισήγηση 3** (Talk 3)

European Health Data Space: Legislative framework

Olga Galanets, *IT Project Manager, International Data Spaces Association*

- **Εισήγηση 4** (Talk 4)

Open Science, AI, and Data Interoperability: Unlocking the Potential of Multivariate Data in Healthcare

Natalia Manola, *CEO at OpenAIRE AMKE, Non-profit pan European e-Infrastructure*

Στρογγυλή τράπεζα / Round Table

Τίτλος θεματικής στρογγυλής τράπεζας / Round table title

Ο ρόλος και η θέση του Μηχανικού Βιοϊατρικής Τεχνολογίας μπροστά στις τεχνολογικές προκλήσεις και στις εξελίξεις στην Ελλάδα / The Role and Status of Biomedical Technology Engineers in Addressing Technological Challenges and Developments in Greece

Οργανωτές / Organisers

Δρ. Χρήστος Χ. ΜΙΧΑΗΛ | **Dr. Eng. Christos Ch. MICHAIL**

Καθ. Γιάννης ΚΑΛΑΤΖΗΣ | **Prof. John KALATZIS**

Περιγραφή αντικειμένου / Abstract

Ο σκοπός της θεματικής στρογγυλής τράπεζας είναι να αναδείξει τη θέση και τον ρόλο του Κλινικού Μηχανικού – Μηχανικού Βιοϊατρικής Τεχνολογίας στο Δημόσιο Σύστημα Υγείας, εστιάζοντας στα Δημόσια Νοσοκομεία της Ελλάδας (Γενικά, Πανεπιστημιακά, Περιφερειακά, Ειδικά) μέσω συγκεκριμένων περιπτώσεων (case studies). Η συζήτηση θα καλύψει την τρέχουσα κατάσταση του τομέα και τη συμβολή των μηχανικών Βιοϊατρικής Τεχνολογίας στις προκλήσεις και εξελίξεις της ψηφιακής υγείας (Digital Health), της Αξιολόγησης Τεχνολογιών Υγείας (HTA), καθώς και των δράσεων που απορρέουν από το Ταμείο Ανάκαμψης και Ανθεκτικότητας (RRF), το ΕΣΠΑ και το πρόγραμμα Ελλάδα 2.0. Επιπλέον, θα αναλυθούν σχετικοί δείκτες που έχουν καταγραφεί από τον Παγκόσμιο Οργανισμό Υγείας (ΠΟΥ) και θα συζητηθούν θέματα όπως η διαχείριση του Ιατροτεχνολογικού Εξοπλισμού (Ι/Ε) στα Νοσοκομεία, η συμβολή στην υιοθέτηση νέων τεχνολογιών, και η λειτουργία ηλεκτρονικών φακέλων ασθενών και ψηφιακών εφαρμογών (PACS, RIS, LIS κ.ά.). Τέλος, θα εξεταστεί η στελέχωση των Τμημάτων Βιοϊατρικής Τεχνολογίας και η θέση τους στο οργανόγραμμα των Νοσοκομείων, αναδεικνύοντας έτσι τη σημασία του κλάδου για την ανάπτυξη και την αναβάθμιση του Δημόσιου Συστήματος Υγείας στην Ελλάδα.

The purpose of the thematic round table is to highlight the position and role of the Clinical Engineer – Biomedical Technology Engineer in the Public Health System, focusing on the Public Hospitals of Greece (General, University, Regional, Special) through specific case studies. The discussion will cover the current state of the sector and the contribution of Biomedical Technology engineers to the challenges and developments of Digital Health, Health Technology Assessment (HTA), as well as the actions stemming from the Recovery and Resilience Fund (RRF) and the NSRF (ESPA) and the Greece 2.0 program. In addition, relevant indicators recorded by the World Health Organization (WHO) will be analyzed and issues such as the management of Medical Equipment (M/E) in Hospitals, the contribution to the adoption of new technologies, and the operation of electronic patient records and digital applications (PACS, RIS, LIS, etc.) will be discussed. Finally, the staffing of the Departments of Biomedical Technology and their position in the organizational chart of the Hospitals will be examined, thus highlighting the importance of the sector for the development and upgrading of the Public Health System in Greece.

Λίστα ομιλητών-εισηγητών / List of speakers

- **Εισήγηση 1** (Talk 1)

Η Ακαδημαϊκή Θεμελίωση του Ρόλου του Μηχανικού Βιοϊατρικής Τεχνολογίας στις Σύγχρονες Προκλήσεις

Καθ. Ι. Καλατζής

- **Εισήγηση 2** (Talk 2)

Ο Μηχανικός Βιοϊατρικής Τεχνολογίας στην Ελλάδα και Διεθνώς: Δείκτες, Συγκρίσεις και Προοπτικές

Δρ. Χρήστος Χ. Μιχαήλ

- **Εισήγηση 3** (Talk 3)

Ο ρόλος και η θέση του Μηχανικού Βιοϊατρικής Τεχνολογίας: Η μελέτη περίπτωσης ενός Γενικού Πανεπιστημιακού Νοσοκομείου - Γ.Π.Ν. «ΑΤΤΙΚΟΝ»

Νικόλαος Κραβαρίτης

- **Εισήγηση 4** (Talk 4)

Ο ρόλος και η θέση του Μηχανικού Βιοϊατρικής Τεχνολογίας: Η μελέτη περίπτωσης ενός Γενικού Νοσοκομείου - Γ.Ν.Α. «Γ. Γεννηματάς»

Ιωάννης Οικονόμου

- **Εισήγηση 5** (Talk 5)

Ο μηχανικός Βιοϊατρικής Τεχνολογίας και η Αξιολόγηση Ιατρικού Εξοπλισμού (HTA): Το Παράδειγμα του Ωνασείου Καρδιοχειρουργικού Κέντρου (Ω.Κ.Κ.)

Γεώργιος Χαλούτσος

Εργαστήριο/Workshop

Τίτλος / Title

Creating a Common Language: Applying Systems Engineering to Healthcare Innovation

Οργανωτές / Organisers

K. Mitsopoulos, V. Mantiou, Dr. K. Nizamis

Abstract

The challenge of interdisciplinary communication in biomedical engineering increases with the proliferation and expanding complexity of healthcare technologies. Systems Engineering (SE) can provide an effective approach to managing complexity through efficient stakeholder involvement, by the integration of their viewpoints throughout a system's life cycle. This 90-minute workshop introduces SE as a common language for biomedical innovation, guiding participants through a practical case study involving a smart pillbox designed to improve medication adherence in elderly patients. Following a brief introduction to the field and its modern applications, participants will operate in diverse teams to explore the problem space, define stakeholders, and iteratively apply a Model-Based Systems Engineering (MBSE) methodology to refine system functions and architecture. Through structured group work and communication, the workshop highlights how SE tools can improve clarity, coordination, and shared understanding across disciplines.

Λίστα ομιλητών-εισηγητών-εκπαιδευτών / List of speakers-trainers

- **Εισήγηση 1** (Talk 1)

  Speaker / *Affiliation*

  Konstantinos Mitsopoulos, *MEng, MSc / Lab of Medical Physics and Digital Innovation, School of Medicine, Aristotle University of Thessaloniki*

  Trainer / *Affiliation*

  Vasiliki Mantiou, *Msc in Medical Engineering and Informatics, Bsc in Electronics Engineering / Lab of Medical Physics and Digital Innovation, School of Medicine, Aristotle University of Thessaloniki*

Εργαστήριο / Workshop

Τίτλος / Title
Ολοκληρωμένος έλεγχος απινιδωτών

Συντονιστής-Ομιλητής / Speaker
Πραματευτάκης Εμμανουήλ, *BIOTECH*

Περιγραφή / Description
Εισαγωγή στον έλεγχο απινιδωτών & **εφαρμογή** με αναλυτές της κατασκευάστριας Rigel Medical:

i. σύνδεση συσκευής υπό έλεγχο στον αναλυτή
ii. έλεγχος λειτουργικών παραμέτρων απινιδωτή
iii. έλεγχος ηλεκτρικής ασφάλειας
iv. δημιουργία φύλλου μετρήσεων, με γραφικές παραστάσεις παλμών απινίδωσης

Συμπόσιο / Symposium

Τίτλος / Title

HEROES Final Meeting & Open Workshop

What is the HEROES project?

The "Human Extremity Robotic Rehabilitation and Outcome Enhancement for Stroke" (HEROES) project aims to investigate and promote neuroplasticity after chronic stroke with severe motor disability.

What technologies did the HEROES project develop?

Brain-computer interfaces and robotic arms, virtual environments, wearable soft robotics (jacket & gloves). Rich feedback through serious gaming applications were also used to enhance patients' motivation and focus. High-density electroencephalography, electromyography and electrical stimulation were used to modulate and monitor the plasticity of the neural system.

What is this meeting?

The HEROES Final Meeting & Open Workshop marks the end of the project, which officially comes in August 2025.The meeting presents to the scientific community and to the general population the outputs and results of the HEROES program: HEROES met its development goals, met critical academic acclaim, achieved scientific output through peer-reviewed publications and conference presentations, while most importantly, engaged with the patient community and conducted pilot trials. Nonetheless, the Clinical Trial is still ongoing, and the members of the HEROES project are determined to not lose the momentum but continue recruiting patients and complete the trials, beyond the program's end.

Panel

Assist. Prof. Alkinoos Athanasiou & Prof. Panagiotis D. Bamidis

Speakers

- **Alkinoos Athanasiou** - A decade of BERD development for neural rehabilitation
- **Konstantinos Mitsopoulos** - The NeuroSuitUp platform of wearable robotics, interfaces and serious gaming
- **Panagiotis Antoniou** and **Konstantinos Tagaras** - Serious gaming for neural rehabilitation: lessons learned during development
- **Vasiliki Fiska** - Integration and validation of soft robotic gloves: HEROES pilots

This interim meeting symposium is organized by the HEROES project which was funded by the Hellenic Foundation for Research and Innovation (H.F.R.I.) under the "2nd Call for H.F.R.I.'s Research Projects to Support Faculty Members & Researchers" (Project Number: 4391).

HEROES Human Extremity Robotic Rehabilitation & Outcome Enhancement for Stroke

H.F.R.I. Hellenic Foundation for Research & Innovation

Συμπόσιο / Symposium

Τίτλος / Title

ThessRoboGlove Forum: TRG2025 Symposium

Περιγραφή / Description

Το TRG Forum αποτελεί έναν πυρήνα συνάντησης για ερευνητές από τον κλάδο της ρομποτικής, καθώς είναι εστιασμένο σε ρομποτικά γάντια και ρούχα, ειδικά σχεδιασμένα για την παρακολούθηση και διαχείριση διάφορων παθήσεων και κλινικών καταστάσεων. Μέσα από αυτή την πλατφόρμα, ερευνητικές ομάδες από διάφορες περιοχές της χώρας έχουν την ευκαιρία να παρουσιάσουν τα ευρήματά τους, να μοιραστούν την πολύτιμη εμπειρία τους και να αναζητήσουν συνεργασίες. Ο κύριος σκοπός του TRG Forum είναι η ανταλλαγή γνώσεων και η ανάδειξη των καινοτομιών στον τομέα της ρομποτικής. Οι συμμετέχοντες αναζητούν τρόπους συνδυασμού τεχνολογίας και ιατρικής, προκειμένου να αναπτύξουν ρομποτικές λύσεις που να προσφέρουν πραγματική βοήθεια στους ασθενείς. Επιπλέον, μέσα από παρουσιάσεις των τελευταίων ερευνητικών εξελίξεων, θα πραγματοποιηθούν συζητήσεις και σχολιασμοί για την αντιμετώπιση των προκλήσεων που συναντούν οι ερευνητές στον συγκεκριμένο τομέα. Στα πλαίσια του 11ου Πανελληνίου Συνεδρίου Βιοϊατρικής Τεχνολογίας τον Μάιο 2025, το **TRG Forum** πραγματοποιεί την **4η συνάντησή** του, μετά το εναρκτήριο Symposium Thessaloniki wearable robotics gloves and apparel knowledge exchange and cooperation forum στο Society of Applied Neurosciences, Θεσσαλονίκη, 17/09/2022, το ThessRoboGlove Forum στο 10 ο Πανελλήνιο Συνέδριο Βιοϊατρικής Τεχνολογίας, Θεσσαλονίκη 7/10/2023 και το TRG Forum Meeting & Workshop στην Περιφερειακή Επιστημονική Ημερίδα Βιοϊατρικής Τεχνολογίας και Μηχανικής, Κρήτη 23/2/2024. Στα τρία χρόνια της πρωτοβουλίας το TRG Forum ενσωμάτωσε νέες ερευνητικές ομάδες, διοργάνωσε φυσικά & online workshops και ξεκίνησε ερευνητικές συνεργασίες διεκδικώντας χρηματοδότηση σε ανταγωνιστικά εθνικά και διεθνή προγράμματα.

Μέλη του Forum

Αθανασίου Αλκίνοος - Επίκουρος Καθηγητής ΑΠΘ, Αντιπρόεδρος ΔΣ ΕΛΕΒΙΤ
Αστάρας Αλέξανδρος - Assistant Professor, American College of Thessaloniki-ACT
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Συντονιστές

Βασιλική Φίσκα
Κωνσταντίνος Μητσόπουλος

Ομιλητές / Speakers

- Invited Speaker
  Panagiotis Vartholomaios (online), *Assistant Professor of Robotics, Department of Computer Science and Biomedical Informatics, University of Thessaly & Institute of Robotics, "Athena" Research Center*

  Ερευνητικές Κατευθύνσεις στην Ιατρική Ρομποτική: Ελαχιστα Επεμβατική Ρομποτική Χειρουργική και Ρομποτικά Συστήματα Αποκατάστασης / Resaerch Directions in Medical Robotics: Minimally Invasive Robotic Surgery and Rehabilitation Robotics

- **Panagiotis Polygerinos**
  Soft Wearable Robotic Garments: The EU SWAG project

- **Eleftheria Vellidou**
  Exoskeletons in balance disorders & the Rehabotics

- **Markos Tsipouras** (online)
  Ανάλυση ΗΕΓ για Νευρολογικές Διαταραχές και ανάπτυξη Διεπαφών Εγκεφάλου-Υπολογιστή

- **Alexander Astaras**
  Results from the online workshop on wearable robotics questionnaires

- **Spiros Nikolopoulos** and **Vasiliki Fiska** (hybrid)
  Collaborations and search for future funding for TRG forum project proposals and actions

- **Panagiotis Bamidis**
  Closing Remarks

Discussion

TRG Forum

Το παρόν συμπόσιο οργανώνεται και υποστηρίζεται στα πλαίσια του Έργου 13170 της Επιτροπής Ερευνών του Αριστοτέλειου Πανεπιστήμιο Θεσσαλονίκης «Ενίσχυση Νέων Μελών ΔΕΠ» στα πλαίσια της προβολής ερευνητικού αντικειμένου.

Συμπόσιο/ Symposium

Τίτλος / Title

Φοιτητικός Διαγωνισμός / Student Paper Competition

Οργανωτές / Organisers

Assist. Prof. Alkinoos Athanasiou, **Prof. Panagiotis D. Bamidis**

Περιγραφή / Description

Για δεύτερη φορά διοργανώνεται στα πλαίσια του συνεδρίου της ΕΛΕΒΙΤ διαγωνισμός καλύτερου άρθρου που υποβλήθηκε για αξιολόγηση από φοιτητή. Ο θεσμός ξεκίνησε με πολύ μεγάλη επιτυχία το 2023 στο 10 ο Πανελλήνιο Συνέδριο και τα άρθρα που παρουσιάστηκαν δημοσιεύτηκαν σε special issue του Global Clinical Engineering Journal (https://globalce.org/index.php/GlobalCE/issue/view/26).

Δικαίωμα συμμετοχής είχαν προπτυχιακοί και μεταπτυχιακοί φοιτητές καθώς και υποψήφιοι διδάκτορες με υποβολές εργασιών που προέκυψαν από ερευνητική δουλειά στα πλαίσια της φοίτησής τους, της πτυχιακής ή διπλωματικής τους εργασίας ή του διδακτορικού τους.

Ο φοιτητής πρέπει να είναι πρώτο όνομα στην εργασία. Στην εργασία πρέπει να συμμετέχει υποχρεωτικά μέλος ΔΕΠ (ή ορισμένος υπεύθυνος μαθήματος/διπλωματικής) επιβλέποντας της πτυχιακής, διπλωματικής ή του διδακτορικού του φοιτητή, ως τελευταίο όνομα στην εργασία προς βράβευση. Ο επιβλέποντας βεβαιώνει (στα ελληνικά ή αγγλικά) την προέλευση της εργασίας καθώς και την πρότασή του για συμμετοχή της στο Student Competition. Οι υποβολές έγιναν στο ίδιο πρότυπο με αυτό της εκτεταμένης περίληψης του συνεδρίου ενώ ο μορφότυπος είναι αυτός του short paper έκτασης ως 4 σελίδες με όλα τα στοιχεία της εργασίας (συμπεριλαμβανομένων σχημάτων, αναφορών ή παραρτημάτων) εντός της έκτασης των 4 σελίδων.

Οι νικητές του Student Competition επιλέγονται με βάση τη βαθμολογία των reviewers και την βαθμολογία της Επιτροπής Βραβείων (Award Committee) του συνεδρίου που παρακολούθησε τις παρουσιάσεις και ανακοινώνονται στην Τελετή Λήξης του 11ου Πανελληνίου Συνεδρίου Βιοϊατρικής Τεχνολογίας στις 23/05/2025 Τα βραβεία αντιστοιχούν σε κάλυψη από την ΕΛΕΒΙΤ των εξόδων συμμετοχής ενός συγγραφέα (συνήθως του πρώτου) σε οποιοδήποτε διεθνές συνέδριο διοργάνωσης ή υπό την αιγίδα της IFMBE, της EAMBES, της GCEA ή της ΕΛΕΒΙΤ.

Συντονιστές

Καθ. Μιχάλης Ζερβάκης, *Πολυτεχνείο Κρήτης*
Assist. Prof. Alexander Astaras, *ACT*

Επιτροπή Βραβείων

Σάββας Αναστασιάδης, Αλέξανδρος Αστάρας, Ελευθερία Βελλίδου, Άρης Δερμιτζάκης, Κωνσταντίνος Διαμαντής

ΕΠΙΣΤΗΜΟΝΙΚΟ ΠΡΟΓΡΑΜΜΑ
ΦΟΙΤΗΤΙΚΟΣ ΔΙΑΓΩΝΙΣΜΟΣ

SCIENTIFIC PROGRAMME
STUDENT COMPETITION

MACHINE LEARNING ALGORITHMIC CLASSIFICATION OF SURFACE ELECTROMYOGRAPHY (SEMG) OF BICEPS & TRICEPS AGONIST/ANTAGONIST ACTIVITY

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Abstract

Surface electromyography (sEMG) signals are a powerful non – invasive tool for analyzing and assessing muscle activity. Muscle state classification is a complex procedure, especially for biceps and triceps, due to crosstalk, noise, artifacts and variability but also due to the limitations that accompany the traditional classification methods. This study aims to test and evaluate machine learning models in classifying sEMG signals of biceps & triceps working as agonist/antagonist pair. The sEMG data include recordings from 100 participants. The data went through a preprocessing stage which included dc artifacts removal, bandpass filtering, notch filter application, rectification, smoothing and normalization. From the feature extraction process, features retrieved from both Time – Domain (TDF) and Frequency Domain (FDF). The machine learning models of k-Nearest Neighbors (kNN), Random Forest (RF), and Extreme Gradient Boosting (XGBoost) were used for the classification task. The XGBoost model achieved the highest accuracy of 97.68%, while RF and kNN achieved 97.60% and 92.85% respectively. Key features in this process were the Shape Factor (SF) and the Root Mean Square (RMS). These results highlight XGBoost's superior performance in classifying sEMG signals, demonstrating its potential for precise muscle activity recognition in rehabilitation, exoskeleton control, and prosthetic applications. Future improvements will include the real – time application of the classifiers as long as applications in wearables for Human – Computer Interfaces (HCI).

Keywords

sEMG, Machine Learning, Muscle State Classification, Biomechanics, Neural Control, Nanotechnology

Introduction

Conditions such as stroke or spinal cord injuries (SCI) are a major problem in the lives of more and more people every day. According to the World Health Organization (WHO), about 16% (1.3 billion people) of the global population is experiencing a disability [1]. The challenge is therefore to achieve the rehabilitation of the damage or to manage the difficulties properly. Rehabilitation faces a number of problems relating both to the lack of knowledge on specific scientific subjects and also to the lack of techniques that can be applied accurately to achieve a significant result.

Rehabilitation includes methods like specialized movement exercises, joint and muscle activation techniques and strengthening exercises among others. Effective rehabilitation often relies on detailed monitoring of motion states, which involves recording and documenting neuromuscular activity. To achieve this, it is essential to describe muscle function, activation patterns, and the signals that can be acquired. Neuromuscular activity generates biosignals that can be recorded and analyzed for rehabilitation purposes. One effective method is sEMG, which uses electrodes placed on the skin above the target muscle [2]. These electrodes detect electrical signals sent by the nervous system to trigger muscle activation. Specifically, these signals result from muscle fiber contractions driven by motor neuron action potentials [3]. According to literature, most studies focus on the lower extremities, therefore the need for data acquisition for biceps and triceps brachii is necessary [4]. The ability to classify these signals using Machine Learning (ML) models has significant implications for assistive technology and biofeedback applications. Such applications include prosthetic limb control, rehabilitation robots, in neurological disorders (e.g.: stroke) and HCIs, among other important fields [5], [6], [7], [8].

The aim of this study is to investigate three ML algorithms for classifying biceps and triceps sEMG signals by acquiring information related to feature extraction and focusing on comparative model evaluation. Finding the most reliable classifier will assist in interpreting the biosignals in a proficient manner, in order to make it more applicable in Engineering and Medical fields.

Materials and Methods

Biomechanics and Neural Control

The major role of biceps brachii is the flexion of the forearm at the elbow joint in which it is the primary agonist, while the major action of the triceps brachii is the extension of the forearm [9]. The triceps' primary role as an extensor opposes the movements of the biceps making it an antagonist muscle. In order for a movement to occur, both agonist and antagonist are jointly involved in the control and moderation of the action [10]. Their coordinated movement is regulated by neural control mechanisms originating from the central nervous system (CNS). The neurons responsible for body movement are called motor neurons and are divided into upper and lower region motor neurons [11]. Every signal that is propagated has its own sEMG recording interpretation. The three areas in the cerebrum that orchestrate and coordinate the motion are the primary motor cortex, the cerebellum and the basal ganglia [9], [12], [13].

Many muscle fibers must be innervated by a single alpha motor neuron in order for the muscle to function holistically. The combination of a motoneuron and the muscle fibers that it innervates is called motor unit [14]. For a completion of a movement, the number of motor units that are activated increases, as the demanding force rises, through a specific process called motor unit recruitment [15]. The recruitment of the motor units is not random but it is governed by the Henneman's size principle according to which, as the signal activity from the axons increases, progressively larger motor units are recruited resulting in the generation of larger forces [15]. This hierarchical activation ensures efficient force generation and fatigue resistance.

A key parameter that determines the final result of force production by the muscle is the length of the muscle at the start of the movement [16]. Near the resting length of the sarcomere, which is around 2.2 μm, optimal overlapping of thick and thin filaments occurs and the sliding takes place along the entire length of the thin filaments [17]. At this state maximum force generation occurs as we have the highest cross – bridge formation percentage. Surface electromyography (sEMG) records electrical signals by detecting voltage changes on the skin over active muscles. These signals represent motor unit activity and provide insights into muscle coordination and activation patterns. By processing sEMG data, we can classify movement dynamics, offering valuable applications in prosthetics, rehabilitation, and human-computer interaction.

sEMG Signal Acquisition and Preprocessing

The dataset contains data collected from 100 participants, 50 males and 50 females, aged from 21 to 34 years [18]. Surface electrodes were placed over the biceps and triceps according to SENIAM guidelines. Signals were acquired at a sampling rate of 1024Hz. The experimental protocol contains a series of discrete steps that are: baseline rest periods, maximum voluntary contractions (MVCs), biceps curls with and without resistance and triceps extensions with and without resistance. The data include a timestamp, a 1- channel signal from the electrode on the bicep, a 1- channel signal from the electrode on the triceps and an annotation for the signal in each timestamp for both arms of the participants, dominant and non dominant.

In EMG signal analysis, preprocessing is a critical step to enhance the quality of the signal and ensure robust feature extraction [19], [20]. To address the challenges caused by noise and artifacts, a series of preprocessing steps were performed to prepare the data for further analysis. The steps include removing dc artifacts, bandpass filtering to isolate relevant frequency components and applying a notch filter to remove power line noise. Additionally, the signal was rectified and smoothed using a moving root-mean-square (RMS) envelope to extract meaningful amplitude information. Finally, normalization was conducted by utilizing Maximum Voluntary Contraction (MVC) values for each participant to allow inter-subject analysis. This preprocessing pipeline allowed the usability of EMG signals for further analysis.

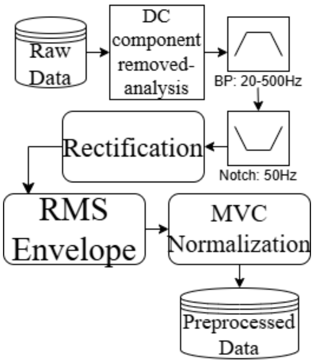

Figure 1. Preprocessing pipeline

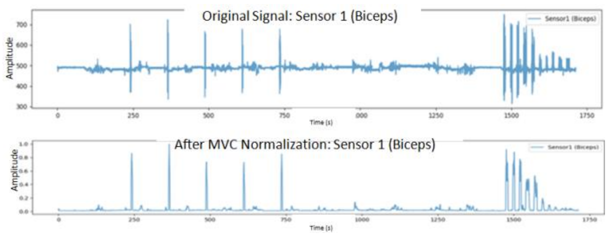

Figure 2. SEMG before and After Filtering (Biceps)

Feature Extraction

Feature extraction is a crucial step in EMG analysis, aiming to capture important information of raw or preprocessed biosignals. Based on the data produced by the preprocessing pipeline, the features that are extracted are grouped into time-domain and frequency-domain. These features aim to help capture the signal's temporal and spectral characteristics while also enabling the quantification of muscle dynamics and activation levels. Time-domain features are essential in EMG signal analysis, as they provide fundamental information about muscle activity over time [21]. Some of the time-domain features extracted for this study are: Mean Absolute Value (MAV), Root Mean Square (RMS), Zero Crossing (ZC) and Shape Factor (SF). In EMG signal analysis, frequency-domain features allow the exploration of spectral characteristics of the signal, which are essential for understanding the underlying muscle activity. These features provide insights into how the signal's frequency components evolve, reflecting muscle performance, fatigue, or even contraction type. Frequency domain analysis typically involves transforming the time-domain EMG signal into its frequency components using methods like Fourier Transform. Some of the frequency-domain features extracted for this study include: Mean Frequency (MNF), Median Frequency (MDF), Power Spectrum Density (PSD), Peak Frequency (PF) and Total Power (TP). To further enhance model performance, feature standardization was applied. Each feature was standardized using the mean and standard deviation calculated across the training data. The same transformation was applied to the test set, using the parameters derived from the training data, to prevent information leakage. Standardization ensures that features with different ranges and scales do not disproportionately influence the model's learning process.

Machine Learning Classification

The algorithms selected and compared for the classification are k – Nearest Neighbors (kNN), Random Forest (RF), and Extreme Gradient Boosting (XGBoost). These algorithms were chosen based on their demonstrated ability to handle high-dimensional data, their robustness to overfitting and their capacity to deliver accurate and interpretable results in complex classification tasks such as EMG signal analysis. kNN is a simple and effective supervised learning algorithm used for both classification and regression tasks. The core principle behind kNN is based on the idea that similar data points tend to be close to each other in the feature space [22]. RF is an ensemble learning method that builds a collection of decision trees to improve the stability and accuracy of the classification process [23]. XGBoost is an efficient and scalable implementation of gradient boosting, an ensemble learning technique that builds trees sequentially [24]. To increase the reliability of the results, a 5-fold cross validation evaluation strategy was implemented, during which, 20% of the subjects were selected as a test set and the other 80% for the training set. With this technique we prevent overfitting, and ensure a robust, unbiased evaluation [25]. For the evaluation, the metrics of Accuracy, Precision, Recall and F1 Score were used.

Results

The performance of each model was evaluated as a first step using 5-fold cross validation. Hyperparameters were tuned using grid search. The XGBoost classifier demonstrated superior performance with a classification accuracy of 97.68%, outperforming RF (97.6%) and kNN (92.85%). Table 1 includes the final performance with all the metrics. The XGBoost confusion matrix, (Figure 3), maps activity labels as follows: 0–Bicep (Res.), 1–Tricep (Res.), 2–Bicep (No Res.), 3–Tricep (No Res.), 4–Bicep (MVC), 5–Tricep (MVC), 6–Rest.

Future Work

While machine learning algorithms exhibit strong performance on the task of activity recognition the use of neural networks tailored for time series analysis, namely Long Short-Term Memories (LSTMs) or Convolutional Neural Networks (CNNs), could exhibit even stronger performance. Future directions could involve automating the detection of a wider array of exercises, including more complex and varied movements. Also, implementing real-time classification for wearable applications enhanced with nanotechnology and biosensors would revolutionize fields of prosthetics and HCI.

Table 1: Classification Performance

Fold	Accuracy (%)	Precision (%)	Recall (%)	F1 Score
RF	97.60	98.14	97.60	0.98
XGBoost	**97.68**	**98.21**	**97.68**	0.98
kNN	92.85	96.46	92.85	0.94

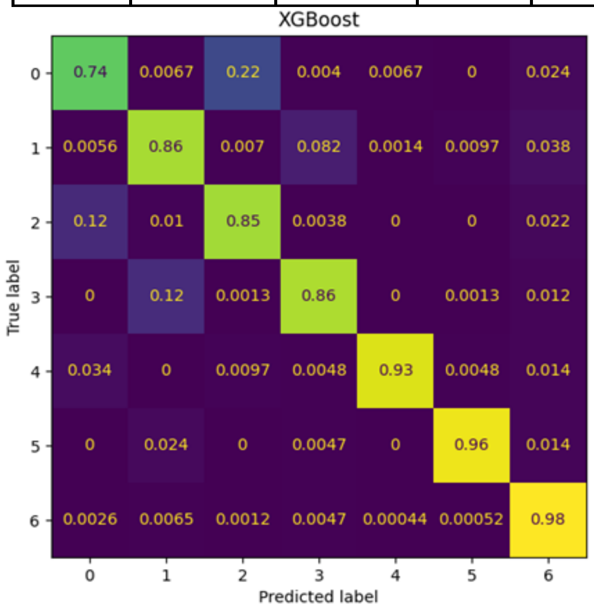

Figure 3. XGBoost Confusion Matrix

Discussion

The study highlights the potential of ML techniques in classifying biceps-triceps sEMG activity. XGBoost emerged as the most effective classifier, owing to its ability to capture complex data relationships. The feature importance analysis suggests that time-domain features (amplitude & shape related) contribute significantly to muscle classification accuracy. These findings could enhance rehabilitation systems and myoelectric prostheses by providing more accurate muscle activity interpretation.

References

[1] World Health Organization (WHO), ‘Disability’. Accessed: Feb. 24, 2025. [Online]. Available: https://www.who.int/health-topics/disability

[2] I. Karacan and K. S. Türker, ‘A comparison of electromyography techniques: surface versus intramuscular recording’, *Eur. J. Appl. Physiol.*, vol. 125, no. 1, pp. 7–23, Jan. 2025, doi: 10.1007/s00421-024-05640-x.

[3] J. Kimura, *Electrodiagnosis in diseases of nerve and muscle: principles and practice*, 4th ed. New York: Oxford university press, 2013.

[4] I. Martín-Fuentes, J. M. Oliva-Lozano, and J. M. Muyor, ‘Electromyographic activity in deadlift exercise and its variants. A systematic review’, *PLOS ONE*, vol. 15, no. 2, p. e0229507, Feb. 2020, doi: 10.1371/journal.pone.0229507.

[5] A. A. Torres Garcia, C. A. Reyes, L. Villasenor-Pineda, and O. Mendoza-Montoya, Eds., *Biosignal processing and classification using computational learning and intelligence: principles, algorithms, and applications*. Amsterdam: Academic Press, 2022.

[6] K. Nizamis, A. Athanasiou, S. Almpani, C. Dimitrousis, and A. Astaras, ‘Converging Robotic Technologies in Targeted Neural Rehabilitation: A Review of Emerging Solutions and Challenges’, *Sensors*, vol. 21, no. 6, Art. no. 6, Jan. 2021, doi: 10.3390/s21062084.

[7] K. Mitsopoulos *et al.*, ‘NeuroSuitUp: System Architecture and Validation of a Motor Rehabilitation Wearable Robotics and Serious Game Platform’, *Sensors*, vol. 23, no. 6, Art. no. 6, Jan. 2023, doi: 10.3390/s23063281.

[8] ‘HEROES – Human Extremity Robotic Rehabilitation & Outcome Enhancement for Stroke’. Accessed: Mar. 30, 2025. [Online]. Available: https://heroes.med.auth.gr/

[9] J. E. Muscolino, *Kinesiology: the skeletal system and muscle function*, 3rd edition. St. Louis: Elsevier Inc, 2017.

[10] J. Hamill, K. Knutzen, and T. R. Derrick, *Biomechanical basis of human movement*, 4th edition. Philadelphia: Wolters Kluwer Health, 2015.

[11] S. Jacobson and E. M. Marcus, *Neuroanatomy for the Neuroscientist*. Boston, MA: Springer US, 2011. doi: 10.1007/978-1-4419-9653-4.

[12] N. Palastanga, D. Field, and R. Soames, *Anatomy and Human Movement: Structure and Function*. Butterworth Heinmann/Elsevier, 2006.

[13] W. L. Kenney, J. H. Wilmore, and D. L. Costill, *Physiology of sport and exercise*, Seventh edition. Champaign, IL: Human Kinetics, 2020.

[14] D. Purves, G. J. Augustine, and D. Fitzpatrick, Eds., *Neuroscience*, Sixth edition. New York Oxford: Oxford University Press, Sinauer Associates is an imprint of Oxford Universitiy Press, 2018.

[15] A. L. Towe and E. S. Luschei, *Motor Coordination*. Boston, MA s.l: Springer US, 1981. doi: 10.1007/978-1-4684-3884-0.

[16] W. C. Whiting and R. F. Zernicke, *Biomechanics of musculoskeletal injury*, 2. ed. Champaign, IL: Human Kinetics, 2008.

[17] R. L. Lieber, *Skeletal muscle structure, function, and plasticity: the physiological basis of rehabilitation*, 3rd ed. Philadelphia: Wolters Kluwer health - Lippincott Williams & Wilkins, 2010.

[18] A. Arvanitidis, ‘Design and implementation of a normative sEMG values database as a tool for quantitative EMG in rehabilitation research’, Master’s Thesis, Aristotle University of Thessaloniki, Thessaloniki, Greece, 2024. [Online]. Available: DOI:10.26262/heal.auth.ir.360881

[19] C. Tang *et al.*, ‘From brain to movement: Wearables-based motion intention prediction across the human nervous system’, *Nano Energy*, vol. 115, p. 108712, Oct. 2023, doi: 10.1016/j.nanoen.2023.108712.

[20] R. Chowdhury, M. Reaz, M. Ali, A. Bakar, K. Chellappan, and T. Chang, ‘Surface Electromyography Signal Processing and Classification Techniques’, *Sensors*, vol. 13, no. 9, pp. 12431–12466, Sep. 2013, doi: 10.3390/s130912431.

[21] Y. Paul, V. Goyal, and R. A. Jaswal, ‘Comparative analysis between SVM & KNN classifier for EMG signal classification on elementary time domain features’, in *2017 4th International Conference on Signal Processing, Computing and Control (ISPCC)*, Solan: IEEE, Sep. 2017, pp. 169–175. doi: 10.1109/ISPCC.2017.8269670.

[22] T. Cover and P. Hart, ‘Nearest neighbor pattern classification’, *IEEE Trans. Inf. Theory*, vol. 13, no. 1, pp. 21–27, Jan. 1967, doi: 10.1109/TIT.1967.1053964.

[23] L. Breiman, ‘Random Forests’, *Mach. Learn.*, vol. 45, no. 1, pp. 5–32, 2001, doi: 10.1023/A:1010933404324.

[24] ‘What is a Decision Tree? | IBM’. Accessed: Feb. 25, 2025. [Online]. Available: https://www.ibm.com/think/topics/decision-trees

[25] P. Refaeilzadeh, L. Tang, and H. Liu, ‘Cross-Validation’, in *Encyclopedia of Database Systems*, L. LIU and M. T. ÖZSU, Eds., Boston, MA: Springer US, 2009, pp. 532–538. doi: 10.1007/978-0-387-39940-9_565.

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DEVELOPMENT OF A NON-RELATIONAL DATABASE AND FRONT-END INTERFACE FOR EXTENDED REALITY IN HEALTHCARE

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Abstract

Advances in big data, artificial intelligence, extended reality (XR), the quick growth of healthcare data calls for flexible and scalable database solutions. Traditional relational databases are often proving unable to handle capacity, variety, and speed of medical data, leading to the adoption of NoSQL approaches. The current work develop a NoSQL database integrated with an front-end interface to support XR healthcare applications. The proposed platform uses MongoDB's schema-less design, flexibility, and capacity to effectively handle organized and unordered data. Encryption, authentication, and adherence to legislation, availability of data, real-time processing and security are key desired features. The database's goal is to support immersive, interactive, XR for surgical preparation, patient education, and medical teaching. The system's performance, adaptability, and efficacy in clinical settings will be analyzed via real world application and usability tests.

Introduction

Traditional relational databases find it difficult to keep up with the needs of flexibility, real-time processing, and scalability as data driven applications keep expanding. Offering schema-less designs, distributed architectures, and high availability, NoSQL databases have emerged as a strong alternative. Ideal for applications driven by artificial intelligence, cloud computing, and big data are their capacity to manage semi-structured and unstructured data. NoSQL databases with smooth horizontal scalability guarantee effective data handling, therefore allowing companies to quickly and dependably operate vast amounts of data.

The healthcare sector is among those significantly benefiting from the adoption of NoSQL databases and big data analytics. NoSQL databases improve patient treatment, research, and operational efficiency from handling large medical files to facilitating predictive analytics [1]. Moreover, the expanding use of Extended Reality (XR) technologies—including virtual and augmented reality—in healthcare increasingly relies on real-time data processing for applications in medical training, surgical operations, and therapeutic interventions. Integrating XR and big data with NoSQL databases will enable medical professionals to enhance treatment accuracy, patient satisfaction, and general healthcare results [2].

NoSQL databases have emerged as an essential alternative to traditional relational databases for managing large and diverse datasets, offering enhanced scalability, flexibility, and fault tolerance [3]. NoSQL databases store and manage semi-structured and unstructured data efficiently using key-value stores, document stores, column family stores, or graph databases, unlike Relational Database Management System, which depend on inflexible table-based structures [4]. This type of database support horizontal scalability, which lets systems grow by means of installing more servers and not upgrading components. Furthermore makes them excellent for large data processing, cloud applications, and dispersed systems, as they distribute data across several nodes to avoid single points of failure and guarantee high availability and resiliency [4]. By storing data in a schema-less format, NoSQL databases provide flexibility and suitability for several different kinds of software. Sharding ensures high performance under heavy loads and allows flawless horizontal scaling. By means of indexing and optimized data storage, easy to install and manage NoSQL databases offer great performance by lowering Input/Output operations. Furthermore, they assure availability by means of replication systems supporting redundancy and automatic failover. NoSQL databases also support several storage engines, which enables customized data management appropriate for particular requirements [5].

Big Data has significantly transformed the healthcare industry by advancing medical research, optimizing treatment strategies, and enhancing patient care. Through the use of sophisticated analytics, healthcare professionals can make data driven decisions guaranteeing that patients get the appropriate treatment when it should be. The system could identify disease, customized treatment, and predictive analytics let proactive healthcare management support, all enabled by Big Data. It also helps to maximize resource allocation, cut costs, and prevent fraud. This along with other things improves operational efficiency. Given the continuous expansion of medical information, Big Data is absolutely essential for driving creativity, discovering new treatments, and enhancing the general value and quality of healthcare [6].

Figure 1. Big Data in Healthcare

By improving medical training, patient care, and treatment results, XR technologies - such as virtual, augmented, and mixed realities - are transforming healthcare. In immersive and interactive learning environments, these innovations enable medical staff to practice complex techniques in a virtual space without any risk [7]. Apart from education, XR allows the use of the technology in surgical planning, patient recovery, and patient education and lets the professionals see procedures in 3D and simulate scenarios for skill training [8].

Aim & Objectives

This research aims to develop a customised non-relational database tailored for medical applications, integrating big data methodologies and XR technology. Rapidly growing quantity of healthcare data challenges traditional relational databases to offer the essential scalability and versatility. The study seeks to explore nonrelational database architectures that can effectively handle many types of medical information from many sources—including organized, semi-structured, and unstructured data from sources including medical pictures and health records—efficiently.

One main aim of the research is to meet the basic needs of databases in healthcare data management—data integrity, security, interconnectivity, and real-time processing - so providing. The suggested approach will help to smoothly store, retrieve, and examine information, all the while guaranteeing legal and quality control in healthcare. This study will also concentrate on creating a scalable and efficient back-end infrastructure that can support high performance inquiries and manage big datasets. We shall investigate the application of distributed computing to increase system availability and reliability.

The project will integrate XR technologies into the frontend interface to better user engagement and data representation. This will give healthcare workers an immersive, natural experience that lets them engage with medical information in creative ways. Surgical planning, patient education, and diagnostic processes could all benefit from the combination of virtual reality (VR) and augmented reality (AR) Ultimately, the system will be validated by means of usability studies and real world usage scenarios to gauge its efficiency and suitability in a healthcare environment. The design will be polished and system performance maximized based on feedback from IT experts and medical professionals. By offering a strong, flexible, and interactive data management answer, the results of this study seek to help advance healthcare informatics.

The proposed system aims to integrate with existing EHRs and telemedicine platforms, enhancing data interoperability and supporting research and training routines.

Database Requirements Analysis

This section discusses the key requirements for designing a medical database that effectively meets the needs of managing medical information. The analysis focuses on important elements such as data volume, velocity, variety, and privacy. Healthcare data presents unique challenges due to its volume, velocity, and variety. The immense volume of data generated by healthcare systems—ranging from electronic health records (EHRs) to medical imaging—requires a database system capable of storing and processing massive datasets [9]. Additionally, the velocity of healthcare data is rapidly increasing, especially with real-time data from patient monitoring devices. A robust system must accommodate real-time ingestion and processing while also handling the variety of data types, including structured (e.g., patient demographics), semi-structured (e.g., clinical notes), and unstructured data (e.g., medical images). A non-relational database architecture is particularly well-suited for managing these diverse data formats and supporting advanced analytics [9]. XR (Extended Reality) technologies, which include virtual, augmented and mixed reality, provide new possibilities for visualising and analysing complex health data. For instance, mixed reality can be used to present medical images or patient data during surgical procedures, enhancing decision-making by making critical information more accessible and understandable to healthcare professionals [10].

The protection of sensitive healthcare information is paramount in data management. Databases must implement strong security measures such as data encryption, user authentication, and role-based access control (RBAC) to protect against unauthorized access and data breaches. Moreover, healthcare databases must adhere to strict regulatory requirements like HIPAA (Health Insurance Portability and Accountability Act) in the U.S. and GDPR (General Data Protection Regulation) in the EU. These regulations ensure that patient data is securely stored and shared, with provisions for encryption, data access controls, and patient consent management [11].

Database Development

Back-End Development

MongoDB, a document-based NoSQL database, is utilized for its flexibility in handling diverse healthcare data types, scalability, and efficient query performance. It stores data in JSON-like BSON documents, enabling seamless integration of structured (e.g., patient demographics), semi-structured (e.g., clinical notes), and unstructured (e.g., medical images) data. MongoDB's schema-less design accommodates dynamic data models, making it ideal for healthcare settings where data formats evolve frequently [12]. As a CP data store per the CAP theorem, MongoDB prioritizes consistency and partition tolerance, ensuring reliable data management in distributed systems [13].

To ensure the security of user registration the doctors and admins collection was modified by adding a status field (pending/approved/rejected) to keep track of registration requests. The new users will fill out the registration form with the status field set as "pending." An email is sent to the administrator to request approval. For organizing data in applications within the healthcare sector, the system architecture depends solely on MongoDB as the main non-relational database (NoSQL). The design has three principal levels:

- Layers of Client: XR programs on VR/AR devices, tablets, and smartphones.
- API Layer: Interfaces that let applications interact with MongoDB using APIs.
- Distribution Layer: MongoDB serves as the principal database for all data storage and administration by central administrator.

Security

Security is a critical aspect when managing healthcare data. MongoDB, as part of its security features, provides end-to-end encryption, role-based access control (RBAC), and the ability to authenticate users through LDAP and Kerberos integration. Field-level encryption is the conduit for protecting sensitive data (e.g., patient records, user passwords). Audit logging, tracking all database activities such as user registration and approvals, ensures that HIPAA and GDPR requirements are met. Self-registration for the administrator role has been removed to mitigate security concerns around user registration. New users register as physicians requesting the collection. They are marked as "pending." An email is then forwarded to the central administrator along with a secure, time-limited link to approve or deny the request. This follows a natural course of events, as only central administrators are allowed to approve account creation through a secure backend mechanism, thus guaranteeing their access control. MongoDB serves as a central database to store all XR application data, as described in the following table:

Table 1: Data Type and MongoDB Collection with Descriptions.

Data Type	MongoDB Collection	Description
Patient Data	patients	• Personal information. • Patient history. • 2D/3D medical images.
Doctors Login Activities	doctors	Doctor's login credentials, including first name, last name, username, password and email.
Administrators Login Activities	admins	Admins' login credentials, including first name, last name, username, password and email.

As shown, two distinct roles exist: admin and doctor. Patient data is presented below in encrypted form to ensure information security. This encryption maintains data integrity and confidentiality, effectively preventing unauthorized access.

Figure 2. Encryption of the patient data.

Front-end

With MongoDB and front-end you provide an integrated healthcare application. Running on VR/AR devices (e.g. HoloLens), tablets and smartphones, the interface provides interactive visualizations of medical data, such as 3D anatomical models. It communicates with MongoDB via APIs, supporting real-time data access and visualization for surgical planning and medical education [7]-[8]. The XR interface enhances engagement by enabling intuitive data interaction. In the next section, practical applications are explored.

Use Cases

The application supports a user login window (4.a). Clicking the "Create User" button (4.b) sends users to the role selection window where they can register themselves as doctors or administrators. The main window has been accessed by the users after logging in (4.c), where there are four main buttons: the first is to show a list of patients assigned to the researchers, the second is for the addition of a new patient (4.d), the third is for the management of patient records with the help of 2D and 3D imaging (4.e) and the fourth gives the possibility to delete a patient.

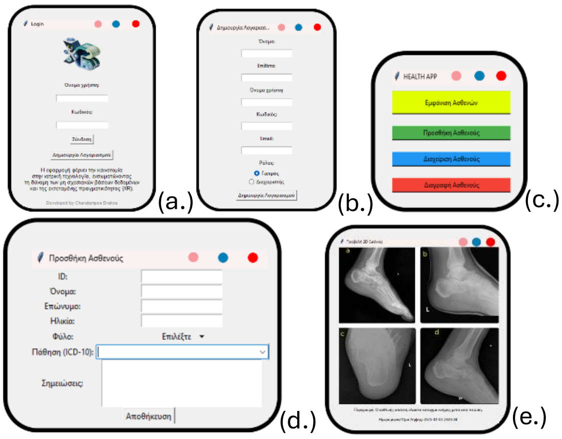

Figure 4.a. User login window, 4.b. User creation window and the option for administrator or doctor, 4.c. Main screen with four buttons. 4.d. Patient addition window, which includes ID, first name, last name, age, gender, condition according to ICD-10 and a note added by the doctor. 4.e. 2D image display window with the description and the date/time of the image capture.

Discussion

In contrast to the conventional relational databases, our MongoDB-driven setup empowers the real-time XR applications with minimal escort to make the surgery planning and medical training highly engaging and require less resource intensity. The MongoDB based medical database that we built can support several XR based use cases. In surgery, enhanced precision in planning can be achieved through the use of three-dimensional models of patient anatomy provided in clinical settings. [14]. Medical training is improved by XR-based simulations, which let learners perform operations in a virtual setting. With real-time progress tracking, rehabilitation programs use XR to help patients follow therapy exercises. Improved too is telemedicine since doctors may remotely review 3D patient information, therefore raising diagnostic accuracy. Interactive XR graphics also improve patient knowledge. Research shows, XR is applied for sophisticated medical imaging that enables in depth analysis of 3D organ reconstructions. Pharmaceutical research uses XR technology to depict molecular structures, helping with drug development [15]. As XR technologies continue to evolve, MongoDB's flexibility and scalability are expected to enhance data management efficiency.

Upcoming research will concentrate on benchmarking performance, integrating with EHR systems, and broadening XR applications for telemedicine.

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Keywords: Extended reality (XR), Non-Relational Database (NoSQL), MongoDB, Big Data, Healthcare

References

1. Kumar Singu, S. (2024). Transforming Healthcare Data Management with NoSQL: A New Era of Scalability and Efficiency. International Journal of Science and Research (IJSR), 13(10), pp.216–220.
2. Arvanitidis, et al. (2024) Design of a Normative sEMG Database for Biometric Comparison in Rehabilitation Research. Global Clinical Engineering Journal, 6(SI6), 96–101.
3. A. Gupta, et al. (2017). NoSQL databases: Critical analysis and comparison, IEEE Xplore.
4. Y. Huang and T. Luo, (2013). NoSQL Database: A Scalable, Availability, High Performance Storage for Big Data. pp.172–183.
5. D. Chauhan, K. L. Bansal, (2017). Using the Advantages of NOSQL: A Case Study on MongoDB, International Journal on Recent and Innovation Trends in Computing and Communication, 5(2), pp. 90–93.
6. H. Asri, H. Mousannif, H.A. Moatassime and T. Noel, (2015). Big data in healthcare: Challenges and opportunities, IEEE Xplore.
6. A. Logeswaran, C. Munsch, Y.J. Chong, N. Ralph and J. McCrossnan (2020). The role of extended reality technology in healthcare education: Towards a learner-centred approach. Future Healthcare Journal, 8(1), pp.e79–e84.
7. A. S. Mahsoom, et al. (2023). Medical Education, Training and Treatment Using XR in Healthcare, IEEE Xplore.
8. J.D. Pickering, et al. (2021) Assessing the difference in learning gain between a mixed reality application and drawing screencasts in neuroanatomy, Anatomical Sciences Education, 15(4), pp. 628–635.
9. SA. Senthilkumar, K.R. Bharatendara, A.A. Meshram, A. Gunasekaran, S. Chandrakumarmangalam (2018). Big Data in Healthcare Management: A Review of Literature. American Journal of Theoretical and Applied Business, 4(2), p.57.
10. P.E. Antoniou, D. Economou, A. Athanasiou and G. Tsoulfas (2021). Editorial: Immersive Media in Connected Health. Frontiers in digital health, 3, 697336.
11. K. Abouelmehdi, et al. (2018). Big healthcare data: preserving security and privacy. Journal of Big Data, 5(1).
12. C. A. Győrödi, D. V. Dumşe-Burescu, D. R. Zmaranda and R. Ş. Győrödi (2022). A Comparative Study of MongoDB and Document-Based MySQL for Big Data Application Data Management. Big Data and Cognitive Computing, 6(2), 49.
13. https://www.ibm.com/think/topics/cap-theorem
14. Antoniou, P. E., & Bamidis, P. D. (2022). 3D printing and virtual and augmented reality in medicine and surgery: tackling the content development barrier through co-creative approaches. In 3D Printing: Applications in Medicine and Surgery Volume 2 (pp. 77-99). Elsevier.
15. T. Morimoto, et al. (2022). XR (Extended Reality: Virtual Reality, Augmented Reality, Mixed Reality) Technology in Spine Medicine: Status Quo and Quo Vadis. Journal of Clinical Medicine, 11(2), p.470.

COMPARATIVE ANALYSIS OF MACHINE LEARNING MODELS OF DEPRESSION DETECTION USING EEG DATA

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Abstract

Depression is a psychiatric disorder with an increasing prevalence in the modern world. Its diagnosis primarily relies on clinical assessment based on globally accepted criteria, including the International Classification of Diseases (ICD-11) and the Diagnostic and Statistical Manual of Mental Disorders (DSM-V). Numerous studies have investigated Electroencephalography (EEG) alterations in depression, identifying differences in the prevalence of specific frequency bands in affected individuals. Recently, there has been a growing research focus on utilizing Machine Learning models in conjunction with EEG data for depression diagnosis. In this study, we present a comparative analysis of different ML models for depression detection using EEG data. Three models were implemented: Random Forest (RF), Support Vector Machine (SVM), and a Stacking Classifier, utilizing Phase Locking Value (PLV) across five different frequency bands. All models achieved accuracy exceeding 90%, with the Stacking Classifier yielding the best performance, achieving 96% sensitivity and 98% specificity. These findings highlight the efficacy of the Stacking Classifier and suggest its potential application in the diagnosis of other psychiatric disorders.

Keywords
Depression Detection, Machine Learning, Phase Locking Value, Electroencephalography.

Introduction

The Nature of Mental Illness

Mental illnesses, due to the distinct nature of their symptoms, raise numerous questions regarding their etiology. Over time, this has led to various social, psychological, and biological approaches to understanding their origins [1]. The manifestation of mental disorders is not limited to isolated clinical symptoms or signs but rather involves interconnected experiences, emotions, expressions, beliefs, and behaviors that exhibit both etiological and phenomenological coherence [2].

Machine Learning in Psychiatry

Machine Learning (ML) has already demonstrated significant results, particularly in the field of differential diagnosis and structured support for clinical decision-making. It has been effectively used to predict the transition of patients with prodromal psychotic symptoms to full-blown psychosis. Regarding mood disorders, ML algorithms have contributed to improving diagnostic accuracy and distinguishing between unipolar and bipolar disorders. Similar approaches have been applied to other conditions, such as autism spectrum disorders and substance use disorders, enhancing the understanding of their neuroanatomical and genetic characteristics. Despite its promising applications, ML faces several challenges, among which reliance on large datasets that can limit its adaptability when applied to new patient groups [3].

Major Depression Disorder (MDD)

Depression is one of the most common mental disorders and is associated with significant negative effects on an individual's social and professional life. Statistical studies indicate that more than 300 million people worldwide suffer from depression, which has been classified by the World Health Organization (WHO) as a leading contributor to global disability [4]. The main symptoms of depression include mood disturbances, loss of interest in daily activities, and sleep disorders, while severe cases are often accompanied by suicidal ideation [5]. The fifth edition of the *Diagnostic and Statistical Manual of Mental Disorders* (DSM-5) outlines nine distinct diagnostic criteria for depression. Diagnosis requires at least five of these criteria, with at least one relating to mood disturbances or loss of interest. According to International Classification of Diseases (ICD-10), additional descriptions of somatic syndromes may supplement the primary and secondary symptoms of depression, further refining the clinical picture. Under ICD-11 criteria, it is also possible to describe an additional somatic syndrome, referred to as the accompanying condition of *Melancholia* [6].

EEG Findings in Depression

There is a wealth of research linking depression to changes in EEG findings. Some studies indicate an increased presence of γ rhythm in patients with depression compared to healthy individuals [7]. Other studies have reported an increased α rhythm in the left hemisphere and a decreased β rhythm in the central-left channels of depressed patients [8]. Finally, the study by Mohammadi et al. [9] suggests that α and δ rhythms are the most effective features for distinguishing depressed patients, regardless of their anatomical localization.

Methods

A) Multi-Modal Open Dataset for Mental Disorder Analysis (MODMA Dataset)

Access to the MODMA Dataset is granted upon request. This dataset comprises continuous EEG recordings obtained using a 129-channel HydroCel Geodesic Sensor Net and processed with Net Station software version 4.5.4. The EEG signals were sampled at 250 Hz, with all raw electrode signals referenced to Cz. The dataset includes 53 participants, consisting of 24 outpatients diagnosed with depression (13 males, 11 females; aged 16–56) and 29 healthy controls (20 males, 9 females; aged 18–55) [10]. Participants were recruited in Gansu, China.

B) EEG Preprocessing

EEG data was preprocessed by renaming channels to match the GSN-HydroCel-129 montage, re-referencing to the average, and applying notch (50 Hz) and bandpass filtering (0.5–40 Hz).

High-frequency artifacts were detected, and bad channels were interpolated. Independent Component Analysis (ICA) was then applied to remove electrooculographic (EOG) artifacts, using EOG channels for automatic detection.

C) Phase Locking Value (PLV)

The Phase Locking Value (PLV) is a widely used measure of synchronization between two signals, particularly in EEG analysis [11]. It is computed by first applying the Hilbert transform, enabling phase comparison between signals. PLV ranges from 0 (no synchronization) to 1 (full phase locking).

Hilbert Transform

$V_j(t) = v_j(t) + i\, u_j(t)$ [11]

$V_j(t)$= Complex representation of the EEG signal

$v_j(t)$= Real part, which is the original recorded waveform

$i\, u_j(t)$=Imaginary part, which represents the analytical signal

Phase Difference Extraction

$\phi j(t) = \arg(Vj(t))$ [11]

arg (Vj(t)) =extracts the instantaneous phase of $V_j(t)$

PLV Extraction Using Euler's Formula

$$PLV = \left|\frac{1}{N}\sum_{n=1}^{N} e^{j\Delta\phi_n}\right| \quad [12]$$

$\Delta\varphi n = \varphi_1(t) - \varphi_2(t)$

N= the number of EEG epochs (time segments)

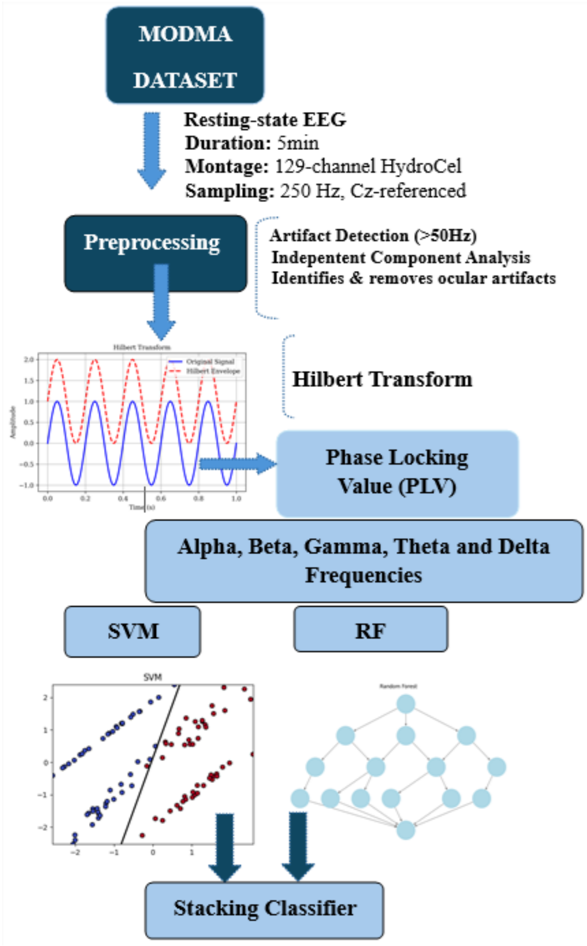

Figure 1: Methods

D) Machine Learning Algorithms

Random Forest is a supervised ML algorithm that constructs multiple decision trees, each trained on different subsets of phase locking value data. To optimize the model, a Grid Search with five-fold cross-validation fine-tunes key hyperparameters. The number of trees determines model stability and predictive power, while maximum tree depth controls complexity and prevents overfitting. Minimum samples per split and per leaf regulate decision granularity, influencing the structure of the trees. Feature selection at each split follows methods like square root or logarithm of the total feature count. By systematically evaluating different configurations, cross-validation ensures that the best-performing model is selected, maximizing accuracy and reliability [13].

Support Vector Machines (SVM) are supervised learning techniques designed to establish an optimal decision boundary that effectively separates different categories of data. When the dataset is linearly separable, SVM identify a hyperplane that maintains equal distance from the nearest points of each class. For non-linearly separatable data, the kernel trick enables SVM to project the data into a higher-dimensional space where a linear boundary becomes feasible. Through careful tuning of hyperparameters, SVM balance classification accuracy with generalization, making them a versatile and powerful tool in pattern recognition and machine learning applications [13].

The Stacking Classifier is an ensemble learning technique that combines the predictions of base classifiers to improve accuracy. In this case, we used SVM and Random Forest as base models, while the stacking classifier employed a meta-classifier using logistic regression, utilizing the sigmoid curve for the classification of the two categories: healthy individuals and patients with depression [14].

Results and Evaluation

For the evaluation of the three models, we used the following parameters.

Precision: The proportion of correctly predicted positive cases out of all predicted positives.

Recall (Sensitivity): The proportion of correctly predicted positive cases out of all actual positives.

Specificity: The proportion of correctly predicted negative cases out of all actual negatives.

F1-score: The harmonic mean of Precision and Recall, providing a balanced evaluation of model performance.

The accuracy of all three ML models was above 90%, with the highest value observed in the stacking classifier model. In the *Random Forest* model, there is a significant gap between sensitivity (0.84) and specificity (0.97), indicating that the model is better at ruling out depression as a diagnosis rather than confirming it (Figure 2). The SVM model has more balanced sensitivity and specificity values (0.92 and 0.95), *with a higher accuracy of 93.8%.* Additionally, *the F1-score of 0.93* suggests a good balance between recall and precision. The *Stacking Classifier* achieves an accuracy of 96.98%,

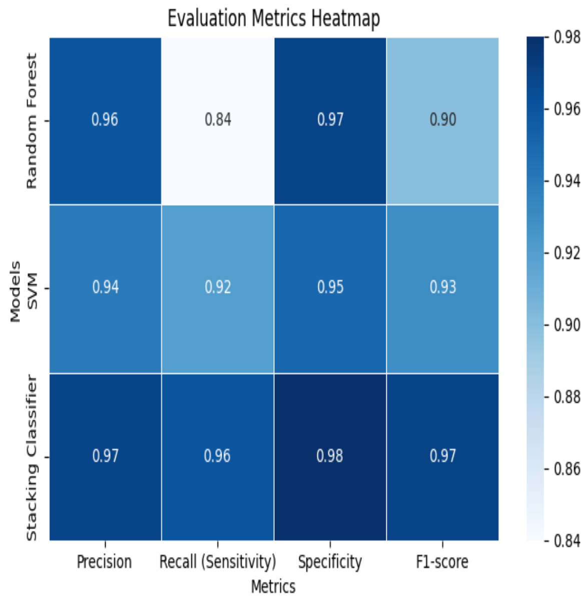

Figure 2: Evaluation Metrics Heatmap

demonstrating a strong balance across all evaluation metrics, with 96% sensitivity and 98% specificity. The *F1-score* is 0.97, which indicates a very good balance of precision and recall for this model. The *Stacking Classifier* achieves significantly better patient recognition compared to other models, while also maintaining a very high specificity. The confusion matrix accurately reflects the performance of the *Stacking Classifier* on the entire test set (Figure 3).

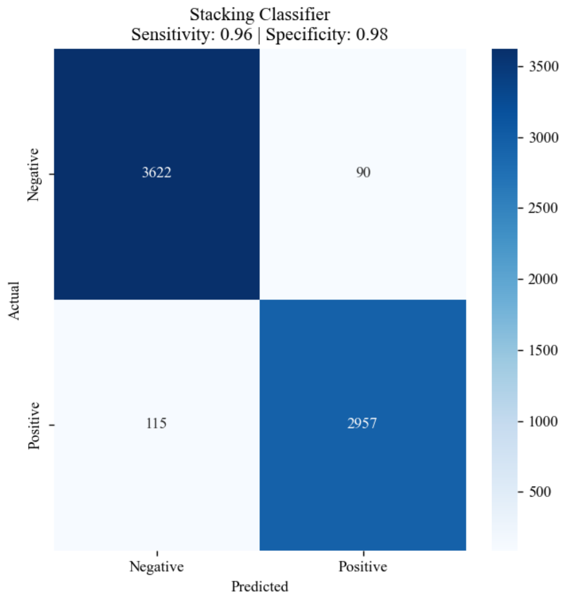

Figure 3: Confusion Matrix-Stacking Classifier

To confirm that the three models operate differently and to ensure that their differences are not due to randomness, we apply the *McNemar's Test* (Figure 4) using the confusion matrices of the models. *The p-values* from the comparisons between models are zero, indicating significant differences. Values below 0.05 suggest that the models function independently and are distinct. The ones on the diagonal of the matrix represent the self-comparison of each model, indicating perfect agreement with itself.

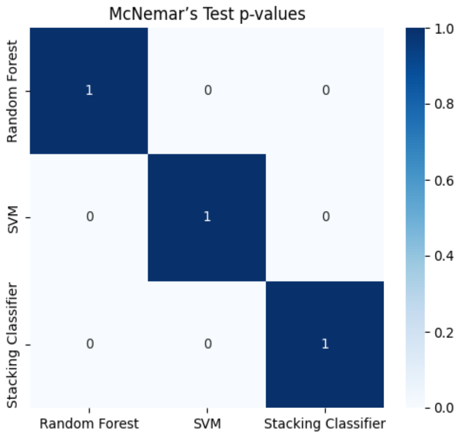

Figure 4: McNemar´s Test p-values

Conclusions

The comparative study of machine learning models highlights their promise in assisting the diagnosis of depression. Stacking classifiers demonstrated more balanced performance, offering a comparative advantage over Random Forest (RF) and Support Vector Machine (SVM) approaches. Importantly, this study suggests that ML can help disentangle clinical symptoms with different etiologies, for instance, by distinguishing depressive symptoms related to organic conditions. ML models may also contribute to evaluating neurophysiological responses to psychotherapy and pharmacological interventions. Although the sample size is modest (n=53), the high-resolution EEG recordings—captured from 128 electrodes across five frequency bands—provide a rich data structure that supports the robustness and interpretability of the results.

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References

[1] S. Kendler, P. Zachar and C. Craver (2011) What kinds of things are psychiatric disorders, Psychological Medicine, 41: 1143–1150.

[2] G. E. Berrios (1989) What is phenomenology? A review, Journal of the Royal Society of Medicine, 82: 425.

[3]D. Popovic, K. Schiltz, P. Falkai and N. Koutsouleris (2020) Präzisionspsychiatrie und der Beitrag von Brain Imaging und anderen Biomarkern, Fortschr Neurol Psychiatr, 88: 778–785.

[4] K. Smith (2014) Mental health: A world of depression, Nature, 515: 180–181.

[5] R. Cui (2015) A Systematic Review of Depression, Current Neuropharmacology, 13(4).

[6]Nationale VersorgungsLeitlinie Unipolare Depression (2022) NVL-Programm Version 3.2, Bundesärztekammer, Arbeitsgemeinschaft der Wissenschaftlichen Medizinischen Fachgesellschaften.

[7] P. J. Fitzgerald and B. O. Watson (2018) Gamma oscillations as a biomarker for major depression: an emerging topic, Translational Psychiatry, 8: 177.

[8] P. F. Lee, D. P. X. Kan, P. Croarkin, C. K. Phang and D. Doruk (2018) Neurophysiological correlates of depressive symptoms in young adults: A quantitative EEG study, Journal of Clinical Neuroscience, 47: 315–322.

[9] M. Mohammadi, F. Al-Azab, B. Raahemi, G. Richards, N. Jaworska, D. Smith, S. de la Salle, P. Blier and V. Knott (2015) Data mining EEG signals in depression for their diagnostic value, BMC Medical Informatics and Decision Making, 15: 108.

[10] Cai, H., Gao, Y., Sun, S., Li, N., Tian, F., Xiao, H., Li, J., Yang, Z., Li, X., Zhao, Q., Liu, Z., Yao, Z., Yang, M., Peng, H., Zhu, J., Zhang, X., Hu, X., & Hu, B. (2020). MODMA dataset: a Multi-modal Open Dataset for Mental-disorder Analysis. arXiv preprint arXiv:2002.09283.

[11] A. Matsuki, H. Kori and R. Kobayashi (2023) An extended Hilbert transform method for reconstructing the phase from an oscillatory signal, *Scientific Reports*, 13: 3535.

[12] Z. Ren, Y. Zhao, X. Han, M. Yue, B. Wang, Z. Zhao, B. Wen, Y. Hong, Q. Wang, Y. Hong, T. Zhao, N. Wang and P. Zhao (2023) An objective model for diagnosing comorbid cognitive impairment in patients with epilepsy based on the clinical-EEG functional connectivity features, *Frontiers in Neuroscience*, 16: 1060814.

[13] S. Raschka, Y. (Hayden) Liu and V. Mirjalili (2022) Machine Learning with PyTorch and Scikit-Learn: Develop Machine Learning and Deep Learning Models with Python, Kindle Edition, 1st Edition, Springer, pp. 76–97.

[14] S.-A. N. Alexandropoulos, C. K. Aridas, S. B. Kotsiantis and M. N. Vrahatis (2019) Stacking Strong Ensembles of Classifiers, IFIP Advances in Information and Communication Technology (AIAI 2019), 559: 545–556.

DEVELOPMENT OF AN EXERGAMES PLATFORM FOR PHYSICAL ASSESSMENT USING DEPTH SENSORS AND UNITY: A GAMIFIED APPROACH TO HUMAN MOTION ANALYSIS

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Abstract

The paper introduces an innovative digital platform that uses gamification and motion detection technologies to enhance the evaluation of physical status in older adults or people belonging to vulnerable groups. The platform developed with the Unity engine uses advanced depth sensors to accurately capture motions, including joint angles, posture, and balance. It involves five assessment tools (Chair stand, Arm Curl, Balance on one leg, Foot Up and Go and Two Minutes step) and provides unbiased information and instant feedback. The gamification of the exercises is considered to encourage motivation and participation of older adults, while the user-friendly interface facilitates use. The collected data provides valuable information for assessing physical status and functional capacity. The platform benefits both users, offering accurate assessments and incentives through virtual rewards, and healthcare professionals, providing objective data for personalized interventions. In future steps, integrating artificial intelligence and cloud-based remote monitoring is expected to contribute further enhance personalization and accessibility, enhancing user's autonomy and assessments efficacy.

Introduction

The global aging population faces significant challenges to healthcare and rehabilitation systems worldwide [1], due to increased life expectancy [2]. Healthcare systems face a range of issues, including the prevalence of chronic diseases and the need for integrated approaches to address the physical, social, psychological, and wellbeing aspects of aging. [3]. For older adults, maintaining strength, balance, and mobility is essential to keep their independence and quality of life. Conventional assessment approaches, such as manual observation and paper-based tests, often have several drawbacks, including limited accessibility, low engagement, and insufficient real-time feedback, limiting their effectiveness and reducing participation of older adults [4].

In order to address these challenges, assistive technologies (AT) are developed to improve an individual's abilities and overall wellbeing by assisting with daily activities to overcome any functional limitations [5]. Exergames are interactive games that require participants to be physically active to play, combine exercise with interactive gaming elements, promote motivation and provide objective motion analysis [6]. This paper introduces a digital platform designed to enhance physical evaluation using advanced motion tracking and real-time analysis. By transforming rehabilitation into an engaging, game-like experience, the system improves accessibility, ensures precise biomechanical evaluation, and fosters sustained participation among older adults. This paper outlines the methods used in its development, the expected outcomes, and the benefits of gamification in rehabilitation and assessment.

Methodology

This exergame platform was created using the Unity platform and a depth sensor. Unity was selected for its adjustability, its rapid development prospects and its simple interface with sensor-based systems. The depth sensor was selected for its accurate identification of body joints and motions in real time. This technology allows accurate skeletal tracking by detecting joint positions, hence enabling detailed motion analysis and intuitive exercise programming. By leveraging these tools, developers can easily access biomechanical parameters such as joint angles, range of motion, and spatial orientation. The system goes beyond basic motion capture, offering rich, multidimensional data that reveals critical information often missed in conventional assessments. As a result, it provides a more comprehensive understanding of the user's overall well-being and functional ability.

Each exercise is designed to gather data with accuracy and provide prompt feedback to the user, therefore improving accuracy and efficacy throughout evaluation sessions. The platform contains five different gamified workout assessments for older adults. These activities include chair-stand assessments [7], single-leg balance evaluations [8] (Figure 1), arm curls exercise [9], foot up and go [10] and two-minute step [11] exercise analysis, all crucial for assessing movement, strength, and stability [12]. The chair-stand assessment, determines lower body strength by counting how many times a person can stand up from a sitting position within the designated time frame of 30 seconds. The single-leg balance evaluation, measures balance by recording how long a person can maintain a standing posture on one leg. Two minute step test, used to assess an individual's aerobic capacity and evaluate their level of functional fitness. The arm curl exercise measures the repetitions of the arm raised and lowered in 30 seconds, and the foot up and go test assesses strength, speed, agility and dynamic balance, as the user have to get up from a chair, walk to and around a cone, and return to the chair in the shortest time possible. The exercises were programmed based on the identification of joints through the depth sensor and the use of colliders, allowing interactions that rely on collision detection, distance and movement analysis.

Figure 1: This image shows the way in which static balance is assessed in the Thessaloniki Action for Health & Wellbeing Living Lab - Thess-AHALL [13]. In the first image, the user is positioned and ready to begin the assessment. Once the operator presses 'Start,' the user has to raise their leg to a 90-degree angle. After the leg is lowered, the program displays the total duration of the assessment.

To ensure accessibility and ease of use, the interface is designed with large, clear icons, audio prompts, and simple navigation. Older adults get immediate visual and auditory feedback regarding their performance, along with corrective guidance if necessary. Features such as score tracking, virtual rewards, and progress monitoring have been added to motivate consistent engagement in assessment exercises. Interactive animations (Figure 2) serve as visual guides to help users complete each exercise properly, minimizing confusion and creating a smooth experience [14].

Figure 2: This image shows how static balance is assessed at the Thessaloniki Action for Health & Wellbeing Living Lab - Thess-AHALL [13] using an interface designed for accessibility and ease of use and interactive animations that provide feedback.. The operator is running the program and the user with the guidance on the screen raises their leg to perform the exercise correctly.

A preliminary test was conducted with four healthy individuals (2 female and 2 male) ranging in age from 18 to 54 years. This initial assessment aimed to examine how well the system captures and interprets key movement patterns. The participants were asked to complete the single-foot balance exercise, wearing sports clothing to mitigate noise introduction from motion artifacts attributed to cloth movement. The accuracy of the evaluation verifies the precision of joint tracking, of movement detection and real-time feedback.
All collected movement data is recorded for analysis, including tracking assessment progress from the previous assessment and identifying patterns and imperfections during the exercise. The data, such as joint angles and heights, are collected in an external csv file once the exercise is completed. Additionally, a commercial anglemeter and a measuring tape were employed to acquire baseline values of joint angles and heights respectively for further system evaluation.

Preliminary Results

Participants were asked to complete the single-foot balance exercise and the results were compared with the baseline values (Table 1). Preliminary results indicate a positive system response to the exercise, but further validation experiments are needed to validate the system's reliability.

Table 1. Results from single-foot balance exercise performed by four participants. Joint Angle and Joint Height present values obtained by the system from the left foot. Baseline Angle contains anglemeter values measured on the left foot and Baseline Height contains height measurements using a measuring tape.

Participant	Joint Angle	Joint Height	Baseline Angle	Baseline Height
1	83°	68cm	87°	63cm
2	85°	70cm	98°	76cm
3	82°	59cm	93°	72cm
4	76°	52cm	89	68cm

Below are described the expected results from the perspective of each stakeholder.

Users' Viewpoint
The user performing the workout benefits from an engaging and intuitive exercise experience. Gamified features like virtual rewards, progress tracking, and real-time feedback encourage the user to stay motivated and engaged in their evaluation process [15]. The platform ensures that workouts are performed correctly by providing visual and audio instructions, hence reducing uncertainty and boosting confidence in the execution of movements. With this platform, users stay informed of their previous performance and can evaluate their progress over time, allowing them to remain aware of their physical improvements and areas requiring greater concentration.

Operators' Viewpoint
For platform operators, such as physiotherapists, caregivers, or fitness instructors, the assessment process is simplified by automating data collection and performance evaluation [16]. Instead of manual observations and subjective evaluation, the system delivers accurate, real-time biomechanical insight. This provides operators with precise additional data-driven insights, allowing them to tailor interventions more effectively and enhance overall movement efficiency. The data collected by the exergame platform captures detailed movement patterns, joint angles, and performance metrics in real-time, offering a level of precision and specificity lacking in manual assessments. This allows for a deeper understanding of movement efficiency, highlighting subtle biomechanical variations that might otherwise go unnoticed.

Doctors' Viewpoint
From a doctor's perspective, recorded movement data provides an in-depth view of the patient's physical status and progress over time [17]. The ability to analyze unique biomarkers, such as joint stability, balance, and movement coordination, enables a more objective assessment of mobility. By analyzing exercise the data, doctors can detect early signs of motor decline, identify rehabilitation needs, and adjust treatment plans accordingly. This data-driven approach improves the accuracy of doctors' decisions and allows more effective, tailored interventions to support healthy aging and recovery.

Discussion
Expanding the range of workouts and refining motion analysis is expected to make the evaluation system more adaptable to individual needs. The platform leverages real-time motion tracking and data-driven insights, enhances engagement, simplifies assessment procedures, and provides valuable metrics for clinical evaluation by combining depth-sensing technology, interactive gaming, and data analysis. It appears to improve user engagement, and offers a variety of exercises, leading to better mobility, reduced fall risk, and improved health outcomes [18]. These features support older adults and vulnerable individuals in maintaining independence and fostering healthier aging.
Future improvements should include artificial intelligence (AI) to personalize interventions and detect fall risks, preventing injuries [19]. Machine learning could enhance long-term tracking and continuously adapt training plans based on user progress [20]. Additionally, cloud-based data storage would enable remote monitoring and telehealth solutions, particularly benefiting those with mobility limitations or in remote areas. Developing a standalone home-use version would allow users to complete assessments and exercises independently, reducing the need for in-person supervision.
Healthcare professionals are expected to benefit from computerised assessments that provide objective movement data, supporting clinical decisions and refining rehabilitation plans [21]. Early detection of movement issues allows for preventive actions, helping to reduce risks such as muscle loss, joint stiffness, and balance problems that may lead to falls. By eliminating subjective biases, the system is estimated to enhance the accuracy of movement evaluations, contributing to better patient outcomes and more efficient rehabilitation strategies.

Conclusion
The exergaming platform was designed by integrating depth sensing technology with gamified exercises to support physical assessment and rehabilitation in elderly and vulnerable populations. Preliminary tests have produced positive initial results, while ongoing data collection is planed to validate the platforms accuracy in real-time with precision in physical assessments. New physical assessment tools might enhance the accuracy of measurements and offer a more detailed view of users' functional capacity and overall wellness.

References
1. Briggs AM, Shiffman J, Shawar YR, Åkesson K, Ali N, Woolf AD. Global health policy in the 21st century: Challenges and opportunities to arrest the global disability burden from musculoskeletal health conditions. Best Pract Res Clin Rheumatol. 2020 Oct;34(5):101549.

2. Jarzebski MP, Elmqvist T, Gasparatos A, Fukushi K, Eckersten S, Haase D, Goodness J, Khoshkar S, Saito O, Takeuchi K, Theorell T, Dong N, Kasuga F, Watanabe R, Sioen GB, Yokohari M, Pu J. Ageing and population shrinking: implications for sustainability in the urban century. Npj Urban Sustain. 2021 May 27;1(1):1–11.
3. Cristea M, Noja GG, Stefea P, Sala AL. The Impact of Population Aging and Public Health Support on EU Labor Markets. Int J Environ Res Public Health. 2020 Feb;17(4):1439.
4. Cooper J, Murphy J, Woods C, Van Nassau F, McGrath A, Callaghan D, Carroll P, Kelly P, Murphy N, Murphy M, Bauman A, Cullen B, Brolly C, Bengoechea EG, Mansergh F, O'Donoghue G, Lavelle J, Mutrie N, Barry N, Smyth P, Kielt R, O'Brien S, O'Shea S, Muppavarapu V, Irish Physical Activity Research Collaboration (I-PARC). Barriers and facilitators to implementing community-based physical activity interventions: a qualitative systematic review. Int J Behav Nutr Phys Act. 2021 Sep 7;18(1):118.
5. Assistive technology [Internet]. [cited 2025 Mar 28]. Available from: https://www.who.int/health-topics/assistive-technology
6. Chapman SB, Aslan S, Spence JS, Keebler MW, DeFina LF, Didehbani N, Perez AM, Lu H, D'Esposito M. Distinct Brain and Behavioral Benefits from Cognitive vs. Physical Training: A Randomized Trial in Aging Adults. Front Hum Neurosci [Internet]. 2016 Jul 18 [cited 2025 Mar 28];10. Available from: https://www.frontiersin.org/journals/human-neuroscience/articles/10.3389/fnhum.2016.00338/full
7. Yoshimura Y, Wakabayashi H, Nagano F, Bise T, Shimazu S, Shiraishi A, Kido Y, Matsumoto A. Chair-Stand Exercise Improves Sarcopenia in Rehabilitation Patients after Stroke. Nutrients. 2022 Jan;14(3):461.
8. Meras Serrano H, Mottet D, Caillaud K. Validity and Reliability of Kinvent Plates for Assessing Single Leg Static and Dynamic Balance in the Field. Sensors. 2023 Jan;23(4):2354.
9. Pedrosa GF, Simões MG, Figueiredo MOC, Lacerda LT, Schoenfeld BJ, Lima FV, Chagas MH, Diniz RCR. Training in the Initial Range of Motion Promotes Greater Muscle Adaptations Than at Final in the Arm Curl. Sports. 2023 Feb;11(2):39.
10. Mayhew AJ, So HY, Ma J, Beauchamp MK, Griffith LE, Kuspinar A, Lang JJ, Raina P. Normative values for grip strength, gait speed, timed up and go, single leg balance, and chair rise derived from the Canadian longitudinal study on ageing. Age Ageing. 2023 Apr 1;52(4):afad054.
11. Berlanga LA, Matos-Duarte M, Abdalla P, Alves E, Mota J, Bohn L. Validity of the two-minute step test for healthy older adults. Geriatr Nur (Lond). 2023 May 1;51:415–21.
12. Sibley KM, Thomas SM, Veroniki AA, Rodrigues M, Hamid JS, Lachance CC, Cogo E, Khan PA, Riva JJ, Thavorn K, MacDonald H, Holroyd-Leduc J, Feldman F, Kerr GD, Jaglal SB, Straus SE, Tricco AC. Comparative effectiveness of exercise interventions for preventing falls in older adults: A secondary analysis of a systematic review with network meta-analysis. Exp Gerontol. 2021 Jan 1;143:111151.
13. Konstantinidis EI, Billis A, Bratsas C, Siountas A, Bamidis PD. Thessaloniki Active and Healthy Ageing Living Lab: the roadmap from a specific project to a living lab towards openness. In: Proceedings of the 9th ACM International Conference on PErvasive Technologies Related to Assistive Environments [Internet]. New York, NY, USA: Association for Computing Machinery; 2016 [cited 2025 Mar 31]. p. 1–4. (PETRA '16). Available from: https://dl.acm.org/doi/10.1145/2910674.2935846
14. Liu W, Cao Y, Proctor RW. How do app icon color and border shape influence visual search efficiency and user experience? Evidence from an eye-tracking study. Int J Ind Ergon. 2021 Jul 1;84:103160.
15. Rytterström P, Strömberg A, Jaarsma T, Klompstra L. Exergaming to Increase Physical Activity in Older Adults: Feasibility and Practical Implications. Curr Heart Fail Rep. 2024 Aug 1;21(4):439–59.
16. Wei L, Wang SJ. Motion Tracking of Daily Living and Physical Activities in Health Care: Systematic Review From Designers' Perspective. JMIR MHealth UHealth. 2024 May 6;12:e46282.
17. Manktelow M, Iftikhar A, Bucholc M, McCann M, O'Kane M. Clinical and operational insights from data-driven care pathway mapping: a systematic review. BMC Med Inform Decis Mak. 2022 Feb 17;22:43.
18. Effectiveness of exergames for improving mobility and balance in older adults: a systematic review and meta-analysis | Systematic Reviews [Internet]. [cited 2025 Mar 31]. Available from: https://link.springer.com/article/10.1186/s13643-020-01421-7
19. Mohan D, Al-Hamid DZ, Chong PHJ, Sudheera KLK, Gutierrez J, Chan HCB, Li H. Artificial Intelligence and IoT in Elderly Fall Prevention: A Review. IEEE Sens J. 2024 Oct;24(4):4181–98.
20. http://jmirpublications-19668141.hs-sites.com/hs-web-interactive-19668141-172519389611 [Internet]. [cited 2025 Mar 31]. Available from: http://jmirpublications-19668141.hs-sites.com/hs-web-interactive-19668141-172519389611
21. JMIR Serious Games - Comparison of Exergames Versus Conventional Exercises on the Health Benefits of Older Adults: Systematic Review With Meta-Analysis of Randomized Controlled Trials [Internet]. [cited 2025 Mar 31]. Available from: https://games.jmir.org/2023/1/e42374

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Exergames, Motion Tracking, Unity, Depth Sensors, Elderly Assessment

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ITERATIVE DEVELOPMENT, TESTING, VALIDATION AND BENCHMARKING OF CUSTOM EEG, fNIRS AND sEMG SENSORS

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Abstract

This paper presents the iterative development, testing, validation, and benchmarking of custom biosignal acquisition systems designed for neurophysiological monitoring, including functional near infrared spectroscopy (fNIRS), electroencephalography (EEG), and surface electromyography (sEMG). The fNIRS subsystem employs dual-wavelength light-emitting diodes (LEDs) and a dedicated Python simulation framework to model light absorption and optimize sensor placement, while the vascular occlusion test is explained in detail to assess its capability to show tissue oxygenation dynamics. In parallel, the custom EEG board leverages a high speed Teensy 4.1 microcontroller in conjunction with ADS1299 analog to digital converters, and integrates an (organic light-emitting diode) OLED FeatherWing display via a Feather adapter to create an intuitive user interface, as well as an ESP32 Feather module for wireless data streaming. Additionally, a custom sEMG board based on an STM32H7 microcontroller is developed to facilitate real-time movement classification and support neurorehabilitation applications. Benchmarking of the custom devices against commercial alternatives, including the OpenBCI Cyton, MiniSim EEG signal simulator, and MyoWare sensor, demonstrates their reliability, accuracy, and overall potential for practical applications in brain–computer interface research and neurorehabilitation.

Introduction

In recent years, the need for accessible and affordable biomedical devices has grown significantly, both for public health applications and research purposes. Cost-effective, modular systems enable a broader range of users to monitor and understand complex physiological signals while driving innovation in neuroscience and rehabilitation [4], [5], [6]. This paper presents an integrated approach to the iterative development, testing, validation, and benchmarking of custom functional near infrared spectroscopy (fNIRS), electroencephalography (EEG), and surface electromyography (sEMG) sensors, demonstrating that high-performance biomedical instrumentation can be achieved without compromising affordability. The development of those sensors will lead to their incorporation into the framework of the NeuroSuitUp platform and NeuroSuitUp/HEROES projects [1],[2].

Functional Near Infrared Spectroscopy (fNIRS)

In the logic of prototyping iteratively, and allowing for the parallel development and testing of different photodiodes for the fNIRS biomedical sensor [3], the decision to split the light-emitting diode (LED) grid emitting the light at the wavelength of 730nm and 850nm into the brain for the detection of oxygenated and deoxygenated hemoglobin accordingly, from the photodiode module meant to act as a detector of the light as it passes human tissue was taken. In LEDs, radiant intensity refers to the amount of optical power, sometimes called radiant flux, which is emitted by the LED per unit of solid angle in a specific direction. Radiant intensity is a measure of how much light the LED emits in a particular direction, making it a directional quantity, which is particularly important when designing optical systems, as it helps determine how much light will be available at a given distance and angle from the emitter LED. Most fNIRS systems take advantage of the dual wavelength LEDs by Marubeni, which have the ability to produce either 750nm or 850nm light according to which cathode of the LED is given power. The Marubeni LEDs can have a current of up to 500mA at 750nm and up to 1A at 850nm, and radiant intensity up to 230 mW/sr and 360 mW/sr for the 750nm and 850nm wavelengths. In an attempt to make an informed decision on the radiant intensity of the LEDs on this development iteration for the fNIRS sensor, a python script was written meant to simulate the absorption of emitted light by the brain using the corresponding absorption coefficients from the bibliography. This python script is used to validate the minimum radiant intensity needed for absorption of emitted light from the biological tissues comprising the human head at different wavelengths and reject LEDs which are not capable of emitting light with the necessary radiant intensity to be absorbed by the brain before scattering. In order to be able to choose accessible and affordable electronic components, two different LEDs were selected in order to create a channel of fNIRS information, meaning an emission of light at 730nm and 850nm, leading to a voxel of fNIRS information. In order to give an accurate measure of loss to the available spatial resolution with the usage of these LEDs, the Marubeni LEDs are 2.7mm in width and 3.5mm in height, while the custom fNIRS channel are about 3mm width and height each, so in this way the possible spatial resolution is half compared to using the Marubeni LEDs, however their affordability and accessibility in procuring them makes these LEDs an appropriate choice for research purposes.

Table 1: Absorption coefficients at different wavelengths

Wavelength (nm)	Scalp (1/mm)	Skull (1/mm)	Brain (1/mm)
730	0.017	0.033	0.025
850	0.018	0.040	0.025

The Python code calculates the light penetration depth in human tissue for two LEDs with different wavelengths of 730 nm and 850 nm. It simulates how light from these LEDs penetrates through layers of the human head taking into account the absorption coefficients of the scalp, skull, and brain based on their absorption coefficients and the Beer-Lambert Law, which describes how light is absorbed as it passes through a medium. Here, it should be noted that with the absorption coefficients for the scalp, skull and brain defined from the according bibliography, along with the wavelength of emission of the LEDs and their radiant intensity, a python script meant to simulate the maximum depth of absorption of light by the human head was created. The code then iterates over the two LEDs and calculates the penetration depths for each LED, computing the total penetration depth and brain penetration depth and printing the results for each LED. The code assumes the initial power of the light is equal to the radiant intensity of the LED, then the calculation of the depth at which only 1% of the light remains after passing through the scalp is performed using the formula:

(1) *scalp depth = −ln(0.01) / scalp_absorption*

This is derived from the Beer-Lambert law, which states that light intensity decreases exponentially with depth. Similarly, the code calculates the depth at which only 1% of the light remains after passing through the skull:

(2) *skull depth = −ln(0.01) / skull_absorption*

After calculating the depths for the scalp and skull, it computes the remaining power of the light after passing through these layers using the exponential decay formula:

(3) *power after scalp = initial power × e^(−scalp_absorption × scalp depth)*

(4) *power after skull = power after scalp × e^(−skull_absorption × skull depth)*

Finally, it calculates the depth into the brain where only 1% of the remaining light, after passing through the scalp and skull is left:

(5) *brain depth = −ln(0.01/power after skull) / brain absorption*

The total penetration depth is the sum of the depths through the scalp, skull, and brain is calculated then.

(6) *total depth = scalp depth + skull depth + brain depth*

Table 2: Results for each wavelength and LED

LED	Wavelength (nm)	Radiant Intensity (mW/sr)	Total Penetration Depth(mm)	Depth into Brain (mm)
CreeLED FR	730	135	422	12
SFH4350 LED	850	200	398	27

For comparison, the same code when executed for the Marubeni LEDs, provides the depth into the brain of 33.32 mm at the 730nm wavelength and 51.24 mm at the 850nm wavelength. In order to drive the LEDs, a constant current driver was needed so the The TPS92630-Q1 Three-Channel Linear LED Driver from Texas Instruments was chosen to prototype a low cost board with a few channels for validation and functional testing. This LED driver was selected due to its availability, affordability, and ability to support a round-robin sequencing scheme, which is crucial for minimizing crosstalk between the LEDs. Crosstalk can occur when multiple LEDs emit light simultaneously, causing interference in the detected signals. To mitigate this, the LEDs are driven in a sequential manner, ensuring that only one LED is active at a given time while the others remain off. This controlled timing approach enhances the accuracy of the recorded signals by preventing overlapping light sources from contaminating the readings. The TPS92630-Q1's capability to regulate current across multiple channels further ensures stable and consistent illumination, making it well-suited for fNIRS applications requiring precise light modulation.

fNIRS Sensor Testing

The fNIRS testing procedure, commonly referred to as the Vascular Occlusion Test (VOT), is a robust method for assessing tissue oxygenation and vascular function. In this procedure, an fNIRS sensor is placed on a target muscle to continuously measure tissue oxygen saturation (StO2). The test is divided into three distinct phases. Initially, the sensor records stable StO2 levels over a three-minute period, establishing a reference point for subsequent measurements. A sphygmomanometer cuff is applied proximally to the sensor and inflated rapidly to approximately 50 mmHg above the subject's systolic blood pressure. This inflation occludes both arterial inflow and venous outflow, inducing a state of ischemia. During this three-minute occlusion, the fNIRS device captures the gradual decrease in StO2 as the tissue consumes its available oxygen, resulting in a desaturation curve. After the occlusion period, the cuff is quickly deflated, allowing blood to flow back into the tissue. The sensor then records the hyperemic response, the rapid increase in StO2 as the tissue reoxygenates. This phase continues until the oxygen saturation returns to near baseline levels. The data collected during these phases are used to extract key parameters such as baseline StO2, the desaturation slope or the rate of oxygen decline, minimum StO2 achieved during occlusion, the reperfusion slope or rate of oxygen recovery, and the rise time or time taken to reach maximum StO2 post-deflation. Together, these metrics provide a detailed picture of the microvascular function and the dynamic changes in tissue oxygenation during vascular stress and recovery.

fNIRS Photoemitters and Photodetectors Locations

The fNIRS device is designed for motor imagery recordings, specifically targeting brain activity related to left and right-hand movements. To ensure optimal sensor placement, the fNIRS Optodes' Location Decider (fOLD) toolbox in MATLAB was utilized [8], providing guidance on the brain regions that need to be covered based on a prior motor imagery experiment. The key anatomical regions selected for the experiment, with a specificity threshold of 30%, include the left and right Precentral and Postcentral areas, as well as the Frontal Sup 2 and Frontal Mid 2 regions on both hemispheres. The toolbox generated a 1020 system-based map indicating the optimal positions for fNIRS sources and detectors, ensuring precise coverage of the motor cortex for capturing cortical activation during imagined movement tasks.

Electroencephalography (EEG)

The EEG board is based on a previous thesis [7], with this iteration standing to improve on the design of the electronics along with working on a more robust testing and validation of its biomedical function procedure. In order to upgrade the microprocessor from the previous design and also raise the sampling frequency to an appropriate level consistent with other EEG data acquisition boards, the Teensy 4.1 microprocessor was chosen, which is capable of reaching up to 500 Mhz sampling frequency allowing for more data heavy EEG recordings. The same design as before is being kept in regards with the ADS1299 which are Analog to Digital Converters specially designed and produced by Texas Instruments for EEG instrumentation. The ADS1299 four channel integrated circuits are used for data acquisition, interfacing directly with the Teensy 4.1, which processes EEG signals with high precision. To enhance usability, the Teensy 4.1 can be connected to an organic LED (OLED) FeatherWing display and integrated into a Feather adapter, leveraging Adafruit's electronics ecosystem. This setup allows for a compact and modular design, making it easy to create an interactive user interface for monitoring EEG data in real time. Additionally, a secondary ESP32 Feather board is responsible for establishing wireless communication, enabling seamless data transmission via the lab streaming layer (LSL) [9]. By combining these elements, the system provides an intuitive and flexible EEG acquisition platform that benefits from Adafruit's well supported hardware ecosystem.

It should be noted that the open-source Mark III cask from openBCI [10] is being used to support the dry electrodes and allow for a more streamlined and comfortable for the users' procedure, for the EEG recordings. Another integral part for the identification of movement noise to be flagged during the data acquisition, in order to be dealt with in the EEG preprocessing is the BNO085 inertial measurement unit, which along with its capabilities in identifying movement noise, could also be useful in the future when it comes to developing Augmented Reality applications which require head tracking along with sampling of electroencephalography signals.

Figure 1. Hardware overview for EEG board supporting wireless LSL streaming

Surface Electromyography (sEMG) board

The sEMG board is based on a previous thesis as well [11] and it is meant to collect data for the future application of neurorehabilitation. At the current time there have been previous and ongoing dissertations which focus on the development of machine learning classification models based on sEMG signals which are meant to identify movement in real time as the recording is taking place. For the hardware to be able to support such capabilities the STM32H7 microcontroller was chosen mostly for its architecture which consists of an M7 Cortex processor which is capable of running machine learning models on the edge, while the M4 cortex of the STM32H7 handles the necessary data recording procedure. The coding of the STM32H7 microprocessor using the STM32 CubeIDE while keeping most of the electronic circuit intact and ensuring a robust testing of the device proves to be the main challenge of developing this particular board. However, With the M7 and M4 two coprocessors working together future neurorehabilitation and augmented reality applications could be developed, which could be especially benefited and customized to fit the capabilities of the sEMG sensor.

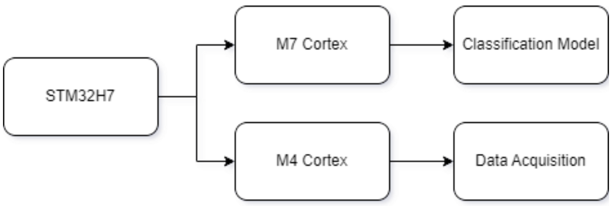

Figure 2. sEMG Hardware Overview for Data Acquisition and real time classification of muscle movement.

Benchmarking

Benchmarking the custom EEG and sEMG devices involves a rigorous evaluation of their performance against commercially available alternatives to ensure reliability, accuracy, and overall functionality. For the EEG board, the OpenBCI Cyton will serve as a reference device, allowing for direct comparison of signal quality, noise levels, and sampling rates. Additionally, the MiniSim EEG signal simulator will be used to generate standardized EEG waveforms, enabling precise validation of the custom device's signal acquisition capabilities under controlled conditions. Similarly, the custom sEMG board will be benchmarked against the MyoWare sensor, assessing factors such as signal fidelity and response time. The benchmarking process will involve robust testing procedures, including controlled data acquisition sessions, statistical analysis of signal integrity, and real-time performance evaluations. By systematically comparing the recorded signals from the custom devices with those obtained from commercial counterparts, the study will highlight the advantages and limitations of the proposed sensors. This approach will ensure that the developed hardware meets the necessary standards for practical applications, including neurorehabilitation and brain-computer interface research.

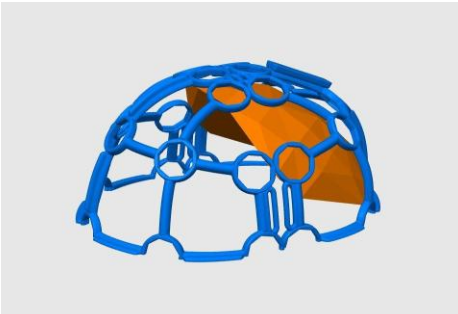

Figure 3. Mark III open-source head set for EEG dry electrodes and fNIRS optodes. The fNIRS locations for motor function imaging are marked with orange color.

Expected Results & Discussion

Validation through standardized tests and compliance to standardization allow for testing procedures with the minimal amount of risk involved. These protocols and standards provide a framework for evaluating sensor accuracy, safety, and performance while addressing possible hazards associated with electrical, mechanical, and optical components. Moreover, to further reduce biases and mitigate any emerging risks, the Aristotle university's ethics committee rigorously reviews and approves each testing procedure for the sensors, and several medical professionals are consulted through the experiment design procedure. This allows for evaluations of participant safety, data integrity, and the use of proper control mechanisms, fostering transparency and accountability in every stage of sensor development and testing. When it comes to iteratively developing biomedical sensors and electronics in general, challenges emerge with ensuring basic functionality being the first step in the iterative design process. The next phases of iterative development are focused on the appropriate sensitivity and capability of acquiring the necessary biomedical signals and filtering them accordingly. Ideally, through continuous testing and data analysis of the acquired signals supervised by medical and academic professionals who are familiar with the procedure, the biomedical capabilities of the system are proved, and then the electronics validation process through rigorous simulations in design programs along with possible experiments to see how the sensors react when faced with electromagnetic interference. All these iterations are helpful in achieving the validation of the custom biomedical sensors in EEG, EMG and fNIRS.

References

[1] K. Mitsopoulos, et al. Neurosuitup: System architecture and validation of a motor rehabilitation wearable robotics and serious game platform. Sensors, 23, 3 2023.

[2] Athanasiou A, et al. Neurorehabilitation Through Synergistic Man-Machine Interfaces Promoting Dormant Neuroplasticity in Spinal Cord Injury: Protocol for a Nonrandomized Controlled Trial JMIR Res Protoc 2022;11(9):e41152 doi: 10.2196/41152

[3] O. Chondroudis, "Design and Implementation of a Device for Recording Brain Activity based on functional Near-Infrared Spectroscopy (fNIRS)," M.Sc. thesis, Dept. of Information and Electronic Engineering, Int. Hellenic Univ., Greece, Jun. 22, 2024. [Online].

[4] O'Brien WJ, et al., "ninjaNIRS: an open hardware solution for wearable whole-head high-density functional near-infrared spectroscopy," Biomed. Opt. Express 15, 5625-5644 (2024)

[5] OpenBCI: Open Source Brain-Computer Interfaces. Retrieved March 30, 2025, from https://openbci.com/

[6] OpenEMG Arduino Sensor, Retrieved March 30, 2025, from https://charleslabs.fr/en/project-OpenEMG+Arduino+Sensor

[7] Vasilopoulos VG, Development of motor imagery brain-computer interface for use in stroke patient rehabilitation, M.Sc. thesis, Dept. of Biomedical Engin., Aristotle Univ. of Thessaloniki, Greece, 2023.

[8] G. A. Zimeo Morais, J. B. Balardin, and J. R. Sato, 'fNIRS Optodes' Location Decider (fOLD): A Toolbox for Probe Arrangement Guided by Brain Regions-of-Interest', Sci. Rep., vol. 8, no. 3341, 2018

[9] LSL, "Lab Streaming Layer (LSL) protocol," Available: https://labstreaminglayer.org/. Accessed: Mar. 30, 2025.

[10] OpenBCI, 'Ultracortex'. Accessed: Mar. 26, 2025. Available: https://github.com/OpenBCI/Ultracortex.

[11] V. Mantiou, "Design, development and validation of an agonist-antagonist pair sEMG flexible PCB," M.Sc. thesis, School of Med., Aristotle Univ. of Thessaloniki, Greece, Jan. 2024.

Keywords: fNIRS, EEG, sEMG, biomedical signal acquisition, neurorehabilitation, augmented reality, BCI

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VITSEG – A WHOLE HEART IMAGE SEGMENTATION MODEL USING VISION TRANSFORMERS

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Abstract
A basic requirement to study cardiovascular diseases (CVDs) is to analyze the spatial content of heart anatomy. Computed Tomography (CT) counts as one of the most relevant imaging modalities, serving as the base for 3D heart modeling and/or digital twin formulation. In this regard, image segmentation plays a vital role, but it can be challenging and time-demanding due to the complexity of the heart structures. We propose a new segmentation approach, the so-called 'ViTSeg', for automated whole heart image segmentation. ViTSeg, with roots from the original Vision Transformer (ViT), is first trained and then tested based on an openly available dataset as provided by the MICCAI Multi-Modality Whole Heart Segmentation (MM-WHS) challenge. Due to the low number of image datasets, we further proceed with data augmentation techniques to expand the dataset. The segmentation performance exhibits a dice score of 92.65 ± 2.17%. By comparing with other evaluated deep-learning based approaches (U-Net, UNETR), ViTSeg demonstrates superior segmentation accuracy while maintaining its computational efficiency. The ViTSeg model shows a major potential for robust automated whole-heart segmentation in medical image analysis.

Introduction
The heart, as the main organ of the cardiovascular system, is responsible for circulating blood throughout the human body. In this regard, even a brief dysfunction of its normal state can have serious consequences. Cardiovascular disease is currently the leading cause of death worldwide; this highlights the need for precise diagnosis and treatment. Efficient monitoring of its physiological state is therefore essential, especially for patients with cardiovascular diseases (CVDs). With its intricate anatomy and critical role in overall health, the heart requires advanced imaging technologies and computational tools. This study focuses, in particular, on the analysis and segmentation of heart anatomy, which is crucial for treatment planning and quantitative analysis.

Imaging modalities such as Computed Tomography (CT) offer clinicians a unique opportunity for getting detailed insights into morphological and functional characteristics of the human heart [8]. Cardiac image segmentation is an essential task, serving as a first step for acquiring quantitative measurements, building the heart 3D model and the formulation of the heart digital twin. In this regard, image processing and analysis and more specifically image segmentation plays a crucial role. However, segmentation is a task that requires high expertise, is very probable to end-up in suboptimal 3D modeling and feature extraction and when it is performed manually, it is very time-consuming, prone to human error, and highly dependent on the expertise of the user. Therefore, the need for automated approaches has grown [15].

Automated segmentation, although promising, faces several critical challenges [7]. Inter-subject variabilities in the heart anatomy, unclear boundaries between substructures, and low image quality between different regions can pose significant challenges to accurate segmentation. Additionally, issues like class imbalance and the need for large, annotated datasets, which are often limited in medical imaging, further complicate the process. Many traditional deep learning models, such as Convolutional Neural Networks (CNNs), have been successful but struggle to capture long-range dependencies crucial for understanding complex anatomical structures [16].

The MICCAI challenge highlighted several of these difficulties, as participants applied various strategies for whole-heart segmentation [3]. One of the leading models explored was the multi-atlas segmentation (MAS), which exhibited anatomical realistic results, but they proved to be computationally expensive and also struggled with the low-resolution data [4, 9]. Several participants used CNN-based deep learning architectures with various implementations, achieving better performance in comparison to MAS-based approaches [9]. However, the challenges mentioned above persisted, highlighting the limitations in current automated segmentation techniques. The recent advancements with Vision Transformers (ViT) have shown promising results in image classification tasks. However, ViTs have seen limited application in 3D medical segmentation tasks [5, 6].

In this paper, we propose a hybrid segmentation model, the so-called 'ViTSeg' that combines both ViT and CNN related model architecture for cardiac image segmentation. ViTSeg is a hybrid model with a ViT-based encoder for capturing long range dependencies and a convolutional decoder for accurate boundary detection. By introducing ViT into the automated whole-heart segmentation task it may facilitate the handling of complex heart anatomies with low computational cost. Our contribution lies in designing the convolutional decoder and optimizing the training process, while the novelty of our approach is the effective combination of ViT with a lightweight convolutional decoder, achieving both high segmentation accuracy and computational efficiency.

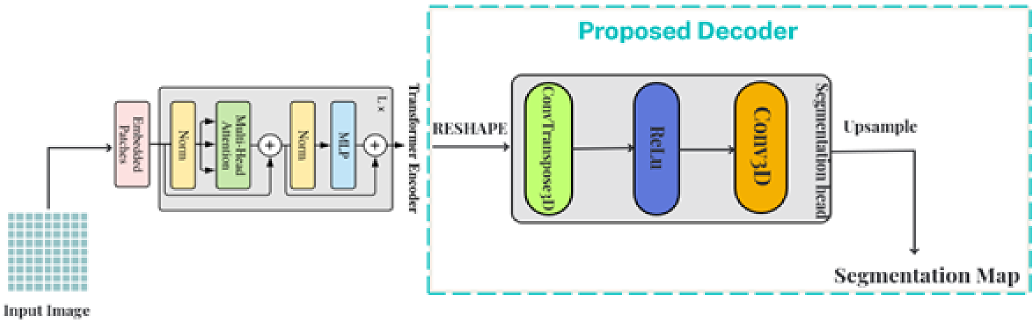

Figure 1. ViTSeg Model Architecture

Materials and methods

The used dataset originates from the MICCAI Multi-Modality Whole Heart Segmentation (MM-WHS) challenge, comprising 60 CT 3D cardiac images [3]. The CT data, considered in this study, were obtained from anonymized healthy patients. A set of 20 annotated 3D image volumes, with fixed dimensions of [96 × 80 × 96], were used for training and validation, while 40 raw 3D image volumes, with varying dimensions, were reserved for testing. The dataset, provided in NIfTI format, covers the entire heart, from the upper abdomen to the aortic arch, capturing the heart's substructures. The in-plane resolution of the axial slices is 0.78 × 0.78 mm, with an average slice thickness of 1.60 mm. The dataset also includes manual annotations of seven cardiac substructures, including the left and right atriums, left and right ventricles, myocardium of the left ventricle, aorta, and pulmonary artery.

Before training the network, we pre-process the training dataset to ensure uniformity and consistency across them. A specific preprocessing procedure was applied to produce images with distinct tissues, the same orientation, and a consistent size. In order to increase dataset diversity and avoid overfitting, data augmentation techniques, including random rotations and Gaussian noise addition, were applied. The preprocessing and augmentation procedures were implemented using the MONAI framework [10]. MONAI is a PyTorch-based library for deep learning in medical imaging with a comprehensive set of tools for medical image analysis, including the RandRotated, and RandGaussianNoised functions, which we leveraged for tasks such as image rotation and noise addition.

Model Architecture

The architecture of the proposed ViTSeg model (Fig. 1) was developed by combining ViT [1,14] encoder for feature extraction and a convolutional decoder to generate the segmentation map. Since the input consists of 3D cardiac CT volumes, the segmentation is performed on the entire volumetric structure rather than individual 2D slices. The ViT encoder is responsible for capturing long-range relationships and the convolutional decoder for accurate boundary detection and preserving local spatial details. In Fig. 1 the model is divided in two parts:

- ViT-based Encoder: The input image is divided into small, non-overlapping patches. Each patch is flattened into a vector and the final output consists of all patches represented as a sequence of embedded vectors. First, the Multi-head Self-attention mechanism captures global dependencies across patches. Residual connections, normalization, and a Multilayer Perceptron (MLP) further refine the features and stabilize training.
- Convolutional Decoder: The goal of the decoder is to generate the segmentation map. The encoder's features are reshaped back into a 3D grid. Transposed convolution [11] reduces features dimensions while increasing the resolution. ReLU activation introduces non-linearity, and convolution reduces feature dimensions to the number of classes creating a 3D probability map for each voxel. The final upscaling ensures the final output matches the input resolution [12].

This approach combines the strengths of ViTs in capturing complex relationships with the spatial accuracy of convolutional layers, making it well-suited for medical image segmentation tasks.

Training Procedure

The ViT encoder that was used in this study was implemented according to the ViT-Base architecture [1]. The model was trained from scratch on the MICCAI MM-WHS dataset, without utilizing any pre-trained weights. The training procedure employed the AdamW optimizer and DiceCELoss [13], which used Dice and Cross-Entropy losses together, as shown in Equation (1). A learning rate scheduler [2] was implemented to adjust the learning rate, ensuring that the model has enough time to adapt during training.

To ensure a robust and reliable evaluation, a 5-fold cross-validation approach was employed on the training images, such that each image is tested exactly once. To create the segmentations in the test set, we trained on all the training images with the same hyperparameters as used for cross validation. Finally, a post-processing transformation is applied after each prediction to convert the output into the desired format for evaluation.

$$DiceCELoss = w_0 \frac{2 * \Sigma_{\{c=1\}}^{N} p_c y_c}{\Sigma_{\{c=1\}}^{N} p_c^2 + \Sigma_{\{c=1\}}^{N} p_c^2 y_c^2} \quad (1)$$

$$-w_1 \Sigma_{\{c=1\}}^{N} y_c \log p_c$$

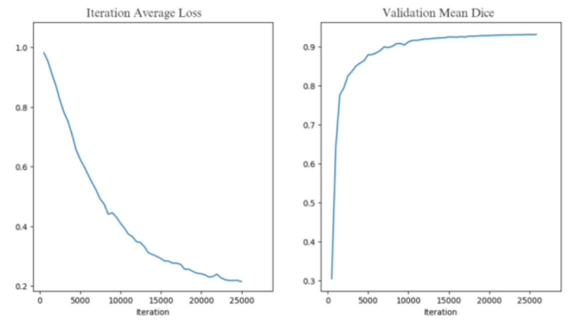

Figure 2. The training Loss and validation Dice score

The model was trained for 25000 iterations with a batch size of 1 due to memory constraints, taking approximately 5 hours. Experiments were conducted on an Intel Core i7-13700K processor with an AMD Radeon RX 7900 XTX GPU (24GB VRAM) using Windows Subsystem for Linux (WSL) and ROCm for PyTorch compatibility.

Results

The ViTSeg model was evaluated on the CT dataset using key metrics: Dice Similarity Coefficient (DSC), Intersection over Union (IoU), and Hausdorff Distance (HD). Training loss decreased steadily, and the validation Dice score improved over iterations, indicating effective learning (Fig. 2). The model achieved an average DSC of 92.65%, with most of the heart substructures exceeding 90% (Table 2). The evaluated heart substructures include the Left Ventricle (LV), Right Ventricle (RV), Left Atrium (LA), Right Atrium (RA), Myocardium (MYO), Aorta (AO), and Pulmonary Artery (PA). Among them, the Pulmonary Artery (PA) had the lowest DSC at 87.93%, indicating challenges in segmenting smaller substructures.

Table 1. ViTSeg overall performance metrics in validation phase.

Metric	Average Value (%)
Accuracy	99.50 ± 0.08
Precision	92.43 ± 3.05
Recall (Sensitivity)	92.88 ± 2.39

Visual Results

A randomly excluded test image *ct_train_1001* was used for additional validation. The predicted segmentation closely matched the ground truth, achieving an average

Table 2. ViTSeg performance metrics in validation phase for the heart substructures.

Heart Substr.	DSC (%)	IoU (%)	HD (mm)
LV	93.66 ± 1.60	87.67 ± 2.70	2.31 ± 0.34
RV	94.56 ± 0.57	87.95 ± 2.11	2.92 ± 1.19
LA	94.58 ± 1.90	90.34 ± 1.96	3.03 ± 1.01
RA	93.48 ± 0.80	86.95 ± 1.31	3.48 ± 0.93
MYO	91.40 ± 1.89	85.59 ± 2.02	2.84 ± 0.81
AO	92.90 ± 1.50	86.81 ± 1.11	2.71 ± 0.38
PA	87.93 ± 1.80	76.67 ± 4.88	6.74 ± 2.24
Average	**92.65 ± 2.17**	**86.41 ± 4.50**	**3.43 ± 1.80**

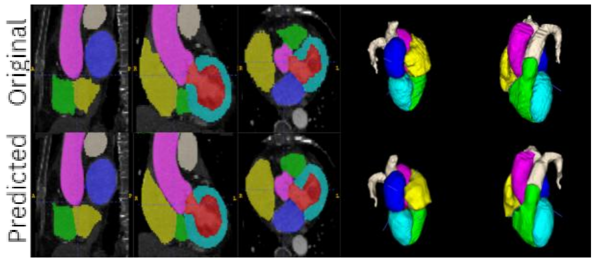

Figure 3. Visualization of the segmentation results. The top row shows the ground truth segmentation, and the bottom row presents the predicted segmentation. The colors represent the following structures: Red (LV), Green (RV), Blue (LA), Yellow (RA), Cyan (MYO), Purple (AO), and White (PA).

DSC of 90.10%, slightly lower than validation results. While the model successfully segmented major heart structures, subtle errors in boundary precision were observed, particularly in the Pulmonary Artery.

Table 3. DSC score for CT Image: *ct_train_1001* in testing.

Heart Substructure	DSC score (%)
Left Ventricle (LV)	86.50
Right Ventricle (RV)	87.50
Left Atrium (LA)	94.73
Right Atrium (RA)	90.10
Myocardium (MYO)	86.71
Aorta (AO)	91.72
Pulmonary Artery (PA)	84.20
Average	**90.10**

Comparison with Other Models

ViTSeg outperformed even traditional models such as U-Net and the Transformer-based U-Net (UNETR) [2]. Both models were trained using the same parameters as ViTSeg. While ViTSeg achieved a Dice score of 92.65%, both U-Net and UNETR obtained lower values, 82.67% and 86.33%, respectively, over all substructures. ViTSeg not only achieved higher accuracy but also demonstrated computational efficiency, completing training in 5 hours. In comparison, UNETR required 24 hours and U-Net 10 hours to train.

Discussion

This study revolves around the use of Vision Transformers (ViTs) for automated cardiac image segmentation. We introduce ViTSeg to improve segmentation accuracy while maintaining computational efficiency. The model is trained and tested on CT images from the MICCAI MM-WHS challenge, achieving a Dice Similarity Coefficient (DSC) of 92.65.

The results demonstrate that ViTSeg exhibited a good segmentation performance, particularly for the ventricles and atria. Although smaller substructures such as the Pulmonary Artery posed challenges, while achieving the lowest DSC (87.93%). The model also exhibited slightly lower performance on the test image, indicating the need for further generalization improvements. In addition to its performance, ViTSeg also proved to be computationally efficient, making it a more practical choice for real-world applications.

ViTSeg showed high segmentation performance results in significantly low computational time compared with other well-known architectures (U-Net and UNETR). This is potentially due to the use of attention-based architecture, which contains the unique feature of better captured global and local features. Recent studies [17,18] for whole heart segmentation have reported strong performance, with a DSC over all substructures of 90.51% using a MAS-based method developed by Yang et al. (2017) and 88.9% with Seg-CNN, the CNN-based segmentation method proposed by Payer et al. (2017). These studies further highlight the competitive performance of our model, ViTSeg.

Despite the good performance of ViTSeg, this approach has limitations. Firstly, the small dataset used for training and validation had a significant impact mainly on the model's performance which can be addressed with future studies by training with a larger and diverse dataset or different imaging modalities (e.g., MRI) to enhance generalizability. Additionally, exploring self-supervised or semi-supervised learning approaches would reduce reliance on labeled data. Then resource constraints during training, such as reliance on a small GPU, which occur on the use of a minimal batch size of 1, affecting optimization and training efficiency. Furthermore, the model is not designed to process different modalities due to the variations in their features. Another area for improvement is the assessment of segmentation quality scores. In future work, incorporating uncertainty indicators or attention maps could help estimate the probability of failure, enabling better detection of segmentation issues and enhancing model reliability and robustness [19]. Future studies will also evaluate the real-time inference performance of ViTSeg to further demonstrate its practical feasibility for deployment in clinical workflows.

Conclusion

We proposed ViTSeg, a novel deep learning architecture for human heart anatomy segmentation. The model was trained and evaluated based on openly available data. ViTSeg showed promising results not only during training and testing phases and when compared with other novel models, but also in terms of computational time. The proposed model might pave the way for accurate whole heart segmentation to offer high-end and real-time 3D modeling and digital twin formulations posing a significant attribute for improved clinical evaluations for CVDs.

References

[1] Dosovitskiy, A., et al. (2020). An image is worth 16x16 words: Transformers for image recognition at scale.
[2] Hatamizadeh, A., et al. (2021). UNETR: Transformers for 3D Medical Image Segmentation. 2022 IEEE/CVF Winter Conference on Applications of Computer Vision (WACV).
[3] Zhuang, X., et al. (2019). Evaluation of algorithms for multi-modality whole heart segmentation: An open-access grand challenge. Medical Image Analysis, 58.
[4] Zhuang, X., & Shen, J. (2016). Multi-scale patch and multi-modality atlases for whole heart segmentation of MRI. Medical Image Analysis, 31:77-87.
[5] Khan, A., et al. (2023). A Recent Survey of Vision Transformers for Medical Image Segmentation.
[6] Khan, R. F., et al. (2023). Transformers in medical image segmentation: a narrative review. Quantitative imaging in medicine and surgery, 13(12): 8747–8767.
[7] Zhuang, X. (2013). Challenges and methodologies of fully automatic whole heart segmentation: a review. Journal of Healthcare Engineering, 4(3): 371–408.
[8] Zhu, Z., et al. (2019). Automated cardiac image segmentation using deep learning: A review. Journal of Cardiovascular Imaging, 27(2): 121-133.
[9] Pop, M., et al. (2018). MM-WHS Challenge., Statistical Atlases and Computational Models of the Heart: ACDC and MMWHS Challenges, 179-260.
[10] Cardoso, M.J. et al. (2022). MONAI: An open-source framework for deep learning in healthcare.
[11] Gao, H., et al. (2018). Pixel Deconvolutional Networks. Proceedings of the IEEE Conference on Computer Vision and Pattern Recognition (CVPR), 5660-5668.
[12] Zheng, S., et al. (2021). Rethinking Semantic Segmentation from a Sequence-to-Sequence Perspective with Transformers. Proceedings of the IEEE/CVF Conference on Computer Vision and Pattern Recognition (CVPR), 6877-6886.
[13] Ben-Hamadou, A., et al. (2023). 3DTeethSeg'22: 3D teeth scan segmentation and labeling challenge.
[14] Vaswani, A., et al. (2017). Attention is All you Need. Neural Information Processing Systems.
[15] Preim, B., Botha, C. (2014). Image Analysis for Medical Visualization. In Visual Computing for Medicine, 111-175.
[16] Chetia, D., et al. (2025). Image Segmentation with Transformers: An Overview, Challenges and Future.
[17] Yang, G., et al. (2017). Automatic whole heart segmentation in CT images based on multi-atlas image registration. Statistical Atlases and Computational Models of the Heart: ACDC and MMWHS Challenges, 8th International Workshop, 250-257.
[18] Payer, C., et al. (2017). Multi-label whole heart segmentation using CNNs and anatomical label configurations. Statistical Atlases and Computational Models of the Heart: ACDC and MMWHS Challenges, 8th International Workshop, 190–198.
[19] Chen, C., et al. (2020). Deep learning for cardiac image segmentation: A review. Frontiers in Cardiovascular Medicine, 7, 25.

Keywords:
Vision Transformers, Segmentation, Biomedical, Heart, Deep Learning, Automated segmentatio

BACKGROUND AND DEVELOPMENT PROTOCOL FOR SENSOR DATA FUSION GESTURE CLASSIFICATION USING A SOFT ROBOTIC GLOVE

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Abstract

Physical therapy and advanced neural rehabilitation are crucial components of the treatment of many neurological disorders, and the use of robotic glove-assisted devices for hand function rehabilitation has become an area of growing research interest. In addition, advances in sensing mechanisms and computational models have enabled the development of systems capable of understanding gestures and tracking joint angles. This work proposes an approach for collecting kinetic and kinematic data through the sensor layer of a soft robotic glove (SRG), with the objective of classifying gestures through data fusion and controlling the SRG. The proposed methodology aims to deliver active therapy that supports rehabilitation with a natural and intuitive user experience.

Keywords
data fusion, bend sensor, flex sensor, force sensor, hand gesture recognition, inertial measurement unit, machine learning, pressure sensor, sensor glove, soft robotic glove, surface electromyography

Introduction

Neurological disorders such as stroke and spinal cord injuries (SCI) can lead to significant hand function impairments, affecting a person's ability to perform daily tasks. Effective neural rehabilitation is essential to restore mobility and independence, and recent advancements in sensor-based technologies have opened new possibilities for improving therapy [14]. Accurate hand tracking enables gesture classification and robotic assistance, which can enhance rehabilitation by providing guided exercises and interactive training. Wearable sensing technologies play a key role in achieving this by offering a non-invasive and continuous method for monitoring hand activity.

Various sensing techniques have been developed to monitor physiological changes during hand movement. These methods often utilize a combination of electrical, mechanical, acoustical, and optical sensing modalities [10] and can be used to identify the movement or gesture performed. Key techniques in this field include surface electromyography (sEMG), force myography, inertial measurement units (IMUs), photoplethysmography, strain and flex sensors. Depending on the application, certain models are trained to predict specific hand gestures, while others focus on predicting discrete joint angles or continuous motion patterns. The fusion of these techniques is also commonly employed to improve the accuracy of such systems. Sensor data fusion approaches are generally classified according to the relationships between data sources (complementary, redundant, or cooperative) and the type of data involved (raw data, computed features, or during decision-making) [2].

In early studies, thresholding techniques were frequently employed to detect specific hand gestures based on sensor signals. For example, in [11], a soft robotic glove (SRG) designed to assist in grasping after SCI integrated various sensors, including strain and force sensors, to identify four distinct states: relaxation, extension, pinch flexion, and power flexion, using thresholding techniques. Similarly, [5] used resistive pressure sensors to detect grasp intentions, identifying states such as open, opening, closed, and closing through a relative detection approach along with thresholding.

Building upon these initial works, several studies have demonstrated the potential of wearable sensor-based systems for hand gesture recognition. For example, [3] created a sensor and motor glove for therapy that uses force and flex sensors to measure finger movements. The glove identified 16 fine grained gestures for mirror therapy and six basic grasping gestures for task-oriented therapy, achieving greater than 95% classification accuracy with the Support Vector Machine (SVM), k-nearest neighbour (k-NN) and Decision Tree (DT) classifiers. In a similar vein, [6] presented NeuroPose, a system designed for 3D hand pose tracking rather than discrete gestures using sEMG (MYO armband with eight channels). They tested user-dependent models and transfer learning, which adapted a pre-trained model to new users in just 90 seconds, reducing training time. The system demonstrated a balance between accuracy and wearability, highlighting the effectiveness of transfer learning and the Encoder-Decoder architecture for real-time, low-latency tracking.

A more recent study [8] introduced the emg2pose benchmark, a large publicly available dataset of sEMG recordings and corresponding hand pose labels, along with vemg2pose, a machine learning model designed to predict joint angular velocities. The dataset was collected from 193 participants over 370 hours using a wristband with 16 bipolar channels and a 2 kHz sampling rate. Ground-truth labels were obtained using a 26-camera motion capture system operating at 60 Hz, utilizing 19 reflective markers to capture joint angles and 3D positions and an inverse kinematics solver to reconstruct joint angles from marker data. The evaluation benchmark included pose regression and pose tracking tasks across three generalization scenarios: held-out users, held-out stages, and held-out users & stages. The vemg2pose model used a causal strided convolutional featurizer based on a Time-Depth Separable Convolution network, downsampling high-frequency signals to 50 Hz. Features were combined with previous joint angle predictions and fed into an LSTM-based decoder to predict angular velocities. This auto-regressive model relied on past predictions to generate future outputs, which were then upsampled to match the 2 kHz ground-truth sampling rate.

The current study aims to further develop and evaluate a multimodal sensor-based system for hand gesture recognition through sensor data fusion, for the SRG component of the NeuroSuitUp platform and NeuroSuitUp/HEROES projects [4], [7], [12], [13]. The device will be tested and validated on both healthy individuals and those with physical impairments. The sensor layer of the SRG is equipped with flex, pressure, sEMG, and accelerometer sensors. It is based on the existing wearable device used in previous research [7], [4] and will guide the glove with the soft pneumatic actuators to provide assistance. The project will assess various signal processing and classification techniques, ranging from traditional machine learning approaches (SVM, k-NN, DT) to advanced deep learning architectures such as convolutional neural networks (CNNs), recurrent neural networks (RNNs), and encoder decoder models. Additionally, the research will investigate the potential of transfer learning to reduce training time and improve classification performance for new users. Ultimately, this work aims to improve the gesture recognition system and enable better control to the actuators designed to provide active assistance.

Methodology

The acquisition setup consists of a sensory data glove (Figure 1) equipped with flex and pressure sensors, a sEMG sensor, and an accelerometer. Five flex sensors are installed on each finger to detect bending or flexion, while two pressure sensors are positioned on the thumb and middle finger to measure the pressure applied to them. The accelerometer is mounted on the dorsal side of the glove. Additionally, a separate sEMG sensor is placed on the forearm to monitor muscle activity. All sensors, including the accelerometer and sEMG, connect to a microcontroller via wired connections. They transmit and receive data to and from a desktop application through a serial connection. The sampling frequency is set to 2 kHz for the sEMG signal and 100 Hz for the other signals.

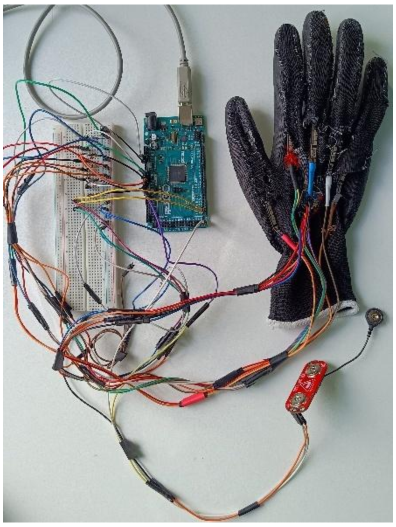

Figure 1: The sensory data glove: The setup includes an Arduino Mega 2560 Rev3, a MyoWare™ Muscle Sensor (AT-04-001), two Resistive Thin Film Pressure Sensors (RFP602), five Flex Sensors by Spectra Symbol, and a Triple Axis Accelerometer (ADXL345)

In this study, data will be collected from two groups: one consisting of healthy individuals and the other of individuals with impairments. The study protocols were approved by the Committee for Bioethics and Ethics of the School of Medicine, Aristotle University of Thessaloniki with the protocol numbers 188117/2022 and 266604/2022. Diversity in both groups will be ensured by considering factors like age, body size, skin condition, and impairment severity. Each participant will perform nine distinct gestures, as outlined in Table 1. For each gesture, participants will hold the position for 60 seconds, with three repetitions per gesture. Between each repetition, there will be a 10-second rest period where participants return to a neutral posture. During the gesture execution, the participant will observe the desired movement on a monitor placed directly in front of them. An operator will supervise the process and confirm when the participant has successfully reached the correct position. At that point, labelled data will be recorded and saved in a CSV file for further analysis. Several signal processing steps will be performed, including noise filtering, data synchronization, and super sampling to match the highest sampling frequency. The data will be segmented into overlapping windows, and various classification approaches will be tested. One approach will involve computing predetermined features such as root mean square, mean absolute value, marginal discrete wavelet transform, variance, and standard deviation. This will be followed by feature selection and the evaluation of classical machine learning models, like SVM, k-NN and Random Forests.

Table 1: Hand gestures, aiming to be classifiable through the SRG [9]

Name	Figure
Power Grip	
Cylindrical Grip	
Hook Grip	
Lateral Grip	
Spherical Grip	
Lumbrical Grip	
Tip Pinch	
Tripod Pinch	
Key Pinch	

classifiers as described in [1]. The second, more advanced approach will utilize deep learning techniques, such as CNNs, RNNs, and encoder-decoder architectures, to automatically extract relevant features from the raw data. Additionally, transfer learning will be explored to leverage pre-trained models, potentially enhancing classification performance.

The models will be trained and tested using different configurations to evaluate their performance under various conditions. In the first setup, each model will be trained using data from two repetitions of gestures performed by an individual, with one-third of the data held out for testing. The testing set will include data from the third repetition, ensuring that the model is evaluated on unseen data from the same individual. This setup allows for an individual specific assessment of the model's ability to classify gestures.

In the second setup, the models will be trained using data from 80% of the subjects, both healthy and impaired individuals, while the remaining 20% will be used for testing. This testing set will consist of data from new, unseen subjects, allowing for an evaluation of the model's generalization capabilities across different individuals. This approach provides insights into how well the model can perform on entirely new subjects beyond those used for training.

In the third setup, transfer learning will be applied to adapt a pre-trained model to a new user by fine-tuning it with a small dataset from that individual. The lower layers, which capture general signal patterns, will remain unchanged, while the upper layers will be adjusted to learn the user's unique signal characteristics. This approach is expected to enable rapid personalization with minimal training data.

Moreover, to assess the contribution of each sensor to classification accuracy, an ablation study will be conducted, where models will be trained and evaluated with different sensor combinations. This analysis will help determine the relative importance of flex sensors, pressure sensors, the accelerometer, and the sEMG sensor in gesture recognition.

In addition to assessing classification accuracy, metrics such as precision, recall, F1-score, and the confusion matrix will be calculated. Furthermore, the training and prediction time (inference time) will be monitored to evaluate the efficiency of the models.

Expected Results & Discussion

Signal characteristics are expected to vary between individuals due to differences in muscle activation patterns, signal amplitude, and noise levels. Factors such as muscle strength, skin conductivity, and sensor placement can potentially influence sEMG readings, while variations in hand size and flexibility may affect flex and pressure sensor outputs. These differences are likely to be more pronounced in impaired individuals, whose muscle activation may be weaker or inconsistent.

As a result, while high classification accuracy is expected in individual-specific assessments, accuracy may be slightly lower in the generalization setup due to inter-individual variability. Classical machine learning models like SVM, k-NN, and DT should perform well with engineered features but may struggle with complex gesture variations. Transfer learning is expected to improve classification, which could be especially helpful for impaired individuals with limited training data. While models trained on many individuals should generalize better, classifying gestures from impaired individuals may still be challenging due to differences in muscle activation.

It is important to acknowledge that individuals with SCI at or above the C-8 level typically lack voluntary finger muscle movement but may exhibit involuntary muscle contractions resulting from spasticity. Such involuntary responses complicate signal interpretation and gesture recognition and machine learning algorithms must be

carefully adapted to recognize and accommodate these physiological differences.
Moreover, the various sensors are anticipated to contribute differently to classification accuracy. sEMG captures muscle activity, while flex sensors can track finger movements and bending patterns. Pressure sensors may prove very effective for gestures that require grip strength, such as power grips, cylindrical grips, and key pinch grips and the accelerometer may be more suitable for identifying dynamic movements and adjustments of the wrist. Integrating these inputs the study aims to enhance performance across individuals and gesture types.

The study aims to address potential biases and risks, in recognizing gestures from impaired individuals by implementing personalized calibration, transfer learning techniques, and advanced signal processing. Lastly, ethical considerations, including data privacy, will also be prioritized through anonymization and secure data handling practices to ensure participant confidentiality and informed consent.

Conclusion
This article provides an overview of research in sensor data fusion, gesture recognition and motion tracking using wearable sensors on an SRG platform. It outlines the proposed methodology for data collection, signal processing, and modelling to develop a system capable of identifying gestures [12]. The system aims to assist the SRG of the NeuroSuitUP/HEROES project, equipped with actuators, in supporting individuals with hand impairments during neural rehabilitation [13].

References
[1] M. Atzori, A. Gijsberts, C. Castellini, B. Caputo,
A. G. M. Hager, S. Elsig, G. Giatsidis, F. Bassetto, and H. Muller. Electromyography data for non-invasive naturally-controlled robotic hand prostheses. Scientific Data, 1, 12 2014.
[2] F. Castanedo. A review of data fusion techniques, 2013.
[3] X. Chen, L. Gong, L. Wei, S. C. Yeh, L. D. Xu, L. Zheng, and Z. Zou. A wearable hand rehabilitation system with soft gloves. IEEE Transactions on Industrial Informatics, 17:943–952, 2 2021.
[4] V. Fiska. Development of a wearable exoskeletal device based on multi-sensor data fusion and soft robotics for neural rehabilitation of the human hand. 2022.
[5] R. Hennig, J. Gantenbein, J. Dittli, H. Chen, S. P. Lacour, O. Lambercy, and R. Gassert. Development and evaluation of a sensor glove to detect grasp intention for a wearable robotic hand exoskeleton. In 2020 8th IEEE RAS/EMBS International Conference for Biomedical Robotics and Biomechatronics (BioRob), pages 19–24, 2020.
[6] Y. Liu, S. Zhang, and M. Gowda. Neuropose: 3d hand pose tracking using emg wearables. In The Web Conference 2021 - Proceedings of the World Wide Web Conference, WWW 2021, pages 1471–1482. Association for Computing Machinery, Inc, 4 2021.
[7] K. Mitsopoulos, V. Fiska, K. Tagaras, A. Papias, P. Antoniou, K. Nizamis, K. Kasimis, P. D. Sarra, D. Mylopoulou, T. Savvidis, A. Praftsiotis, A. Arvanitidis, G. Lyssas, K. Chasapis, A. Moraitopoulos, A. Astaras, P. D. Bamidis, and A. Athanasiou. Neurosuitup: System architecture and validation of a motor rehabilitation wearable robotics and serious game platform. Sensors, 23, 3 2023.
[8] S. Salter, R. Warren, C. Schlager, A. Spurr, S. Han, R. Bhasin, Y. Cai, P. Walkington, A. Bolarinwa, R. Wang, N. Danielson, J. Merel, E. Pnevmatikakis, and J. Marshall. emg2pose: A large and diverse benchmark for surface electromyographic hand pose estimation. 12 2024.
[9] T. M. Skirven, A. L. Osterman, J. Fedorczyk, P. C. Amadio, S. Felder, and E. K. Shin. Rehabilitation of the Hand and Upper Extremity, Seventh Edition. Rehabilitation of the Hand and Upper Extremity. Elsevier, 2021.
[10] R. Tchantchane, H. Zhou, S. Zhang, and G. Alici. A review of hand gesture recognition systems based on noninvasive wearable sensors, 10 2023.
[11] Y. M. Zhou, D. Wagner, K. Nuckols, R. Heimgartner, C. Correia, M. Clarke, D. Orzel, C. O'neill, R. Solinsky, S. Paganoni, and C. J. Walsh. Soft Robotic Glove with Integrated Sensing for Intuitive Grasping Assistance Post Spinal Cord Injury. 2019.
[12] Sarra, P.-D., Fiska, V., Mitsopoulos, K., Mylopoulou, D., & Bamidis, P. D. (2024). Kinematic and Dynamic Analysis of the Human Hand's Articulation for Wearable Soft-Robotic Device Applications . Global Clinical Engineering Journal, 6(SI6), 84–88. https://doi.org/10.31354/globalce.v6iSI6.281
[13] Athanasiou A, Mitsopoulos K, et al. Neurorehabilitation Through Synergistic Man-Machine Interfaces Promoting Dormant Neuroplasticity in Spinal Cord Injury: Protocol for a Nonrandomized Controlled Trial JMIR Res Protoc 2022;11(9):e41152 doi: 10.2196/41152
[14] Szabo, D. A., Neagu, N., Teodorescu, S., Apostu, M., Predescu, C., Pârvu, C., & Veres, C. (2023). The Role and Importance of Using Sensor-Based Devices in Medical Rehabilitation: A Literature Review on the New Therapeutic Approaches. In Sensors (Basel, Switzerland) (Vol. 23, Issue 21). https://doi.org/10.3390/s23218950

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AN INVESTIGATION INTO THE USE OF CONVOLUTIONAL NEURAL NETWORKS FOR CLASSIFYING NEURODEGENERATIVE DISEASES USING RESTING-STATE EEG

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Abstract
Convolutional Neural Networks (CNNs) are a type of Machine Learning (ML) algorithm particularly well-suited for image classification. Resting-state EEG signals can be converted into images to be fed into a CNN. This study investigates the use of CNNs for classifying neurodegenerative diseases (NDDs), specifically Alzheimer's disease (AD) and Frontotemporal Dementia (FTD), using resting-state EEG data. A novel method that utilizes the inherent advantage of CNNs in image-based processing and the discriminative power of time-frequency domain features for EEG signal representation is presented. The approach follows distinct steps: EEG signal preprocessing and segmentation, time-frequency domain feature extraction and conversion into images, CNN training, and image classification. The classification is limited to distinguishing AD and/or FTD from a control group of healthy subjects (HC). The performance and behavior, of the used CNN model, across different classification scenarios, are evaluated using standard metrics, including Test Accuracy, precision, recall, and F1-score.

Introduction

Neurodegenerative diseases (NDD) encompass a broad group of disorders characterized by the progressive degeneration of neuronal groups, leading to functional impairments in cognition, movement, or both. They can be classified based on clinical symptoms/primary clinical features (e.g. dementia, parkinsonism, motor neuron disease), anatomical distribution of degeneration (e.g. frontotemporal, extrapyramidal or spinal degenerations), or the main molecular abnormality (with the most common being amyloidosis, tauopathies, α-synucleopathies and protein diseases TDP-43 proteinopathies) [1-2]. NDD are a common and increasing cause of mortality and morbidity worldwide, especially in the elderly. Being heterogeneous in their clinical manifestations and underlying physiology, often with overlapping characteristics, there is a need for high diagnostic accuracy that will also allow more reliable prognosis and/or specific treatment and management.[3]
The main methods of diagnosis include clinical evaluation (cognitive abilities and neurological function), imaging techniques (MRI, CT, PET, SPECT scan), biomarker analysis (blood/cerebrospinal fluid) and electrophysiological tests (EEG/MEG).
Electroenfephalography (EEG) signal analysis has become widely available, particularly in the diagnosis of various neurological and neuropsychiatric disorders such as various forms of dementia (Alzheimer's (AD), Frontotemporal Dementia (FtD), Mild Cognitive Impairment (MCI), Parkinson's disease (PD) and takes advantage of the specific frequency changes and connectivity patterns observed in NDD.
EEG records the changes in the electrical potentials of the brain obtained from electrodes placed on the human scalp. It is low-cost, safe and painless procedure. The steps of an EEG pipeline are shown in Figure 1.
Due to the nature of the EEG signal (non-stationary low signal/noise ratio) and the need for more accurate diagnoses, there is a need for automated methods.
Machine Learning (ML) and Deep Learning (DL), based on Artificial Neural Networks, offer the possibility of using automated processesing for Feature Extraction and/or Classification. In particular, DL can replace both Feature Extraction and Classification into one step (Figure 1)[4]

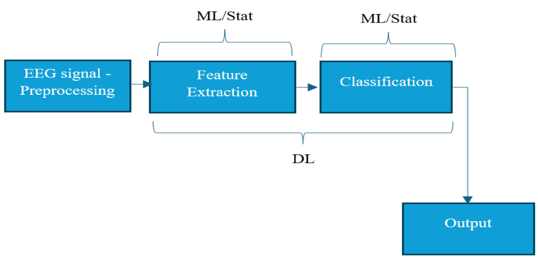

Figure 1. – Typical EEG processing using ML/DL

Convolutional neural networks (CNNs) is a type of ML algorithms mainly used in image classification and object recognition tasks. Compared to other methods, CNN requires no or very little preprocessing of input data, making it suitable for EEG signal analysis [4].
The main architecture consists of 3 levels (Figure 2). CNN input is usually a matrix, and the typical architecture consists of:

- Convolutional layer (CL): Extracts features from input data and passes these to the next level in the form of feature maps. To accomplish this, CL consists of several small arrays called filters or kernels. A convolution operation (element wise matrix multiplication and sum up) is performed as the filter "slides" over the input matrix and the convolution produces a point. The set of points forms the feature map for the next level.

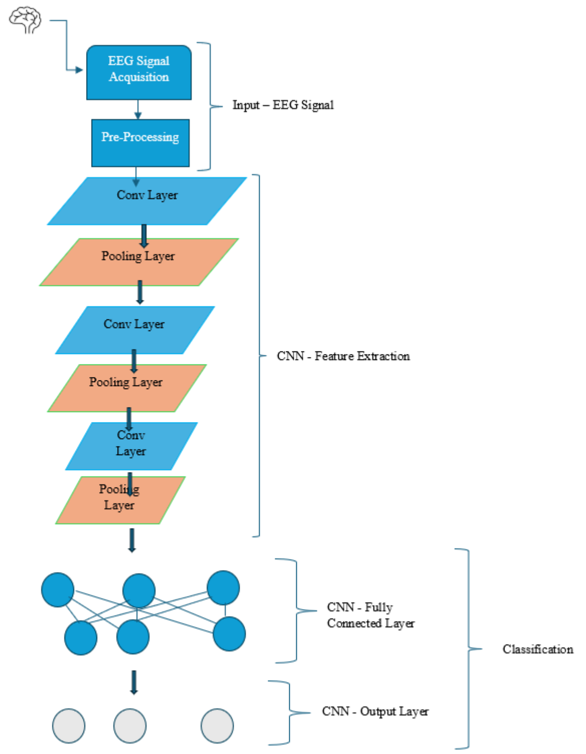

Figure 2. Typical architecture of CNN

- Pooling Layer (PL). Is used to reduce the spatial dimensions of feature maps while preserving the most important information. Different strategy selection can be applied such as max/average pooling.
- Fully connected layer (FC). Performs the classification. Feature maps from the last convolutional or pooling layer are converted into a 1D vector and fed forward to the neural network that uses Softmax (for multi-class classification) or Sigmoid (for binary classification) to produce class probabilities. The class with the highest probability score is the output or prediction made by the model.

The purpose of this study is to investigate the potential of convolutional networks (CNN) in the classification of EEG signals for patients with NDD (Alzheimer's and FtD). In particular, an attempt is made to answer questions such as:

1. is it appropriate to use CNN for such classification?
2. How accurate is the method?
3. What may be the difficulties/limitations that we might encounter?

Methodology

The EEGs used in this study are provided, as a dataset, in the form of a set of EEG files in standardized .set format [5]. The dataset contains the EEGs of a total of 88 subjects which are divided into three groups (AD = 36, FtD = 23 and control HC = 29 healthy subjects). Each EEG contains the recording of 19 electrodes according to the 10-20 system with two reference electrodes. The sampling frequency is 500 Hz. Each recording lasts approximately 13.5 minutes for the AD group (total: 485.5 minutes), 12 minutes for the FTD group (total: , 276.5 minutes), and 13.8 minutes for the CN group (total: 402 minutes). The dataset provides the data in two formats: raw and processed (in which a 0.5-45 Hz Butterworth band-pass filter has been applied and signals have been re-reported to A1-A2. ASR (Artifact Subspace Reconstruction routine) was then applied to correct artifacts, remove bad data periods, and then, RUNICA converting the 19 EEG signals into 19 ICA components ICA components and the ICLabel of the eeglab tool was used to remove existing artifacts.

In this work, the dataset with processed data was used without any further preprocessing. The general process flow is shown in Figure 3.

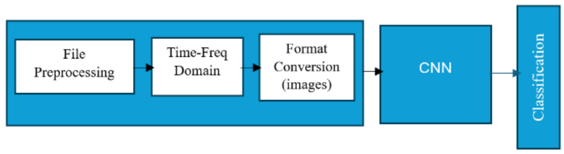

Figure 3. Pipeline test process flow

File preprocessing involved splitting each EEG file into parts of 4 secs – (each segment has 2000 points). In this way – on average from each file result: (Average time category *60)/4, 202 for AD, 180 for FtD and 207 for HC segments with no overlap. In later experiments the time was increased to 8 and 30 secs. In each segment, the time-frequency representation was obtained using the Morlet continuous wavelet transform (CWT). Based on the fact that the dataset data are bandlimited to 0.5-45 Hz, this gives a typical matrix, in matlab, of 61x2000 [freq. coefficients x time points] which we initially limit it to a table of 50x250.

In general, there are two ways to split the data: (1) split by segment, meaning that segments from the same subject can be in both the Training and Test sets, and (2) split by subject, where segments from any subject can be in either the Training or Test dataset, but not both. The Training/Test data can be split using either the 80-20 (Training-Test) or its variant 80-10-10(/70-15-15) (Training-Validation-Test) method, in which case the Validation data are used to tune the model hyperparameters while in previous case the 80% is used for both Training and Validation). Alternatively, the LNSO (Leave N Subjects Out) method can be used (but only when spliting by subjects). In fact LNSO is similar

to split 80-20 by subject only more models are trained (same number as the number of groups into which the original data is split). With LNSO the trained model from each iteration is also stored.
For the 80-20/80-10-10 methods used, input to CNN (Figure 4), was, initially, provided as a group of 19x50x250 3D array and after as 500x500 gray scale png images, as CNNs typically perform better when the input consists of (rectangular) images. These images were constructed by reshaping the 19x50x250 array. At first due to memory management issues the data was a group of 30 patients - 10 from each category. Later, by modifying memory management/hw, the experiments used a total of 60 patients (20-20-20).

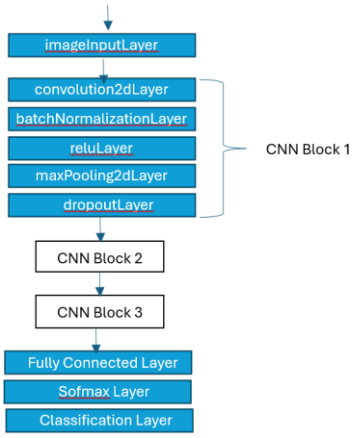

Figure 4. Typical CNN Architecture used in the tests

Overfitting is a common issue in CNN models, and this case is no exception. To minimize overfitting, model behavior was carefully monitored, especially during the initial tests. Model hyperparameters were manually fine-tuned at first and later optimized using grid search optimization. Additionally, and in order to make the network, overfitting resilient, ReLU activation and dropout layers were implemented after each convolutional layer. The resulting network was tested to evaluate itself on a small set of initial data that did not participate in the initial training to determine behavior in unknown data.
There were instances where, depending on the CNN input, an additional 2D convolutional layer was added.
Our approach is similar to the work in [6], with the main differences being the time duration of the segments used (4 vs. 30 seconds) and the EEG signal decomposition method (CWT vs. spectrogram (FFT)). The results from this study are compared with those from [6].

Table 1 – Typical CNN hyperparameters

	Split by Segment	Split by Subject
Mini Batch Size	16	16
Max Epochs	30	40
Init Learning Rate	0.0007	0.0005
L2 reg	0.0004	0.0005
Dropout	0.230000	0.23
Dropout final	0.350000	0.35

Results
Split by segment: we ran many times using this method. It achieves the highest classification rates, above 95% in all cases. Hyperapameters of the model were fine tuned using grid-search optimization. In general the CNN contains 3 convolutional layers and the input was usually a group of 19x50x250 array.

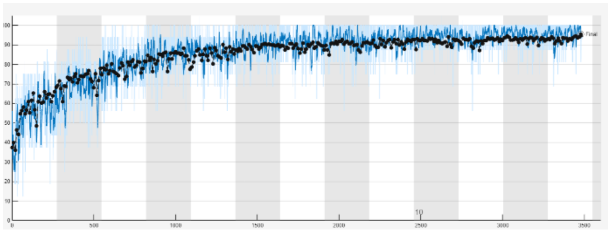

Figure 5. Split by segment. – Y-Axis: Accuracy(%) X-Axis: Iterations - Final Test Acc: 95.43% Training Loss: 0.2 - Validation Loss: 0.17.

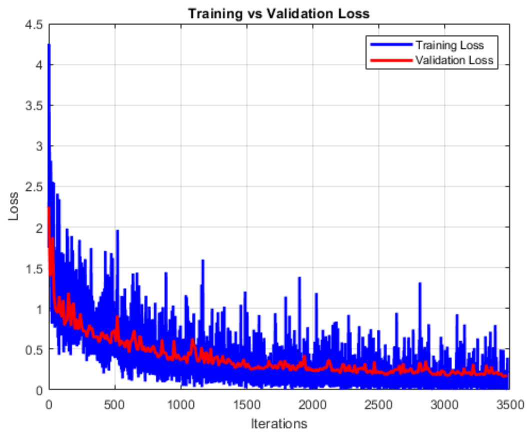

Figure 6. Training-Validation Loss (Cross-Entropy Loss is used in matlab)

Table 2.1 -Typical split by segment run

Test Accuracy:	95.43%
Macro F1-Score	0.90
Final Training Loss	0.207570
Final Validation Loss	0.172832

Table 2.2 - Class-wise Performance – Split by segment AD/FtD/HC Case

	Precision	Recall	F1-Score
AD	0.87	0.94	0.90
FtD	1.00	0.78	0.87
HC	0.88	1.00	0.94

It was observed that the model exhibits poor performance when classifying unknown data. This is a data leakage issue already described in [7]. For this reason split by subjects and LNSO methods were also explored.
Split by subject: Using this method, the data were split using both the "80-20/80-10-10" as well as the LNSO

method. We present, here, only the results from the first method using 500x500 gray scale images as the LNSO is still work in progress.

Table 3.1 – Test Accuracy (Average)

	Test Acc
AD/FtD/HC	57.78%
AD/HC	80.47%
FtD/HC	64.10%
AD+FtD/HC	79.61%

Table 3.2 – Class wise performance – Split by subject

Case	class	Precision	Recall	F1-Score
AD/FtD/HC	AD	0.49	0.62	0.55
	FtD	0.62	0.51	0.53
	HC	0.73	0.62	0.65
AD/HC	AD	0.86	0.73	0.79
	HC	0.75	0.88	0.81
FtD/HC	FtD	0.79	0.45	0.57
	HC	0.58	0.86	0.69
AD+FtD/HC	AD+FtD	0.93	0.75	0.83
	HC	0.65	0.89	0.75

Conclusions

A novel method has been explored that combines the intrinsic image classification strengths of CNNs with time-frequency decomposition-based feature extraction to classify resting-state EEG signals distinguishing between AD/FtD and healthy controls (HC). This approach has led to several conclusions:

CNNs provide an effective method for classifying resting-state EEG signals.

Splitting by segment, although achieving high classification rates (above 95% in most experiments), does not generalize well to unseen data due to the well-known data leakage issue. For this reason, split by subjects should be the preferred method.

As already mentioned, CNNs perform best with image inputs, but low-resolution images can miss subtle EEG signal details, affecting generalization. High-resolution images preserve these features but at a higher computational cost.

Three-class classification (AD/FtD/HC) is more challenging than binary classifications (AD/HC, FtD/HC, or AD+FtD/HC), and the results for this task are not yet satisfactory. Binary classification performance of FtD/HC is always worse than AD/HC or AD+FtD/HC. There seems to be a diffusion of FtD into the other two classes, AD or HC.

Our results compare with the results presented in [6] where an average of 79.45%, 72.85%, 80.69%, 54.28% was reported whereas in our case 80.47%, 64,10%, 79.61%, 57,78% was achieved for the AD/HC, FtD/HC, AD+FtD/HC and AD/FtD/HC cases respectively.

Exactly because the use of CNNs for resting-state EEG classification consists of clearly defined stages, automated modular pipelines could be particularly effective and beneficial for evaluating various configurations.

References

1. Pathak, N., Vimal, S. K., Tandon, I., Agrawal, L., Hongyi, C., & Bhattacharyya, S. (2022). Neurodegenerative Disorders of Alzheimer, Parkinsonism, Amyotrophic Lateral Sclerosis and Multiple Sclerosis: An Early Diagnostic Approach for Precision Treatment. Metabolic brain disease, 37(1), 67–104. https://doi.org/10.1007/s11011-021-00800-w
2. Dugger, B. N., & Dickson, D. W. (2017). Pathology of Neurodegenerative Diseases. Cold Spring Harbor perspectives in biology, 9(7), a028035. https://doi.org/10.1101/cshperspect.a028035
3. Erkkinen, M. G., Kim, M. O., & Geschwind, M. D. (2018). Clinical Neurology and Epidemiology of the Major Neurodegenerative Diseases. Cold Spring Harbor perspectives in biology, 10(4), a033118. https://doi.org/10.1101/cshperspect.a033118
4. Rajwal, S., Aggarwal, S. Convolutional Neural Network-Based EEG Signal Analysis: A Systematic Review. Arch Computat Methods Eng **30**, 3585–3615 (2023). https://doi.org/10.1007/s11831-023-09920-1
5. Miltiadous, A., Tzimourta, K. D., Afrantou, T., Ioannidis, P., Grigoriadis, N., Tsalikakis, D. G., Angelidis, P., Tsipouras, M. G., Glavas, E., Giannakeas, N., & Tzallas, A. T. (2023). A Dataset of Scalp EEG Recordings of Alzheimer's Disease, Frontotemporal Dementia and Healthy Subjects from Routine EEG. *Data*, *8*(6), 95. https://doi.org/10.3390/data8060095
6. Stefanou, K., Tzimourta, K. D., Bellos, C., Stergios, G., Markoglou, K., Gionanidis, E., Tsipouras, M. G., Giannakeas, N., Tzallas, A. T., & Miltiadous, A. (2025). A Novel CNN-Based Framework for Alzheimer's Disease Detection Using EEG Spectrogram Representations. *Journal of Personalized Medicine*, *15*(1), 27. https://doi.org/10.3390/jpm15010027
7. Brookshire, G., Kasper, J., Blauch, N. M., Wu, Y. C., Glatt, R., Merrill, D. A., Gerrol, S., Yoder, K. J., Quirk, C., & Lucero, C. (2024). Data leakage in deep learning studies of translational EEG. Frontiers in neuroscience, 18, 1373515. https://doi.org/10.3389/fnins.2024.1373515

Keywords
NDD, CNN, EEG, resting-state EEG

ORTHOTROPIC APPROACHES OF HUMAN JAWBONE IN FINITE ELEMENT METHOD

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Abstract

Understanding the biomechanical behavior of the human jawbone is crucial for optimizing dental implant design and improving their long-term stability. Finite Element Analysis (FEA) is widely used to simulate mechanical responses, but accurately modeling bone properties remains a challenge due to its complex anisotropic nature. This study reviews existing literature on orthotropic approaches for jawbone modeling in FEA, assessing various methodologies, including simple orthotropic bone blocks, regional material property assignments, Voronoi lattice structures, Fourier series, Hounsfield unit-based stiffness mapping, harmonic fields, B-spline curves, and principal stress-based orthotropy. While these methods enhance model accuracy, there is no consensus regarding standards for anisotropic jaw modeling. The findings highlight the need for continued refinement in orthotropic modeling techniques to achieve more reliable and patient-specific simulations.

Introduction

Dental implants are biocompatible prosthetic devices that are surgically embedded into the jawbone to restore the function and aesthetics of missing teeth. Understanding their biomechanical response to stresses and strains during mastication is essential for optimizing their design and ensuring long-term stability. Finite Element Analysis (FEA) is a numerical method used to solve complex engineering and biomechanical problems by dividing a structure into smaller, manageable elements. Each element follows mathematical equations that describe how it responds to external forces, such as stress, strain, and displacement. By solving these equations, FEA helps predict how a structure will behave under different conditions. In general it can be defined as *a general discretization procedure of continuum problems posed by mathematically defined statement* [6]. FEA was firstly introduced in 1973, and since then, significant advancements have been made, leading to increasingly accurate yet more complex models [7].

One of the ongoing areas of research in FEA is the optimal methodology for developing bone models and defining their material properties. Accurately representing bone behavior remains a challenge due to its complex, heterogeneous, and anisotropic nature, necessitating continuous refinement of modeling

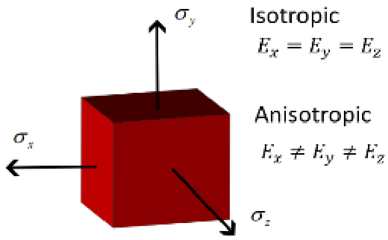

Figure 1. Illustration of an element with σ representing stress tensors and E denoting elastic moduli

techniques and parameter selection. The accurate and realistic assignment of material properties is regarded as one of the three key factors influencing the validity of Finite Element Models [9].

However, when modeling biological tissues, accurately defining and assigning material properties remains challenging. As a result, many studies adopt isotropic models to approximate bone behavior, despite biological research indicating that human bone exhibits orthotropic characteristics or at least transversely anisotropic. [3, 10, 11] In isotropic material, mechanical properties remain uniform in all directions, whereas in an orthotropic material, properties differ along the x, y, and z axes. (Figure 1) Assigning the correct directional stiffness properties in an orthotropic jaw model presents a significant challenge due to the complex geometry of the mandible, its lack of symmetry, and the absence of a uniform shape. Additionally, the observed variation in material properties throughout the bone further complicates the accurate definition of stiffness parameters. As a result, many researchers have focused on modeling only small segments of bone diaphysis. However, these localized models cannot be reliably generalized to represent the mechanical behavior of the entire mandible.

This study aims to review the existing literature and gather the primary approaches used in constructing orthotropic models of the jaw.

Materials and Methods

For the purposes of this study a literature review has been carried out on Pubmed and Cochrane with the search string: (mandible) OR (maxilla) OR (jaw)) AND ((orthotropy) OR (orthotropic) OR (anisotropy) OR (anisotropic)) AND ((FEM) OR (finite element analysis)). We considered all relevant literature available up to March 2024, with no restrictions on publication year. The studies identified through our literature search were assessed by their titles and abstracts, with the most relevant ones subjected to a comprehensive evaluation. The references of the included studies were also examined for papers that we missed during our search.

Results

We identified 14 relevant studies for inclusion. (Table 1)

Table 1. Main approaches on the anisotropic jaw modeling

Researchers of the main studies	Approach of the study
Chang (2010)[1], Chang (2012)[4],dos Santos (2017)[5], Shen (2010)[8]	Simple orthotropic model of a bone block
Al-Sukhun (2007) [12]	Division in multiple regions
Alemayehu (2024) [13]	Voronoi-latticed trabecular bone
Natali (2010) [14]	Fourier series
Hellmich (2008) [15], Gacnik [16]	Hounsfield units-stiffness components
Sheng Liao (2011), Xi Ding (2015), Xi Ding (2014)[17-19]	Harmonic fields
Sheng Liao (2007) [21]	B-spline curves
Dhatrak (2019) [23]	Orthotropy based on principal stresses

Discussion

Simple orthotropic model of a bone block

The most traditional approach for generating a finite element model (FEM) of the mandibular bone supporting a dental implant involves creating a bone block with an embedded 3D model of the implant. (Figure 2) The orthotropic model is developed by assigning appropriate values for the elastic modulus (Young's modulus), shear moduli, and Poisson's ratio, which vary across different directions. (Table 2) Extensive research has been conducted in this field to compare these models with conventional isotropic ones. The findings indicate significant differences in the results, particularly in the distribution of Von Mises stress between isotropic and anisotropic models.[1, 4, 5, 8]

Table 2. Anisotropic coefficients of elasticity for compact and trabecular bone used in several studies. [E=Young's modulus (GPa), G=Shear moduli (GPa), v=Poisson's ratio]

[2, 3]	CORTICAL	TRABECULAR
E_x	12.5	0.21
E_y	17.9	1.148
E_z	26.6	1.148
G_{xy}	4.5	0.068
G_{yz}	5.3	0.068
G_{xz}	7.1	0.434
v_{xy}	0.18	0.055
v_{yz}	0.31	0.055
v_{xz}	0.28	0.322

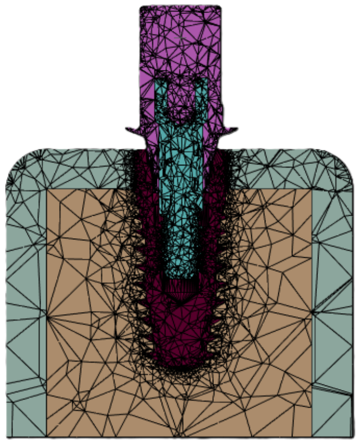

Figure 2. Example of a simplified meshed FEM model of a bone block with an embedded implant

Division in multiple regions

A 2007 study attempted to model the entire mandible and assign anisotropic properties by dividing it into seven regions, each with distinct material values and orientation axes. [12]Building on the research of Dechow and Korioth, a detailed model was developed and tested under various scenarios.[10, 20]

Voronoi-latticed trabecular bone

A different approach was proposed by Alemayehu [13], who utilized Voronoi geometry to model cancellous bone. A Voronoi lattice refers to a specific type of Voronoi diagram applied in a lattice structure. Building on previous studies [22], it was assumed that Voronoi geometries can effectively replicate complex biological tissues, such as cancellous bone, which exhibits a porous structure. This contrasts with classical finite element (FE) models, which assume a solid geometry. They further attempted to compare four biomimetic Voronoi lattice models with varying pore sizes and concluded that this variation influences the stress distribution and micromotion across the dental implant components, as well as the surrounding cancellous bone. They incorporated anisotropic characteristics into their models and highlighted that this approach provides a more accurate representation of biomechanical interactions in the oral environment, leading to more reliable implant designs.

Fourier series

Natali et al. [14] developed a mandible model in which the elastic properties of the bone were distributed using Fourier series. To achieve this, a specific procedure was designed to obtain continuous distributions of cortical thickness, elastic moduli, and orthotropic directions.

Hounsfield units (HU)-stiffness components

In other studies, efforts have been made to develop more personalized models based on patient CT data. One such approach was introduced by Hellmich et al., who designed a model based on voxel averaging rules for attenuation coefficients, allocating a volume fraction to each voxel to represent water (marrow) and solid bone matrix. This method enabled the assignment of stiffness properties to each voxel based on its HU, leading to the creation of isotropic, transversely isotropic, and orthotropic models. [15] A slightly different approach was proposed in another study [16], where HU were used to determine bone density at each voxel. Subsequently, based on the study by Rho et al.[24], the elastic moduli E_x, E_y and E_z were calculated. This led to the development of an orthotropic model, which was then compared with both isotropic and conventional orthotropic models. The findings indicated that their model provides more precise predictions.

Harmonic fields

Some studies, beginning with the first publication in 2011[17], proposed the development of a FEM model based on harmonic fields. This approach aimed to address the challenge of orienting the orthotropic axes along the mandible, which, as experimentally demonstrated, vary from point to point within the bone. The methodology was founded on the observation that the longitudinal axis direction, as dictated by the structural configuration of most bone tissues, aligns with the trajectory of maximum material stiffness. Additionally, the scalar distribution pattern of the harmonic field, characterized by high-quality scalar iso-contours and gradient vectors, was found to conform closely to the shape of the object. Two additional studies applied the same technique to develop a detailed model of an edentulous mandible with dental implants.[18, 19] A comparison was conducted with isotropic and simple orthotropic models, revealing variations in the results among the different approaches. The findings suggested that such models can be adopted to provide realistic and reliable outcomes.

B-spline curves

Another approach was proposed by Liao et al., who developed a model utilizing two B-spline curves running along the upper and lower borders of the mandible as auxiliary baselines to address the challenge of assigning orthotropic material orientations. Based on these curves, cross-sectional surfaces perpendicular to the direction of maximum stiffness were generated. Ultimately, the axial (longitudinal) material orientation, corresponding to the direction of maximum stiffness, was determined. The results seem to be acceptable.

Orthotropy based on principal stresses

Dhatrak et al. [23] applied a different approach, inspired by previous femur studies, in which the directions of orthotropy were assigned based on the principal stress directions.[25] In their model, the orientation of orthotropy was determined by the principal stresses generated by masticatory forces. Their findings indicated that the orthotropic material model provides more accurate stress predictions compared to the isotropic model.

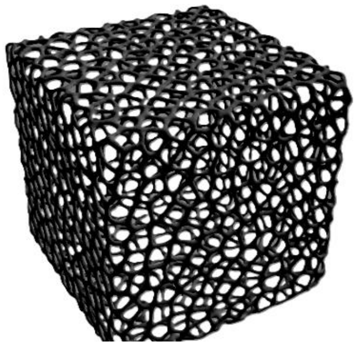

Figure 3. Voronoi-latticed cubic structure

Although several approaches have been proposed, a widely accepted FEM bone model that integrates bone remodeling algorithms and allows for personalized adjustments based on age and bone quality is still lacking. Current research is increasingly focused on addressing these challenges to develop more biologically accurate and individualized models.

Conclusions

From the above study, it is evident that a widely accepted anisotropic model of the human jaw is still missing. Researchers may select from existing models based on the specific objectives of their study and the level of accuracy required.

References

[1] C.L. Chang, C.S. Chen, M.L. Hsu, Biomechanical effect of platform switching in implant dentistry: a three-dimensional finite element analysis, The International journal of oral & maxillofacial implants, 25 (2010) 295-304.
[2] C.L. Schwartz-Dabney, P.C. Dechow, Edentulation Alters Material Properties of Cortical Bone in the Human Mandible, Journal of Dental Research, 81 (2002) 613-617.

[3] A.M. O'Mahony, J.L. Williams, P. Spencer, Anisotropic elasticity of cortical and cancellous bone in the posterior mandible increases peri-implant stress and strain under oblique loading, 12 (2001) 648-657.
[4] C.-L. Chang, C.-S. Chen, T. Yeung, M.-L. Hsu, Biomechanical Effect of a Zirconia Dental Implant-Crown System: A Three-Dimensional Finite Element Analysis, The International journal of oral & maxillofacial implants, 27 (2012) e49-57.
[5] M.B.F. dos Santos, G.d.O. Meloto, A. Bacchi, L. Correr-Sobrinho, Stress distribution in cylindrical and conical implants under rotational micromovement with different boundary conditions and bone properties: 3-D FEA, Computer Methods in Biomechanics and Biomedical Engineering, 20 (2017) 893-900.
[6] O.C. Zienkiewicz, R.L. Taylor, The Finite Element Method: Its Basis and Fundamentals, Butterworth-Heinemann2013.
[7] J.A. Tesk, O. Widera, Stress distribution in bone arising from loading on endosteal dental implants, 7 (1973) 251-261.
[8] W.L. Shen, C.S. Chen, M.L. Hsu, Influence of implant collar design on stress and strain distribution in the crestal compact bone: a three-dimensional finite element analysis, The International journal of oral & maxillofacial implants, 25 (2010) 901-910.
[9] J. Gao, W. Xu, Z. Ding, 3D finite element mesh generation of complicated tooth model based on CT slices, Computer methods and programs in biomedicine, 82 (2006) 97-105.
[10] P.C. Dechow, G.A. Nail, C.L. Schwartz-Dabney, R.B. Ashman, Elastic properties of human supraorbital and mandibular bone, American journal of physical anthropology, 90 (1993) 291-306.
[11] D.H. Chung, P.C. Dechow, Elastic anisotropy and off-axis ultrasonic velocity distribution in human cortical bone, 218 (2011) 26-39.
[12] J. Al-Sukhun, C. Lindqvist, M. Helenius, Development of a three-dimensional finite element model of a human mandible containing endosseous dental implants. II. Variables affecting the predictive behavior of a finite element model of a human mandible, Journal of biomedical materials research. Part A, 80 (2007) 247-256.
[13] D.B. Alemayehu, M. Todoh, S.J. Huang, Advancing 3D Dental Implant Finite Element Analysis: Incorporating Biomimetic Trabecular Bone with Varied Pore Sizes in Voronoi Lattices, Journal of functional biomaterials, 15 (2024).
[14] A.N. Natali, E.L. Carniel, P.G. Pavan, Modelling of mandible bone properties in the numerical analysis of oral implant biomechanics, Computer methods and programs in biomedicine, 100 (2010) 158-165.
[15] C. Hellmich, C. Kober, B. Erdmann, Micromechanics-based conversion of CT data into anisotropic elasticity tensors, applied to FE simulations of a mandible, Annals of biomedical engineering, 36 (2008) 108-122.
[16] F. Gačnik, Z. Ren, N.I. Hren, Modified bone density-dependent orthotropic material model of human mandibular bone, Medical engineering & physics, 36 (2014) 1684-1692.
[17] S.H. Liao, B.J. Zou, J.P. Geng, J.X. Wang, X. Ding, Physical modeling with orthotropic material based on harmonic fields, Computer methods and programs in biomedicine, 108 (2012) 536-547.
[18] X. Ding, S.H. Liao, X.H. Zhu, H.M. Wang, Influence of orthotropy on biomechanics of peri-implant bone in complete mandible model with full dentition, BioMed research international, 2014 (2014) 709398.
[19] X. Ding, S.-h. Liao, X.-h. Zhu, H.-m. Wang, B.-j. Zou, Effect of orthotropic material on finite element modeling of completely dentate mandible, Materials & Design, 84 (2015) 144-153.
[20] T.W. Korioth, A. Versluis, Modeling the mechanical behavior of the jaws and their related structures by finite element (FE) analysis, Critical reviews in oral biology and medicine : an official publication of the American Association of Oral Biologists, 8 (1997) 90-104.
[21] S.-H. Liao, R.-F. Tong, J.-X. Dong, Anisotropic finite element modeling for patient-specific mandible, Computer methods and programs in biomedicine, 88 (2007) 197-209.
[22] S. Ataollahi, A review on additive manufacturing of lattice structures in tissue engineering, Bioprinting, 35 (2023) e00304.
[23] P. Dhatrak, V. Girme, U. Shirsat, S. Sumanth, V. Deshmukh, Significance of Orthotropic Material Models to Predict Stress Around Bone-Implant Interface Using Numerical Simulation, BioNanoScience, 9 (2019) 652-659.
[24] J.Y. Rho, M.C. Hobatho, R.B. Ashman, Relations of mechanical properties to density and CT numbers in human bone, Medical engineering & physics, 17 (1995) 347-355.
[25] T. San Antonio, M. Ciaccia, C. Müller-Karger, E. Casanova, Orientation of orthotropic material properties in a femur FE model: a method based on the principal stresses directions, Medical engineering & physics, 34 (2012) 914-919.

Keywords:
Finite Element Method, Mandible, Implant, Anisotropy

ENHANCING HOUSEHOLD OBJECTS INTO SMART HEALTH MONITORING DEVICES: AN UNOBTRUSIVE REMOTE HEALTH MONITORING SYSTEM TO ASSIST HEALTHY AGING

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Abstract

Providing integrated, personalized care for older adults is a global priority to ensure healthy aging, dignity, and well-being in aging populations, according to the WHO and the the Decade of Healthy Aging. Unobtrusive health monitoring is critical for independent aging, as traditional wearable sensors often introduce discomfort and compliance challenges. This paper presents an ongoing work about an innovative, remote health monitoring system that employs computer vision (CV) technologies to estimate heart rate (HR) and emotions through video sequences, aiming to support healthy and independent aging of the elderly inside their homes. The proposed system utilizes remote photoplethysmography (rPPG) to calculate HR (pulse) through RGB frames and a pre-trained emotion recognition model to estimate emotional states through facial expressions. Ground truth data for heart rate was obtained using a pulse oximeter. Measurements were taken under 4 distinct lighting conditions to correlate noise introduction from ambient lighting with measurement error and explore suitable lighting conditions for optimal performance.

Introduction

Healthy aging is an important challenge for global development. There has been a significant increase in life expectancy over the last decades [1]. This rise has been accompanied by a corresponding rise in health-related issues, particularly prevalent among elderly individuals (aged 65 and older). Recognizing this problem, international bodies such as the United Nations (UN) and the World Health Organization (WHO) have launched a common initiative called the Decade of Healthy Ageing (2021-2030) [2]. This global initiative outlines strategic actions intended to enhance quality of life for older adults and provide integrated healthcare tailored to their needs. Traditionally, technologies used for health monitoring of the elderly population rely mostly on wearable sensors, extensive data logging (usually in the form of daily or weekly questionnaires), and elaborate protocols around the use of the various technologies [3]. While effective, these methods are often perceived by elderly users as overwhelming, burdensome, and disruptive to their daily routines [4]. This paper presents an ongoing study concerning an innovative remote health monitoring system, specifically designed for assisting healthy and independent aging at home. This technology enables remote monitoring of the individual's overall health and aims to support independent living and empower elderly individuals to comfortably age at home without disruption to their daily activities.

Materials & Methods

The system was designed and built around the idea of augmenting everyday objects used by the elderly in their everyday activities into smart, health monitoring devices that could provide vital information about an individual's health, without disrupting their routine [5,6]. The aim of this design strategy focuses on creating interactive, unobtrusive solutions for remote health monitoring that integrate seamlessly into daily life, demand minimum user effort, and operate without disrupting the users' daily routine. Our approach involved creating a system that visually resembles a conventional household mirror, a common object that can be found in every household and is daily used. To realize this, we designed a system comprising of an RGB camera, which serves as the system's sensor, and a microprocessor to control the system, which are housed within a wooden frame, and styled to resemble a standard household furniture frame (Fig. 1). A display monitor is placed onto the front side of the frame, which serves as the primary user interface. A reflective display surface covers the monitor to closely resemble a typical mirror. Additionally, the frame is bordered by an LED lighting source, offering supplementary illumination to enhance visibility under dark lighting conditions (Fig. 1). The system employs computer vision technologies to provide a general health state estimation of the user. The RGB signal is preprocessed and analyzed with computer vision algorithms to estimate the user's heart rate and emotions. If the predicted values stray from the predefined baseline, the system issues audiovisual warnings, encouraging timely interventions and, ultimately, promoting better health outcomes.

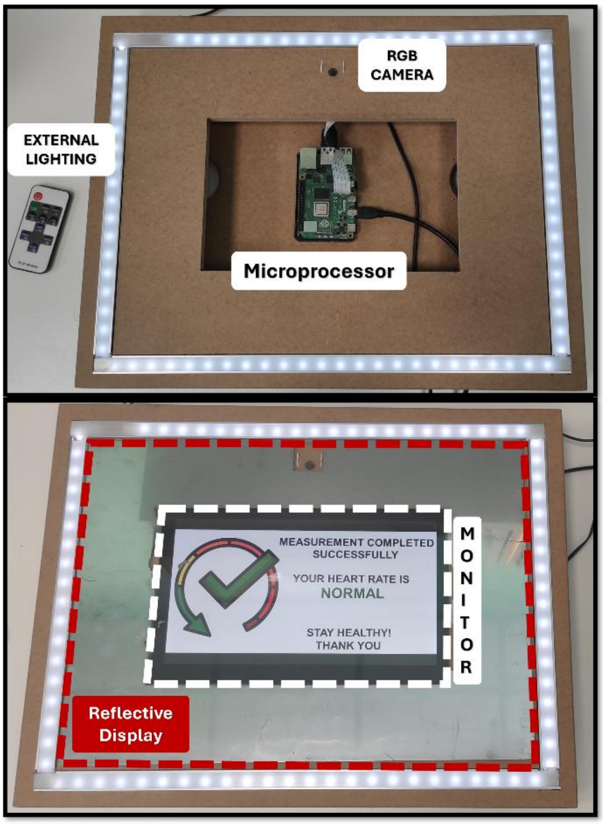

Figure 1. Overview of the system architecture adopted to resemble a household smart mirror. The setup features a microprocessor incorporating Computer Vision (CV) capabilities and an RGB camera (top screen). A reflective display is integrated into the frame, accompanied by a monitor that facilitates user interaction with the system. A LED lighting source is surrounding the reflective display to provide external lighting in dark lighting conditions.

A heart rate estimation algorithm was implemented to estimate heart rate from RGB video stream, which is based on remote photoplethysmography (rPPG) [7,8]. This method begins by detecting faces from real-time RGB video inputs using Haar Cascades [9]. Initially, a specific region of interest (ROI) on the face is identified, and feature points within this region are tracked throughout the video frames with the use of OpenCV [9]. The mean RGB values are extracted for each face detected in the video sequence. This process repeats until a threshold of 900 frames is reached. This threshold is set based on the processing time of the system, which requires a time window of at least 30 seconds. A 30-second time window along with the use of a 30FPS camera translates to 900 frames. Once the threshold of 900 frames is reached, the system starts calculating heart rate (pulse) on the collected RGB values over each subsequent frame. At this point, signal pre-processing is performed by removing absolute brightness using Z-score transformation. Subsequently, Principal Component Analysis is applied to the preprocessed signal to break the three channels (RGB) into three independent components and the green channel component is selected. Research has shown that the green channel is the component with the most feature-filled frequency [10,11]. Thus, the selected green component undergoes frequency analysis using Fast Fourier Transform (FFT). A bandpass filter between 0.75Hz and 4Hz is applied to exclude all the frequencies that don't represent pulse-like values. This frequency range translates to a heart rate range between 45 and 240 beats-per-minute (BPM). Finally, the most prominent frequency found in frequency analysis is selected to represent the heart rate (HR) frequency and is converted to the time domain. Once the process is completed, the BPM values with their corresponding timestamps are stored in a CSV log file and the video stream is deleted. This ensures data privacy and compliance with bioethics.

Furthermore, an emotion detection algorithm has been employed to estimate mood based on emotions tracked from facial features [12,13]. The model was pre trained on the Facial Expression Recognition (FER-2013), a publicly available dataset [14] which contains around 60.000 grayscale images of people labeled into six (6) emotion categories (Neutral, Happy, Sad, Angry, Disgust, Fear). This algorithm uses the same video stream pipeline with the heart rate estimation algorithm. Once the face region is detected by the HR estimation pipeline it is passed to the emotion recognition pipeline for classification. The emotion detection model calculates the input and produces a distribution of probabilities across all 6 categories, out of which the emotion with the biggest probability is selected as the final prediction. The predicted emotion along with its timestamp are then logged into the same CSV log file mentioned before, along with heart rate data.

<u>Experimental Process</u>

We conducted a validation experiment to evaluate the proposed system inside the A-HALL living lab at the Medical Physics & Digital Innovation Laboratory site in Thessaloniki [15]. The living lab was chosen because it is designed to closely simulate the intended real-world deployment environment. An elderly participant aged 65 years old was assessed for three individual sessions, ensuring repeatability and providing sufficient data for further statistical analysis.

A framework of three questionnaires is used to evaluate the participants' ability to operate and interact with the system, as well as providing a quick assessment of their mental state and cognitive abilities. Specifically, the Digital Literacy Questionnaire (DLQ) was developed to assess participants' ability to handle and interact with digital technologies [16]. Also, the State-Trait Anxiety Inventory (STAI) was administered to make a quick assessment of the participants' mental state prior to interacting with the system [17]. The Mini-Mental State Questionnaire was also utilized to evaluate participants' cognitive functioning [18].

A pulse oximeter was employed as a ground truth gold standard to establish cardiac rhythms for each participant. Moreover, ambient lighting conditions during each session were measured using a commercial lux meter.

Upon completion of interacting with the system, participants were prompted to additionally fill out system usability and acceptability questionnaires to provide feedback on their experience with the system. For this purpose, the System Usability Scale (SUS) [19] was used to measure system usability aspects, and the User Experience Questionnaire (UEQ) [20] was used to evaluate user acceptance and overall experience.

During data acqusition, the participant is placed in front of the mirror and interacts with the system through automated audiovisual prompts for a predefined period of 3 minutes. During this session, they are prompted to perform various facial expressions and emotions and their reactions along with their heart rate are recorded and stored for further statistical analysis. Concerning statistical analysis of the data, BPM values are categorized according to the emotion detected at each lux level and for each session. The median bmp values, along with the interquartile range (IQR), are computed across iterations for each corresponding emotion. The pooled BPM values and their respective IQRs are then ploted based on the corresponding emotion and lux level in Figure (2).

Institutional Review Board Statement

The study was conducted in accordance with the Declaration of Helsinki. The study's protocol was approved by the Committee for Bioethics and Ethics of the School of Medicine, Aristotle University of Thessaloniki with the protocol number 303791/2024 in the Committee sitting 133/17-12-2024 following the application with the protocol number 286395/2024.

Informed Consent Statement

Informed consent was obtained from all subjects involved in the study.

Results

Figure 2 illustrates the mean heart rate estimates across, measured in beats per minute (BPM), under four (4) lighting conditions (50, 350, 500 and 1000 lux). Each bar corresponds to an emotion and encapsulates the variability of heart rate values obtained across the six (6) emotional states.

Preliminary results indicate that 'Disgust' and 'Happy' emotional states tend to show relatively higher mean heart rates, whereas 'Sad' state consistently exhibits the lowest values. The IQRs indicate standard deviations, suggesting some overall and moderate variability within each state-condition combination. Concerning lighting conditions, measurements taken under 350 lux present less fluctuations compared to the rest, with measurements taken under dark conditions (50 lux) presenting the highest fluctuations.

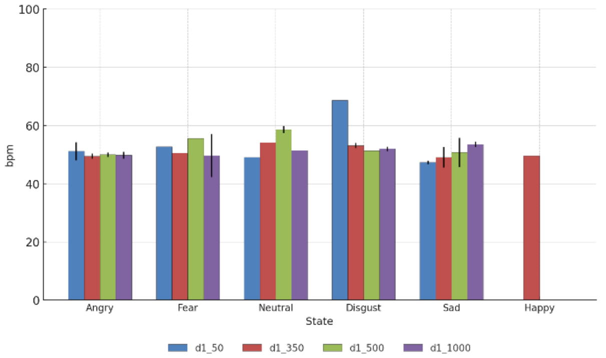

Figure 2. Distribution of heart rate estimates (BPM) across different emotion classes in four distncit lighting settings. Each bar represents a heart rate estimation and each color represents a light condition. Interquartile ranges, indicated by the horizontal line inside the box, represent the standard deviation. The plot highlightis individual variability in heart rate stability and lighting induced noise.

Responses collected from questionnaires, although positive, are insufficient to form any preliminary conclusions, as they were collected from a single participant, and this does not provide an adequate basis for evaluating the system.

Discussion

The system demonstrated susceptibility to external lighting conditions and motion artifacts, which resulted in deviations in heart rate estimations from ground truth values. Emotion recognition demonstrated variability in heart rate for different emotional states with 'Disgust' and 'Happy' being the emotions that presented the highest mean HR values and sad being the emotion that demonstrated the lowest HR values. Preliminary results concerning optimal lighting conditions for rPPG indicate that the system demonstrated better stability under 350 lux lighting. Next steps include recruiting more participants to evaluate the system, while constantly working on refining the algorithms based on the collected data.

Conclusion

The participant interacted successfully with the system, providing valuable heart rate and emotion data. Measurements under darker lighting conditions exhibited greater variability in HR data compared to measurements taken under room lighting conditions (350 lux). Motion artifacts further increased those fluctuations. These findings highlight the need for motion artifact compensation techniques [21,22] as well as ambient lighting filtering methods [10,23]. The positive reception recorded from responses to the questionnaires was insufficient to provide conclusions. Currently, we are actively trying to recruit participants in order to form a comprehensive dataset to validate the proposed system.

Keywords

Remote Health Monitoring, Biomedical Engineering, Computer Vision, Healthy Aging, Sensors

References

1. Vaupel JW, Villavicencio F, Bergeron-Boucher MP. Demographic perspectives on the rise of longevity. Proc Natl Acad Sci USA. 2021 Mar 2;118(9):e2019536118.

2. Amuthavalli Thiyagarajan J, Mikton C, Harwood RH, Gichu M, Gaigbe-Togbe V, Jhamba T, Pokorna D, Stoevska V, Hada R, Steffan GS. The UN Decade of healthy ageing: strengthening measurement for monitoring health and wellbeing of older people. Age and ageing. 2022;51(7):afac147.

3. Ariño Blasco S, Navarro Llobet D, Koumanakos G. Obtrusiveness Considerations of AAL Environments. In: Karkaletsis V, Konstantopoulos S, Voros NS, Annicchiarico R, Dagioglou M, Antonopoulos CP, editors. RADIO--Robots in Assisted Living [Internet]. Cham: Springer International Publishing; 2019 [cited 2025 Mar 31]. p. 19–32. Available from: http://link.springer.com/10.1007/978-3-319-92330-7_3

4. Sharma N, Brinke JK, Van Gemert-Pijnen J, Braakman-Jansen LMA. Implementation of unobtrusive sensing systems for older adult care: scoping review. JMIR aging. 2021;4(4):e27862.

5. Yang Y, Wang H, Jiang R, Guo X, Cheng J, Chen Y. A review of IoT-enabled mobile healthcare: technologies, challenges, and future trends. IEEE Internet of Things Journal. 2022;9(12):9478–502.

6. Marques G, Bhoi AK, Hareesha KS. IoT in healthcare and ambient assisted living. 2021;

7. Karthick R, Dawood MS, Meenalochini P. Analysis of vital signs using remote photoplethysmography (RPPG). Journal of Ambient Intelligence and Humanized Computing. 2023;14(12):16729–36.

8. Di Lernia D, Finotti G, Tsakiris M, Riva G, Naber M. Remote photoplethysmography (rPPG) in the wild: Remote heart rate imaging via online webcams. Behavior Research Methods. 2024;56(7):6904–14.

9. Arya Z, Twiari V. Automatic Face Recognition and Detection Using OpenCV, Haar Cascade and Recognizer at Different Angle of Face. International Journal of Engineering Research and Applications. 2020;10(6):2020.

10. Guler S, Ozturk O, Golparvar A, Dogan H, Yapici MK. Effects of illuminance intensity on the green channel of remote photoplethysmography (rPPG) signals. Physical and Engineering Sciences in Medicine. 2022;45(4):1317–23.

11. Ontiveros RC, Elgendi M, Missale G, Menon C. Evaluating RGB channels in remote photoplethysmography: a comparative study with contact-based PPG. Frontiers in Physiology. 2023;14:1296277.

12. Khopkar A, Adholiya A. Facial expression recognition using CNN with Keras. Biosci Biotechnol Res Commun. 2021;14(05):47–50.

13. Maurya A, Sharma V. Facial emotion recognition using Keras and CNN. In: 2022 2nd International Conference on Advance Computing and Innovative Technologies in Engineering (ICACITE). IEEE; 2022. p. 2539–43.

14. Khaireddin Y, Chen Z. Facial emotion recognition: State of the art performance on FER2013. arXiv preprint arXiv:210503588. 2021;

15. Konstantinidis EI, Billis A, Bratsas C, Siountas A, Bamidis PD. Thessaloniki active and healthy ageing living lab: The roadmap from a specific project to a living lab towards openness. In: Proceedings of the 9th ACM International Conference on PErvasive Technologies Related to Assistive Environments. 2016. p. 1–4.

16. Digital Life Learning [Internet]. garagErasmus Foundation. [cited 2025 Mar 31]. Available from: https://garagerasmus.org/project/digital-life-learning/

17. Marteau TM, Bekker H. The development of a six-item short-form of the state scale of the Spielberger State—Trait Anxiety Inventory (STAI). British journal of clinical Psychology. 1992;31(3):301–6.

18. Cockrell JR, Folstein MF. Mini-mental state examination. Principles and practice of geriatric psychiatry. 2002;140–1.

19. Lewis JR. The system usability scale: past, present, and future. International Journal of Human–Computer Interaction. 2018;34(7):577–90.

20. Schrepp M, Hinderks A, Thomaschewski J. Construction of a benchmark for the user experience questionnaire (UEQ). International Journal of Interactive Multimedia and Artificial Intelligence. 2017;4(4):40–4.

21. Cho D, Kim J, Lee KJ, Kim S. Reduction of Motion Artifacts From Remote Photoplethysmography Using Adaptive Noise Cancellation and Modified HSI Model. IEEE Access. 2021;9:122655–67.

22. Maity AK, Wang J, Sabharwal A, Nayar SK. RobustPPG: camera-based robust heart rate estimation using motion cancellation. Biomed Opt Express. 2022 Oct 1;13(10):5447.

23. Raysad T, Swarubini P, Ganapathy N. Effect of Different Lighting Conditions on Camera-based Non-Contact Vital Sign Monitoring. In: 2024 IEEE Applied Sensing Conference (APSCON) [Internet]. 2024 [cited 2025 Jan 13]. p. 1–4. Available from: https://ieeexplore.ieee.org/abstract/document/10465694

AI-DRIVEN RADIOMICS FOR PROSTATE CANCER DIAGNOSIS: INTEGRATING AUTOMATED CLINICAL DECISION SUPPORT WITH HARMONIZED MACHINE LEARNING MODELS

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Abstract

Prostate cancer (PCa) remains a leading cause of cancer-related mortality in men, necessitating improved diagnostic methods. Traditional approaches, such as PSA testing and biopsy, are invasive and prone to variability. This study explores the integration of AI-driven radiomics with the ADC ratio—a biomarker derived from diffusion-weighted imaging—to enhance PCa diagnosis. Utilizing a multicenter dataset of 207 prostate lesions, we extracted 1246 radiomic features and applied ComBat harmonization to mitigate scanner variability. Feature selection methods, including Recursive Feature Elimination (RFE) and Random Forest (RF), were employed to optimize model performance. The radiomics-ADC ratio model, combined with RFE and RF, achieved superior diagnostic accuracy (AUC-PR: 0.92±0.04, F1 score: 0.86±0.04) compared to radiomics-only and ADC-only models. AI-generated clinical reports were developed to enhance interpretability, providing actionable insights for clinicians. This study underscores the potential of integrating radiomics with harmonization techniques and simple biomarkers to improve non-invasive PCa diagnosis, offering a robust, generalizable approach for multicenter applications.

Introduction

Prostate cancer (PCa) is the second most diagnosed cancer in men worldwide and a major cause of cancer-related deaths [1]. Early detection significantly improves survival, yet traditional diagnostic methods—digital rectal examination (DRE), PSA testing, and TRUS-guided biopsy—are invasive and prone to variability. Multiparametric MRI (mpMRI) has emerged as a crucial non-invasive tool, incorporating T2-weighted imaging (T2w), Diffusion-Weighted Imaging (DWI), ADC maps, and Dynamic Contrast-Enhanced (DCE) imaging to improve lesion detection. However, PI-RADS, the standardized mpMRI scoring system, still faces challenges in accurately assessing tumor aggressiveness. Radiomics, an AI-driven approach that extracts quantitative imaging features, has shown promise in addressing these limitations. This study integrates radiomics with the ADC ratio—a simple, interpretable biomarker calculated as the mean ADC of a lesion divided by the mean ADC of contralateral normal tissue—to enhance PCa diagnosis.

Multicenter studies are essential for validating ML models but face challenges due to scanner variability. ComBat harmonization mitigates such differences while preserving biological signals, improving model generalizability[2]. Feature selection methods, combined with ML classifiers like Random Forest (RF) and SVM, further optimize diagnostic performance.

This study evaluates the impact of radiomics-ADC ratio integration, feature selection, ML classifiers, and ComBat harmonization on PCa diagnosis within a multicenter framework. By developing robust, generalizable models, it aims to improve non-invasive PCa detection and patient outcomes.

Materials and Methods

A multicenter dataset was used, comprising 207 prostate cancer lesions (152 csPCa and 55 cinsPCa) from both a private cohort and the publicly available PROSTATEx2 dataset. ADC maps were obtained from DWI sequences with standardized preprocessing steps, ensuring consistency across different scanner manufacturers. The private dataset included cases from both 1.5T and 3T scanners, while PROSTATEx2 consisted of standardized imaging protocols with expert-verified lesion annotations.

Radiomics features were extracted using Pyradiomics following voxel resampling, intensity normalization, and standardization. A total of 1246 radiomic features were computed, encompassing first-order statistical measures, shape and texture features (GLCM, GLRLM, GLSZM, NGTDM). Additionally, ADC ratio was computed as the mean ADC value of the tumor lesion relative to the mean ADC value of the contralateral normal prostate tissue. ComBat harmonization was applied to mitigate scanner-induced variability, ensuring feature consistency across datasets.

Prior to feature selection, dimensionality reduction was performed. Low variance features were excluded using a variance of 0.01 and multicollinear features were eliminated using a Pearson correlation threshold of 0.85. Subsequently, supervised feature selection was applied solely to the training data to prevent data leakage. To

retain only features correlated with the outcome, a Wilcoxon rank sum test was performed with a significance threshold of 0.1, allowing us to prioritize a subset of features for further analysis. This approach significantly reduced the number of features, facilitating a more exhaustive feature selection. Additionally, a clustered correlation heatmap was used to illustrate the relationships among the features both with and without the application of ComBat harmonization *(Figure 1)* after dimensionality reduction process. Feature selection was performed using filter, wrapper, and embedded methods, including ANOVA, Boruta, Kruskal-Wallis, mRMR, Recursive Feature Elimination (RFE), LASSO, Random Forest variable importance (RF-imp) and Sequential Feature Selection (SFS).
Machine learning classifiers such as RF, SVM, and Boosted linear models (Boosted GLM) were trained using nested stratified cross-validation to ensure robustness. The assessment of the models was performed based on the Area Under the Curve Precision-Recall (AUC-PR), which is more informative than AUC-ROC because it focused on the performance of the positive class, and F1 score, but other metrics were also computed, including Balanced Accuracy, Precision and Recall. Radar plots were created to find the most robust and repeated features across different feature selection methods and harmonization schemes.
AI-generated reports were developed to provide explainability and interpretation based on model predictions. These reports included probability estimates for csPCa and cinsPCa and clinical recommendations such as "Active Surveillance" or "Necessary Biopsy" based on risk thresholds. The reliability of these reports was assessed by comparing them to standard radiological assessments.

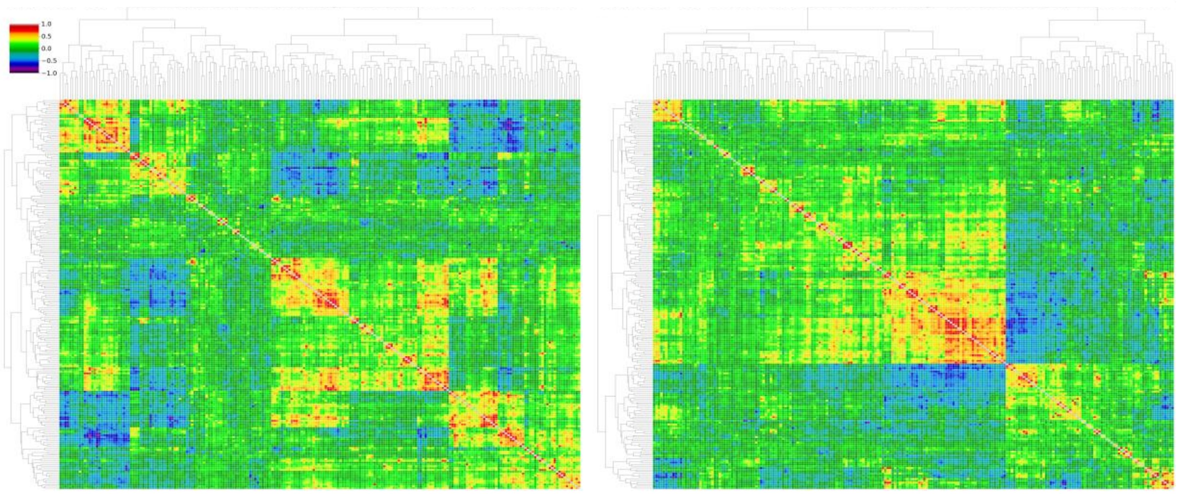

Figure 1: Clustered correlation heatmap after dimensionality reduction without (left figure) and with (right figure) ComBat harmonization

Results
The radiomics-ADC_{ratio} model, which combined RFE and RF with ComBat harmonization, emerged as the best-performing model. This approach achieved an AUC-PR of 0.92±0.04 and an F1 score of 0.86±0.04. It outperformed both the radiomics-only model (AUC-PR: 0.91±0.06, F1: 0.84±0.03) and the ADC-only model (AUC-PR: 0.71±0.13, F1: 0.58±0.15).
The integration of radiomics features and the ADC_{ratio} provided supplementary information, capturing both the complex textural characteristics of tumor microarchitecture and the simpler quantitative measure of tumor aggressiveness. This combination improved diagnostic accuracy and robustness, particularly in multicenter settings.
ComBat harmonization played a pivotal role in enhancing model performance by addressing inter-scanner variability. The harmonized models demonstrated greater generalizability, as evidenced by consistent improvements in metrics across test set. Statistical validation using permutation testing confirmed the significance of these findings. The radiomics-ADC_{ratio} model significantly outperformed the ADC-only model (p=0.0339), while the difference between the radiomics-ADC_{ratio} and radiomics-only models was not statistically significant (p=0.2383). So, the inclusion of the ADC_{ratio} further enhanced the radiomics-ADC_{ratio} model, establishing it as the overall most effective approach.
A summary of the best-performing models, in training/validation and test set is presented in *Table 1.*

Table 1: Best models' combinations across training/validation and test set

Cohorts	Feature selection + classifier + harmonization scheme	AUC-PR	P-value	Precision	Recall	F1
Training/Cross-validation cohort	**Radiomics Model**	0.92 ± 0.04	0.2744	0.77 ± 0.02	0.98 ± 0.02	0.87 ± 0.02
	Radiomics – ADC ratio model	0.92 ± 0.04	Ref	0.79 ± 0.06	0.95 ± 0.03	0.86 ± 0.04
	ADC ratio model	0.71 ± 0.13	0.0002	0.73 ± 0.16	0.50 ± 0.15	0.58 ± 0.15
Test cohort	**Radiomics Model**	0.79	0.2383	0.74	0.96	0.84
	Radiomics – ADC ratio model	0.82	Ref	0.77	0.72	0.74
	ADC ratio model	0.72	0.0339	0.73	0.50	0.59

Feature importance analysis revealed that higher-order features derived from wavelet-transformed images were the most frequently selected across all feature selection methods *(Table 2)*.

Table 2: Frequency of the most selected features across all the feature selection algorithms with different harmonization schemes

Feature	Frequency (no ComBat)	Frequency (with ComBat)
Wavelet_HLH_glszm_LowGrayLevelZoneEmphasis	5	3
Wavelet_HLL_gldm_LowGrayLevelEmphasis	3	3
Wavelet_HHH_firstorder_Kurtosis	2	2

These features captured subtle textural variations, reflecting tumor heterogeneity and biological aggressiveness. Radar plots further emphasized the robustness of these features, which consistently improved model performance.

The application of RFE as a feature selection method in combination with RF classifiers proved highly effective. RFE systematically removed less relevant features, focusing on those with the greatest predictive utility. RF, as an ensemble method, excelled in handling high-dimensional datasets by reducing overfitting through its inherent averaging mechanism.

To enhance the interpretability of radiomics-based prostate cancer diagnosis, AI-generated clinical reports were developed using ChatGPT. These reports aimed to provide structured and automated interpretations of model predictions, assisting clinicians in decision-making (Figure 2).

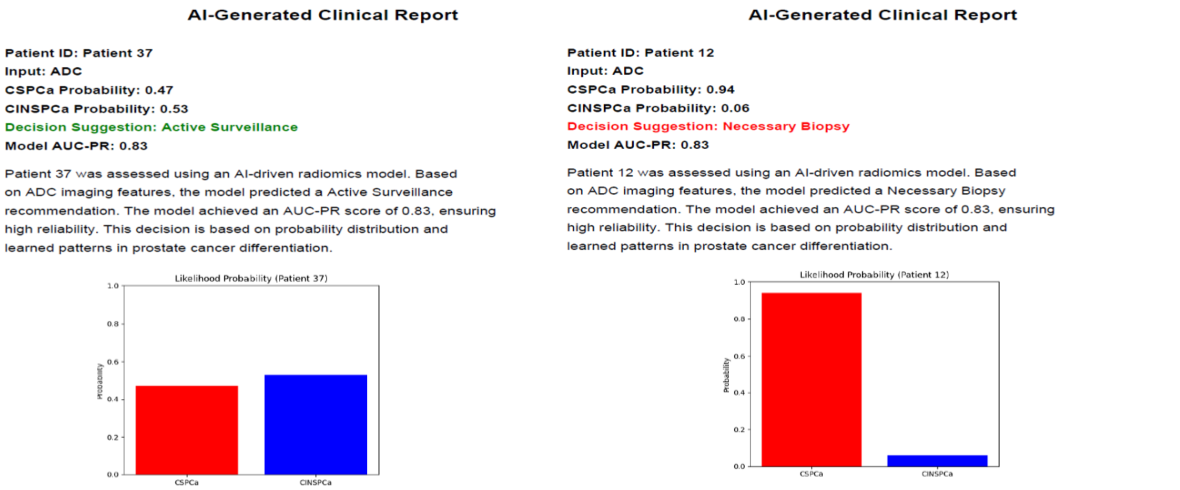

Figure 2: AI-generated clinical report

Discussion

This study highlights the benefits of combining radiomics features with ADC ratio to differentiate between clinically significant (csPCa) and insignificant prostate cancer (cinsPCa). The radiomics-ADC ratio model, enhanced by feature selection, AI-generated clinical reports, and ComBat harmonization, demonstrated superior diagnostic accuracy (AUC-PR: 0.92±0.04, F1 score: 0.86±0.04) compared to radiomics-only or ADC-only models.

ComBat harmonization effectively addressed scanner variability, improving model generalizability across multicenter datasets aligning with existent literature [3]. Recursive Feature Elimination (RFE) combined with Random Forest (RF) emerged as the optimal approach, underscoring the importance of ensemble methods in high-dimensional data. Recent studies have shown that RFE is a well-performed feature selection algorithm due to its ability to perform an iterative refinement of the set of features by sorting out the most informative variables [4].

Higher-order features from wavelet-transformed images were consistently selected, reflecting tumor heterogeneity and microarchitecture [5]. Future research should integrate additional imaging modalities (e.g., T2-weighted, PET) and clinical parameters to enhance diagnostic precision. AI-generated reports improved interpretability, supporting clinical decision-making. This study underscores the value of combining radiomics with harmonization techniques and biomarkers for robust prostate cancer diagnosis.

Conclusion

In conclusion, the study showcases, the superior performance of radiomics features combined with ADC ratio, while applying ComBat harmonization and robust feature selection, in diagnosing prostate cancer from different centers. Combined, the radiomics-ADC ratio demonstrated improved generalizability and diagnostic performance, where wavelet features emerged as significant biomarkers. These results further strengthen the promise of integrating imaging biomarkers with harmonization techniques toward the development of reliable non-invasive clinical tools for prostate cancer. These will undoubtedly need to be further honed and tested in much wider clinical applications to more fully achieve the generalization of results with broader clinical impacts.

References

1. Bray F., Laversanne M., Sung H. et.al. (2024) Global cancer statistics 2022: GLOBOCAN estimates of incidence and mortality worldwide for 36 cancers in 185 countries, CA Cancer J Clin., May-Jun:74(3):229-263
2. Crombé A., Kind M., Fadli D. et al. (2020) Intensity harmonization techniques influence radiomics features and radiomics-based predictions in sarcoma patients4, Sci Rep 10, 15496
3. Orlhac F., Eertink J.J., Cottereau A.S. et al. (2022) A Guide to ComBat Harmonization of Imaging Biomarkers in Multicenter Studies. J Nucl Med. Feb;63(2):172-179.
4. Mylona E., Zaridis, D.I., Kalantzopoulos, C.N. et al. (2024) Optimizing radiomics for prostate cancer diagnosis: feature selection strategies, machine learning classifiers, and MRI sequences, Insights Imaging 15, 265
5. Zhou J., Lu J., Gao C. et al. (2020) Predicting the response to neoadjuvant chemotherapy for breast cancer: wavelet transforming radiomics in MRI. BMC Cancer 20, 100

Keywords: Radiomics, Prostate Cancer, ComBat harmonization, ADC Ratio, Machine Learning

Acknowledgements

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ΕΠΙΣΤΗΜΟΝΙΚΟ ΠΡΟΓΡΑΜΜΑ
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OPTIMIZING RADIATION SAFETY IN CHRONIC TOTAL OCCLUSION (CTO) PROCEDURES: DOSIMETRIC ASSESSMENT WITH AND WITHOUT THE IMPLEMENTATION OF EGG NEST RADIOPROTECTIVE SHIELDING

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Background

Cardiovascular diseases remain the leading cause of mortality, with a higher incidence in males. As a result, Interventional Cardiology has become increasingly important, particularly in the treatment of Chronic Total Occlusion (CTO)—a complete coronary artery blockage causing significant ischemia and angina. CTO is managed using a catheter-based approach via the femoral or radial artery [1],[2], followed by guidewire navigation and standard Percutaneous Coronary Intervention (PCI), including balloon angioplasty and stent placement [3]. CTO-PCI has proven effective in relieving symptoms and reducing antianginal medication in patients with ischemia and myocardial hibernation [4]. However, the procedure involves extended radiation exposure, as indicated by elevated Air-Kerma values [5],[6].

Materials and Method

Radiation doses were measured using real-time, active personal dosimeters worn by interventional cardiologists and nursing staff, recording exposure every minute. This approach enabled accurate assessment of radiation based on role, exposure duration, and proximity to the source. Measurements were taken before and after introducing the Egg Nest shielding system under consistent conditions. The Egg Nest mitigates scattered and leakage radiation, reducing exposure for all personnel. Equivalent Dose and Effective Dose (mSv) were calculated using dosimeter data, adjusted by radiation and tissue weighting factors. Estimated Cancer Risk (ECR) was derived from Effective Dose using established risk coefficients. Statistical analysis compared pre- and post-shielding doses to determine effectiveness.

Results

The analysis confirmed a significant reduction in radiation exposure across all personnel following Egg Nest implementation, evidenced by decreased equivalent and effective doses. This reduction translated into a lower ECR, emphasizing the shielding's efficacy in enhancing occupational safety. The real-time dosimetry not only validated these improvements but also revealed procedural inefficiencies and sources of avoidable exposure. These findings highlight the critical role of dynamic radiation monitoring and targeted protective measures in optimizing long-term safety in interventional cardiology.

Discussion

The results emphasize the need for continuous radiation monitoring and improved protection strategies in interventional cardiology. Real-time dose tracking revealed exposure inefficiencies, leading to enhanced safety protocols. The Egg Nest shielding significantly reduced radiation, underscoring the value of ongoing optimization to minimize long-term exposure risk.

Conclusion

Minimizing radiation exposure is vital to reduce long-term risks in interventional cardiology. Ongoing optimization of protection measures and innovative shielding is key to safeguarding healthcare staff, with future research needed to assess sustained effectiveness.

References

1. Corewell Health. *Chronic total occlusion percutaneous coronary intervention (CTO PCI)*. From https://www.beaumont.org/treatments/cto-pci
2. Jérémie Dabin, et al. "dosimetry during percutaneous coronary interventions of chronic total occlusions." DOI: 10.1093/rpd/ncx303.
3. Azzalini, Lorenzo, et al. "Contemporary Issues in Chronic Total Occlusion Percutaneous Coronary Intervention." DOI: 10.1016/j.jcin.2021.09.027.
4. Maen Assali, et al. "Update on Chronic Total Occlusion Percutaneous Coronary Intervention." DOI: 10.1016/j.pcad.2021.11.004.
5. Davide Maccagni, et al. "Noise Reduction Technology Reduces Radiation Dose in Chronic Total Occlusions Percutaneous Coronary Intervention: A Propensity Score-Matched Analysis." DOI: 10.1007/s10554-018-1343-z.
6. Tajti, Peter, et al. "Update in the Percutaneous Management of Coronary Chronic Total Occlusions." DOI: 10.1016/j.jcin.2017.10.052.

Keywords: Interventional Cardiology, Real-Time Dosimetry, Protective shielding, Egg Nest, Dosimeters, Chronic Total Occlusion (CTO).

VOLUMETRIC MODULATED ARC THERAPY (VMAT) VERSUS OPTIMIZED DYNAMIC CONFORMAL ARC (OptDCA) TECHNIQUES FOR LINAC-BASED STEREOTACTIC RADIOTHERAPY OF SINGLE BRAIN METASTASES

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Introduction

Stereotactic radiotherapy (SRT) and stereotactic radiosurgery (SRS) are highly precise radiation treatment techniques used for the management of brain metastases offering excellent local tumor control with minimal impact on surrounding healthy tissues[1]. Two linac-based techniques used for these treatments are Volumetric Modulated Arc Therapy (VMAT) and Dynamic Conformal Arc (DCA). VMAT enables highly conformal dose distribution through continuous modulation of the multi-leaf collimator (MLC), gantry speed, and dose rate, potentially enhancing dose conformity and sparing organs at risk (OARs). In DCA, both the gantry speed and dose rate remain constant, while the MLCs adjust slightly to match the shape of the target for each gantry angle. The dose distribution of the DCA plan is usually not as conformal as that of the VMAT plan. Therefore, performing optimization of the DCA plan (optDCA) can potentially enhance dose conformity[2]. This study aims to evaluate and compare the plan quality metrics, dosimetric parameters and the delivery efficiency for single brain metastases SRS/SRT plans for VMAT and optDCA techniques.

Material and methods

Ten patients with a single brain metastasis who were previously treated with VMAT techniques using an Edge linac were retrospectively randomly selected. New optDCA plans were generated using the same geometry and energy (6 flattening filter free (FFF) with dose rate 1400 MU/min) such as the original VMAT using the treatment planning system (TPS) Eclipse (version 15.6.06). The optDCA plans were optimized utilizing parameters that limit the modulation of the plan, such as aperture shape controller and MU objective. Paddick conformity index (PCI), gradient index (GI), number of Monitor Units (MU) and brain $V_{12/20Gy}$ were recorded for each plan. Gamma Passing Rates (GPR) were calculated for the criteria of 3%/1mm and 5%/1mm dose difference and distance-to-agreement, respectively. These indices were statistically assessed to evaluate differences between VMAT and OptDCA. Statistical analysis with non-parametric Wilcoxon signed rank test was performed.

Results

No statistically significant difference between the two techniques was found for GI ($p = 0.726$), GPR [3%/1mm ($p = 0.507$), 5%/1mm ($p = 0.917$)], V12 ($p = 0.646$), and V20 ($p = 0.678$). However, a statistically significant difference was observed for PCI ($p = 0.005$) and MU ($p = 0.028$), suggesting that VMAT demonstrated superior conformity however requiring a higher number of MU compared to OptDCA.

Discussion

In this study, it was observed that the VMAT technique offers better PCI compared to OptDCA, which is expected due to the higher modulation of the MLCs. However, OptDCA requires fewer MU due to the smaller modulation of the beam and lower complexity. OptDCA seems to be a promising technique for single brain metastasis SRS/SRT. Future steps will involve the evaluation for its further implementation in multiple metastases cases.

Conclusion

Both techniques generate clinically acceptable plans with comparable dosimetric parameters. The optDCA technique provides similar plans to the VMAT technique with less complexity and shorter treatment delivery time.

References

[1] C. Velten, et al. "Single isocenter treatment planning techniques for stereotactic radiosurgery of multiple cranial metastases," *Phys Imaging Radiat Oncol*, vol. 17, pp. 47–52, Jan. 2021.

[2] D. Pokhrel, et al. "Dynamic conformal arcs-based single-isocenter VMAT planning technique for radiosurgery of multiple brain metastases," *Medical Dosimetry*, vol. 46, no. 2, pp. 195–200, Jun. 2021.

Keywords: SRS, Radiosurgery, Single brain metastases, Single isocenter, VMAT, DCA, dosimetric parameters

NANOPARTICLES IN MEDICAL IMAGING: ADVANTAGES AND CHALLENGES

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Introduction
Nanotechnology has significantly advanced in recent years, enabling important applications in clinical diagnostics, particularly in medical imaging. The use of nanoparticles (NPs) as contrast agents has emerged as a promising alternative to traditional agents, aiming to improve both sensitivity and specificity in imaging techniques.

Materials and Methods

This literature review focuses on studies published in the past decade, highlighting key applications of nanoparticles in various imaging modalities such as Magnetic Resonance Imaging (MRI), Computed Tomography (CT), Positron Emission Tomography (PET), Single Photon Emission Computed Tomography (SPECT), ultrasound, and optical imaging. Particular emphasis was given to each nanoparticle category's types, mechanisms of action, and physicochemical properties.

Results
In MRI, iron oxide-based nanoparticles have been widely used as T2 agents, demonstrating notable biocompatibility and magnetic properties. Gadolinium-, manganese-, and gold-based nanoparticles have also been explored, showing improved image enhancement and reduced toxicity. In CT, gold, bismuth, and superparamagnetic iron oxide nanoparticles (SPIONs) serve as efficient contrast agents due to their high atomic number and X-ray attenuation. Furthermore, nanoparticles are increasingly utilized in PET, SPECT ultrasound imaging, and novel modalities such as optical imaging.

Discussion
The multifunctional nature of nanoparticles allows for multimodal imaging and potential integration of therapeutic agents (theranostics). While their advantages are considerable, including increased specificity, prolonged circulation time, and lower toxicity, limitations such as biocompatibility, clearance, and regulatory challenges persist.

Conclusions
Nanoparticles represent a transformative advancement in medical imaging. Their role as contrast agents is expanding, with promising prospects in personalized diagnostics and therapy. Further research is essential to overcome current limitations and fully realize their clinical potential.

References
1. J. Wahsner, E. M. Gale, A. Rodriguez-Rodriguez and P. Caravan (2019) Chemistry of MRI Contrast Agents: Current Challenges and New Frontiers, *Chemical Reviews*, 119:957–1057.
2. S. M. Dadfar, K. Roemhild, N. Drude, S. von Stillfried, R. Knüchel-Clarke and T. Lammers (2019) Iron oxide nanoparticles: Diagnostic, therapeutic and theranostic applications, *Advanced Drug Delivery Reviews*, 138:302–325.
3. T. Bauerle, M. Saake and M. Uder (2021) Gadolinium-based contrast agents: What we learned from acute adverse events, nephrogenic systemic fibrosis and brain retention, *Rofo*, 193:1010–1018.
4. C. Henoumont, M. Devreux and S. Laurent (2023) Mn-Based MRI Contrast Agents: An Overview, *Molecules*, 28:21
5. J. A. Park, H. S. Choi, Y. J. Lee, H. C. Kim and J. S. Kim (2013) Gadolinium Complex of (125)I/(127)I-RGD-DOTA Conjugate as a Tumor-Targeting SPECT/MR Bimodal Imaging Probe, *ACS Med Chem Lett*, 4:216–219.
6. D. H. Hu, J. Y. Zhang, F. Gao, J. Liang, Y. Wang and X. W. Li (2013) Hybrid gold-gadolinium nanoclusters for tumor-targeted NIRF/CT/MRI triple-modal imaging in vivo, *Nanoscale*, 5:1624–1628.
7. X. Luo, L. Wang, J. Duan, Q. Li, Y. Ma and Z. Xu (2017) Dual-functional lipid-like nanoparticles for delivery of mRNA and MRI contrast agents, *Nanoscale*, 9:1575–1579.

Keywords:
Nanoparticles, Contrast Agents, Medical Imaging, MRI, CT, Theranostics.

DOSIMETRY IN NON-STANDARD FIELDS OF 1.5T MR-LINACS: CORRECTION FACTORS FOR TWO COMMERCIALLY AVAILABLE OSL DOSIMETERS

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Introduction

In small and non-standard field dosimetry in MR-Linac systems, the TRS-483 code-of-practice needs to be extended to account for potential changes in the detector's response associated with the presence of the strong magnetic field [1]. Optically Stimulated Luminescence (OSL) dosimeters are excellent candidates for Quality Assurance procedures and remote audit tests in MR-linacs [2]. The aim of this study is to implement a Monte Carlo based framework for the determination of the relevant correction factors for two commercially available Optically Stimulated Luminescence (OSL) dosimeters under non-standard irradiation fields.

Materials and Methods

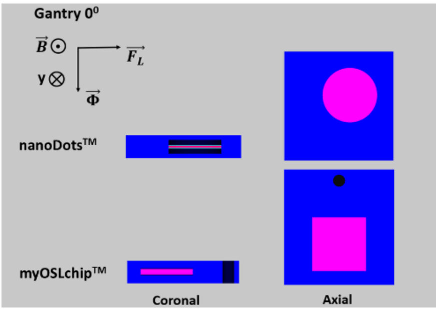

Figure 1: The two commercially available OSL dosimeters modelled in EGSnrc. The two detector orientations with respect to the magnetic field are defined.

The EGSnrc V2019 Monte Carlo software package was employed throughout this study. Phase space files for two clinical fields (i.e., 3x3 and 2x2 cm^2), f_{clin}, and the machine-specific reference 10x10 cm^2 field, f_{msr}, of the Unity 1.5T/7MV MR-Linac (Elekta, UK) were provided by the vendor and used as the source models. The nanoDots™ (Landauer Inc., USA) and the myOSLchip™ (RadPro International GmbH, Germany) commercially available dosimeters were considered in this study. They comprise active volumes made of Al_2O_3 (disk of 5mm in diameter and 0.2mm thick, density ρ=1.41g/cm^3) and BeO (square disk of 4.65x4.65mm^2 and 0.5 mm thick, density ρ=2.85g/cm^3), respectively.

Both detectors were modelled according to blueprints provided by the corresponding manufacturers (Figure 1). OSL dosimeters were simulated at a depth of 5cm inside an RW3 (PTW, Germany) solid phantom. The magnetic field was always perpendicular to the irradiation beam and parallel to the treatment couch. Gantry angle was fixed at 0°. Two detector orientations were considered: (i) coronal and (ii) axial (Figure 1). The correction factors were determined as the field output factor multiplied by the ratio of detector readings under the f_{msr} and f_{clin} field in the presence of the static magnetic field B, i.e., [3,4]:

$$k_{Q_{clin},Q_{msr}}^{B,f_{clin},f_{msr}} = \frac{D_{w,Q_{clin}}^{B,f_{clin}}}{D_{w,Q_{msr}}^{B,f_{msr}}} \cdot \frac{D_{det,Q_{msr}}^{B,f_{msr}}}{D_{det,Q_{clin}}^{B,f_{clin}}}$$

Results

The calculated magnetic field correction factors are presented in Table 1.

Table 1: Magnetic field correction factors $k_{Q_{clin},Q_{msr}}^{B,f_{clin},f_{msr}}$ for the two OSL detectors and both orientations. Overall combined uncertainties at 68% confidence level are given in the parentheses.

OSL dosimeter type	OSL dosimeter orientation	Nominal field size (cm^2)	
		3x3	**2x2**
nanoDots™	**coronal**	1.017 (6)	1.016 (6)
	axial	1.012 (6)	0.995 (6)
myOSLchip™	**coronal**	1.008 (6)	1.018 (6)
	axial	1.002 (6)	0.994 (6)

Conclusion

A set of correction factors for two commercially available OSL detectors were determined, enabling more options for experimental dosimetry, Qaulity Assurance procedures and remote audit tests in non-standard MR-linac irradiaiton fields.

References

1. de Pooter et al, Phys Med Biol 66 (2021) 05TR02
2. Episkopakis et al, Phys Med Biol 68 (2023) 225002
3. Blum et al, Phys Med Biol 66 (2021) 155003
4. Margaroni et al, Phys Med Biol 70 (2025) 025011

Keywords

OSLD, small field, dosimetry, correction factors, MR-Linac, Unity

Acknowledgements

Elekta Ltd is acknowledged for providing the phase space files. Landauer Inc. and RadPro International GmbH are acknowledged for providing detailed schematics of the corresponding OSL dosimeters.

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EVALUATION OF A DEEP LEARNING IMAGE RECONSTRUCTION ALGORITHM ON RADIATION DOSE AND IMAGE QUALITY IN CT EXAMINATIONS.

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Abstract
Deep learning image reconstruction algorithms in medical imaging reduce radiation dose and improve image quality, by employing artificial intelligence. The aim of this study was to investigate the effect of the deep learning image reconstruction algorithm, Advanced intelligent Clear-IQ Engine (AiCE), integrated into Aquilion ONE Prism (Canon Medical Systems) CT scanner on radiation dose and image quality in CT examinations.

Materials and Methods
A cylindrical TOS-SS phantom was used for data acquisition. The phantom was scanned using the Aquilion ONE Prism CT scanner at 6 different dose levels by modifying the tube current (100/200/300/400/500/600 mA). Images were reconstructed using AiCE (Standard level), FBP, and AIDR-3D algorithms. CTDIvol and DLP were recorded from dose report and effective dose (ED) was calculated. Parameters such as noise (SD), signal-to-noise ratio (SNR), and contrast-to-noise ratio (CNR) were calculated for image quality evaluation.

Results
Effective dose ranges from 1.25 to 7.80 mSv. In comparison with the FBP algorithm, the noise reduction in AiCE images ranged from 34.72% to 39.72%, depending on the x-ray tube current, while in the case of the iterative reconstruction algorithm AIDR-3D, the reduction varied from 32.50% to 36.63% (Table 1). The SNR and CNR values were comparable in both AiCE and AIDR-3D images, while both parameters were higher compared to the FBP images (Figure 1).

Conclusion
The use of deep learning image reconstruction algorithms can reduce image noise, especially at lower doses, while improving image quality by increasing the SNR and CNR parameters. Additional measurements at lower exposures (<100 mA) are needed to explore the behaviour of AiCE algorithmon on radiation dose and image quality.

Table 1: Noise reduction (%) using AiCE and AIDR-3D algorithms compared to the FBP, for six different x-ray tube current values.

	Noise Reduction (%)					
Algori-thm	**100 mA**	**200 mA**	**300 mA**	**400 mA**	**500 mA**	**600 mA**
AiCE	39.72	36.70	34.73	35.50	34.72	35.57
AIDR-3D	36.63	34.41	32.54	32.87	33.14	32.50

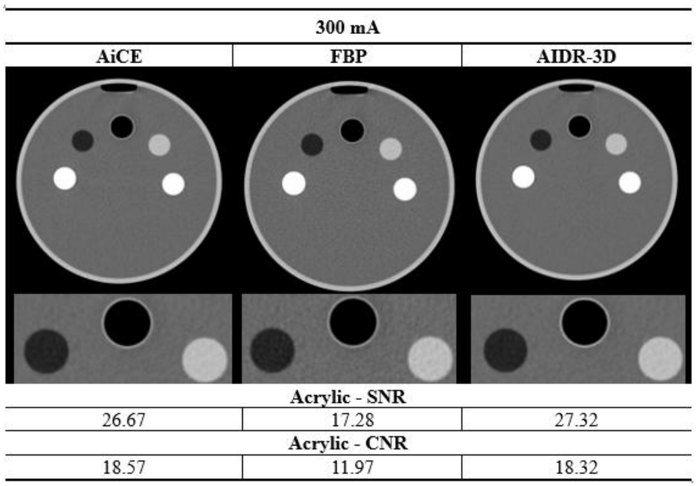

Figure 1. Reconstructed images acquired at 120 kVp and 300 mA using the AiCE, FBP, and AIDR-3D algorithms, respectively, along with the corresponding SNR and CNR values for the acrylic region of interest.

References
1. J. Greffier, Effect of a new deep learning image reconstruction algorithm for abdominal computed tomography imaging on image quality and dose reduction compared with two iterative reconstruction algorithms: a phantom study, Quant Imaging Med Surg 2022;12(1):229-243
2. Higaki et al., Deep Learning Reconstruction at CT Phantom Study of the Image Characteristics, Academic Radiology,Vol 27, No 1, January 2020

Keywords
Deep-learning image reconstruction algorithm, Computed Tomography, artificial Intelligence, Radiation Dose, Image Quality.

AGGREGATION-INDUCED EMMISION OF ANTICANCER NATURAL SUBSTANCES: NANOFORMULATION WITH RANDOM COPOLYMERS AND PHYSICOCHEMICAL STUDIES

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Introduction

Aggregation-induced emission (AIE) molecules are at the forefront of research as they present unique optical properties. These molecules in their aggregate state present enhanced emission and can be utilized in bioimaging applications [1]. Curcumin and quercetin are two natural substances that have been actively studied as anticancer agents. It has been proven that these molecules, upon encapsulation in polymeric nanoparticles, can be stabilized and enhance their emission. In this study, the synthesis and self-assembly study of an amphiphilic copolymer was carried out. Encapsulation of curcumin and quercetin was performed. Stability and physicochemical studies, and preliminary biocompatibility tests proved the successful formulation of nanocarriers [2].

Materials

Linear and statistical amphiphilic copolymers of poly(oligoethylene glycol methylether methacrylate-co-methyl methacrylate), P(OEGMA-co-MMA), were synthesized in varying comonomer ratios by controlled polymerization. Self-assembly studies were carried out in water. Curcumin and quercetin were loaded in the polymeric nanocarriers while preliminary biocompatibility was tested via the addition of fetal bovine serum in all copolymer-drug solutions.

Methods

Copolymer synthesis was carried out by reversible addition fragmentation chain transfer (RAFT) polymerization and confirmed with the Size Exclusion Chromatography (SEC), Proton Nuclear Magnetic Resonance Spectroscopy (^{1}H-NMR), and Attenuated Total Reflectance (ATR)-Fourier Transform Infrared (FTIR) Spectroscopy. Nanoformulations were prepared with the co-solvent protocol and studied with Dynamic Light Scattering (DLS), Electrophoretic Light Scattering (ELS), Fluorescence (FS), and UV–Vis Absorption Spectroscopy (UV–Vis).

Results

Copolymer characterization proved the successful synthesis of the materials with low polydispersity indexes. Self-assembly studies revealed the formation of nanoaggregates for all copolymers in water. The maximum encapsulation efficiency that was achieved for curcumin was 54%, and 49% for quercetin. The nanosystems proved to be stable for 20 days. Photophysical characterization confirmed the AIE phenomenon. FBS assays also showed no interaction between the nanocarriers and the proteins.

Discussion

MMA and OEGMA are two well-known and biocompatible monomers. The hydrophilic properties of OEGMA comonomer and the hydrophobic ones of MMA resulted in the self-assembly of the synthesized copolymers in water and the creation of nanoaggregates. The hydrophobic drugs were encapsulated in the hydrophobic domains of these nanostructures. Due to the entrapment of the drugs, the aromatic rings of these molecules were stabilized and aggregated, therefore the AIE phenomenon was observed.

Conclusions

Herein, we focused on the synthesis and self-assembly properties of these novel copolymers as well as on encapsulation studies for the drug molecules, which also show photophysical properties.

References

1. Pantelaiou, M.A.; Vagenas, D.; Karvelis, E.S.; Rotas, G.; Pispas, S. Co-Assembled Nanosystems Exhibiting Intrinsic Fluorescence by Complexation of Amino Terpolymer and Its Quaternized Analog with Aggregation-Induced Emission (AIE) Dye. *Nanomaterials* 2024, *14*, 1631, doi:10.3390/nano14201631.
2. Pantelaiou, M.A.; Vagenas, D.; Pispas, S. Poly(Oligoethylene Glycol Methylether Methacrylate-Co-Methyl Methacrylate) Aggregates as Nanocarriers for Curcumin and Quercetin. *Polymers* 2025, *17*, doi:10.3390/polym17050635.

Keywords: Amphiphilic random copolymers, Nanocarriers, Nanomedicine, Curcumin, Quercetin

ASSESING THE DOSIMETRIC EFFECT OF GOLDEN BEAM DATA AND MACHINE EQUIVALENCE IN VMAT AND IMRT TREATMENT PLANS

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Introduction

In radiotherapy Golden Beam Data (GBD) consist of measurements like Percentage Depth Dose (PDD), beam profiles, and output factors for various field sizes and energies, obtained under standardized conditions representing a “reference” linear accelerator (LINAC). The aim of this work is to assess the impact that the differences between measured data and GBD may have on the dosimetry of radiotherapy treatment plans.

Materials and Methods

The clinical aspect of the use of GBD was examined via the comparison of Dose Volume Histograms (DVH) for Planning Target Volumes (PTVs) and Organs At Risk (OARs) for 69 patients of different treatment sites (24 lung, 15 breast, 15 prostate and 15 head and neck cancer patients) based on Normal Tissue Constraint Guidelines. Originally delivered treatment plans of Attikon’s two LINACs (VB1, VB2) were recalculated using the Anisotropic Analytical Algorithm (AAA) for the simulated LINAC (VB3) and dose related parameters were analyzed and compared.

Results

The differences between VB1 and VB2 were insignificant (Fig. 1), a fact that confirms the equivalence of the LINACS. Furthermore, comparison with the VB3 showed differences in volumetric DVH parameters (Fig. 2).

Conclusion

While GBD provides a standardized approach to beam modeling, measured data could ensure increased accuracy, reducing possible dosimetric uncertainties. Careful validation of beam data selection is recommended to optimize clinical treatment quality.

Site	Structure	DVH Parameter	VB1-VB2	Initial-VB3
Lung	PTV	$D_{95\%}$	0,0338	0,0379
		V_{95}	1,0001	6,1672
	Lungs	D_{mean}	0,027	3,15
		V_{20}	4,6295	5,622
	Spinal cord	D_{max}	0,154	2,148
	Esophagus	D_{mean}	1,637	2,366
		V_{45}	1,0603	4,6745
		V_{60}	1,0317	9,8111
	Heart	V45	0,304	2,8106
		V_{60}	0,2147	2,4445
Breast	PTV	$D_{95\%}$	0,0209	0,0336
		V_{95}	0,2072	11,1669
	Lungs	D_{mean}	0,117	1,844
		V_{20}	0,8635	0,6787
		V_{25}	0,1346	0,7213
		V_{5}	0,7808	3,3583
		V_{5} contra	0,9889	1,389
	LAD	D_{max}	0,232	8,885
		D_{mean}	0,177	2,04
	Breast contra	D_{mean}	0,015	0,244
	Spinal cord	D_{max}	0,21	0,402
	Heart	D_{mean}	1,203	0,528
		V_{45}	0,2976	0,0948

Figure 1. Average dose differences between VB1-VB2 and initial machine-VB3 for treatment sites of lung and breast. The largest differences are highlighted.

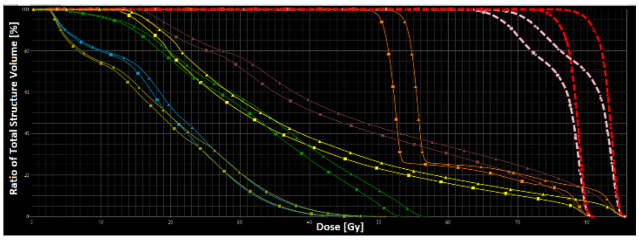

Figure 2. DVH curve comparison of a prostate plan calculated in VB1(■ points) and VB3(▲ points).

References

1. Beam modeling and beam model commissioning for Monte Carlo dose calculation-based radiation therapy treatment planning: Report of AAPM Task Group 157
2. Y. A. M. Yousif et al, “Golden beam data provided by linear accelerator manufacturers should be used in the commissioning of treatment planning systems”

Keywords: Radiation Therapy, Golden Beam Data, Dosimetry

SOFTWARE SOLUTIONS FOR SHIELDING CALCULATIONS IN RADIOTHERAPY ROOMS

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Introduction

Effective shielding in radiation therapy is crucial to protect staff and the public from harmful radiation. Linear accelerators produce high-energy beams that can penetrate walls, making proper shielding design essential. Shielding calculations determine barrier thickness based on radiation type, energy, and exposure conditions. Designing these shields must balance safety, cost, and space. Existing methods often prioritize dose estimation, but they tend to be complex and expensive, making them less accessible for smaller departments. This study aims to develop a user-friendly software tool for simplifying shielding calculations for radiotherapy rooms with linear accelerators, offering an accessible solution for radiation protection planning.

Materials and Methods

The "Radiotherapy Infrastructure Shielding Calculations" (RISC) software, developed in MATLAB, allows users to calculate shielding thicknesses without needing MATLAB installed. It features a user-friendly GUI with separate interfaces for primary and secondary barrier calculations. The primary barrier interface includes tabs for primary radiation, patient scattered and leakage radiation, IMRT techniques, and shielding cost. The secondary barrier interface offers tabs for scattered and leakage radiation, IMRT techniques, and shielding cost. RISC uses NCRP 151[1] methods to compute barrier thickness with concrete (density: 2.35 g/cm^3) for photon energies ranging from 4 to 30 MV. The software also estimates the cost of radiotherapy rooms with linear accelerators, supporting both conventional and IMRT techniques, and includes instantaneous dose rate (IDR) calculations. It comes with two supporting files: a "Terminology" document that defines the parameters and a "User's Manual" for detailed guidance.

Results

The RISC has been validated against all comparative examples in NCRP 151, as well as calculations from shielding reports for the Varian IX linear accelerator at Methodist Hospital of Willowbrook[2] and the Elekta Infinity at the University Hospital of Patras[3].

Discussion

The RISC software simplifies shielding calculations for primary and secondary barriers in radiotherapy rooms with linear accelerators, providing detailed and efficient results. Future updates will expand its capabilities to include various radiation treatments (IMRT, IGRT, VMAT, TBI), radiotherapy machines (gamma knife, cyber knife, Co-60), radiation types (photons, protons, electrons), and shielding materials (heavy concrete, steel, lead, earth, wood, BPE). Additional features will include calculations for maze door, skyshine, and groundshine radiation, along with graphical representations of barrier thicknesses. RISC is also a valuable educational tool for graduate students and medical physicists learning shielding calculations.

Conclusions

The RISC software is user-friendly, providing fast and accurate shielding thickness and cost calculations for primary and secondary barriers in radiotherapy rooms with linear accelerators using conventional or IMRT techniques. Validated against NCRP 151 examples and previous shielding reports, it is freely available online as a standalone application. With an intuitive GUI, RISC simplifies input parameter selection, making it useful for graduate education and assisting medical physicists in planning new radiotherapy facilities. As an open project, it will be periodically updated with new features, including additional treatments, machines, shielding materials, and specialized calculations for skyshine, groundshine, and maze door shielding.

References

1. NCRP Report No 151 (Bethesda, MD: National Council on Radiation Protection and Measurements) (2005)
2. Richardson, S., Shielding Calculation Report of Varian iX. Methodist Hospital-Willowbrook (2007)
3. RISC software. Available from: RISC Software - Google Drive

Keywords: Shielding, radiotherapy, radiation protection, software

INVESTIGATING THE STABILITY OF RADIOMIC FEATURES ACROSS DIFFERENT MRI FIELD STRENGTHS AND THE IMPACT OF HARMONIZATION TECHNIQUES

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Introduction

Radiomics analysis of prostate cancer (PCa) relies on MRI-derived quantitative features. Variations in magnetic field strength introduce scanner-related variability, potentially affecting feature stability. This study evaluates the robustness of radiomic features and the effectiveness of ComBat harmonization in mitigating field strength effects.

Material and Methods

We analyzed 207 PCa lesions (152 clinically significant, 55 insignificant) from local and PROSTATEx2 [1] datasets. Features were extracted from Original, Gradient, LoG, and Wavelet images. ComBat harmonization was used to address multicenter variability [2]. Stability across 1.5T and 3T MRI was assessed using p-values and Cohen's d. Normality was tested via Shapiro-Wilk; comparisons used t-tests or Mann-Whitney U accordingly. Effect sizes were interpreted as large ($d > 0.8$), small ($d < 0.2$), with significance at $p < 0.05$.

Results

Before ComBat harmonization, Wavelet features had the highest number of statistically significant differences (599), followed by LoG (209), Original (88), and Gradient (73), indicating substantial variability due to field strength effects. LoG-derived features exhibited the highest stability, whereas Gradient and Wavelet-derived features were the most unstable, demonstrating significant shifts. Applying Combat normalization dramatically improved stability by reducing the number of statistically significant features to 152 (Wavelet), 11 (LoG), 5 (Original), and 3 (Gradient).

Discussion

These findings emphasize the need for careful feature selection in radiomics studies [3]. The results suggest that Combat normalization is a good approach for harmonizing MRI-derived features across different field strengths. The high instability observed in Wavelet and Gradient features highlights the importance of considering scanner effects when selecting radiomic biomarkers.

Conclusion

ComBat harmonization enhances feature stability across MRI field strengths, supporting its application in multi-center radiomics studies. Future research should explore additional harmonization techniques to further improve reproducibility.

References

1. Litjens, G., Debats, O., Barentsz, J., Karssemeijer, N., & Huisman, H. (2017). SPIE-AAPM PROSTATEx Challenge Data (Version 2) [dataset]. The Cancer Imaging Archive.
2. Orlhac F, Eertink JJ, Cottereau AS, Zijlstra JM, Thieblemont C, Meignan M, Boellaard R, Buvat I.. (2022) A Guide to ComBat Harmonization of Imaging Biomarkers in Multicenter Studies, J Nucl Med., Feb;63(2):172-179.
3. Peerlings J., Woodruff H.C., Winfield J.M., Ibrahim A., Van Beers B.E., Heerschap A., Jackson A., Wildberger J.E., Mottaghy F.M., DeSouza N.M., Lambin P. (2019) Stability of radiomics features in apparent diffusion coefficient maps from a multi-centre test-retest trial, Sci Rep **9**, 4800

Keywords: Radiomics, Prostate cancer, MRI field strength, Feature stability, ComBat harmonization

Acknowledgements

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LOW GAMMA PASSING RATE ANALYSIS FOR VMAT AND IMRT TREATMENT PLANS

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Introduction

Patient Specific Quality Assurance (PSQA) is a standard procedure used to compare the calculated distribution with the delivered one. For this purpose, Gamma Passing Rate (GPR), Dose Difference (DD) and Distance to Agreement (DTA) metrics are commonly used. This study aimed to identify parameters syste-matically associated with low GPR values in VMAT and IMRT treatment plans for Head & Neck, Prostate, Lung and Breast cancer patients.

Materials & Methods

Radiotherapy treatment plans were categorized as "Low" or "High" GPR using institution-specific Tole-rance and Action Limits. Geometry and dose related metrics such as Plan Averaged Beam Area (PA), Edge Metric (EM) and Dose Rate (DR) among others were calculated and assessed for various treatment sites and irradiation phases. Correlation and statistical analyses were performed against GPR values, using the 3%/2mm and 2%/2mm DD/DTA criteria.

Results

Although no strong correlations were found, site- and irradiation phase-specific trends were observed. Statistical comparisons between "Low" and "High" GPR groups showed statistically significant differences in ce-rtain metrics values. ROC analysis and scatter plots suggested potential threshold values for metrics that could help flag plans more likely to fail.

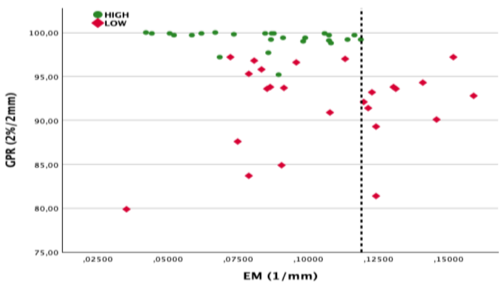

Figure 1. Scatter plot of EM which reflects the aperture complexity. Head & Neck low risk irradiation phase.

Table 1: ROC & Spearman's analysis for EM as a predictive metric for identifying low GPR plans.

Statistic	Value
Cutoff Point	0,119 mm^{-1}
Low GPR plans above cutoff	11/11
Sensitivity	0,440
Specificity	1
Positive Predictive Value	1
Area Under Curve (AUC)	0,702
r_s against GPR (2%/2mm) / p-value	-0,402 / 0,004

Conclusion

Correlation analysis revealed the direction of impact for several parameters. Further subcategorization of treatment plans, not only by treatment site but also by irradiation phase, revealed stronger correlations and clearer trends. It was observed that some parameters- although negatively affecting plan's deliverability (PSQA GPR value) might be compensated for by others with a positive impact, thereby weakening the observed correlations. Thus, further research and potentially further sub-categorization based on metrics' values may provide insights towards better understanding of deliverability's fluctuations.

References

[1] Miften, M. et al. Tolerance limits and methodologies for IMRT measurement-based verification QA: Recommendations of AAPM Task Group No.218 Med Phys 45, e53-e83 (2018).
[2] Younge, K.C. *et al.* Penalization of aperture complexity in inversely planned volumetric modulated arc therapy. *Med Phys* 39, 7160–7170 (2012).

Keywords:
Gamma Passing Rate, Patient-Specific QA, Complexity Metrics, Radiotherapy Plan Deliverability

Acknowledgment

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THE THERANOSTICS ERA: FROM TREATING WHAT YOU SEE TO SEEING WHAT YOU TREAT

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Introduction

Recent breakthroughs in medtech and radiopharma engineering have ushered in a new era of Nuclear Medicine-based personalized diagnosis and treatment. Theranostics, combining targeted radionuclide therapy with precise diagnostic processes, epitomizes precision care, promising long-term survival and cure within a multidisciplinary framework. While not a new concept, new tracers and advanced imaging systems have unlocked novel clinical strategies, offering advanced tools for targeted therapy and monitoring. In theranostics, patients are not imaged solely to detect metastatic disease but also to determine whether cancer cells express a specific therapeutic target, aiming a high therapeutic index with efficacy markedly surpassing toxicity. This work aims to present the theranostic pathway's conceptual framework and provide clinical evidence for its efficacy in neuroendocrine tumors (NETs) and prostate cancer.

Building a personalized treatment strategy

The fundamental principle of theranostics involves creating pharmaceutical targeting ligands that bind specifically to overexpressed biomarkers unique to each type of cancer (fig.1). Neuroendocrine tumors (NETs) overexpress somatostatin receptors (SSTRs), targeted by SSTR-ligands which are labeled with ^{68}Ga for PET/CT imaging and ^{177}Lu for therapy. Similarly, prostate tumors, overexpressing prostate-specific membrane antigen (PSMA), are imaged using ^{18}F- or ^{68}Ga-PSMA, and treated with ^{177}Lu-PSMA [1-2].

Advanced radiopharmaceutical engineering is required to produce a ligand that, on one end, perfectly matches the overexpressed biomarker and, on the other end, can be bound to different radionuclides through a linker chemical compound. Recent advances in cyclotron technology have given access to different PET/CT isotopes and have expanded the range of theranostic applications. Once the hot-radioactive isotope has been produced, sophisticated synthesis systems are employed to chemically bind the isotope (hot part) with the linker-ligand pair (cold part) and formulate the end theranostic product for imaging purposes

Modern PET/CT scanners, with advanced reconstruction algorithms, AI technologies, and ultra-sensitive detectors, leverage theranostic tracers in clinical practice. These systems enhance diagnostic confidence with sub-2mm spatial resolution and exceptional small lesion detectability, operating at low scan times and radiation doses, empowering physicians to 'treat what they see.' Post-therapy, patients are monitored using state-of-the-art SPECT/CT scanners, enabling doctors to 'see what they treat.' Advanced AI-powered dosimetry tools evaluate the radiotoxicity in sensitive organs to determine whether to continue, modify, or discontinue treatment.

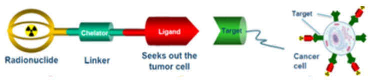

Figure 1. The development process of a theranostic tracer

The prostate Ca paradigm

Figure 2 shows the theranostic pathway of a 78-year-old prostate cancer patient with biochemical failure. The patient was imaged with 8 mCi of 18F-PSMA using a GE HealthCare OMNI Legend 32 PET/CT scanner (total time, 8 mins) to determine eligibility for 177Lu-PSMA therapy. Multiple metastatic lesions were detected, and 220 mCi of 177Lu-PSMA were administered in the first cycle. At 24 hours post-treatment, imaging with a CZT-based system (Discovery 870 CZT, GE HealthCare) was performed to monitor treatment and conduct dosimetry, assessing doses to critical organs and comparing against toxicity levels. All pathological lesions shown on PET/CT absorbed the Lu-PSMA, indicating a highly personalized treatment strategy.

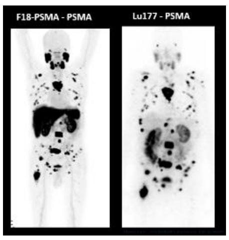

Figure 2. An example of advanced theranostics

Discussion

In the era of precision care, NM-theranostics require multidisciplinary advanced technology synergies to deliver great therapy outcomes.

References

1. Strosberg J et al. Phase 3 trial of (177)Lu-dotatate for midgut neuroendocrine tumors. N Engl J Med. 2017;376:125–35.
2. Emmett L et al. Lutetium177 PSMA radionuclide therapy for men with prostate cancer: a review of the current literature and discussion of practical aspects of therapy. J Med Rad Sci. 2017;64:52–60

Keywords: Theranostics, Precision Care, Personalized medicine

IS AI ENDING THE COMPROMISE BETWEEN DOSE AND IMAGE QUALITY? THE LUNG CT PARADIGM

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Introduction

While X-ray (XR) remains the frontline modality for assessing chest pathology, published evidence indicates that the 3D nature of CT imaging provides enhanced diagnostic confidence and increased clinical value. Taekker et al. reported that Ultra-low-Dose CT (ULDCT) is more sensitive than XR for detecting pneumonia and pneumothorax, and equally accurate for diagnosing cardiogenic pulmonary edema and pleural effusion [1]. Kroft et al. highlighted ULDCT's value, showing a 20% reduction in false-positive and false-negative XR results [2]. Gheysens et al. (2022) demonstrated ULDCT's efficiency in detecting solid lung nodules (> 50 mm³) in lung cancer screening, regardless of patient size [3]. Despite the significant advantages of CT imaging over XR, the radiation dose burden remains a matter of concern. A novel deep learning-based image reconstruction (DLIR) algorithm, Truefidelity™ (TF), has been recently introduced in GE HealthCare CT systems, featuring a DNN trained with high quality FBP datasets to learn how to differentiate noise from signals, and to intelligently suppress the noise without impacting anatomical and pathological structures. The objective of this study was to investigate whether the implementation of TF on a GE HealthCare Revolution APEX CT scanner can reduce thorax CT radiation doses to XR levels, while preserving the superior diagnostic quality inherent to 3D CT imaging over planar imaging.

Methodology

A series of scans with varying exposure parameters (kV, pitch), DLIR strengths (low, medium, high), and edge enhancement filters (E1-E3) were conducted on a 39.7 cm chest region of a CT whole body phantom (PBU-60, Kyoto Kagaku). All scans used a fixed current of 10 mA, keeping CTDIvol below 0.3 mGy. Image quality was subjectively evaluated based on the “European Guidelines on Quality Criteria for Computed Tomography”, and the top-ones qualified for objective IQ evaluation based on Contrast-to-Noise (CNR) metrics and dose-independent figures of merit (FOMs). To this end, regions of interest (ROIs) of 0.5 cm² were drawn bilaterally in the anterior, middle, and posterior lung parenchyma of the Kyoto phantom, to measure CTlung,mean (HU) and SDlung. Similar ROIs were placed in the right inferior pulmonary vein and left ventricle to assess CTpv and CTheart, respectively. The parameters yielding the best combination of subjective and objective image quality (IQ) were assessed, and then applied in clinical practice**.**

Results

For lung parenchyma imaging, helical acquisitions obtained at 140 kV, 10 mA, with a pitch of 1.375 and reconstructed at 0.625 mm slices with TF at high strength provided the highest CNR and recorded a top-5 performance on the dose-independent FOM. These scan parameters resulted in a striking 0.2 mGy CTDIvol, reducing the radiation risk to an effective dose of 0.117 mSv. For mediastinum imaging, axial scans at 120 kV, 10 mA reconstructed at 0.625 mm slices with TF at high strength demonstrated the top performance at 0.21 mGy CTDIvol, and an effective dose of 0.12 mSv.

Discussion

DLIR reconstructed images provide enhanced 3D diagnostic insights, reaching the global mean effective dose of a complete chest X-ray (UNSCEAR) and reducing lung CT radiation risk below the mean effective dose of a planar chest X-ray in Greece (0.13 mSv).

Conclusions

Deep learning has enhanced diagnostic confidence by providing much richer information to doctors reviewing chest images with the 3D data of CT at dose levels comparable to 2D imaging. While ending the trade-off between dose and image quality is challenging, ongoing research promises a bright future in CT imaging.

References

[1] Tækker M et al. Diagnostic accuracy of ultra-low-dose chest computed tomography in an emergency department. Acta Radiol. 2022;63(3):336-344.
[2] Kroft LJM et al. Added Value of Ultra-low-dose Computed Tomography, Dose Equivalent to Chest X-Ray Radiography, for Diagnosing Chest Pathology. J Thorac Imaging. 2019; 34(3):179-186.
[3] Gheysens G et al. Detection of pulmonary nodules with scoutless fixed-dose ultra-low-dose CT: a prospective study. Eur Radiol. 2022; 32(7):4437-4445

Keywords:
TrueFidelity, Deep Learning, lung/thorax CT screening, ULD

TOPICS

- Biomaterials
- Biomedical Modelling
- Bioinformatics

- Βιοϋλικά
- Βιοϊατρική μοντελοποίηση
- Βιοπληροφορική

HEMODYNAMIC AND ANATOMIC EFFECTS OF THE ANTERIOR CEREBRAL ARTERY IN ANEURYSM FORMATION

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Introduction

Cerebral aneurysms affect 0.5–6% of the population, with 31–35% located in the anterior communicating artery (ACoA), exhibiting a higher rupture risk. Rupture can lead to severe complications and even death. Hemodynamic factors, especially wall shear stress (WSS), are strongly linked to aneurysm formation, progression, and rupture [1], [2]. Clinical challenges in prognosis, treatment, and rupture risk assessment serve as the main motivation for this study, which aims to identify hemodynamic and geometric parameters related to the formation of ACoA aneurysms through computational fluid dynamics (CFD).

Methods

Three-dimensional models of the ACoA region were reconstructed from time-of-flight magnetic resonance angiography images of seven healthy individuals and seven patients with ACoA aneurysms [3]. Blood flow was modeled as laminar and Newtonian with a density of 1060 kg/m3, and viscosity of 0.0035 Pa·s. Boundary conditions included rigid and non-slip walls, zero pressure conditions at the outlets and both steady and transient velocity at the inlets [2]. The primary hemodynamic parameters analyzed included wall shear stress (WSS) and static pressure. Statistical analysis of the results was also performed. The workflow of the study is shown in Fig. 1.

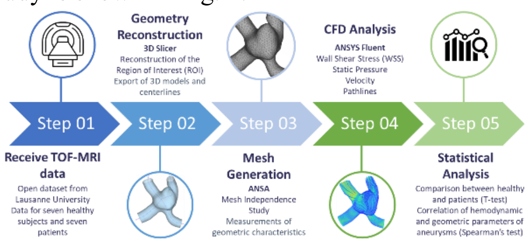

Figure 1. Workflow of the study.

Results

The results demonstrated statistically significant lower WSS values in the aneurysm area compared to the corresponding area in healthy models, as is shown in Fig. 2a where the time-averaged WSS (TAWSS) in the case of transient flow is presented. Among the geometric parameters, only the angle between the segments A1 and A2 of the anterior cerebral artery (ACA) showed statistical significance, with a smaller angle correlating with aneurysm presence. Statistical correlation analysis of hemodynamic and geometric parameters of the aneurysms showed that the left angle between A1 and A2 is positively related to WSS (Fig. 2b), indicating the effect of parent artery anatomy on the hemodynamics of the aneurysms.

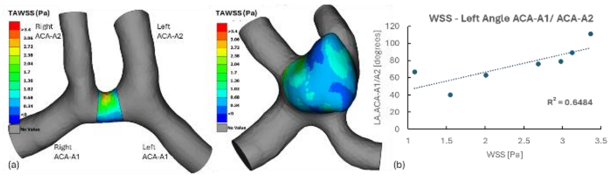

Figure 2: a) TAWSS contour plots b) correlation of left angle ACA-A1/A2 with WSS in steady-state flow.

Conclusions

A statistically significant difference was found between the two groups in WSS and the angle between the A1 and A2 segments, highlighting key factors in aneurysm formation. These findings may enhance early detection and inform treatment strategies.

References

1. P. Texakalidis, A. Sweid, N. Mouchtouris, et al. (2019) Aneurysm Formation, Growth, and Rupture: The Biology and Physics of Cerebral Aneurysms, World Neurosurg., 130: 277-284.
2. F. Liang, X. Liu, R. Yamaguchi, and H. Liu (2016) Sensitivity of flow patterns in aneurysms on the anterior communicating artery to anatomic variations of the cerebral arterial network, *J Biomech.*, 49(15): 3731-3740.
3. T. Di Noto, G. Marie, S. Tourbier, Y. Alemán-Gómez, O. Esteban, G. Saliou, M. Bach Cuadra, P. Hagmann, and J. Richiardi (2022) Lausanne_TOF-MRA_Aneurysm_Cohort, OpenNeuro. [Dataset]

Keywords: Cerebral Aneurysm, Anterior Communicating Artery, Anterior Cerebral Artery, CFD, Wall Shear Stress

ANGIOPLASTY BALLOON DEPLOYMENT IN 3D RECONSTRUCTED ARTERIES

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Introduction

Cardiovascular diseases (CVDs) are the leading cause of mortality globally, primarily driven by atherosclerosis. Drug Eluting Balloons (DEBs) offer an emerging alternative to stents by delivering antiproliferative agents without leaving permanent implants.

Materials and Methods

Seven swine coronary arteries were reconstructed using inSilc software from Optical Coherence Tomography (OCT) and angiography data. A detailed mesh was created for both the balloon and arterial wall using ANSYS. The balloon was modeled as a linear elastic polyamide structure (Grilamid L25[1]), while the artery was assigned Mooney-Rivlin hyperelastic properties. Simulations included folding and pleating, followed by balloon deployment using clinically pressure profiles (0.8–1.2 MPa [2]). Frictional coefficients (μ=0.2) were considered between the balloon and the arterial wall.

Table 1: The mechanical properties used.[1], [3]

Geometry	Parameter	Value
Balloon	Young's Modulus	1100 (MPa)
	Poisson ratio	0.4
	Density	1010 (Kg/m^3)
Artery	C_{10}	0.7 (MPa)
	C_{01}	4.5 (MPa)
	D_1	0.0003 (1/MPa)

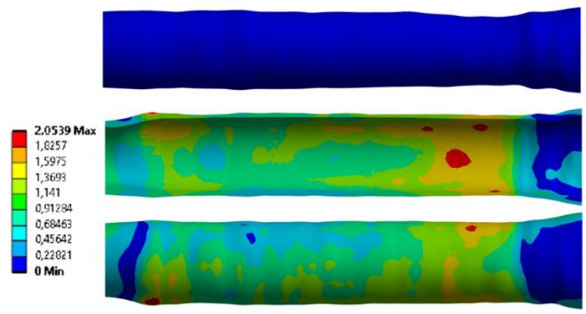

Figure 1: The Von mises stresses distribution.

Results

Simulations showed consistent performance in luminal expansion without excessive stress on the arterial wall. Maximum stress remained below 2.5 MPa. The DEB's compliance matched the manufacturer's chart. Stress distribution analysis indicated that stenosed regions experienced the most mechanical remodeling. Strain values remained within physiological tolerance, with no simulated tissue rupture or delamination.

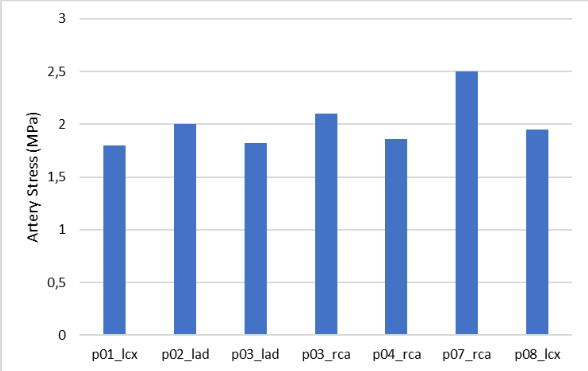

Figure 2: The max Von Mises stress in all cases.

Conclusion

The *in silico* deployment framework effectively assessed the Everolimus DEB's performance in realistic coronary artery models. Results highlight its safety and mechanical reliability for Percutaneous Transluminal Coronary Angioplasty (PTCA).

References

[1] M. A. Geith et al., "Experimental and mathematical characterization of coronary polyamide-12 balloon catheter membranes," PLoS ONE, vol. 15, no. 6, Jun. 2020, doi: 10.1371/journal.pone.0234340.
[2] C. S. Katsouras et al., "Safety and Efficacy of an Innovative Everolimus-Coated Balloon in a Swine Coronary Artery Model," Life, vol. 13, no. 10, Art. no. 10, Oct. 2023, doi: 10.3390/life13102053.
[3] C. Noble et al., "Patient specific characterization of artery and plaque material properties in peripheral artery disease," J. Mech. Behav. Biomed. Mater., vol. 101, p. 103453, Jan. 2020, doi: 10.1016/j.jmbbm.2019.103453.

Keywords:
Drug Eluting Balloon, Finite Element Analysis, Coronary Artery Disease

Acknowledgement

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MACHINE LEARNING MODELS FOR LONG-TERM CARDIOVASCULAR AND RELATED EVENTS PREDICTION: A MULTI-STUDY COMPARATIVE ANALYSIS

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Introduction

Cardiovascular disease (CVD) remains the leading cause of death worldwide [1]. This work synthesizes findings from nine independent studies employing machine learning (ML) to predict major CVD-related outcomes, including myocardial infarction (MI), stroke, heart failure (HF), atrial fibrillation (AF), and peripheral vascular events, over 5-20 follow-up periods.

Materials and Methods

All analyses used clinical and laboratory data from the Ludwigshafen Risk and Cardiovascular Health (LURIC) study and the German Epidemiological Trial on Ankle Brachial Index (getABI). ML models were implemented, including Logistic Regression (LR), Support Vector Machines, Random Forest (RF), eXtreme Gradient Boosting (XGBoost), Light Gradient Boosting Machine (LightGBM) and Decision Trees. Pre-processing involved imputation, standardization, feature selection, and hyperparameter tuning. Performance metrics included Accuracy, Area Under the Receiver Operating Characteristic Curve (AUC), Sensitivity, Specificity, Precision and F1-score. The best performing model was selected based mainly on the highest accuracy. In cases of comparable accuracy, models with higher AUC and interpretability were prioritized.

Results

Each study identified a best-performing ML model specific to the clinical endpoint under investigation. Table 1 summarizes the highest performing model from each study, with XGBoost and LightGBM consistently demonstrating superior predictive ability. Notably, the highest accuracy (87.56 %) was achieved by LightGBM in the prediction of CVD/cerebrovascular mortality.

Conclusions

This work demonstrates the potential of ML-based tools to enhance CVD – risk prediction and enable earlier, more tailored interventions. Performance varied across endpoints, with simpler models occasionally matching the performance of more complex ones, highlighting the importance of outcome-specific model selection. Limitations related to cohort-specific characteristics and potential variability in endpoint definitions-may affect the generalizability of the findings and should be addressed in future research.

Table 1: Best Performing Ml Models Across Studies.

Outcome (follow-up)	Best model	Accuracy
All-cause mortality (20 years)	XGBoost	76.00 (%)
MI (10 years)	XGBoost	74.27 (%)
CVD Death (10 years)	LR	72.20 (%)
Stroke (7 years)	LightGBM	68.00 (%)
Amputation/Revascular ization (7 years)	RF	73.27 (%)
Fatal MI (10 years)	LightGBM	69.42 (%)
CVD/Cerebrovascular mortality (7 years)	LightGBM	87.56 (%)
AF (7 years)	XGBoost	71.19 (%)
HF (5 years)	LightGBM	68.00 (%)

References

[1] ‘World Health Organization. Cardiovascular diseases (2023)’. Accessed: Apr. 21, 2025. [Online]. Available: https://www.who.int/health-topics/cardiovascular-diseases

Keywords:
Cardiovascular diseases, Machine Learning, Prediction

Acknowledgement
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4D FLOW MRI-ENABLED PATIENT-SPECIFIC COMPUTATIONAL HEMODYNAMICS OF THORACIC AORTA: CFD PREDICTIONS vs. IN VIVO IMAGING DATA

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Introduction

4D Flow MRI enables in vivo, time-resolved, three-directional velocity measurements but has spatial and temporal resolution limitations. Computational fluid dynamics (CFD) simulations may complement MRI by providing patient-specific hemodynamic predictions [1]. This study compares CFD simulations with 4D Flow MRI data to evaluate the accuracy of CFD in replicating in vivo hemodynamics, employing patient-based MRI-derived aortic geometry and boundary conditions.

Methods

Anonymized 4D Flow MRI data, including magnitude (anatomical) and phase (velocity) images across three velocity encoding directions, were acquired from a normal volunteer. The transient velocity field was reconstructed using Ferdian et al. [2], generating 4D velocity arrays (u, v, w) across all cardiac time steps (t). The magnitude images were used to reconstruct the 3D model of the thoracic aorta (TA). Blood flow simulations were conducted in both SimVascular and CRIMSON software using the same TA model, boundary conditions, and solver settings. The blood velocity profile at the inlet surface was reconstructed from the 4D Flow MRI data and was applied as boundary condition. Three-element Windkessel models were attached at the outlets. The resistance and compliance values were iteratively tuned to achieve physiological pressure. Pressure distribution, flow rates, and wall shear stress (WSS) were calculated. CFD data were reconstructed into 4D arrays, downsampled [2] to match MRI resolution, and aligned for direct comparison. A descending aorta cross-section was analyzed, computing mean velocity mangitude for comparison.

Results & Discussion

Similar flow conditions are predicted by both programs, though CRIMSON exhibits slightly higher velocities and some differences in velocity distribution along the flow domain. MRI comparisons show that while both software tools capture major flow trends, minor discrepancies appear in velocity magnitudes and flow oscillations, particularly in the aortic arch region. Rigid-wall assumption contributes to overestimated systolic velocities and diastolic fluctuations.

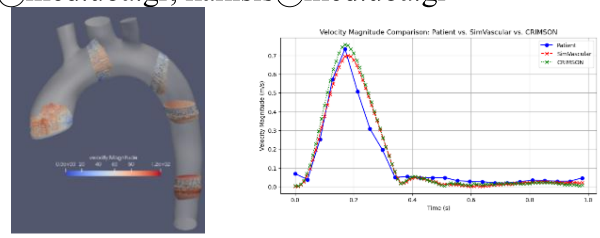

Figure 1. Velocity vectors at peak systole by CFD (left). Time-resolved mean velocity magnitude at a descending aorta cross-section: MRI vs SimVascular vs CRIMSON comparison (right)

Conclusions

Patient-specific inlet conditions are essential for replicating physiological flow dynamics, as they more accurately capture realistic flow patterns and WSS variations, than parabolic profiles, which overestimate velocities and introduce extra discrepancies. This approach enables disease progression prediction through WSS analysis and supports virtual testing of interventions. Future work should integrate FSI to improve physiological realism and refine boundary condition calibration for more accurate hemodynamic parameters.

References

1. L. Shahid, et al. (2022) Enhanced 4D Flow MRI-Based CFD with Adaptive Mesh Refinement for Flow Dynamics Assessment in Coarctation of the Aorta. Annals of Biomedical Engineering, 50:1001–16
2. E. Ferdian, A. Suinesiaputra, et al. (2020) 4DFlowNet: Super-Resolution 4D Flow MRI Using Deep Learning and Computational Fluid Dynamics. Frontiers in Physics, 8:138

Keywords:
4D Flow MRI, Computational Hemodynamics, Aortic Flow, Patient-Specific Modeling

Acknowledgements

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DISSECTION MECHANICS OF TISSUE COMPONENTS IN HUMAN AORTA

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Introduction

The study of the mechanical properties of the aneurysmatic ascending aorta is of significant clinical and scientific interest due to its role in systemic circulation and the risk of dissection or rupture. The focus of this research is the examination of the mechanical properties of the aortic wall under radial tensile stress, specifically to explore how the different layers respond to rupture propagation.

Materials and Methods

74 samples were collected from 12 patients (33– 76 yr) at Hygeia Hospital. The experimental procedures were conducted at the Center of Clinical, Experimental Surgery & Translational Research (BRFAA). The number of specimens depended on the size of the tissue, with the left lateral quadrant yielding the fewest samples due to its morphology. For the mechanical testing [1], a fully automated tensile testing machine was used, equipped with a force cell with a maximum load of 500g. The sampling frequency of the machine is set at 10Hz.

Results

The graph presents the maximum force (F_{max}) values in grams for both inner and outer layers across different anatomical regions of the aortic wall: anterior, right lateral (rl), posterior, and left lateral (ll). F_{max} represents the maximum force the tissue can withstand before failure. Notable differences are observed between the inner and outer layers across the two areas. The anterior and left lateral regions were grouped together, as were the posterior and right lateral regions, due to their shared biomechanical properties in the aortic wall.

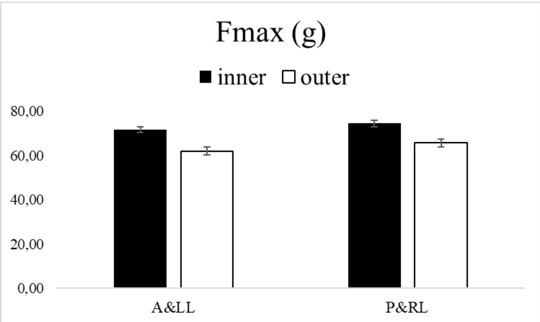

Figure 1. Comparison of F_{max} (g) across aortic wall regions and layers.

Discussion

The study found that the intima-media interface exhibits significantly higher mechanical resistance, with greater F_{max} and elastic modulus values compared to the media-adventitia interface, indicating that the inner layers of the aorta are stronger and more resistant to rupture. These findings align with previous studies [2] that have demonstrated the mechanical vulnerability of the media-adventitia interface. Furthermore, regional differences were observed, with the posterior and right lateral regions exhibiting higher mechanical resistance compared to the anterior and left lateral regions, suggesting that the structural integrity of the aorta varies across different anatomical locations.

Conclusion

The findings highlight the critical role of the intima-media interface in maintaining the mechanical stability of the aortic wall, as well as the vulnerability of the media-adventitia interface to rupture initiation. The regional differences observed in this study also underscore the importance of considering anatomical location when assessing rupture risk. By integrating these findings with existing literature, this study contributes valuable data to the field and provides a foundation for future research aimed at improving the diagnosis and treatment of aortic aneurysms.

References

1. Sommer, G., Gasser, C., Regitnig, P., Auer, M., & Holzapfel, G. (2008). Dissection Properties of the Human Aortic Media: An Experimental Study. Journal of Biomechanical Engineering, 130.
2. Tong, J., Sommer, G., Regitnig, P., & Holzapfel, G. (2011). Dissection Properties and Mechanical Strength of Tissue Components in Human Carotid Bifurcations. Annals of Biomedical Engineering, 39(6), 1703-1719.

Keywords: Ascending aorta, aortic wall, aortic aneurysm, aortic dissection, rupture propagation, tensile testing

Acknowledgement

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STRUCTURAL MODELLING AND SIMULATION OF ABDOMINAL AORTIC ANEURYSMS ACCOUNTING FOR INTRALUMINAL THROMBUS AND CALCIFICATIONS

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Introduction

Abdominal aortic aneurysms (AAAs) constitute a pathology of the aorta, which is characterized by a permanent increase in diameter. Although this pathology is well known, the factors influencing its development as well as the likelihood of vessel rupture remain highly unclear. In the present study, the influence of intraluminal thrombus (ILT) and calcifications is examined in the intense response of the arterial wall under normal loading conditions. The purpose of this process is to assess the role of each co-developing vascular pathology in the development of an index for estimating rupture risk.

Materials & Methods

Based on the segmentation of computed tomography images, a 3D geometry of the AAA is created. The inability to capture the aneurysmal wall in computed tomography introduces challenges in constructing the overall aneurysm geometry. Therefore a new in-house software is used to integrate the patient-specific 3D geometry of calcifications within the aneurysmal wall, accurately simulating the real case. As a result a finite element analysis-compatible model is created, consisting of spatial meshes of three distinct entities (ILT, calcifications and aortic wall) [1]. For the aneurysmal wall a transversely isotropic hyperelastic Holzapfel–Gasser–Ogden nonlinear material is applied. The ILT is modeled through an isotropic linear elastic material, and lastly for the calcifications a brittle material model is adopted [2]. An intraluminal pressure equal to the mean systolic pressure under normal conditions (80 mmHg) is applied, while the geometry is fixed on its distal and proximal ends.

Results & Discussion

The deformation and developing stresses within the wall, thrombus, and calcifications are calculated. The stress concentrations and their maxima across the entire extent of the wall are evaluated. It is evident that the locations of the stress maxima on the ILT and aneurysm wall surface, are not altered by the intraluminal pressure increase. Regarding the ILT, the highest values of stress are observed on the boundaries of the thrombus, where its thickness is minimized. The stress fields along the wall's surface are modified in the case of integrating or removing the calcifications in the modeling process. There is evidence that the presence of calcifications in the aneurysmal wall can dictate high stress localization.

Conclusions

Following the analysis of the results, it is concluded that calcifications significantly influence local stress concentrations. In conjunction with the thrombus, which acts as a stress-relieving factor for the wall, it becomes evident that the stress distribution is significantly altered by the introduction of these factors.

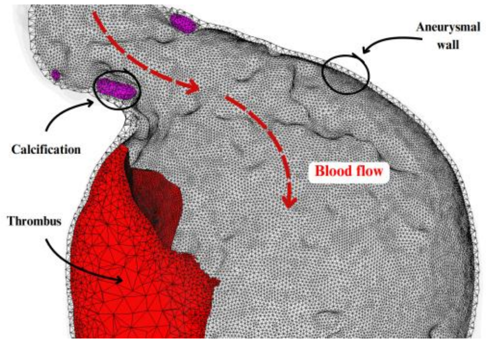

Figure 1. Meshing of aneurysmal wall (white), intraluminal thrombus (red) and calcification (pink).

References

1. P. Sarantides, A. Raptis, D. Mathioulakis, K. Moulakakis, J. Kakisis and C. Manopoulos (2024) Computational Study of Abdominal Aortic Aneurysm Walls Accounting for Patient-Specific Non-Uniform Intraluminal Thrombus Thickness and Distinct Material Models: A Pre- and Post-Rupture Case. Bioengineering, 11:144
2. C. Luo, X. Yang and J. Li (2022) Mechanical Properties of Single-Crystal Calcite and Their Temperature and Strain-Rate Effects. Materials, 15:4613

Keywords: Abdominal aortic aneurysm, ILT, calcification, rupture risk, Finite element analysis

Acknowledgement

This research was carried out within the framework of the Action "Flagship actions in interdisciplinary scientific fields with a special focus on the productive fabric", which is implemented through the National Recovery and Resilience Plan Greece 2.0, funded by the European Union – NextGenerationEU (Project ID: TAEDR-0535983).

EXPLORING STATE-OF-THE-ART DEEP LEARNING ARCHITECTURES FOR BLOOD FLOW PREDICTION IN PATHOLOGICAL VESSELS

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Introduction

Accurate hemodynamic assessment is vital for understanding vascular disease progression. While computational simulations provide non-invasive evaluations, they require individual runs for similar anatomies and significant expertise and resources. Accelerating these simulations for real-time analysis could improve clinical decision-making. This study investigates deep learning architectures to predict hemodynamic fields in vascular pathologies.

Materials & Methods

A physics-informed neural network (PINN) architecture was employed for hemodynamic predictions in 2D geometries of vessel stenosis. A multi-case PINN strategy was employed, in accordance with [1]. The PINN was trained without the use of labeled data, utilizing the parameterized incompressible steady state Continuity and Navier-Stokes equations. The degree of stenosis was set to vary from 20% to 60%, and Reynolds number (Re) from 500 to 2000. To measure the accuracy, computational fluid dynamics (CFD) ground truth data were generated using COMSOL.

Moreover, a graph neural network (GNN) architecture was employed for hemodynamic predictions in 3D abdominal aortic aneurysm (AAA) geometries. A large training set of synthetic hemodynamic data was created, employing 3D patient-based AAA models from the repository of the SAFE-AORTA project and performed 3D transient hemodynamic simulations in SimVascular. To ensure the training set had sufficient variability, we applied varying flow rate inputs and resistance-compliance output parameters. The GNN was trained to predict velocity, pressure and wall shear stress (WSS) fields at peak systole, as well as the time averaged wall shear stress (TAWSS). To overcome the scalability limitation of MeshGraphNets, our model partitions large input graphs into smaller subgraphs to reduce training memory overhead [2].

Results & Discussion

Overall, the PINNs achieve very low errors but also fail to capture details in the hemodynamic field after the stenosis which may hide within accuracy metrics that are more general by design. Moreover, it was found that the biggest error in velocity prediction occur for higher stenosis degree and lower Re (Figure 1). On the contrary, pressure prediction accuracy drops for bigger Re but increases for bigger degrees of stenosis.

The partitioned GNN architecture seems to maintain the predictive accuracy of full-graph GNNs while substantially enhancing the scalability. Increased accuracy has been achieved for the prediction of hemodynamic quantities of interest on unseen patient geometries at a fraction of the time that a conventional simulation requires

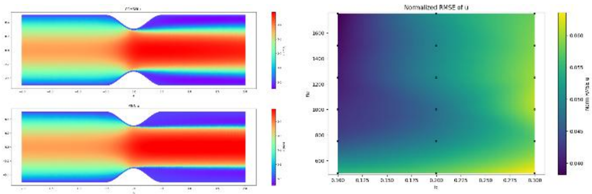

Figure 1. PINN vs CFD for u velocity with stenosis degree =40% and Re=750. Normalized root mean squared error of u velocity for various stenosis degrees and Re.

Conclusions

Multi-case PINNs enable a single training process to handle various geometries and flow conditions, but the accuracy is limited, locally at the stenosis area. The partioned GNN seems to be a more efficient DL architecture for hemodynamic predictions. A combination of the two architectures will be tested in the future.

References

1. H. S.Wong, W. X. Chan, B. H. Li and C. H. Yap (2024) Strategies for multi-case physics-informed neural networks for tube flows: a study using 2D flow scenarios. Scientific Reports, 14:11577.
2. M.A. Nabian, C. Liu, R. Ranade and S. Choudhry (2024) X-MeshGraphNet: Scalable Multi-Scale Graph Neural Networks for Physics Simulation. arXiv preprint. arXiv:2411.17164

Keywords: Pathological vessels, Hemodynamics, Physics informed neural networks, Graph neural networks

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MODELING OF THREE-DIMENSIONAL SCAFFOLDS FOR BONE REGENERATION USING CFD ANALYSIS

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Introduction

Bone tissue regeneration is one of the largest challenges in regenerative medicine, particularly for large defects where natural healing is not successful. Conventional strategies are not effective, and new strategies are required. Tissue engineering (TE) combines biology and engineering to create scaffolds to promote bone healing. In this work, Computational Fluid Dynamics (CFD) is employed to model and optimize 3D scaffolds for bone regeneration. It simulates fluid flow through different scaffold geometries, analyzing the effect of inlet velocities on significant parameters. Two scaffold models, "PCL-50" and "PCL-250," with different strut architecture and porosity, were compared at inlet velocities 0.05, 0.1, and 0.5 mm/s. [1], [2], [3]

Materials and Methods

CFD simulation was performed employing ANSYS 16.2 software. The Navier-Stokes and the continuity equations were employed to simulate pressure, velocity, WSS, and permeability within the scaffold regions. The fluid was defined as cell culture media. A no-penetration boundary was applied to the scaffold surface, and an outer fluid domain minimized boundary effects. Three inlet velocities (0.05, 0.1, and 0.5 mm/s) were tested assuming zero outlet pressure [3].

Results

Results showed that scaffold architecture plays an important role compared to inlet velocity in influencing permeability and WSS distribution. Between the two models, the "PCL-50" scaffold had higher permeability and higher WSS values, which are favorable to increased cell proliferation and bone tissue growth. On the other hand, the "PCL-250" scaffold had lower fluid flow within its pores. The results are in agreement with current experimental findings, confirming the effectiveness of the CFD-based method in assessing scaffold performance. In addition, in this work we can emphasize the importance of scaffold geometry design to enhance biophysical indications essential for tissue regeneration. Larger WSS zones, particularly around the unit cell junctions in the "PCL-50" design, reflect regions of enhanced mechanical stimulation, which is important for osteogenic differentiation.

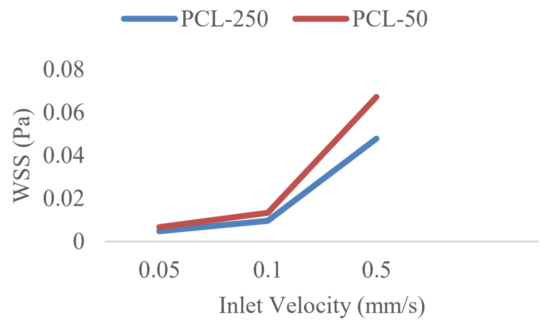

Figure 1. WSS distributions in the "PCL-250" and "PCL-50" scaffolds. The distributions were induced by an inlet velocity 0.5, 0.1 and 0.05 mm/s.

Conclusion

This approach provides significant insight into scaffold geometry and flow condition impacts on biological performance The "PCL-50" scaffold showed the best permeability, similar to human bone, though inlet velocity variations had little impact. Permeability is crucial for osteogenesis and vascularization. WSS was mainly influenced by scaffold architecture, with a linear relationship to fluid flow rate. Higher WSS in the "PCL-50" scaffold supports better cell adhesion, proliferation, and osteogenic differentiation, promoting bone growth [2], [3].

References

[1] S. Zhang, et al., 'A review on the use of computational methods to characterize, design, and optimize tissue engineering scaffolds, with a potential in 3D printing fabrication', *J Biomed Mater Res*, vol. 107, no. 5, pp. 1329–1351, Jul. 2019
[2] D. Ali and S. Sen, 'Permeability and fluid flow-induced wall shear stress of bone tissue scaffolds: Computational fluid dynamic analysis using Newtonian and non-Newtonian blood flow models', *Computers in Biology and Medicine*, vol. 99, pp. 201–208, Aug. 2018
[3] N. Jusoh et al., 'CFD Simulation on Permeability of Porous Scaffolds for Human Skeletal System', *HumEnTech*, vol. 1, no. 1, pp. 39–47, Feb. 2022

Keywords
CFD analysis, Bone, scaffold, biomedical modeling

A PRELIMINARY COMPARISON OF UNSUPERVISED AND DEEP LEARNING APPROACHES FOR AUTOMATIC ABDOMINAL AORTIC ANEURYSM SEGMENTATION ON CT IMAGES

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Introduction

Abdominal Aortic Aneurysm (AAA) is a life-threatening condition with a high mortality risk if ruptured, often developing silently [1]. This study explores an unsupervised segmentation method based on image intensity patterns, comparing it to deep-learning models like TotalSegmentator [2] for improved AAA detection.

Material and Methods

The study includes 18 patients with AAA (≥40 mm) undergoing conservative treatment due to aneurysm size or surgical contraindications, regardless of cause, symptoms, or morphology. For AAA segmentation in CT images, the study combines conventional image analysis and deep learning. An in-house algorithm uses intensity-based and morphological operations to detect aorta without large training datasets. Additionally, the nnU-Net framework, TotalSegmentator [2], optimizes segmentation for high accuracy, allowing a comparison of traditional, feature-based, and AI-driven methods.

Results and Discussion

The results showed that TotalSegmentator slightly outperformed the proposed method in extracting the 3D aortic volume (Jaccard Index 0.763±0.261, Dice Index 0.828±0.255), while the unsupervised approach demonstrated better slice-wise segmentation accuracy when the aorta was visually distinct (Jaccard Index 0.772±0.183, Dice Index 0.855±0.155).

The discrepancy arises from cases where the aorta blends with neighboring structures; the proposed method struggles in such instances, whereas TotalSegmentator, trained to recognize anatomical structures, can infer plausible aortic shapes even when visibility is poor.

Conclusions

The findings highlight the potential of deep learning models to improve aorta segmentation and indicate that fusing training-free and deep models' segmentation could lead to a robust system of AAA detection and monitoring, enabling earlier, personalized interventions that reduce rupture risk and improve patient outcomes.

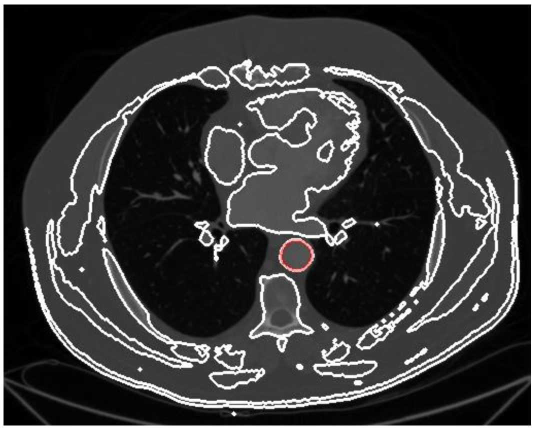

Figure 1. A CT slice depicting the segmented structures' boundaries in white and the ground truth one in red

References

1. Bobadilla, J. L. & Kent, K. C., (2012), Screening for abdominal aortic aneurysms. Adv.Surg. 46, 101–109
2. Wasserthal, J. et al., (2023), TotalSegmentator: Robust Segmentation of 104 Anatomic Structures in CT Images. Radiol. Artif. Intell. 5, e230024

Keywords:

X-ray CT, segmentation, aortic aneurysm

Acknowledgement

This research is carried out within the framework of the Action "Flagship actions in interdisciplinary scientific fields with a special focus on the productive fabric", which is implemented through the National Recovery and Resilience Plan Greece 2.0, funded by the European Union –NextGenerationEU (Project ID: TAEDR-0535983).

VISION TRANFORMER FOR THYROID ULTRASOUND IMAGE CLASSIFICATION

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Introduction

Thyroid nodule classification remains a significant challenge in medical imaging due to the variability in ultrasound images [1]. Vision Transformer (ViT) [2] have shown a promising potential for classification in biomedical imaging for diagnostic purposes. In this study, we apply a ViT model on the Algerian Ultrasound Images Thyroid Dataset (AUITD) for thyroid ultrasound classification.

Materials and Methods

The AUITD dataset [3] includes 1,472 benign, 1,895 malignant, and 171 normal thyroid ultrasound images from hospitals in Setif, Algeria, labeled by experts according to clinical standards. Due to the dataset's variability and imbalance, we employed a ViT-Tiny model pretrained on ImageNet, chosen for its ability to capture long-range dependencies more effectively than CNNs. Images were resized to 224×224, normalized, and augmented. Class imbalance was handled using a Weighted Random Sampler and Focal Loss. Training was conducted over 100 epochs using the Adam optimizer with OneCycleLR.

Results

The proposed model achieved a 98% overall test accuracy, with high precision and recall for benign and malignant cases. However, the normal thyroid class exhibited lower recall (14%), indicating further dataset balancing or augmentation techniques needed. The confusion matrix and classification report reveal the strengths and weaknesses of the approach, highlighting the necessity of additional data for rare cases.

Table 1: ViT classification performance.

	Precision (%)	Recall (%)	f1-score (%)	support
Benign	92	100	96	60
Malignant	99	100	99	292
Normal Thyroid	100	14	25	7
accuracy			98	359
macro avg	97	71	73	359
weighted avg	98	98	97	359

Discussion and Conclusion

This study shows that ViT is well-suited for thyroid ultrasound image classification, achieving 98% accuracy. Its global attention mechanism enables better handling of complex patterns compared to CNNs, especially for benign and malignant cases. However, performance remains limited for the underrepresented normal class. Future work will focus on data balancing and self-supervised methods to improve generalization.

References

[1] Gao, X., et al. (2022). Deep learning-based thyroid nodule classification in ultrasound images: A review of the methods and models. *Frontiers in Oncology*, 12, 888005.
[2] Chen, J., et al. (2023). Medical image classification with vision transformers: A comprehensive review. *Medical Image Analysis*, 84, 102707.
[3] Azouz, M., & Maroua, A. (2023). Algeria Ultrasound Images Thyroid Dataset (AUITD). Kaggle.Available at: https://www.kaggle.com/datasets/azouzmaroua/algeria-ultrasound-images-thyroid-dataset-auitd

Keywords:
Vision Transformer, Thyroid Ultrasound, Deep Learning, Medical Image Classification.

Acknowledgement

This study was supported by "the framework of the Action "Flagship actions in interdisciplinary scientific fields with a special focus on the productive fabric", which is implemented through the National Recovery and Resilience Fund Greece 2.0 and funded by the European Union—NextGenerationEU (Project ID: TAEDR-0535985).

THE HEMATOMA FLUID AND SERUM PROTEOMES OF CHRONIC SUBDURAL HEMATOMA PATIENTS

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Introduction
Chronic subdural hematoma (CSDH) is a common neurosurgical condition. Numerous lines of evidence indicate that the subdural fluid characterizing CSDH partly contains blood and its products. Previous research has also identified proteins putatively involved in CSDH pathophysiology [1]. Nevertheless, the proteome of CSDH remains poorly understood. Herein, we assessed and compared the hematoma fluid and serum proteomes of CSDH patients.

Materials and Methods
Hematoma and serum from 7 patients were analyzed using mass spectrometry-based proteomics. Data processing and t-tests were performed in Perseus, creating volcano plots with FDR set at 0.05 and S0 at 0.1. Gene Ontology (GO) analysis for the hematoma was conducted using Gorilla [2].

Results
789 proteins were identified. 502 passed quality filtering and were included in the final analysis. Of these, 499 were detected in hematoma fluid and 461 in serum, with 458 proteins shared between both sample types. 41 proteins were unique to hematoma, and 3 to serum. The analysis identified 182 proteins, 167 of which had significantly higher levels in hematoma compared to serum and 15 in serum (Figure 1).

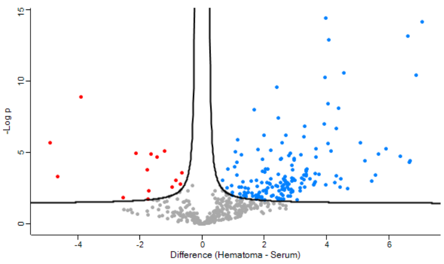

Figure 1. Volcano Plot Showing Differential Protein Expression in Hematoma vs. Serum

GO analysis indicated extracellular matrix organization and related terms as the most significantly enriched processes. Inflammatory pathways, including toll-like receptor and pattern recognition receptor signaling were also enriched. Coagulation and fibrinolysis related processes were also significantly represented. Additional highlighted pathways related to wound healing, vascular regulation, apoptosis, hormone/peptide secretion and the control of vascular tone and diameter.

Discussion
Enriched pathways related to matrix remodeling, innate immunity, and vascular regulation may underlie clinical features like membrane formation and postsurgical recurrence. Activation of toll-like receptor and cytokine signaling indicate inflammation and immune responses to blood degradation or injury. Coagulation and fibrinolysis pathways highlight ongoing hemostatic imbalance, while apoptotic and vascular terms reflect cell turnover and vascular instability. These processes are apparent during the postulated evolution of CSDH, from tissue repair and inflammation to bleeding and cycles of coagulation/fibrinolysis [1]. Overall, several pathways and related proteins indicated by the present data highlight potential novel targets for biomarker and therapeutic strategy development.

Conclusions
We provide state-of-the-art proteomic data on CSDH. While the serum and hematoma proteomes exhibit considerable overlap, qualitative and quantitative differences are apparent. Our findings can lead to further investigation into biomarkers and therapeutic targets in CSDH.

References
1. Edlmann E, et al. Pathophysiology of chronic subdural haematoma: inflammation, angiogenesis and implications for pharmacotherapy.J Neuroinflammation. 2017;14(1):108.
2. Eden E, et al. GOrilla: a tool for discovery and visualization of enriched GO terms in ranked gene lists. BMC Bioinformatics. 2009;10:48.
Keywords:
Chronic subdural hematoma, proteomics, biomarker, gene ontology

Acknowledgement: None

GLUCOSE CONTROL IN ARTIFICIAL PANCREAS SCHEME WITH PID AND PSO-OPTIMIZED PID CONTROLLERS

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Introduction

Type 1 Diabetes Mellitus (T1DM) patients are using artificial pancreas (AP) implementations [1], which aim to replace or support pancreatic functionality by regulating insulin production. A significant amount of research has been conducted to explore glucose control options for commercial applications employing PID-based control formulations [1] to optimize glucose production, particularly to insulin dosing calculation. This work presents an AP scheme using a continuous PID controller, which is shown to outperform rival particle swarm optimization (PSO) [2]-tuned PID control schemes in a case study also incorporating exogenous glucose disturbance.

Materials & Methods

Simulation has been performed in MATLAB/Simulink environment and includes the following parts:

I) Mathematical model for human body: T1DM patient is modeled by Bergmans' Minimal Model [1]

II) Continuous glucose monitoring sampled every 1 min outputting a running mean of 5 samples.

III) Insulin pump algorithm:

$$u(t) = Basal + \frac{G(t)-G_{targ}(t)}{ISF} \quad (1.1)$$

where $\frac{G(t)-G_{targ}(t)}{ISF}$ is bounded between 0 and $Bolus_{max}$.

IV) Continuous Parallel PID controller is described by:

$$PID = K_P e(t) + K_I \int_0^t e(t) + K_D \frac{de\,(t)}{dt} \quad (1.2)$$

V) PSO framework (ITAE and MAPE obj. functions):

$$v_i(t+1) = wv_i(t)c_1r_1\left(p_{best,i} - x_i(t)\right) + \cdots$$

$$\ldots c_2r_2\left(g_{best} - x_i(t)\right) \quad (1.3)$$

$$y_i(t+1) = \begin{cases} y_i(t), & if\ \boldsymbol{f}(x_i(t+1)) \geq \boldsymbol{f}(y_i(t)) \\ x_i(t+1), & if\ \boldsymbol{f}(x_i(t+1)) < \boldsymbol{f}(y_i(t)) \end{cases} \quad (1.4)$$

$$\hat{y}_i(t+1) = arg\,\min_{yi} \boldsymbol{f}\left(y_i(t+1)\right) \quad (1.5)$$

$$x_i(t+1) = x_i(t) + v_i(t+1) \quad (1.6)$$

Table 1: Simulation Metrics

	PSO-PID	PSO-PID	Proposed PID
Obj.Function (*f*)	MAPE	ITAE	-
T_0 to T_{dist}			
Steady-state error	3.030	3.033	**2.071**
MSE	11.970	11.981	**8.180**
MAPE	5.311	5.313	**4.155**
MACA	0.829	0.828	**0.876**
MAPA	17.497	17.495	**18.313**
T_{dist+1} to T_{end}			
Steady-state error	0.474	0.476	**0.429**
MSE	4.063	4.069	**1.116**
MAPE	5.563	5.569	**4.601**
MACA	1.379	1.379	**1.559**
MAPA	24.643	24.643	**26.418**

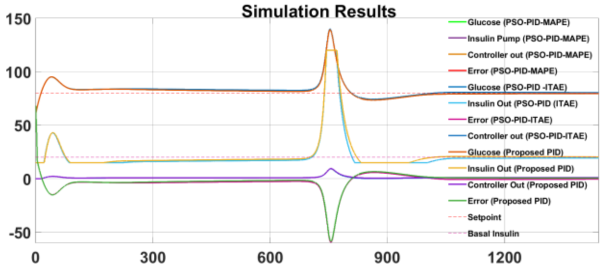

Figure 1: Full AP closed loop simulation results

Metrics Used

Controllers' performance was evaluated using MSE, which quantifies the mean squared deviation from the setpoint, MAPE, which represents the mean absolute percentage error, and steady-state error (SSE), which corresponds to the error in the last sample for each of the two predefined time periods T_0–T_{dist} and T_{dist+1}–T_{end}. MACA measures mean absolute controller actions to determine more conservative or aggressive behavior, while MAPA quantifies pump actions.

Experimental Results

The case study models a T1DM patient consuming a 50g-carbohydrate rich meal at T_{dist}=700min. Results of the simulation (Table 1 and Figure 1) show that the proposed control scheme leverages the controller's dynamics to a greater extent by performing more aggressive control actions (higher MACA) compared to the other controllers. It also utilizes the pump more efficiently, reflected in higher MAPA. Consequently, the proposed scheme operates more efficiently, achieving better performance in steady-state error, MSE and MAPE. This improvement comes at the cost of a trivial increase in overshoot. Future work will evaluate the results across a wider range of virtual patient scenarios and will also focus on more advanced control techniques, such as Model Predictive Control (MPC) schemes.

References

[1] S. Echajei, *et al.*(2025) Implementation of PID control strategies on Bergman model representing Type 1 Diabetes-T1D, *Commun. Math. Biol. Neurosci.*, 2025:1.

[2] A. Kapnopoulos and A. Alexandridis (2022) A cooperative particle swarm optimization approach for tuning an MPC-based quadrotor trajectory tracking scheme, *Aerospace Science and Technology* **127**:107725.

Keywords: Artificial pancreas,T1DM,PSO, PID control

TOPICS

- Medical Equipment Inventory
- BME Education
- Biosensors & Biomechanics

- Μητρώο Ιατροτεχνολογικού Εξοπλισμού
- Εκπαίδευση στην Βιοϊατρική Μηχανική
- Βιοαισθητήρες και Εμβιομηχανική

STRUCTURED DATA ENTRY WORKFLOW FOR MEDICAL EQUIPMENT INVENTORY MANAGEMENT

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Introduction

Efficient medical equipment (ME) management is crucial for health-care facilities to ensure optimal performance, safety, and regulatory compliance. An accurate and continuously updated equipment inventory serves as the foundation for effective HTM systems. The proposed inventory management process involves two key stages: (i) data acquisition and (ii) data entry. While data acquisition involves collecting photos of ME's identification label and relative information, data entry focuses on structuring and integrating extracted information into the inventory system.

This work focuses on the data entry stage, which translates raw image-based data into structured inventory records. Key fields extracted from ME images include Model, Manufacturer, Serial Number, Unique Device Identification (UDI), Year of Manufacturing, and GMDN[2]/EMDN[3] nomenclature codes. Among these, nomenclature assignment remains a complex and time-intensive process due to the variations between classification systems and the lack of standardized mapping[4]. This study proposes a structured, hierarchical workflow to streamline the data entry process for large-scale national ME inventories.

Materials and Methods

The proposed workflow is implemented by INBIT[1] and follows a three-level pyramid structure. Each level varies in workforce size, specialization, and training requirements:

Bottom Level: Handles basic data entry tasks, where equipment images are matched with pre-existing "Triplets"—a combination of Model, Manufacturer, and GMDN/EMDN code—from a predefined database. If a suitable Triplet is found, it is assigned to the registered equipment.

Second Level: Addresses cases where no existing Triplet is available. In this stage, new Triplets are created using the available GMDN codes database. Once verified, these new entries become Local Temporary Triplets, accessible to the bottom-level team for future assignments.

Top Level: Manages complex cases flagged as requiring expert review. This includes handling new or emerging medical technologies requiring new nomenclature codes. Additionally, the top level supervises the entire workflow and validates new Triplets, which are then permanently integrated into the database as Global Validated Data.

INBIT currently utilizes a repository comprising 1,020 GMDN codes, 2,030 manufacturer entries, and 11,300 Triplets. The workflow ensures continuous expansion and refinement of this database, progressively reducing manual effort over time.

Results

The national ME inventory project is expected to take one year and is currently in its second month. At the beginning of data entry, approximately 35% of cases required second- and third-level processing. However, as the database has expanded and more Triplets have been created, this percentage has already started to decrease, currently at around 30%. This early result indicates that the structured approach is progressively minimizing the need for expert intervention, making data entry more efficient and less time-consuming.

Discussion

The structured workflow distributes workload efficiently. Initially, manual intervention is high, but as the database grows, most data is processed at the bottom level, minimizing expert involvement and improving overall efficiency.

Nomenclature assignment is a key challenge due to the lack of direct GMDN-EMDN mapping. The hierarchical approach ensures expert input at higher levels while maintaining rapid lower-level processing. The adaptable workflow allows resource redistribution as the database expands.

Conclusion

A structured, multi-level workflow improves ME inventory management efficiency and accuracy. This scalable approach streamlines large-scale data processing and addresses nomenclature complexities. As the database grows, expert intervention decreases, optimizing resource use and processing time. The proposed framework supports sustainable and efficient HTM systems.

References

1. INBIT https://www.inbit.gr/en/
2. GMDN https://www.gmdnagency.org/
3. EMDN https://webgate.ec.europa.eu/dyna2/emdn/
4. A. Daskalaki, M. Marinou, A. Dermitzakis, Medical Devices Nomenclature Systems: Challenges and Considerations in Health-Care Equipment Inventory Management, Proceedings 5th ICEHTMC 2023

Keywords: Medical Equipment Inventory, Health-care Technology Management, Data Entry Workflow, Nomenclature Assignment, GMDN, EMDN

CREATING A UNIFIED MEDICAL EQUIPMENT INVENTORY IN GREECE

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Introduction

During the last decades, medical technology has become a key factor in all modern healthcare delivery systems. However, WHO 2022 Global atlas of medical devices shows that most countries worldwide do not have any form of national medical equipment (ME) inventory, and when data is available, it mainly refers to high capital value equipment [1]. The Institute of Biomedical Technology (INBIT) has undertaken a pivotal role in the Unified Medical Equipment Management System (MEMS) section of a broader National Digital Transformation Project in the Greek Healthcare System. The scope of this project includes all 128 Hospitals of Greece's public healthcare sector intended to be registered within a 10-month horizon.

Methods

Three Working Groups (WGs) of Biomedical Engineers have been assembled and trained in the inventorying process. These WGs are based in different areas (Athens, Thessaloniki and Northern Greece, Rest of mainland and Islands) for maximum geographic coverage. The process implemented for this project is an adaptation of other regional projects that have been successfully completed in the past [2,3], specialized for a nationwide scale (Figure 1).

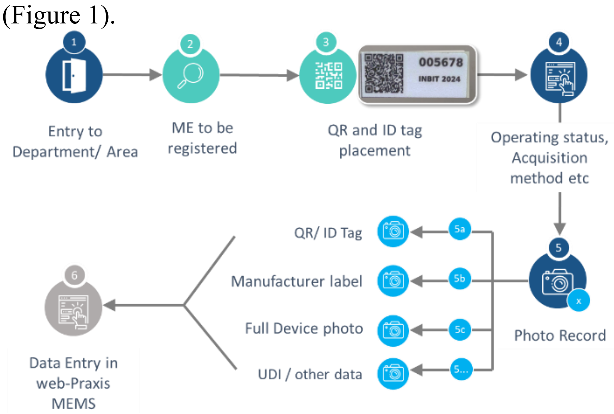

Figure 1. ME registration process

This process includes the creation of an Electronic Record for each individual ME. This is done by the WGs on a room-by-room basis, where each device is labelled with a tag bearing a unique national device ID that will be used throughout its lifecycle. The tag also contains a QR code that can be scanned with a specialized smartphone app to register new ME, view existing device details and report failures. Photographic record of every device is also created, including the unique ID label, manufacturer label, UDI and a full device photo. This will lead to the assignment of model, manufacturer and Global/ European Medical Device Nomenclature (GMDN/ EMDN) groups, during the sequential data entry phase of the project, as the data are fed to the *web-Praxis* MEMS. Finally, data such as acquisition method, operating status, department/area of installation etc. are registered in collaboration with the hospital staff. Due to the challenges of the modern healthcare environment, a robust communication scheme had to be developed. A kick-off meeting with all hospital management units was performed to provide the overarching goals of the project. Each month, a list of hospitals to be registered is created and the Management and Biomedical Eng. Departments are informed in detail by the Social Security e-Governance (IDIKA). Sequentially, the final schedule is made by each WG, and the Hospitals are informed of the exact date and the registration process.

Conclusions

As of the time of writing, 35,084 devices have been registered in 34 Hospitals. These preliminary results indicate steady progress, highlighting the project's feasibility. The implementation of a Unified MEMS across Greece's public healthcare sector marks a significant step toward improving national ME practices. Taking advantage of digital transformation, this initiative enhances ME traceability, lifecycle management, and overall healthcare efficiency, through the creation of various national databases. As the project continues, its outcomes will provide valuable insights into future large-scale healthcare improvements that rely on evidence-based decisions such as centralized contracts, homogenized maintenance practices and equipment redistribution.

References

1. WHO, Global atlas of medical devices, 2022 at https://www.who.int/publications/i/item/9789240062207
2. S. Zisimopoulos, A. Dermitzakis, C. Roilos and N. Pallikarakis (2022) Implementation of a Medical Equipment Inventory at a Regional Healthcare System in Greece, IFMBE Proceedings, 87:721-728
3. A. Dermitzakis, S. Zisimopoulos and N.Pallikarakis (2023) Implementation and Streamlining of the Medical Equipment Inventorying Process, J Global Clinical Engineering, Special Issue 5:157

Keywords: Clinical Engineering, Medical Equipment Management, Medical Device Inventory

ADVANCING UNIVERSAL ACCESSIBILITY IN HEALTHCARE

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Introduction

HOSP4ALL is an initiative that aims to enhance healthcare accessibility and inclusivity [1] through innovative assistive technologies and user-centered design. Focusing primarily on individuals with visual impairments, it aspires to create hospital environments without barriers, facilitating patient autonomy. A pilot installation was carried out at the University General Hospital of Patras (UGHP), supported by the Panhellenic Association for the Blind (PST) and the Norwegian Association of the Blind and Partially Sighted (NABP), both of which provided highly positive feedback on system effectiveness.

Materials and Methods

The core component of HOSP4ALL is a Bluetooth-based indoor positioning system. Bluetooth Low-Energy (BLE) beacons equipped with Angle of Arrival (AoA) technology [2] deliver real-time location data to a user's smartphone, guiding them through audio prompts and haptic feedback. Physical modifications, including tactile paving (haptic tiles) and Braille signage, further support safe, independent navigation. This design was developed collaboratively with user feedback from PST members, ensuring the solutions directly address the needs of blind and low-vision users.

Results

Initial findings suggest significant improvements in accessibility, safety, and user autonomy. Participants reported reliable guidance in navigating hospital corridors and identifying key service points. The PST formally praised the system as a "pioneering step toward equitable healthcare," recommending expansion to other hospital departments. Additionally, visiting representatives from NABP commended the system's ease of use and expressed interest in exploring its adoption in Norwegian healthcare facilities.

Discussion

Beyond its primary focus on assisting individuals with visual impairments, HOSP4ALL demonstrates the broader potential of real-time indoor navigation and asset tracking in healthcare. Challenges remain in scaling the system to encompass entire hospital complexes and in integrating it with existing digital services. Nevertheless, the strong user acceptance underscores the feasibility and importance of widespread deployment.

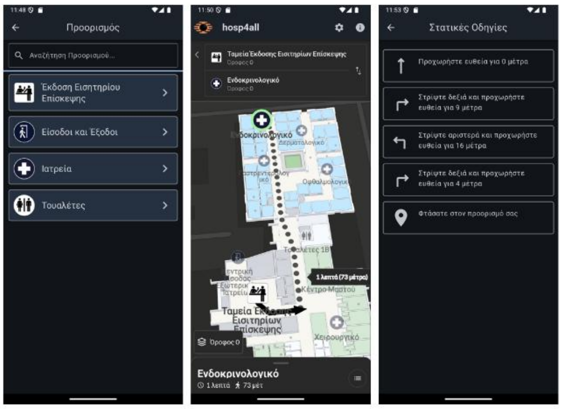

Figure 1. Navigation App Environment. *Left:* the info and destination-selection menu where users choose clinics, ticket desks, entrances, etc. *Centre:* the live guidance map, providing a visual route for sighted or low-vision users. *Right:* step-by-step textual instructions that are also delivered through audio and haptic feedback.

Conclusions

HOSP4ALL shows how innovative technology, combined with inclusive design principles [1], can substantially improve the hospital experience for visitors with visual impairments. Positive evaluations from both the PST and NABP validate the pilot's impact and indicate a clear path for wider adoption. Future work will expand coverage within UGHP, refine the application's interface, and explore additional features such as SOS alerts, asset tracking, and data analytics for more effective hospital management.

References

1. Center for Inclusive Design and Environmental Access (2020) Principles of All-Inclusive Design in Healthcare Facilities.
2. BlueIot (2025) "Bluetooth AoA Technology." Retrieved from https://www.blueiot.com/bluetooth-aoa-technology

Keywords:
Healthcare Accessibility, Inclusive Design, Indoor Navigation, Visual Impairment

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ΕΜΠΕΙΡΙΕΣ ΑΠΟ ΤΗ ΧΡΗΣΗ ΕΡΓΑΛΕΙΩΝ ΤΕΧΝΗΤΗΣ ΝΟΗΜΟΣΥΝΗΣ ΣΤΗΝ ΜΕΤΑΠΤΥΧΙΑΚΗ ΕΚΠΑΙΔΕΥΣΗ ΓΙΑ ΤΟΝ ΨΗΦΙΑΚΟ ΜΕΤΑΣΧΗΜΑΤΙΣΜΟ ΤΗΣ ΥΓΕΙΑΣ

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Εισαγωγή

Ο ψηφιακός μετασχηματισμός στον τομέα της υγείας αποτελεί επιτακτική ανάγκη, καθώς οι τεχνολογικές εξελίξεις επηρεάζουν την παροχή και τη διαχείριση των υπηρεσιών υγείας. Η ενσωμάτωση της Τεχνητής Νοημοσύνης (ΤΝ) στην εκπαίδευση των επαγγελματιών υγείας δημιουργεί νέες ευκαιρίες, αλλά και προκλήσεις, ιδιαίτερα όσον αφορά την ακαδημαϊκή ακεραιότητα και την αξιολόγηση των φοιτητών. Το ManagiDiTH[2] (Master of Managing Digital Transformation in the Health Sector) είναι ένα καινοτόμο διαπανεπιστημιακό πρόγραμμα, που υλοποιείται μέσω της συνεργασίας τριών πανεπιστημίων του Αριστοτελείου Πανεπιστημίου Θεσσαλονίκης (AUTH, Ελλάδα), του ISCTE (Πορτογαλία) και του LAUREA (Φινλανδία). Στόχος του είναι η κατάρτιση επαγγελματιών υγείας στις σύγχρονες τεχνολογικές εξελίξεις, ενώ παράλληλα φιλοδοξεί να λειτουργήσει ως πρότυπο για την ανάπτυξη ενός Κοινού Ευρωπαϊκού Πτυχίου[1] (European Common Degree). Ωστόσο, η πολυμορφία των εκπαιδευτικών πολιτικών και οι διαφορετικές προσεγγίσεις στη χρήση της ΤΝ ανέδειξαν κρίσιμα ζητήματα που σχετίζονται με την αξιολόγηση των φοιτητών και την ενσωμάτωση της ΤΝ στη διδασκαλία. Το άρθρο αυτό φιλοδοξεί να αναδείξει αυτές τις πρώιμες εμπειρίες που θα φανούν χρήσιμες και σε άλλα μεταπτυχιακά του χώρου της βιοϊατρικής μηχανικής.

Μέθοδος

Η παρούσα εργασία βασίζεται στην εμπειρία διδασκαλίας του μαθήματος "Healthcare and Resource Management" (OH02), όπου αξιοποιήθηκε η χρήση εργαλείων ΤΝ από τους φοιτητές. Η διδάσκουσα μέσω του συστήματος Turnitin, εντόπισε υψηλά ποσοστά χρήσης ΤΝ στις εργασίες των φοιτητών. Η ανάλυση των υποβληθέντων εργασιών μέσω εργαλείων ανίχνευσης ΤΝ οδήγησε σε συζητήσεις εντός της Επιτροπής Προγράμματος Σπουδών σχετικά με τις πολιτικές χρήσης ΤΝ. Στη συνέχεια διερευνήθηκε το πλαίσιο αξιοποίησης ΤΝ από τους φοιτητές και η μέθοδος καθοδήγησης από τους διδάσκοντες.

Αποτελέσματα

Η έλλειψη σαφών κατευθυντήριων οδηγιών προκάλεσε σύγχυση στους φοιτητές και διαφωνίες του εκπαιδευτικού προσωπικού των εμπλεκόμενων πανεπιστημίων σχετικά με την αποδεκτή χρήση της AI. Ως αποτέλεσμα α) αποσύρθηκε το συγκεκριμένο assignment από την τελική βαθμολογία, β) υπήρξαν αντιδράσεις από τους φοιτητές, που δεν είχαν σαφή ενημέρωση για τα όρια χρήσης της ΤΝ και γ) η Επιτροπή Προγράμματος Σπουδών διαπίστωσε την ανάγκη για ενιαία εκπαιδευτική πολιτική σχετικά με την αποτελεσματική αξιοποίηση της ΤΝ.

Συζήτηση

Το περιστατικό ανέδειξε την ανάγκη για διαμόρφωση ενός σαφούς πλαισίου ενσωμάτωσης της ΤΝ στην εκπαίδευση. Οι βασικές προτάσεις περιλαμβάνουν την υποχρεωτική δήλωση από τους φοιτητές σχετικά με τον τρόπο χρήσης ΤΝ στις εργασίες τους, την καθοδήγηση των διδασκόντων ώστε να μπορούν να διαφοροποιούν την ανθρώπινη συγγραφή από τη χρήση ΤΝ και την εναρμόνιση των εκπαιδευτικών πολιτικών μεταξύ των πανεπιστημίων που συμμετέχουν στο πρόγραμμα.

Συμπεράσματα

Η ενσωμάτωση της Τεχνητής Νοημοσύνης στην εκπαίδευση απαιτεί ξεκάθαρες κατευθυντήριες γραμμές τόσο για τους φοιτητές όσο και για τους εκπαιδευτικούς. Το ManagiDiTH[2], ως ένα διαπανεπιστημιακό πρόγραμμα, αποτελεί μια σημαντική ευκαιρία για την ανάπτυξη και διαμόρφωση ενιαίας εκπαιδευτικής πολιτικής στην Ευρώπη, στο πλαίσιο ενός Κοινού Ευρωπαϊκού Πτυχίου. Η υιοθέτηση σαφών κανόνων και η κατανόηση των ορίων χρήσης της ΤΝ θα συμβάλουν στην ομαλή ενσωμάτωσή της στην ανώτατη εκπαίδευση και στη δίκαιη αξιολόγηση των φοιτητών. Μέσω αυτών των καινοτομιών, το ManagiDiTH[2] συμβάλλει στη διαμόρφωση ενός σύγχρονου, βιώσιμου μοντέλου εκπαίδευσης που ανταποκρίνεται στις εξελισσόμενες ανάγκες του τομέα της υγείας, ενώ παράλληλα προωθεί την ευρωπαϊκή ολοκλήρωση στην ανώτατη εκπαίδευση.

References

1. European Commission. "A blueprint for a European degree." Available at: https://education.ec.europa.eu/news/commission-presents-a-blueprint-for-a-european-degree

2. ManagiDiTH Consortium. "Master's Programme Details." Available at: https://managidith.eu/masters-programme-details/

Keywords: Ψηφιακός Μετασχηματισμός στην Υγεία, Τεχνητή Νοημοσύνη, Ευρωπαϊκό Πτυχίο, Εκπαίδευση, Καινοτομία

MAPPING DIGITAL SOFT SKILLS FOR IMPLEMENTATION OF DIGITAL SCENARIO BASED LEARNING EDUCATIONAL RESOURCES

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Introduction

Digital Soft Skills (DSS) such as communication, collaboration, problem solving, and adaptability in digital healthcare context (telemedicine, digitalized health) are in high demand. These skills are essential for the digital workplace. Therefore, the European Higher Education area has continually increased expenditures in the training and promotion of digital soft skills among their student populations [1,2]. Such training is especially effective through the use of Digital Scenario Based Learning (D-SBL).

D-SBL uses interactive digital scenarios, in the form of virtual patients, or other serious games, to support active learning strategies such as problem-based learning. Virtual patients have become, for quite a while now, a standard for medical education with digital enablers [3,4]. This work presents the conceptualization and mapping of DSS to EU frameworks and healthcare terminologies for use with Digital Scenario Based Learning (D-SBL) in the context of the DISCERN-DSS EU funded project.

Methods

The educational activities that are planned in the DISCERN-DSS aim to implement 15 D-SBL VPs in the equivalent of 2 modules that will be used to educate more than 350 learners on digital soft skills. In that context our team set-out to create a conceptual mind-map for defining a terminology of digital soft skills that can then be used for the identification of DSS learning objectives in Higher Education curricula.

Initial Results and Conclusion

Taking cues from existing projects [5], the EU DIGICOMP framework [6] and previous attempts to standardize the healthcare soft skills landscape, we have created a list of related DSS concepts. After that step we brainstormed, based on past hierarchies, and organized these terms into a conceptual mind-map [7]. This work is currently being used to identify learning objectives for D-SBL, and a Delphi study is planned for prioritizing and organizing a concrete list of educational episodes that support DSS teaching.

Through D-SBL-based upskilling of healthcare professionals in DSS we will foster both cross-regional cooperation between EU and SE Asia and upskill the medical professionals of the crucial aptitudes that comprise digital soft skills.

References

1. Szczepanski, M. "Digital Europe programme: Funding digital transformation beyond 2020." (2019)
2. DIGITAL Europe Programme at https://digital-skills-jobs.europa.eu/en/about/digital-europe-programme
3. Antoniou, P. E., Athanasopoulou, C. A., Dafli, E., & Bamidis, P. D. (2014). Exploring design requirements for repurposing dental virtual patients from the web to second life: a focus group study. Journal of medical Internet research, 16(6), e3343.
4. George, Pradeep Paul, Olena Zhabenko, Bhone Myint Kyaw, Panagiotis Antoniou, Pawel Posadzki, Nakul Saxena, Monika Semwal et al. "Online digital education for postregistration training of medical doctors: systematic review by the digital health education collaboration." Journal of medical Internet research 21, no. 2 (2019): e13269.
5. Digital Soft Skills for Educators and Students. https://d2s.ulysseus.eu/wp-content/uploads/sites/2/2022/04/Digital-Soft-Skills-Framework-for-Educators-and-Students.pdf
6. European Commission: Joint Research Centre, Vuorikari, R., Kluzer, S. and Punie, Y., DigComp 2.2, The Digital Competence framework for citizens – With new examples of knowledge, skills and attitudes, Publications Office of the European Union, 2022, https://data.europa.eu/doi/10.2760/115376
7. Bouwmans M, Lub X, Orlowski M, Nguyen T-V (2024) Developing the digital transformation skills framework: A systematic literature review approach. PLoS ONE 19(7): e0304127. https://doi.org/10.1371/journal. pone.0304127
8. DSS Conceptualization Mind Map https://miro.com/app/board/uXjVLs1XuZI=/?share_link_id=651206643820

Keywords:
Digital Soft Skills, Digital Scenario Based Learning, Medical Education, Technology Enhanced Learning.

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BRAIN TUMOR DIGITAL TWIN WITH DEEP LEARNING

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Introduction

Brain tumors and glioblastoma especially, the most common malignant primary brain tumor, are characterized by poor overall prognosis and rare long-term survival[1]. To assist tumor treatment management and surgical planning, technologies simulating brain tumor growth are thus required. In this context, Digital Twins (DTs) represent a promising solution. They are designed to replicate physical systems intending to reproduce and forecast the actions of their real-world counterparts. In light of this potential, this study aims to develop a DT able to predict the progression of the brain tumor using deep learning.

Materials and Methods

For this work, the LUMIERE dataset[2], an open-source single center longitudinal glioblastoma MRI dataset with expert RANO evaluation, is used. A subset of the dataset, comprising 39 patients and their MRI scans around 0, 15 and 41 weeks post-operation, is utilized to validate the feasibility of the proposed approach. The MRI scans include segmented tumor masks, which serve as input for the predictive modeling pipeline.

For the prediction of the progression of brain tumors, a Convolutional Long Short-Term Memory (Conv-LSTM) model is deployed. This type of neural network plays a key role in the task of future image frame prediction since it is capable of capturing both spatial and temporal correlations. In line with the aims of this research, Conv-LSTM has been previously employed successfully for the forecasting of pancreatic neuroendocrine tumor growth[3].

The model is trained to take as input the tumor segmentation masks from the first two MRI scans of each patient and predict the tumor mask corresponding to the third scan. To prevent overfitting, the dataset subset is augmented by rotating the segmentation masks.

Results

The results represented are preliminary findings intended to demonstrate proof of concept. Using the tumor segmentation masks from two sequential MRI scans, the trained model can effectively generate the segmentation mask for a subsequent scan. The model was evaluated with five-fold cross-validation using the Dice similarity coefficient and Relative Volume Difference (RVD) metrics. The average evaluation metrics remain modest in initial experiments due to dataset imbalance and limited number of training samples. However, it is worth noting that there is a best-case performance in the five-fold cross-validation, achieving 84% Dice similarity coefficient and -5% RVD. As illustrated in Figure 1, the model is able to predict lesion growth patterns with sufficient accuracy producing a visualization of the progressed tumor.

Figure 1. Ground truth (left) and predicted (right) tumor segmentation mask of a patient's third week scan

Discussion and Future Work

This study demonstrates the potential of DTs that utilize deep learning models for predicting brain tumor progression and thus aiding clinical decisions and personalized treatment planning. Future work includes exploring the capabilities of Generative Adversarial Networks (GANs) in utilizing radiomic features from the tumor region, as a more efficient alternative to the model showcased in this research.

References

1. A.C. Tan, et al. (2020) Management of glioblastoma: State of the art and future directions, CA Cancer Journal for Clinicians, 70: 299-312
2. Y. Suter, et al. (2022) The LUMIERE dataset: Longitudinal Glioblastoma MRI with expert RANO evaluation, Scientific Data, 9: 768.
3. L. Zhang, et al. (2020) Spatio-Temporal Convolutional LSTMs for Tumor Growth Prediction by Learning 4D Longitudinal Patient Data, IEEE Transactions on Medical Imaging, 39: 1114-1126.

Keywords:
Artificial Intelligence, Deep Learning, Brain Tumor, Digital Twins

Acknowledgment
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MODELING LATE-AGE ADVERSE EFFECTS OF BREAST CANCER SURVIVORS FROM REAL-WORLD EHR DATA

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Introduction

The emergence of Real-World Data, i.e. Electronic Health Records (EHR), has gained attention as a valuable source for research analysis, however analytical applications remain problematic due to EHR collection focusing on clinical uses [1]. Leveraging EHR data in the context of older breast cancer survivors requires addressing additional obstacles, such as the pronounced multimorbidity in the subject population, which results in mixed observations of treatment and adverse effects. Given these challenges, our study focused on predicting the changes in the frequency of adverse effects after hormonotherapy in older breast cancer survivors.

Materials and methods

Our methodology aimed at structuring an integrative framework for drawing explainable insights by pre-processing and analyzing timestamped data from EHR. In summary, the dataset we analyzed included a cohort of older breast cancer patients (>65 years old) treated with hormone therapy, alongside recorded comorbidities and/or symptoms observed before, during, and after treatment. Primary features were extracted from the raw data, corresponding to cohort information and records of 100 adverse effects. The observations involved 500 anonymized patients, aged 65 to 100 years at the time of diagnosis. However, exploring the real-world dataset revealed several quality issues concerning age inconsistencies, low cohort representation and large time gaps between the date of diagnosis and starting date of treatment. Abundance of noisy observations resulted in a significantly reduced final size of 238 subjects. Our target variable was set as the frequency change in subjects with a recorded condition between two periods: prior to and after the treatment's start date. A custom transformation was also applied to compare identical values originating from different percentage magnitudes, aiming to capture relative growth and maintain control of the original range at the same time. Predictors were limited to the age at diagnosis and the corresponding cohort's survival duration. The final model was selected by fitting all possible polynomial regression models up to second degree for each condition and evaluating performance metrics. In addition, interpretational simplicity and predictive power of the model were boosted, while bias and artifacts were minimized.

Results

Our analytical framework managed to support the implementation of informative models with desirable performance metrics, given the limitations of the datasets and the trade-offs of boosting interpretability. As an example, the model of anemia scored moderate adjusted R-squared and RMSE values, corresponding to 0.5 and 0.1. Coefficient p-values fell below the threshold of 0.05, confirming statistical significance. Notably, survival duration and age at diagnosis positively correlate with the frequency change in anemic observations (see Figure 1).

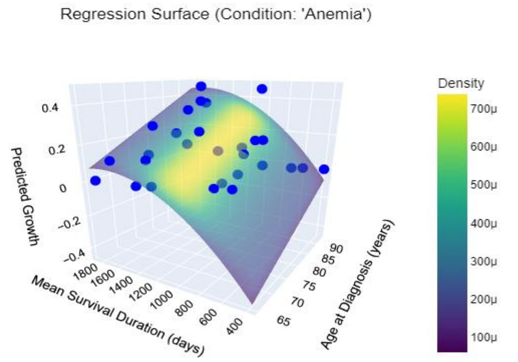

Figure 1. Predicted surface for the model of anemia

Discussion

While the analysis of EHR data can contribute to explaining the increase of recorded condition frequency during breast cancer hormone therapy, mixed signals of comorbidities and side-effects observed in late-age cancer survivors introduce significant biases, which affect statistical inference.

References

1. Sauer, C. M., Chen, L. C., Hyland, S. L., Girbes, A., Elbers, P., & Celi, L. A. (2022). Leveraging electronic health records for data science: common pitfalls and how to avoid them. The Lancet Digital Health, 4(12), e893–e898. https://doi.org/10.1016/S2589-7500(22)00154-6

Keywords

EHR, breast cancer, multimorbidity, side effects, real-world data

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AI-POWERED PERSONALISED LIFESTYLE COACHING FOR NUTRITION & PHYSICAL ACTIVITY IN BREAST CANCER

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Introduction

Breast cancer (BC) is a condition in which abnormal breast cells develop uncontrollably and produce tumors [1]. Approximately half of all BCs arise in women who have no identifiable risk factors other than their gender and age [1]. Research shows that regular exercise and a balanced diet can reduce recurrence risk and improve survival in BC [2]. Adopting such lifestyle changes can be challenging due to various personal and environmental barriers. The Capability – Opportunity – Motivation – Behavior (COM-B) model [3] is a behavior change framework designed to identify key factors influencing behavior: individuals require capability, opportunity, and motivation to adopt and maintain a behavior. By assessing deficits in these areas, interventions can be tailored to address specific barriers to behavior change. This paper presents the Personalized Lifestyle Coaching (PLC) service architecture and concept as part of MELIORA [4], an EU-funded project aiming to empower women at risk of BC, patients, and survivors, to adopt a healthy lifestyle.

Methodology

Artificial intelligence (AI) and digital health technologies will apply COM-B principles to deliver personalized interventions. The proposed PLC Service architecture (Figure 1) features an AI-driven component that integrates user input—from self-reported questionnaires to real-time activity tracking—with output data generated from other AI MELIORA modules to identify individual barriers across the COM-B domains. It will deliver content and recommendations providing through the MELIORA mobile app personalized physical activity and nutrition guidance. For example, if the app detects low activity levels (an Opportunity and/or Capability deficit), it issues customized exercise suggestions, educational resources, and motivational prompts. All data collection processes will adhere to GDPR requirements and receive institutional ethics approvals, with informed consent obtained from participants prior to data collection. Decision-support algorithms—from rule-based systems to machine learning models (including supervised and unsupervised learning, neural networks and real-time adaptive algorithms)—will be evaluated in order to develop a strategy to map the input data to specific behavior-change strategies, with the optimal approach chosen based on pilot testing outcomes.

Discussion & Conclusion

The integration of COM-B with AI through the proposed PLC can provide unique benefits compared to conventional behavioral interventions. AI allows for scalable personalization that adapts in real time to a user's evolving needs. However, challenges remain in ensuring user uptake and adherence. Future research should focus on refining the proposed PLC adaptive algorithms to enhance user engagement while also evaluating long-term outcomes to establish robust, user-centred models for cancer and survivorship care.

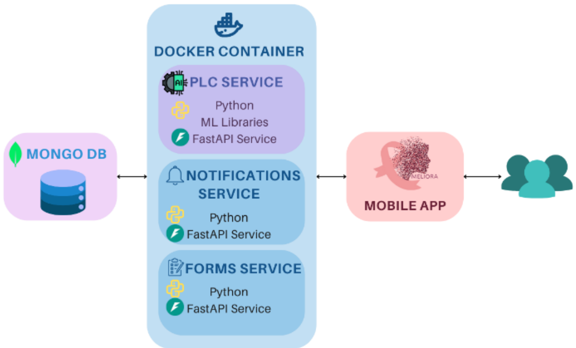

Figure 1. Personalized Lifestyle Coaching Interconnections Architecture

References

1. WHO Breast Cancer: https://www.who.int/news-room/fact-sheets/detail/breast-cancer
2. Wolff, J., et al. App-Based Lifestyle Intervention (PINK! Coach) in Breast Cancer Patients-A Real-World-Data Analysis. Cancers (Basel). 2024 Feb 29;16(5):1020. doi: 10.3390/cancers16051020. PMID: 38473378; PMCID: PMC10930534.
3. Michie, S., van Stralen, M.M. & West, R. The behaviour change wheel: A new method for characterising and designing behaviour change interventions. Implementation Sci 6, 42 (2011). doi: 10.1186/1748-5908-6-42
4. MELIORA project: https://melioraproject.eu/

Keywords:
Breast cancer, Artificial Intelligence, Behavior Models, Personalized Interventions

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EXPLORING THE IMPACT OF AGE AND WEIGHT ON SLEEP QUALITY: INSIGHTS FROM THE URBANOME PROJECT

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Introduction

Sleep is considered to play an important role in cognitive and physiological functions in humans. Poor sleep quality has been studied as a risk factor for weight gain [1]. Furthermore, the quality of sleep has been found to decrease with healthy aging [2]. The objective of the present analysis is to evaluate the relationship between sleep quality, age and weight, utilizing data acquired for the interventional study in Thessaloniki as part of the URBANOME Horizon 2020 project.

Materials and methods

A custom risk-scoring methodology identified 121 high-risk volunteers to be included in this analysis based on pneumological exams and a survey regarding Sleep Quality, Quality of Life, Mental Health, Physical Health and Urban Environment, Housing, and Personal Habits. Participants were provided with a Xiaomi Smart Band 7 and a portable sensor to measure particulate matter (PM), humidity and temperature. They were instructed to wear these sensors for 1 week to monitor activity, sleep quality and exposure to environmental factors. The objective was to evaluate the relationship between sleep quality and demographics using two-way ANOVA to analyze weekly durations of light, deep, and REM sleep, as well as wake time.

Results

The tests confirmed that the data followed a normal distribution (Table 1). A statistically significant interaction was observed between sleep stage, weight, and age (p-value = 0.03). As shown in Figure 1, the deep sleep ratio increases with age among participants with lower weight (adjusted p-value = 0.04).

Table 1: Normality test results.

Data subset	p-value
Older & overweight	0.17
Young & overweight	0.25
Older & normal weight	0.11
Young & normal weight	0.98

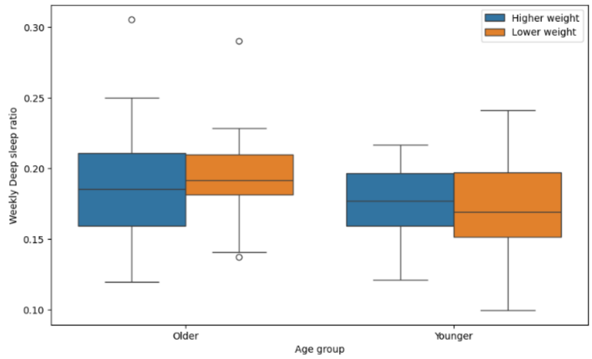

Figure 1: Weekly deep sleep ratio by age and weight.

Discussion

The analysis suggests that older adults tend to have a higher deep sleep ratio than younger individuals, while weight affects deep sleep in both age groups, with higher-weighted older adults having a lower deep sleep ratio than lower-weighted, while the opposite effect is noted in younger participants.

Conclusions

The findings of this analysis provide valuable insights into the relationship between sleep quality, age, and weight, highlighting the importance of good physiology to maintain sleep quality across lifespan. Targeted interventions, such as promoting weight management and optimizing sleep environments, could be tailored by age group to enhance sleep quality, offering valuable guidance for urban health policy and personalized public health strategies.

References

1. Patel, S. R., & Hu, F. B. (2008). Short sleep duration and weight gain: a systematic review. *Obesity*, *16*(3), 643-653.
2. Luca, G., Haba Rubio, J., Andries, D., Tobback, N., Vollenweider, P., Waeber, G., ... & Tafti, M. (2015). Age and gender variations of sleep in subjects without sleep disorders. *Annals of medicine*, *47*(6), 482-491.

Keywords: Sleep, physiological aging, demographics

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AI-ENHANCED TELE-REHABILITATION: RESEARCH-ORIENTED MODELING FOR FALL RISK, TREATMENT EFFECTIVENESS, AND ADVERSE EVENTS IN BALANCE DISORDERS

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Introduction

Balance is a critical function for human mobility and independence [1]. Balance disorders in older adults increase fall risk and reduce quality of life, with 28-42% of adults over 65 falling annually, emphasizing the need for effective prevention strategies [2]. AI advancements are improving balance assessment and fall risk prediction [1]. Our study aims to develop and validate AI-driven models for fall risk, treatment effectiveness, and adverse events within a tele-rehabilitation context.

Materials & Methods

The study utilizes data from the TeleRehaB project, including retrospective data from the Holobalance project (HOL), the EMBalance project (EMB), and UCL, UK, covering patients aged 16-98 with balance disorders. The dataset comprises clinical, demographic, and symptom-related data. Data preprocessing involves feature encoding, imputation (Simple and Iterative), normalization, and handling of imbalanced classes via SMOTE. Multiple classifiers (XGBoost, KNN, Neural Networks, etc.) were trained using a 10-fold cross-validation strategy. Model interpretability was achieved through SHAP values to explain feature contributions. These models improve clinical decision-making and patient outcomes in rehabilitation settings by addressing key clinical endpoints, including Risk of Fall (RoF), Treatment Effectiveness (TE), and Adverse Events (AE).

Results & Discussion

The study addressed three specific clinical use cases: predicting RoF, evaluating TE, and identifying AE. Table I details the models, endpoints, and metrics, with some models being particularly relevant to clinical relevance.

Table I. Results overview of Research-oriented models.

End point	Source	Target	Model	Accuracy	Sensitivity	Specificity	Key Aspect
RoF	EMB	FALL	XGB	0.94 ± 0.06	0.93 ± 0.07	0.94 ± 0.02	Tendency to Fall
TE	UCL	HADA	XGB	0.94 ± 0.06	0.87± 0.10	0.87± 0.13	HADD
AE	HOL	SYMPTOMS	RF	0.86± 0.14	0.85± 0.13	0.80 ± 0.20	WHODAS 7

Results show a high accuracy of 94%, using the EMB dataset, for RoF with the most important feature being the tendency to fall. For TE, UCL data targeting HADA yielded 94% accuracy with the XGBoost classifier and HADD as a key aspect. Lastly, the RF with the HOL dataset and symptoms as the target reached an accuracy of 86% for AE. SHAP values reveal the impact of input variables on research-oriented models' predictions. For instance, at RoF (Figure 1), Tendency_to_fall and age are dominant drivers, while features like the Dizziness emotional subscore, and the Hospital Anxiety and Depression Scale (HAD_A_D) have moderate influence.

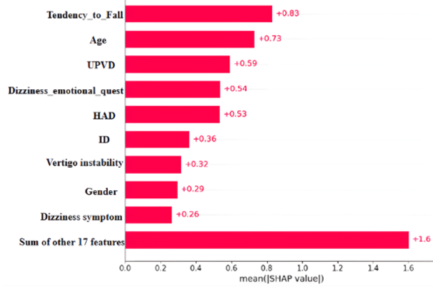

Figure 1. SHAP value for Risk of Fall.

The study demonstrates that AI models can predict critical endpoints, aid early risk stratification, guide personalized rehabilitation, and improve long-term tele-rehabilitation outcomes, but face limitations like retrospective data and potential bias.

References

[1] E. Antoniadou *et al.*, “Reliability and validity of the mCTSIB dynamic platform test to assess balance in a population of older women living in the community,” *J Musculoskelet Neuronal Interact*, vol. 20, no. 2, pp. 185–193, 2020.

[2] “WHO global report on falls prevention in older age.” Accessed: Jul. 29, 2024. [Online]. Available: https://www.who.int/publications/i/item/9789241563536

Keywords: AI predictive analytics, Fall Risk, Treatment Effectiveness, Adverse Events, Rehabilitation

Acknowledgement

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SWARM LEARNING WITH WEAK SUPERVISION FOR AUTOMATIC BREAST CANCER DETECTION IN MRI

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Introduction

Breast cancer screening guidelines increasingly incorporate magnetic resonance imaging (MRI) for early detection [1], leading to a surge in imaging volume. Artificial intelligence (AI)-driven solutions can aid radiologists in interpreting these images. However, developing AI models is often hindered by data privacy constraints and the need for extensive manual annotations. This study investigates the integration of weakly supervised learning and Swarm Learning (SL) to facilitate privacy-preserving breast cancer detection [2].

Materials and Methods

A combination of weak supervision reducing reliance on detailed manual annotations and SL allowing decentralized model training across institutions was utilized. The Duke dataset was obtained from The Cancer Imaging Archive (TCIA), while the USZ, CAM, UKA, and Mitera Hospital Athens (MHA) datasets were collected by institutional partners within the ODELIA project under approved ethical protocols. The training dataset consisted of 1372 bilateral breast MRI exams from the US, Switzerland, and the UK. External validation was performed on 649 exams from Germany (UKA) and Greece (MHA). We benchmarked several deep learning models including 2D-ResNet50, 3D-ResNet18/50/101, 3D-DenseNet121, and multiple instance learning (MIL) variants (Att-MIL, ViT-MIL, and ViT-LSTM-MIL).

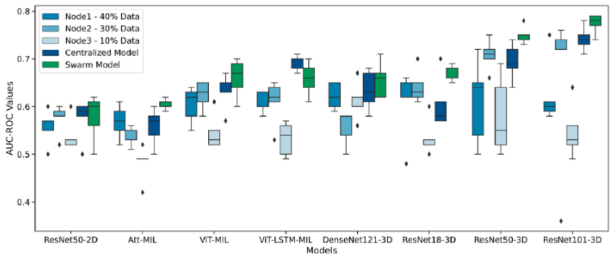

Figure 1. AUROC comparison of models trained locally, centrally, and via Swarm Learning. 3D-ResNet101 with Swarm Learning achieved the highest performance.

Results

The study demonstrated that 3D-ResNet-101 achieved superior classification accuracy compared to other architectures. Furthermore, models trained using swarm learning (SL) consistently outperformed those trained on individual institutional datasets, highlighting the benefits of decentralized collaborative training. On the UKA dataset, the SL model achieved an AUROC of 0.807, compared to 0.743 (Duke), 0.538 (USZ), and 0.703 (CAM). On the real-world MHA validation cohort, the SL model again outperformed local models, achieving an AUROC of 0.821 versus 0.729 (Duke), 0.520 (USZ), and 0.673 (CAM). Additionally, explainability analyses using GradCAM++ and occlusion sensitivity analysis (OCA) indicated that SL models effectively focused on tumor-relevant regions, reinforcing their potential for improving breast cancer detection in MRI.

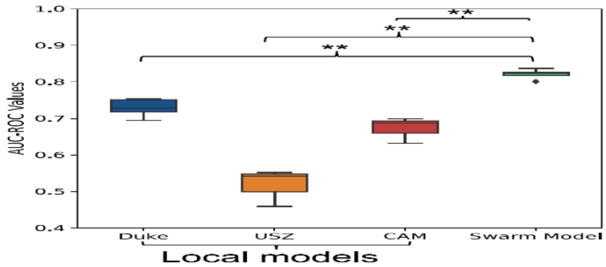

Figure 2. Swarm Learning outperforms local models in external validation on the MHA dataset, achieving an AUROC of 0.821

Discussion

This study confirms that weakly supervised learning can be effectively applied to breast cancer detection in MRI. The integration of SL enables multi-institutional AI training without centralized data sharing, preserving patient privacy and addressing data heterogeneity. These findings support the feasibility of deploying collaborative AI frameworks in real-world clinical environments.

Conclusion

The combination of weak supervision and Swarm Learning enhances breast cancer detection in MRI by enabling decentralized AI model training across multiple institutions. Future work should focus on expanding dataset diversity, optimizing model interpretability, and evaluating the model's performance in longitudinal settings. Additionally, addressing integration into real-world clinical workflows will be essential for deploying this approach at scale.

References

1. Mann R.M. et al., "Breast Cancer Screening in Women with Extremely Dense Breasts," Eur Radiol., 2022.
2. Rieke N. et al., "The Future of Digital Health with Federated Learning," NPJ Digit Med., 2020.

Keywords:
Swarm Learning, Weak Supervision, Breast Cancer Detection, Medical AI, MRI

Acknowledgement
This study was supported by the ODELIA consortium.

A FUNCTIONAL NEAR INFRARED SPECTROSCOPY ACQUISITION PROTOCOL

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Introduction

Functional Near Infrared Spectroscopy (fNIRS) is a novel neurodiagnostic technique that uses infrared radiation and physiologically relies on the hemodynamic response phenomenon.[1] This pilot study proposes an fNIRS acquisition protocol for the evaluation of the prefrontal lobe activation during the performance of cognitive tasks.[2]

Materials and methods

The signals were collected with the 18 optode fNIRS 2000C Imager from BIOPAC with a sample rate of 10Hz. The acquisition protocol (fig. 1) was applied to five healthy adults. It started with a resting state recording that served as a baseline for the calculation of oxygenated hemoglobin (HbO) concentration variations. The cognitive task chosen was the N-back (for N=1 and 2), where the participant is asked for each presented stimulus whether it matches a stimulus N trials before.

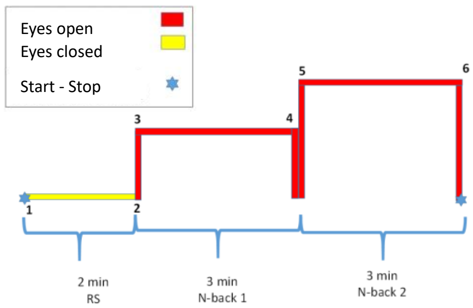

Figure 1. N-back task acquisition protocol. RS (resting state), N-back 1 (cognitive task 1-back), N-back 2 (cognitive task 2-back)

The raw data were preprocessed by applying a correlation based signal improvement filter, a band pass filter (0.01-0.1Hz) and a linear detrending filter. The obtained signal was converted to HbO concentration (fig. 2) using the modified Beer – Lambert's law.

Results

The HbO concentration values for each subject were separated in three blocks corresponding to the resting state, the 1-back task period and the 2-back task period. Welch's ANOVA and Games – Howell post hoc tests were performed on the three blocks. In all cases a statistically significant difference ($p<0.01$) is observed between all three blocks. HbO concentration is highest during the 2-back task performance.

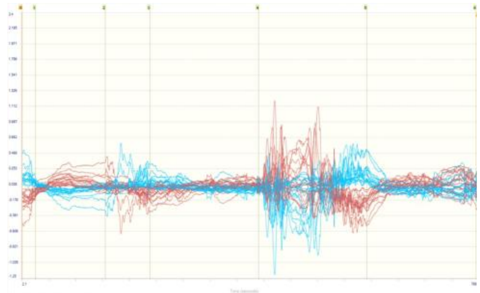

Figure 2. Oxygraph: Time variation of HbO (red) and HbR (blue) relative concentrations, calculated after data preprocessing for the 18 optodes.

Discussion - Conclusions

fNIRS is a non-invasive and flexible diagnostic technique that can record activation in the prefrontal cortex. Despite the limited number of participants, the proposed protocol demonstrates reliability, as the small sample rate along with the duration of each task provides a considerable number of measured values per person. Further research should be conducted to investigate the efficacy of the method in normal controls and cognitively impaired subjects, using additional variations of the acquisition as well as the data processing protocol.

References

1. T. Nguyen et al., 'Investigation of brain functional connectivity in patients with mild cognitive impairment: A functional near-infrared spectroscopy (fNIRS) study', Journal of Biophotonics, vol. 12, no. 9, p. e201800298, 2019; doi: 10.1002/jbio.201800298.
2. Rahman, M. A., Siddik, A. B., Ghosh, T. K., Khanam, F., & Ahmad, M. (2020). A Narrative review on Clinical applications of FNIRS. Journal of Digital Imaging, 33(5), 1167–1184; doi:10.1007/s10278-020-00387

Keywords:
Hemodynamic Response, fNIRS, Neurodiagnosis

Acknowledgement
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A NOVEL WEARABLE NAVIGATION DEVICE FEATURING INTUITIVE TACTILE FEEDBACK FOR VISUAL IMPAIRMENT (NAVISENSE)

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Introduction

The field of wearable haptics has been benefiting from rapid technological development during the current and past decades. Multi-sensor data acquisition and fusion, novel sensors and advances in microcontroller capabilities have been technologically converging, allowing for the development of devices which can aid people to independently navigate through unfamiliar environments during their daily routine [1]. Thus, wearable haptic systems could improve mobility and safety for visually impaired people (VIP) beyond the white cane [2]. This paper presents a wearable-computing prototype device of our own development, aiming to assist VIP in navigating safely, whilst improving their mobility, confidence and autonomy.

Methods

The system's efficiency was assessed in three different types of experiments. The first experiment included blindfolded navigation through an obstacle course with randomly placed cardboard boxes comparing the NaviSense prototype to a broomstick. The second experiment evaluated the system's ultrasonic sensor obstacle detection capability for obstacles of different height. The final experiment tracked user improvement while using the system in which the participant was challenged repeatedly to cross the obstacle course, each time with a different but equivalent layout, to assess performance improvements as they gained experience using our prototype device. The device features a hat equipped with ultrasonic sensors for obstacle detection, vibration motors embedded on a belt to provide haptic feedback for the detected obstacles and the ATmega328P microcontroller to process the sensors' data. The system's software is implemented in C and runs on the microcontroller.

Discussion

This study investigated the NaviSense prototype's potential to enhance the daily mobility and safety of VIP by using its sensing capabilities and vibration feedback. Experimental results, including the performance improvements shown in Figure 1, provided insights into the system's performance and useability, indicating that user proficiency improves over time. We believe this is due to the relatively intuitive user interface and a reasonable learning curve. Further research is needed to confirm this assessment across multiple users and obstacle course scenarios.

Conclusions

Overall, the results support our initial conjecture that a wearable computing device taking advantage of ultrasonic sensing and intuitive tactile feedback could enhance the navigation and obstacle detection capabilities of VIP. However, the study's limited sample size and short duration, makes it necessary for future work to be lengthier with more participants, to evaluate its long-term impact on independence and confidence.

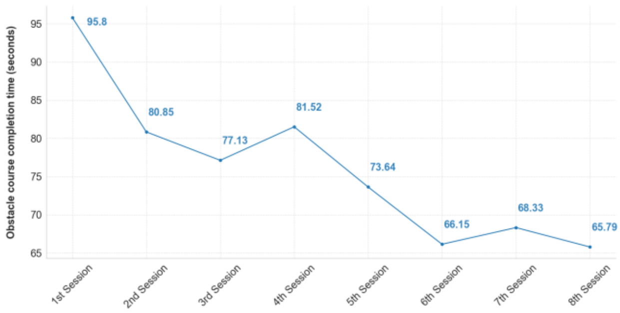

Figure 1. Indicative graph of a participant's improving performance in a navigational obstacle-course challenge, while using the prototype device for several sessions (subject 11)

References

1. F. Barontini, M. G. Catalano, L. Pallottino, B. Leporini, and M. Bianchi, "Integrating Wearable Haptics and Obstacle Avoidance for the Visually Impaired in Indoor Navigation: A User-Centered Approach," IEEE Trans. Haptics, vol. 14, no. 1, pp. 109–122, Jan. 2021, doi: 10.1109/TOH.2020.2996748.
2. B. Leporini, M. Rosellini, and N. Forgione, "Haptic Wearable System to Assist Visually-Impaired People in Obstacle Detection," in Proceedings of the 15th International Conference on PErvasive Technologies Related to Assistive Environments, Corfu Greece: ACM, Jun. 2022, pp. 269–272. doi: 10.1145/3529190.3529217.

Keywords:
Wearable computing, multi-sensor fusion, microcontroller, visual impairment aid, biomedical engineering, assistive technology

A NOVEL SOFT-ROBOTIC GLOVE FOR PHYSICAL REHABILITATION FEATURING ADJUSTABLE AGONIST/ANTAGONIST MUSCLE ASSISTANCE

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Introduction

There have been several approaches to develop technologically-enhanced gloves aimed at active or active-assisted hand rehabilitation [1]. The most common solutions can broadly be classified into two groups: cable, pulley and motor systems implemented as either hard- and soft-robotics solutions, and solely soft-robotics approaches based on actuators made using soft materials. Combining rehabilitation techniques with serious gaming and virtual reality (VR) has also shown promise, as users have been found to benefit both cognitively and physically from such an approach [2]. Some studies have also demonstrated that having a system which combines the simulation of virtual objects with real, physical haptic feedback from a glove is also a promising approach. A pilot study conducted using a VR environment found that participants demonstrated a significant decrease in time required to perform standard functional tasks [3]. Integrating these approaches into a single device, we believe it is possible to create a cheap assistive glove which leverages the advantages of each type of system.

Materials and Methods

The prototype device comprises two main components. The pneumatic soft-robotics actuator, which provides curling assistance, and a hard-robotics cable-and-pulley system whose purpose is to detect finger position, emulate tactile resistance and generate the feeling of a virtual object being grasped by the patient. We use silicon for the construction of the pneumatic actuators, which are inflated and deflated by a miniature air compressor via electronically-addressable valves. The position of a patient's finger is determined by fixing a 3D-printed strip of thin plastic at the top of each glove finger. The strip is serrated at one end in a pattern which matches the teeth of a gear, causing it to rotate it as the finger curls and extends (fig 1).

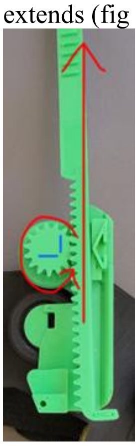
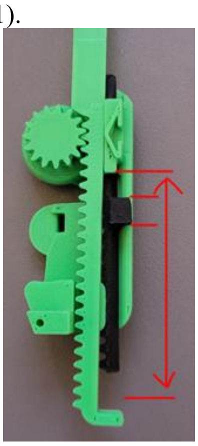

Fig. 1: The red arrow shows the movement of the plastic strip which rotates the gear, sensed by the Hall Effect sensors (blue) and interpreted as finger flexion.

Fig. 2: The strip's range (red) is limited by the black stopper component, which is adjusted by a servo motor.

The haptic feedback of the glove for each finger is generated by a servo motor. The hook on the plastic strip prevents the finger from curling past a certain point, as demonstrated in fig. 2. The device is partially assembled and currently undergoing functionality testing. Initial testing includes sensor functionality, curling assistance, haptic feedback, data aggregation and compilation. Our development team includes physical rehabilitation experts, including a neurosurgeon, who will subsequently assess the glove's utility in a clinical setting. Final pilot testing at the Medical School of the Aristotle University of Thessaloniki will involve actual patients undergoing physical rehabilitation, aiming to validate the glove's effectiveness in realistic scenarios. During the pilot testing phase, we plan to assess the impact of prototype glove with and without haptic feedback, to determine this particular feature's efficacy.

Discussion

The microcontroller, translational and client PC software is partially developed, while the prototype hardware is undergoing iterative improvements. Development of real-time data processing and integration of VR is in progress and initial testing.

Conclusion

Our prototype device combines soft pneumatic actuators -for curling assistance, increased safety and comfort- with hard robotic tendons for precise resistive pressure and extension assistance. We believe and aim to prove that it leverages the comparative advantages of each design approach. The device acquires and compiles data into a report suitable to support the attending physician's decisions. User's comfort is enabled through use of a breathable glove and cushioning layers between the user's hand and the hard parts of the glove. The silicon actuators can be swapped out and cast to fit exact finger lengths of the user. The project is currently in the prototyping stage and will be fully assembled for testing shortly. Final pilot testing is planned in collaboration with the Medical School of the Aristotle University. Additionally, the glove will be run through rigorous and durability testing in order to confirm long-term efficacy.

References

[1] M. Tiboni and C. Amici, "Soft Gloves: A Review on Recent Developments in Actuation, Sensing, Control and Applications," *Actuators*, v. 11, no. 8, Art. no. 8, Aug. 2022
[2] K. Mitsopoulos et al., "NeuroSuitUp: System Architecture and Validation of a Motor Rehabilitation Wearable Robotics and Serious Game Platform," doi: 10.3390/s23063281.
[3] H. C. Fischer, et al. "Hand Rehabilitation Following Stroke: A Pilot Study of Assisted Finger Extension Training in a Virtual Environment," doi:10.1310/tsr1401-1.

Keywords: Hand rehabilitation, Wearable computing, Microcontroller, Biomedical Engineering, Virtual reality, Haptic feedback

DEVELOPMENT OF A FUNCTIONAL ELECTRICAL STIMULATION PROTOTYPE DEVICE WITH NOVEL OPTIMIZATION METHODOLOGY FOR NEUROREHABILITATION (OPTIPULSE)

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Extended Abstract

Attenuation or interruption of neural pathways leads to significant motor and sensory impairments. Conditions such as stroke and spinal cord injury disrupt communication between the central nervous system (CNS) and peripheral muscles, inhibiting voluntary muscle activation and sensory feedback. Recovery remains possible through neuroplasticity of the CNS, which enables the reorganization and formation of new neural pathways in response to stimuli.

Electrical Muscle Stimulation (EMS) involves the application of electrical pulse-trains to peripheral nerves or muscle, eliciting contractions even without voluntary control. EMS provides sensory input to the CNS, which is proven to enhance neuroplasticity. Functional Electrical Stimulation (FES) elicits contractions, synchronized with functional activities like walking or grasping. Over time, FES improves performance in Activities of Daily Living (ADLs), leading to independence and better quality of life.

Higher stimulation parameter values (frequency, amplitude, width etc.) typically elicit stronger contractions but increase discomfort, fatigue, and skin irritation. Electrode placement also affects contraction quality as small shifts can significantly alter outcomes.

An adaptive FES system is necessary to optimize electrode placement and stimulation parameters for efficacy and fewer drawbacks. This is achievable through automatic calibration at the start of each therapy session, allowing individualized treatment and home-based rehabilitation. This paper examines optimization methods and in vivo experimental results.

Experimental Setup and Method

Our prototype employs a microcontroller to drive two waveform generators for electrical stimulation. Muscle response is monitored via accelerometers on the bicep and wrist, measuring localized twitch and flexion-related acceleration, respectively. This setup enables real-time contraction evaluation across 15 electrode configurations and multiple frequency pairs.

Discussion

The graph in fig. 1 is a result of the described process.

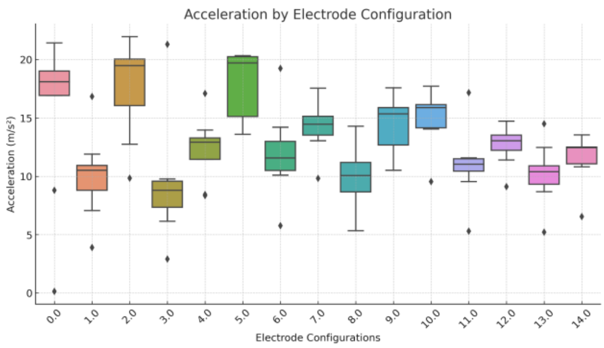

Fig. 1. Max Acceleration by Electrode Configuration

Results show significant variability across electrode configurations, highlighting the need for automatic calibration and signal parameter optimization. Stable configurations are identified through median peak acceleration and low variability. To enhance parameter selection, we plan to implement a rule-based AI system and fuse accelerometer data with EMG and flex sensor input. We intend to increase the number of subjects to strengthen our findings and explore real-time parameter updates using machine learning.

References

1. Shiyu Luo, Haonan Xu, Yi Zuo, Xiaogang Liu and Angelo H. All (2020) Review of Functional Electrical Stimulation Treatment in Spinal Cord Injury, NeuroMolecular Medicine, 22: 447–463.

Keywords

Functional Electrical Stimulation (FES), Neurorehabilitation, Stroke, Spinal Cord Injury (SCI), Physical Therapy (PT), Nervous System, Artificial Intelligence (AI), Medical and Biomedical Engineering

ΕΠΙΣΤΗΜΟΝΙΚΟ ΠΡΟΓΡΑΜΜΑ
ΑΝΑΡΤΗΜΕΝΕΣ ΑΝΑΚΟΙΝΩΣΕΙΣ

SCIENTIFIC PROGRAMME
POSTER PRESENTATIONS

APPLICATION OF TELEHEALTH IN CANCER CARE: EXPERIENCES FROM THE GREEK PILOT OF THE eCAN PROJECT

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Introduction

Cancer patients' access to healthcare has been limited due to the Covid-19 pandemic [1], making the need for a comprehensive e-health monitoring framework apparent for both patients and health care professionals (HCPs). The eCAN Joint Action [2] aimed at employing a patient-centered telehealth ecosystem, consisting of a teleconsultation platform, a patient mobile application for health data collection and a web dashboard addressed to HCPs for the monitoring of the patients. The present work presents the real-world deployment and insights gained from the Greek pilot within the context of the project, emphasizing challenges and lessons learnt.

Materials and methods

During the eCAN Greek pilot study cancer patients following the intervention arm (experiencing care through a telemedicine platform and remote monitoring of symptoms) participated for a period of 8 weeks. Their participation entailed the utilization of a mobile application. The patients were instructed to use the mobile application on a weekly basis to report their level of distress on a scale between 1 and 10, with 1 being no distress. Additionally, the QLQ-C30 questionnaire [3] was integrated within the mobile application, to be filled in by patients on a bi-weekly basis. HCPs were instructed to remind the patients to fill out the questionnaires. Patients in the intervention group participated also in weekly psychological teleconsultation sessions through the Edumeet platform [4]. After each teleconsultation, the HCP filled in a structured report on the web dashboard, following the SOAP framework. The questionnaire consisted of subjective and objective questions filled by the HCP to evaluate the psychological state of the patient and their experience with telehealth.

The control group followed their regular consultation in-person schedule, as designed by their HCPs. After each consultation, the HCPs filled in the SOAP report, involving the same sections as the one for the intervention group, except for a few questions addressing teleconsultation experiences. The control group reported their distress level to the HCPs, and they filled out the QLQ-C30 during the first and last consultation through the web dashboard, guided by the HCPs.

Results

18 patients with advanced cancer were invited to participate in the study. Among them, six (6) were immediately excluded, due to non-willingness to participate. One (1) patient dropped out after the initial session, wanting to attend only in-person consultations. This resulted in eleven (11) patients completing the study, six (6) of them belonging to the intervention group, eight (8) females. The mean age of participants was 54,91 years, with a SD=13,2. Participants of the intervention group missed a mean of 1,6 sessions due to health issues, except for one patient who only attended 5 teleconsultations. Distress data were consistently reported by only one patient, while a mean of 4,6 distress entries with an SD of 2,3 were missing from the intervention group. No patient completed all QLQ-C30 reports, one (1) patient of the intervention group reported less than 0.5h, 3 reported 0.5-1.5h, while the other 2 reported 1.5-3h travel time to the hospital.

Discussion

The missing data observed during the pilot was coherent with the notes taken by the HCPs in the objective sections of SOAP, reporting the difficulty of the patients in the use of the mobile application. Patients' low digital literacy and lack of access to technology were also reported by the HCPs, during the collection of lessons learnt through a SWOT analysis conducted after the pilot completion. While the far proximity of the patients to specialized cancer care should have acted as a facilitator for the adoption of telehealth in comparison to in-person psychological consultations and despite the satisfaction of the patients reported by the physicians, the adherence to the study protocol was extremely low. More in-depth research, collecting personal views and a higher number of participants is required to extract conclusions towards the application of telehealth services in the Greek reality.

References

1. Filip, ... Savage, W. K. (2022). Global challenges to public health care systems during the COVID-19 pandemic: a review of pandemic measures and problems. *Journal of personalized medicine*, *12*(8), 1295.
2. eCAN at https://ecanja.eu/
3. Aaronson, ... Takeda, F. (1993). The European Organization for Research and Treatment of Cancer QLQ-C30: a quality-of-life instrument for use in international clinical trials in oncology. *JNCI: Journal of the National Cancer Institute*, *85*(5), 365-376.
4. eduMEET at https://edumeet.org/

Keywords:
Cancer, telehealth, telemonitoring

Acknowledgement
This work was funded by the eCAN Joint Action GA number 101075326

STRUCTURAL AND FUNCTIONAL OPTIMIZATION OF PNEUMATICS-BASED SOFT ROBOTIC GLOVE USING FINITE & BOUNDARY ELEMENT ANALYSIS

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Introduction

Soft robotics rapidly evolve focusing on designing robots with flexible materials to enhance safety, adaptability and ease of use during robot-user interaction. Pneumatic soft robotic gloves (pSRGs) have been developed to assist individuals with hand disabilities by providing controlled movements through pump-fed 3D printed actuators. Important aspects of pSRGs include strength, flexibility and user comfort [1]. In our design approach, Finite Element Method (FEM) is used to analyze stress distribution, deformation, and material performance, while Boundary Element Method (BEM) is applied to study boundary interactions and reduce computational complexity. This study aims to further develop the pSRG actuators of the NeuroSuitUp/HEROES project [2].

Methods

FEM/BEM combined approach will be used to optimize the project's pSRG development. FEM can discretize the whole model while BEM only the boundaries. In this project we will use the quadratic method, as it provides balance between accuracy and computational cost, in order to determine the values of stress, strain and deformation using FEM and noise reduction of the pump using BEM. [3]. Simulations in Abaqus utilize Silicone elastic material. We divided the elements using FEM and BEM with quadratic interpolation into 260000 elements while setting the steady point for finger bending and apply 30KPa of pressure and gravitational pull.

Expected Results and Discussion

Post-simulation the points of increased load are checked for redesign and reinforcement needs. The results show the maximum bending of the actuator (Figure 1) as well as the places where increased load is applied (Figure 2). Post-model creation, the project will entail Arduino code development and testing values components creation. Finally, it will lead to 3D printing the actuator prototypes, pSRG assembly, testing and validation. The prototype must meet easiness to wear and user comfort needs. The initial testing and safety check will be conducted with the necessary calibrations in order to be deployed for further validation. Final goals include actuator integrity and strength, flexibility and safety as essential parts of the SRGs in order to achieve the project's purposes of patient rehabilitation.

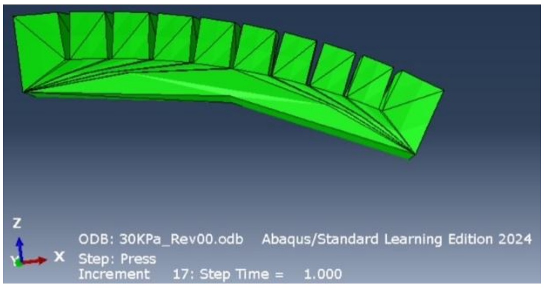

Figure 1. An individual pneumatic actuator's ("finger") bending model

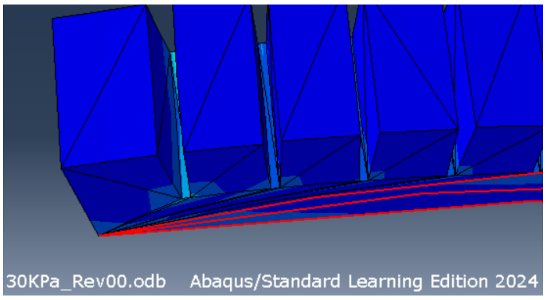

Figure 2. Modeling increased load points during bending

References

[1] Fumiya I & Laschi C (2011) Soft Robotics: Challenges and Perspectives. Procedia Computer Science, 7; 99-102
[2] Mitsopoulos K, et al. (2023) NeuroSuitUp: System Architecture and Validation of a Motor Rehabilitation Wearable Robotics and Serious Game Platform. Sensors, 23, 3281
[3] Hunter P & Pullan A (2001) FEM/BEM NOTES. Auckland, NZ: Department of Engineering Science

Keywords:
Soft Robotics, Finite Element Method, Boundary Element Method, Actuator Design, Rehabilitation

Acknowledgement
This research project was supported by the Hellenic Foundation for Research and Innovation (H.F.R.I.) https://www.elidek.gr under the "2nd Call for H.F.R.I. Research Projects to support Faculty Members & Researchers" (Project Number: 4391).

MONITORING SCATTERED RADIATION FOR OPTIMIZING STAFF POSITIONING IN FLUOROSCOPICALLY-GUIDED HIP INTERVENTIONS

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Introduction

Dose monitoring is necessary for optimizing occupational radiation protection in fluoroscopically-guided interventions [1,2]. The aim of this study is to monitor scattered radiation in case of a phantom-based study simulating fluoroscopically-guided hip interventions, for optimizing staff positioning.

Materials and Methods

The phantom consisted of a titanium total hip replacement implant (femoral stem component with length 19.5 cm and a femoral head), embedded in a plastic water tank (L=45cm, W=36cm, H=18cm). The implant was placed on 6cm PMMA plates within the water tank. The phantom was imaged with a C-arm Siemens Cios Select Fluoroscopy system, in pulsed fluoroscopy (5pps), employing three fluoroscopy modes [low dose rate (LDR), normal dose rate (NDR) and high dose rate (HDR)], field of view (FOV) = 23 cm, in undercouch geometry. Scattered radiation (dose rate) was measured utilizing an RTI ion chamber survey meter. Measurement points considered various angles around the phantom (0° to 315°; step: 45°) at a distance of 50 cm and height 85 cm from the ground. Dose rate was used for estimating gonad equivalent dose for various staff positions, considering average fluoroscopy time 60s per intervention, normal fluoroscopy mode, annual workload of 250 interventions and presence of protective apron of 0,5 mm Pb equivalence.

Results and Discussion

Figure 1 provides scattered radiation distribution (dose rate) for LDR, NDR and HDR fluoroscopy mode. Table 1 provides scattered radiation (dose rate) and corresponding annual gonad equivalent dose values for optimized staff positions during fluoroscopy-guided hip interventions. Optimized positions for Head surgeon and Assistant surgeon were selected by the lowest dose rate values, corresponding to 45^0 and 135^0, respectively.

Conclusions

Monitoring spatial distribution of scattered radiation under intervention-specific conditions can be used for reviewing and optimizing staff positioning.

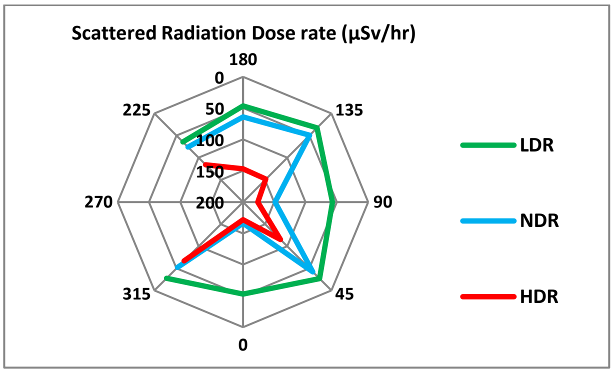

Figure 1. Scattered radiation (dose rate) distribution during low dose rate (LDR), normal dose rate (NDR) and high dose rate (HDR) pulsed fluoroscopy (no zoom).

Table 1: Scattered radiation (dose rate) and corresponding annual gonad equivalent dose for optimized staff positions during hip interventions.

Medical Staff	Staff Position (Distance/ Angle)	Scattered Dose Rate (μSv/h)	Gonad Equivalent Dose (μSv/year)
Head surgeon	50 cm / 45^0	49.41	10.29
Assistant surgeon	50 cm / 135^0	42.21	8.79
Nurse	100 cm / 315^0	18.97	3.95
C-arm operator	200 cm / 270^0	0.12	0.03

References

1. T. Dorman, B. Drever and S. Plumridge (2023) Radiation dose to staff from medical X-ray scatter in the orthopaedic theatre, Eur J Orthop Surg Traumatol, 33:3059-3065.
2. M. Dadabhoy, P. Waldock, T. Brammar, S. Pryke and R. Coomber (2022) Gonad irradiation from fluoroscopy during upper limb orthopaedic procedures in a UK District General Hospital. Br J Radiol, 95(1133):20211087.

Keywords: Occupational Radiation Protection, Orthopaedic Surgery, Metallic Implants, Fluoroscopy, Scattered Radiation

AUTOMATED ALGORITHM AND USER INTERFACE FOR SPATIAL DISTORTION DETECTION IN MR IMAGES USED FOR TARGET LOCALIZATION IN STEREOTACTIC RADIOSURGERY

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Introduction

Stereotactic radiosurgery (SRS) is a radiotherapy treatment approach, employing high dose gradients and increased dose per fraction. In cranial SRS, stringent dose delivery spatial requirements (<1mm) may be necessary to ensure treatment efficiency especially if small targets are involved [1]. Target localization accuracy often relies on spatial fidelity of Magnetic Resonance (MR) images used in treatment planning due to superior soft-tissue contrast as compared to other imaging methods.

MR-related spatial distortion is distinguished in two types [2]. Sequence-independent distortions are related to the nonlinearity of the gradient magnetic fields, while sequence-dependent distortions are related to static magnetic field inhomogeneities, susceptibility-induced spatial offsets and the chemical shift effect.

A proposed method for determining MR-related distortion is by scanning a phantom with high contrast markers (referred to as control points, CPs) and processing the obtained images with a localization algorithm to facilitate distortion detection and evaluation. For this purpose, a custom software was developed, using python programming language.

Materials and Methods

A phantom made of acrylic was used for scanning. The phantom consists of 11 parallel acrylic planes which contain 1978 holes in total. A CP is defined as the geometric centroid of each hole.

An algorithm for CP was developed, requiring minimum user input. More specifically, the user enters a reference image (e.g., a geometrically accurate CT scan) and up to two MR scans with opposite read gradient polarity. A threshold level is selected by the user and the rest of the processing is automated. The algorithm applies different shape filters to distinguish between holes and other objects or noise in the created 3D binary image. The geometric centroids of all qualified objects are calculated in the 3D space, serving as CPs. The latter are matched among images after applying a rigid transformation matrix to spatially co-register all images. Finally, the algorithm statistically analyzes the detected distortion of both types and presents relevant distortion maps in a user-friendly graphical interface.

Results

Threshold sensitivity was estimated to be (0.031 ± 0.001) mm per 10 pixel intensity units. Moreover, the overall uncertainty of the CP localization procedure was estimated to be <0.2 mm.

As a feasibility study, the phantom was MR- and CT-scanned by a Philips Achieva 1.5T MRI scanner and a Siemens Somatom scanner, respectively. The sequence independent distortion was quantified by implementing the developed software and the reversed read gradient polarity method [2]. An analysis of the detected distortion magnitude is presented in Table 1. An indicative distortion map, using one of the software's plotting options is shown in Figure 1.

Table 1: Statistics of absolute sequence independent distortion

	X (mm)	Y (mm)	Z (mm)	Magnitude (mm)
maximum	1.3	1.5	0.6	1.7
mean	0.5	0.5	0.2	0.8
median	0.4	0.4	0.1	0.8
st. deviation	0.3	0.3	0.1	0.3

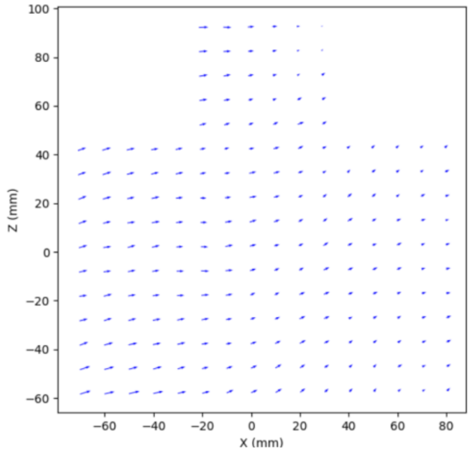

Figure 1: Quiver plot showing sequence independent distortion vectors on a plane at 61 mm from machine's isocenter on Y axis

Conclusion

The developed algorithm demonstrates adequate overall uncertainty of the order of 0.2mm. Results are user-independent due to the insensitivity of the selected threshold. With the use of this software, the distortion magnitude of MR imaging protocols can be efficiently quantified and visualized for further evaluation in a user-friendly interface.

References

[1] Grishchuk et al 2023, Pract Rad Oncol (13): 183-194
[2] Baldwin et al 2009, Med Phys 36 (9): 3917–3926

Keywords: MRI, geometric distortion, stereotactic radiosurgery

UNDERSTANDING BARRIERS AND ENABLERS OF INNOVATION IN TRANSITIONAL CARE: A MIXED-METHODS STUDY

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Introduction

Innovation in transitional care is essential for improving patient outcomes, reducing hospital re-admissions, and ensuring a seamless healthcare experience. However, its implementation is often hindered by various barriers such as financial constraints [1] and communication [2] challenges. This study explores the barriers and enablers in Greek healthcare system, incorporating the experiences of healthcare professionals and patients.

Materials and methods

A mixed-methods approach examined perspectives of patients and healthcare professionals in Greece. A structured questionnaire identified challenges and enablers, while semi-structured interviews provided deeper insights. Quantitative data was collected from health care professionals and patients through an online questionnaire that included multiple choice questions for the barriers and enablers of innovation in transitional care. Questionnaire responders were asked if they agree to be contacted for a follow-up interview that validated and expanded on the findings of the quantitative analysis.

Results

Nine (9) patients (8 female, 1 male) and nine (9) healthcare professionals (3 female, 6 male) answered the online questionnaire. Five (5) healthcare professionals and three (3) patients participated in the interviews.

From the patient perspective, the most commonly reported challenges included emotional stress (60%) and financial difficulties (40%). Support services during the transition were scarce, with only 30% receiving a follow-up call or access to a care support group. Satisfaction with the transition process was low, with 44% reporting they were unsatisfied or very unsatisfied. Most participants selected better community resources and financial assistance (70%) and personalized care (60%) as top areas for improvement.

Healthcare professionals identified the creation of clearer reimbursement and funding models to support innovation as the most important need (55%). Technology was seen as a key enabler, enhancing team communication (55%) and supporting remote monitoring (40%). Key areas for innovation included discharge instructions and medication management (66%), data sharing and interoperability (66%), healthcare coordination (55%), and post-discharge home-care services (55%). The main challenges to adopting innovation were staff resistance to change (55%) and difficulty integrating new technologies into existing systems (55%).

All interviews highlighted gaps in post-discharge care, especially the need for better follow-up and digital support. Resistance to new technologies was a major barrier for both patients and professionals, emphasizing the need for improved communication and training to support adoption and enhance care transitions.

Discussion

The study identified key barriers and enablers in care transitions. However, its findings may be influenced by the small sample size and uneven gender representation. Despite these limitations, several notable insights emerged. Financial challenges were a significant concern for both patients and healthcare professionals—patients struggled with affordability, while professionals sought clearer reimbursement and funding models. Additionally, patients lacked follow-up calls and support services, while healthcare professionals recognized technology as a crucial enabler that could address these gaps.

Conclusions

This study reinforces previous research within the context of the Greek healthcare system. The findings highlight the urgent need for innovation in transitional care services, particularly through the integration of advanced technologies.

References

1. Fakha, A., Groenvynck, L., de Boer, B. et al. A myriad of factors influencing the implementation of transitional care innovations: a scoping review. Implementation Sci 16, 21 (2021). https://doi.org/10.1186/s13012-021-01087-2

2. Gass, B., McFall, L., et al. (2023). Perspectives of acute, post-acute, physician and community support providers on community collaborative efforts to improve transitions of care. *Healthcare*, *11*(1), 100673. https://doi.org/10.1016/j.hjdsi.2022.100673

Keywords: innovation, transitional care, health tech

Acknowledgement

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MORPHOLOGICAL ANALYSIS OF INTRALUMINAL THROMBUS OF ABDOMINAL AORTIC ANEURYSM

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Introduction
In cardiovascular physiology, the size, shape, and structure of the intraluminal thrombus (ILT) are particularly important since, in 70–80% of patients with abdominal aortic aneurysms (AAA), an ILT covers the vessel wall [1]. However, the exact role of ILT in this context remains unclear and controversial. Building on previous studies that primarily examined the presence, size, and consistency of ILT [1,2], this study aims to clarify the dimensions of the two distinct layers of ILT: the luminal layer and the medial/abluminal layer. Additionally, it seeks to explore how these layers relate to the AAA maximal diameter and other relevant AAA parameters.

Methods: In a retrospective study involving 17 patients with AAA, STL files from 3D models of intraluminal thrombus were utilized to analyze its layers. The 3D ILT models used as input were generated from patient CT scans in the context of the SAFE-AORTA project. The structure of the intraluminal thrombus was classified into established layers, including the luminal layer and the medial/abluminal layer. To extract the luminal layer and calculate its exact surface, we employed various filters from the Paraview post-processing visualization engine, such as *Surface Normals*, *Connectivity*, and *Threshold* method. Paraview was also utilized to estimate the integration of ILT surface value and visualize the results of each patient.

Results: ILT was observed in nine out of 17 patients (age, mean ± SD: 70.23 ± 8.57, male: 94.12%). Representative distinct ILT layers are shown in Figure 1. Table 1 shows the results for the surface of both ILT layers in patients with AAA.

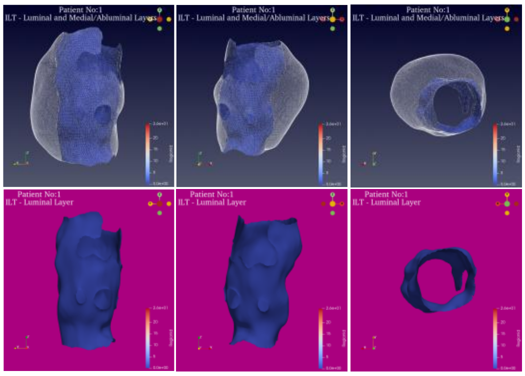

Figure 1. Representative Figures of the distinct ILT layers.
Up: Both Layers (Luminal & Medial/Abluminal)
Down: Luminal Layer.

Table 1: Calculation of the surface of ILT layers in patients with AAA using the Paraview toolbox

Patient No-maxD AAA[1] (Gender-Age)	whole ILT surface[2]	luminal ILT layer surface[2]	medial/ abluminal ILT layer surface[2]	medial/ abluminal to luminal layer
1-**33** (**M**-81)	10642.7	4090.02	6552.68	1.6021
2-**73** (**M**-89)	10516	4267.32	6248.68	1.4643
3-**43** (**M**-63)	11025.9	4427.71	6598.19	1.4902
4-**45** (**M**-57)	19134.1	6983.57	12150.53	1.7399
5-**33** (**M**-57)	14535.1	5139.59	9395.51	1.8281
6-**34** (**M**-70)	13619.7	5030.83	8588.87	1.7072
7-**36** (**M**-81)	10398	3584.95	6813.05	1.9004
8-**55** (**M**-76)	3421.81	1488.12	1933.69	1.2994
9-**39** (**M**-65)	15368.4	5430.69	9937.71	1.8299

[1]maxDiameter of AAA in mm, [2]surface in mm^2

Discussion: Moderate negative correlations were observed between the entire ILT or its layers, and both age and neck diameter. Additionally, strong negative correlations were identified between the ratio of the medial/abluminal layer to the luminal layer and: a) neck diameter ($r = -0.73$, $p = 0.03$) and b) maximum AAA diameter ($r = -0.65$, $p = 0.05$). Future research involving a larger and more diverse population could further validate and expand these findings.

Conclusion: This approach may improve our understanding of ILT's role in AAA progression and could benefit decision-making in pre-operative planning in endovascular repair.

References
1. A. Piechota-Polanczyk, et al (2015) The Abdominal Aortic Aneurysm and Intraluminal Thrombus: Current Concepts of Development and Treatment. Front Cardiovasc Med., 2:19
2. VL. Nguyen, T. Leiner, FA. Hellenthal, et al (2014) Abdominal aortic aneurysms with high thrombus signal intensity on magnetic resonance imaging are associated with high growth rate, Eur J Vasc Endovasc Surg., 48(6):676-84

Keywords:
Abdominal Aortic Aneurysm, Intraluminal Thrombus, Morphological Analysis, Paraview

Acknowledgement
This research was part of the “Flagship Actions in Interdisciplinary Scientific Fields” initiative, implemented by the National Recovery and Resilience Fund Greece 2.0 and funded by the EU's NextGenerationEU program (Project ID: TAEDR-0535983).

SOURCE-LEVEL EEG FUNCTIONAL CONNECTIVITY ANALYSIS IN SCHIZOPHRENIA PATIENTS

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Introduction

Schizophrenia is a chronic psychiatric disorder characterized by disruptions in cognition, thought, and perception and is linked to regional brain disconnection [1]. EEG signal analysis has offered unique insights into brain region interactions through neuronal oscillations and cross-frequency coupling with high temporal resolution. This study utilized source-level EEG analysis for localization of neural networks involved.

Methodology

The used dataset comprised of two groups (paranoid schizophrenia patients (F20.0) and healthy controls) of 14 subjects (7m:7f each, age (27±5 y.o.) and gender matched). Patients were unmedicated for a minimum of 7 days and were not very early stage (i.e. first psychotic episode) or suffered another organic or major neurological disorder. In this preliminary analysis, Multivariate Autoregressive (MVAR) modelling was performed on 2 recordings (15 min eye-closed resting state) from both groups. A 19-channel 10-20 EEG montage and sampling frequency 250Hz were used.

Preprocessing included mapping channel locations, down-sampling (100 Hz), re-referencing to average reference electrode and applying FIR filter at 1 Hz (shown to improve Independent Component Analysis (ICA) performance) [2]. Bad channels and/or time series were removed and after interpolating rejected channels, ICA and ICLabel were used to differentiate ICs that contribute linearly to produce the recorded signal and flag them as brain or artifact. Non-brain ICs were removed. Locations were co-registered on the MNI head model and dipoles were fitted for each of the ICs using DipFit (representing sources in 3D space). Connectivity metrics such as Dynamic Directed Transfer Function (dDTF) were calculated using the Source Information Flow Toolbox (SIFT), utilizing a MVAR model the order of which is specified using the Akaike Information Criterion.

Results

The EEG processing pipeline managed to reduce artifacts and localize neural sources using DipFit. Preliminary application of SIFT produced band-specific connectivity measures of metrics such as dDTF and Complex Spectral Density (S) as shown in the figure below.

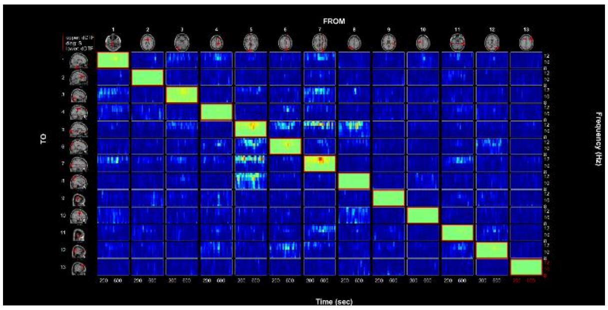

Figure 1: Time-Frequency Grid of alpha activity. Frequency is represented on the y-axis and time on the x-axis. dDTF is plotted between sources (from row to column) and the diagonal highlighted row represents S.

Discussion

Data preprocessing was essential for isolating source-level neural activity and extracting reliable connectivity metrics. Future advancements will involve calculating these metrics across subjects for validation and integrating statistical tools to explore group-level differences.

Conclusions

This novel MVAR modeling approach provides a useful framework for studying functional connectivity for schizophrenia, as with other neurological conditions [3]. By improving artifact rejection and source localization, we aim to enhance connectivity analysis reliability, in order to further advance functional neuroimaging schizophrenia research.

References

[1] Schmitt A, Hasan A, Gruber O, Falkai P. Schizophrenia as a disorder of disconnectivity. Eur Arch Psychiatry Clin Neurosci. 2011; 261 Suppl 2:S150–4.
[2] Winkler, I., Debener, S., Müller, K.-R., & Tangermann, M. (2015). On the influence of high-pass filtering on ICA-based artifact reduction in EEG-ERP. Conference Proceedings: IEEE Engineering in Medicine and Biology Society, 4101–4105.
[3] Athanasiou A, et al. (2018) Functional Brain Connectivity during Multiple Motor Imagery Tasks in Spinal Cord Injury. Neural Plast. 2018:9354207

Keywords:
Schizophrenia, Functional connectivity, EEG analysis, Neural Networks, Source-level Analysis

EYE TRACKING IN SERIOUS GAMES AND ITS REHABILITATION APPLICATIONS

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Introduction

Serious Games (SGs) have evolved since the 1970s from military training tools to applications in healthcare, research, and professional training [1]. With advancements in technology, serious games have integrated new interaction methods, such as eye tracking, to enhance user experience and data collection [2]. This study focuses on designing an ergonomically optimized UI and evaluating usability through eye movement efficiency, task performance, and user engagement. By combining eye-tracking data with user feedback, it aims to assess the role of eye tracking in rehabilitation-focused SGs and its impact on game design.

Methodology

The study follows a structured research protocol, including user interface design analysis, ergonomic assessments and best practices, and data collection on gaze behavior [3]. To investigate the effectiveness of eye tracking in serious games, a rehabilitation-focused serious game, developed for the HEROES project [4] with optimized eye-based UI elements, incorporating the eye tracker Gazepoint GP3 Eye model for collection of fixations, gaze duration, and saccades. Data will be collected through eye movement patterns, user feedback, reaction time, UI navigation efficiency, user fatigue levels and task completion efficiency. Following the data collection, a statistical analysis will be conducted to measure the system's effectiveness in enhancing engagement, reducing fatigue and the overall success rate, key factors for a successful UI design.

Discussion

The integration of eye tracking in serious games has demonstrated the proper UI methodologies that enhance user engagement and the user experience and reduce strain in the past while also providing crucial information that would have otherwise been hidden [2].

Results

This research is expected to produce similar results, while also slightly translating them into this different category of serious games, namely for rehabilitation. A comparative analysis will be conducted between datasets collected before and after incorporating the eye tracking data to assess its contribution and the degree to which it impacts data quality and overall outcomes.

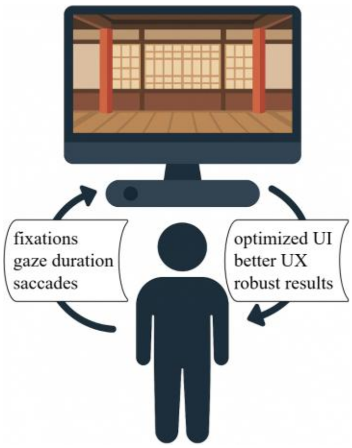

Figure 1. Experimental methodology diagram

References

[1] Giagloglou E., Panagiotis A., Macuzic I., Bamidis P. 2015. Improving Safety through gaming: A serious game's application for risky professions. 49th ESReDA Seminar

[2] K. Kiili, H. Ketamo, and M. D. Kickmeier-Rust, "Evaluating the usefulness of Eye Tracking in Game-based Learning," *Int. J. Serious Games*, vol. 1, no. 2, Jun. 2014, doi: 10.17083/ijsg.v1i2.15.

[3] Z. Chen, "Research on the application of ergonomics in UI interface design," *Appl. Math. Nonlinear Sci.*, vol. 9, no. 1, p. 20230787, Jan. 2024, doi: 10.2478/amns.2023.2.00787.

[4] K. Mitsopoulos *et al.*, "NeuroSuitUp: System Architecture and Validation of a Motor Rehabilitation Wearable Robotics and Serious Game Platform," *Sensors*, vol. 23, no. 6, p. 3281, Mar. 2023, doi: 10.3390/s23063281.

Keywords:
Eye Tracking Serious Games, User Interaction, Ergonomics in Gaming, Rehabilitation Technology

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BRAIN NETWORK BIOMARKERS IN PSYCHIATRIC DIAGNOSIS

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Introduction

Mental disorders are conditions that affect a person's thinking, emotions, behavior, and overall ability to function in daily life. These disorders can be temporary or chronic and may vary in severity. Electroencephalography (EEG) is a powerful tool for studying and diagnosing mental disorders because it records electrical activity in the brain in a non-invasive manner, requires a lower level of patient cooperation than functional magnetic resonance imaging, and is relatively inexpensive and easily available [1].

Methods

The aim of this study is to conduct a narrative review examining the use of EEG and functional Magnetic Resonance Imaging (fMRI) in the diagnosis of mental disorders. The review focused on analyses that could provide useful information to clinicians by tracking neuroimaging biomarkers, and especially on functional brain connectivity, that can be detected in various psychiatric disorders. Searches were performed on Pubmed and Google Scholar repositories. During Jan-Feb 2025, 178 sources were examined, of which 84 were considered most suitable based on the keywords "SWNs", "Functional connectivity", "schizophrenia", "bipolar disorder", "ADHD", "MDD", "EEG", "fMRI". Sources dated before the year 2000 were excluded and emphasis was placed on those that had been published in international journals.

Discussion

The two basic principles on which the organization of the brain is based are functional segregation and functional integration [2]. More intense activity is recorded in specific areas of the cortex that are not observed in normal conditions and alterations in small-world networks (SWNs) are present (Figure 1). The biomarkers detected in schizophrenia are EEG-microstates, the evoked potentials mismatch negativity (MMN) and P50. In bipolar disorder there is an increase in the waveforms Delta, Theta, Beta and Gamma and a decrease in Alpha. A characteristic biomarker in the case of major depressive disorder (MDD) is the evoked potential P300. In the case of attention deficit-hyperactivity disorder (ADHD), the suggested biomarkers are the ratio of Theta to Beta waveforms and the evoked potentials P300 and contingent negative variation (CNV).

Conclusion

In conclusion, we can say that there are certain stable biomarkers that can be used for the diagnosis of schizophrenia (Figure 1), bipolar disorder and major depressive disorder, while in the case of ADHD the results are not yet clear [3].

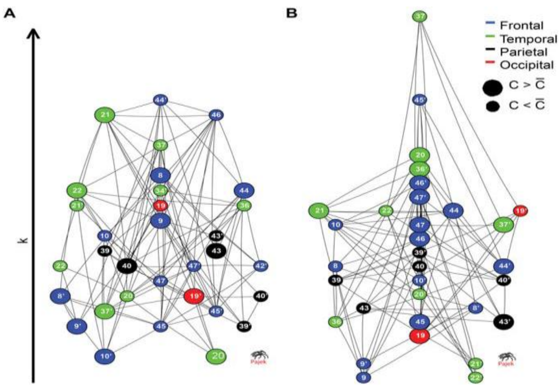

Figure 1. Highly clustered nodes are concentrated at the bottom of the normal hierarchy (A); conversely, in people with schizophrenia (B), highly clustered nodes are more evenly distributed in terms of their degree [4].

References

[1] Freeman D, Garety PA (2003) Connecting neurosis and psychosis: the direct influence of emotion on delusions and hallucinations. Behav Res Ther.41:923-47
[2] Khaleghi Ali et al, (2019). Abnormalities of Alpha Activity in Frontocentral Region of the Brain as a Biomarker to Diagnose Adolescents With Bipolar Disorder. Clin EEG Neurosci. 50(5):311-318.
[3] Luo Y et al. (2020) Biomarkers for Prediction of Schizophrenia: Insights From Resting-State EEG Microstates. IEEE Access. 8:213078-213093
[4] Bassett D et al, (2008) Hierarchical Organization of Human Cortical Networks in Health and Schizophrenia. doi:10.1523/JNEUROSCI.1929-08.2008

Keywords:
brain connectivity, brain network biomarkers, brain biomarkers, electroencephalography, psychiatric disorders

A PHANTOM-BASED STUDY FOR OPTIMIZATION OF IMAGE QUALITY AND RADIATION DOSE IN PEDIATRIC CT

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Introduction

Pediatric CT scans require careful attention due to children higher sensitivity to ionizing radiation. Balancing image quality and radiation dose is essential [1,2]. This study evaluates the effect of image acquisition parameters (tube voltage and tube current) on image quality and radiation dose, aiming to define optimized protocols (that ensure diagnostic accuracy at the lowest possible dose) tailored to clinical indication.

Materials and Methods

A Mini CT QC acrylic phantom (diameter: 15.25 cm), that incorporates structures of varying electron density (bone and soft-tissue equivalent materials), was used to simulate pediatric head. CT image acquisition was performed using a 128-slice scanner (Somatom go.Top, Siemens). Vendor-suggested pediatric head protocol (100 kVp, IQ=350) was considered as a reference for comparison purposes. Additional exposure protocols included tube voltage ranging from 70 to 110 kVp (step 10 kVp) and a range of tube current values (mA) defined by user selected “IQ level” (100 to 400, step 50). Default iterative reconstruction parameters were adopted (strength S2 and reconstruction kernel for bone and soft tissue).

For each tissue-equivalent material, image quality was assessed quantitatively [Contrast-to-Noise Ratio (CNR), Signal-to-Noise Ratio (SNR), and noise] on reconstructed images corresponding to varying exposure settings. The relationship between tissue-specific image quality and radiation dose (CTDIvol) was investigated towards optimization.

Results and Discussion

For all materials analyzed, at specific x-ray energy spectrum (kVp constant), CNR was improved with tube current increase (attributed to noise reduction), at the expense of increased radiation dose (CTDIvol was increased). Image quality indices (CNR and SNR) are differentiated with respect to material composition.

Further considering x-ray energy dependence, the relationship between image quality and radiation dose is material composition dependent (Figure 1, Figure 2), suggesting the importance of clinical indication-specific optimization.

Conclusions

Optimizing image acquisition parameters in pediatric CT is essential for maintaining diagnostic image quality while minimizing radiation exposure. Optimized protocols tailored to tissue/lesion properties and clinical requirements ensure patient safety. Future research should focus on refining dose reduction strategies (further exploiting optimized image reconstruction parameters) and validating optimized protocols in clinical settings.

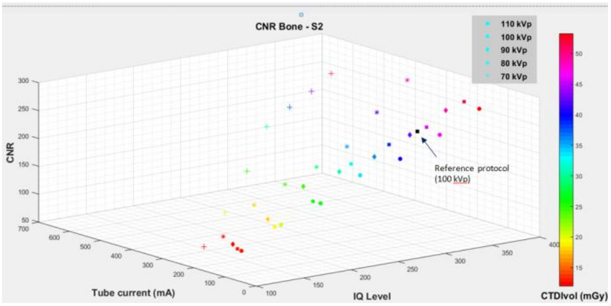

Figure 1. Diagram illustrating the relationship between scan parameters, radiation dose, and image quality in case of Bone equivalent material. The "Reference protocol" (100 kVp) serves as a standard benchmark for comparison.

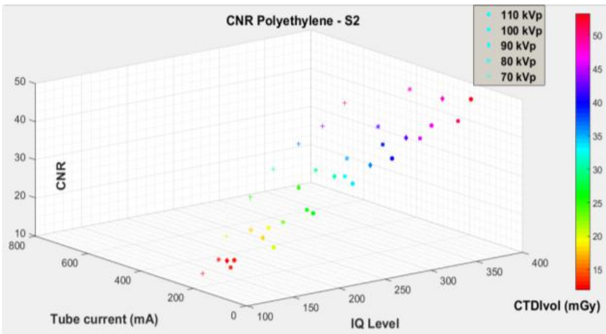

Figure 2. Diagram illustrating the relationship between scan parameters, radiation dose, and image quality in case of Polyethylene material.

References

1. E. Sagy, S. Tschauner, C. Schramek and E. Sorantin (2023) Paediatric CT made easy, Pediatr Radiol, 53: 581-588
2. C. Granata, E. Sorantin, R. Seuri and C.M. Owens (2019) European Society of Paediatric Radiology Computed Tomography and Dose Task Force: European guidelines on diagnostic reference levels for paediatric imaging, Pediatr Radiol, 49(5):702-705

Keywords: Pediatric Imaging, Computed Tomography, Image Quality, Radiation Dose, Optimization

STUDY OF THE SELF-ABSORPTION EFFECT IN THE GAMMA SPECTROSCOPIC ANALYSIS OF ENVIRONMENTAL SAMPLES

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Introduction

One of the main challenges encountered in gamma spectrometry, particularly in the low-energy region, is the self-absorption effect. Self-absorption refers to the fact that photons emitted by the sample, are absorbed by the sample itself. This study examines aspects of this phenomenon in the gamma spectroscopic analysis of environmental samples. The objective was to develop a correction method for this phenomenon with direct implementation in measurements performed by the Environmental Radioactivity Monitoring Unit (ERMU) of the Greek Atomic Energy Commission (EEAE).

Materials and Methods

Experimental and computational calibration of the detection system used for the measurements was performed, and a correction method was developed, based on estimating a corrective factor of the efficiency as the calibration source differs from the sample material leading to different self-absorption intensity. The extraction of the efficiency reduction factor values involves a double integral calculation.[1] The parameters involved in this calculation were experimentally studied. One of them is the linear attenuation coefficient for which there is no complete database for environmental samples due to their variation in density and chemical composition. Within the framework of this study, an experimental setup and a method of determination were developed and tested for their accuracy.

Results

The contributing parameters were successfully determined, and the correction factors were calculated through numerical integration. Experimental values of the linear attenuation coefficient were determined for the calibration source and the samples of interest.

Discussion

An interactive user-interface application was created for the sufficient utilization of the correction method, which achieves the extraction of tabulated self-absorption correction factor values for any detection system, provided the user inputs a dataset of the contributing parameters. This can be employed for systematical correction for the self-absorption effect, which is a requirement of the ISO 20042:2019 standard [2] implemented by the ERMU of EEAE.

Conclusions

The precise assessment of radioactivity in environmental samples is of high importance within the environmental radioactivity monitoring field to ensure the radiation protection of workers and the environment, in compliance with the international basic safety standards.

References

[1] K. Debertin and R.G. Helmer, Gamma- and X-ray Spectrometry with Semiconductor Detectors. Netherlands, North-Holland, 1988.
[2] ISO at ISO-20042:2019

Keywords:

Self-absorption, Environmental radiation, gamma spectrometry

STUDY OF EVENT-RELATED POTENTIALS IN EEG DATA IN MAJOR DEPRESSIVE DISORDER

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Introduction

The aim of this study was to investigate the differences in electroencephalographic (EEG) responses between patients diagnosed with major depressive disorder (MDD) and healthy controls [1],[3],[4]. The dataset was provided by the MODMA organization [6] and included EEG measurements from 24 MDD patients and 29 healthy participants, aged between 16 and 52 years. Such a comparison could benefit advancements in early diagnosis and improve the understanding of MDD.

Methods

Event-Related Potentials (ERPs)[fig2] were extracted from the dataset's 128-channel EEG recordings.Data processing was performed on the EEGLAB toolbox in MATLAB [2]. Sampling rate was 125 Hz, band-pass filtering was performed at 1-20 Hz,and,through extentions background noise, artifacts, and bad channels were recognized and eliminated, ensuring the removal of any unwanted data .

Results

Initial analyses revealed distinct differences in EEG patterns between the MDD group and the healthy control group [fig1]. Statistical comparisons of event-related potential (ERP) amplitudes and latencies showed no significant deviations between the two groups, with p-values exceeding 0.05. These comparisons were conducted using permutation statistics with False Discovery Rate (FDR) correction to account for multiple comparisons.

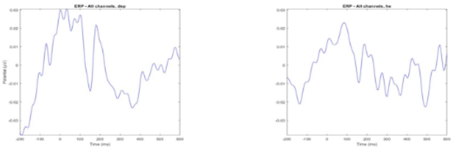

Figure 1: avarage erp of healtyh (left) and MDD (right) participants

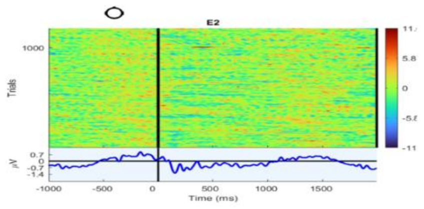

Figure 2: erp of a single participant

Discussion

Despite extensive analysis, our findings suggest no clear electrophysiological differences between individuals with MDD and healthy controls. The lack of significant ERP amplitude and latency differences may indicate that the specific ERP components examined in this study are not sensitive markers of MDD under the current experimental conditions. Further studies with larger sample sizes, different experimental paradigms, or additional neurophysiological measures may be required to better capture potential group differences.

Conclusion

These results highlight the complexity of identifying reliable biomarkers for MDD in EEG studies and underscore the importance of refining both methodological and conceptual approaches to studying depression using neurophysiological techniques.

Keywords:

Major Depressive Disorder, Event-Related Potentials, ERP Analysis

Acknowledgements

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References

[1] Bruder G et al. (2002). Cognitive ERPs in Depressive and Anxiety Disorders during Tonal and Phonetic Oddball Tasks. Clinical EEG, 33. 119-24
[2] The MathWorks Inc. (2022). MATLAB version: 9.13.0 (R2022b), Natick, Massachusetts: The MathWorks Inc
[3] Nandrino J et al. (1996). Endogenous evoked potentials assessment in depression: a review.Eur Psychiatry. 11:357-68
[4] Proudfit GH, et al. (2015). Depression and Event-related Potentials: Emotional disengagement and reward insensitivity. Curr Opin Psychol. 1; 110-113.
[5] Sur S, et al. (2009 Event-related potential: An overview. Ind Psychiatry J. 18(1):70-3
[6] Zhang, Y., et al. (2002) MODMA Dataset: A Multi-modal Open Dataset for Mental-disorder Analysis.

ΕΡΓΑΣΤΗΡΙΑΚΗ ΕΜΒΙΟΜΗΧΑΝΙΚΗ ΑΞΙΟΛΟΓΗΣΗ ΙΣΤΟΜΗΧΑΝΙΚΑ ΑΝΕΠΤΥΓΜΕΝΩΝ ΕΜΦΥΤΕΥΜΑΤΩΝ ΜΕΣΟΣΠΟΝΔΥΛΙΟΥ ΔΙΣΚΟΥ

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Εισαγωγή

Η Εκφυλιστική Νόσος του Μεσοσπονδυλίου Δίσκου αποτελεί μία νοσολογική οντότητα με αυξανόμενη επίπτωση στην σύγχρονη εποχή, με τις διαθέσιμες θεραπευτικές μεθόδους να παρουσιάζουν περιορισμένη αποτελεσματικότητα [1]. Υπό αυτό το πρίσμα, η αντικατάσταση του παθολογικού μεσοσπονδυλίου δίσκου με ένα ανεπτυγμένο με τις μεθόδους της Ιστομηχανικής, βιολογικά ενεργό εμφύτευμα (Ιστομηχανικά Ανεπτυγμένος Μεσοσπονδύλιος Δίσκος – ΙΑΜΔ) αποτελεί μία θεωρητικά ελκυστική επιλογή [2]. Σκοπός της μελέτης αυτής είναι η αξιολόγηση της εμβιομηχανικής συμπεριφοράς εμφυτευμάτων ΙΑΜΔ, προς συσχέτιση της εγγύτητας με τον φυσιολογικό μεσοσπονδύλιο δίσκο.

Υλικό και Μέθοδος

Αρχικά, εννέα πρόβειοι αυχενικοί μεσοσπονδύλιοι δίσκοι αξιολογήθηκαν ex vivo εμβιομηχανικά σε ελεγχόμενο εργαστηριακό περιβάλλον. Η ανάλυση πραγματοποιήθηκε με την διενέργεια μονοαξονικών αξιολογήσεων με την εφαρμογή δοκιμών κυκλικής συμπίεσης, ερπυσμού και ελέγχου ορίου θραύσης με σκοπό την απόκτηση δεδομένων αναφοράς. Εν συνεχεία, πραγματοποιήθηκε in vitro ανάπτυξη ΙΑΜΔ με την εμφύτευση ανθρώπειων μεσεγχυματικών βλαστικών κυττάρων προερχόμενων από λιπώδη ιστό, σε υβριδικά διφασικά ικριώματα, αποτελούμενα από τρισδιάστατα εκτυπωμένη πολυκαπρολακτόνη και κόλλα ινικής. Η εμβιομηχανική αξιολόγηση πραγματοποιήθηκε με τις προαναφερθείσες δοκιμασίες σε ακυτταρικά ικριώματα πολυκαπρολακτόνης και εν συνεχεία στα ολοκληρωμένα κυτταρικά εμφυτεύματα, με συγκριτική αξιολόγηση των εμφυτευμάτων τα οποία καλλιεργήθηκαν ή όχι σε μέσο χονδρογενούς διαφοροποίησης.

Αποτελέσματα

Αρχικά, η αξιολόγηση των ακυτταρικών ικριωμάτων πολυκαπρολακτόνης συνεισέφερε σημαντικά στην ρύθμιση των παραμέτρων της εκτύπωσης για την κατασκευή του πλέον αντιπροσωπευτικού ικριώματος, υπό την έννοια της μεγαλύτερης εγγύτητας με τους φυσιολογικούς δίσκους στις τρεις δοκιμασίες. Εν συνεχεία, τα κυτταρικά εμφυτεύματα παρουσίασαν υψηλότερη μηχανική αντοχή, με την υποομάδα των εμφυτευμάτων καλλιέργειας σε μέσο χονδρογενούς διαφοροποίησης να παρουσιάζουν περαιτέρω αύξηση της αντοχής στην συμπιεστική φόρτιση στην δοκιμασία ελέγχου ορίου θραύσης, εύρημα το οποίο συσχετίζεται με την προαγωγή της παραγωγής εξωκυττάριας θεμέλιας ουσίας.

Συμπεράσματα

Τα σύνθετα εμφυτεύματα ΙΑΜΔ παρουσίασαν αξιόλογη εγγύτητα με τους φυσιολογικούς μεσοσπονδύλιους δίσκους σε επίπεδο εμβιομηχανικής συμπεριφοράς και στις τρεις δοκιμασίες, γεγονός το οποίο τα καθιστά κατάλληλα προς ευρύτερη αξιολόγηση με πλέον πολυπαραμετρικά μέτρα έκβασης σε μελλοντικές μελέτες.

References

1. N. Gkantsinikoudis, et al. (2024). Int J Mol Sci. 25:12579
2. N. Gkantsinikoudis, et al. (2022). Tissue Eng Part B Rev. 28:848-860.

Keywords:
Μεσοσπονδύλιος δίσκος; Ιστομηχανική; Ικρίωμα; Μεσεγχυματικά βλαστικά κύτταρα λιπώδους ιστού; Εμβιομηχανική; Αναγεννητική ιατρική.

WAYFINDING IN HOSPITALS - A NARRATIVE REVIEW OF EXISTING SOLUTIONS AND UPCOMING TECHNOLOGICAL ADVANCEMENTS

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Introduction

Modern hospitals are vast and often complex environments. Their intricate layouts can make navigation challenging for patients and caregivers, especially those unfamiliar with the hospital's internal organization. Wayfinding solutions seek to enhance the efficiency and quality of intra-hospital navigation for all visitors. Five key stages are involved in such an effort: (1) review existing literature on hospital navigation aids to understand current solutions and gaps, (2) conduct targeted surveys to assess the specific needs of different communities and the unique requirements of the hospital in question, (3) develop a unified action plan with input from all stakeholders, addressing legal, logistical, and technological considerations, (4) implement the navigation aid infrastructure, ensuring accessibility, reliability, and integration with existing systems and lastly, (5) monitor system performance continuously, analyzing user feedback to guide iterative improvements. This extended abstract focuses on building a foundational understanding that will inform subsequent stages of the initiative.

Materials and Methods

A narrative review of relevant literature was conducted using the PubMed and Scopus online databases. Search terms included "hospital site navigation" and "hospital wayfinding." Books relevant with site navigation were also utilized. In addition to academic sources, a search for already established hospital navigation service providers was performed using standard web search engines. The technologies and techniques employed by these providers are summarized in the following section.

Results

Hospital visitors' wayfinding behaviour is influenced by the reason for their visit, as well as by space and time constraints. Visual cues that allow them to confirm time and distance are essential in emergencies [1]. People usually follow the main route unless they already know a shortcut. Providing pre-visit information, such as directions to the hospital, parking availability, and customized floor maps with step-by-step guidance to the intended destination can significantly reduce wayfinding time and stress for patients and visitors [2]. A variety of technological aids have been implemented to improve hospital navigation for visitors, spanning from traditional installments (stationary digital info kiosks) to solutions that integrate hospital infrastructure with data provided through visitors' smartphone applications. These solutions provide turn-by-turn instructions using maps, combining audiovisual cues with multi-layered interactive maps, and can even implement augmented reality. The wireless technologies supporting these systems include Wi-Fi, Radio-frequency Identification (RFID), Global Positioning System (GPS), and Bluetooth Low Energy (BLE) [3]. An alternative smartphone-based approach, which avoids the need for continuous wireless infrastructure maintenance, involves the use of QR codes placed throughout the hospital. These can be scanned to instantly convey the user's location to a navigation app [4]. Modifications of the above solutions, such as embedding the wireless beacons in indoor flooring, or using specialized smartphones with haptic feedback, have been proposed to assist visually impaired visitors in hospital navigation. More forward-looking ideas include autonomous electronic wheelchairs or assistant robots [5]. Existing hospital navigation service providers are listed in **Table 1**.

Table 1: Existing hospital navigation service providers

Website	Services offered
https://www.mappedin.com/industries/hospitals-healthcare/	Developer and end-user tools (software development kit, site directory, directions, map building)
https://navigine.com/industries/healthcare	Navigation, asset tracking, indoor traffic monitoring
https://register.apple.com/indoor	Existing Wi-Fi infrastructure-based indoor positioning, developer tools
https://www.rfiddiscovery.com/en/solutions/indoor-wayfinding-for-hospitals	Navigation, wandering patient and healthcare staff safety system, asset tracking

Conclusion

Improving wayfinding in hospitals requires a multi-step, systematic approach. Recent technological aids offer a stress-free hospital visit, tailored to users' custom needs.

References

[1] Carpman JR, Grant MA (2016). Design that cares: Planning health facilities for patients and visitors (3rd ed.). Jossey-Bass.
[2] Mollerup P (2016) The challenge of wayfinding in health care Environments. In: Hunter R, Anderson L, Belza B (eds) Community wayfinding: pathways to understanding. Springer
[3] Lee E, et al. (2020). Journal of perianesthesia nursing: official journal of the American Society of PeriAnesthesia Nurses, 35:250-54
[4] Tim HC, et al. (2016). World hospitals and health services: the official journal of the International Hospital Federation, 52, 7-9.
[5] Nguyen QH, et al. (2017). Multimed Tools Appl 76, 2645–2669

Keywords: Hospital Navigation, Wayfinding, Assists for Visually Impaired, Interactive Maps, Asset Tracking

DOSIMETRIC VERIFICATION OF THE VIRTUAL CONE TECHNIQUE FOR STEREOTACTIC RADIOSURGERY

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Introduction

Stereotactic radiosurgery (SRS) can be utilized not only for treating cranial tumors, but also for functional disorders including Parkinson's disease (PD) tremor and trigeminal neuralgia (TGN) [1]. For this to be achieved, a high amount of beam energy must be focused on a very small target volume (~mm) [2, 3] using conical collimators (physical cones) adapted on the Gantry Head of a Linear Accelerator (LINAC).[4]

Due to many limitations associated with physical cones,[5] Popple et.al.[6] developed an alternative method known as Virtual Cone Technique. In this approach, the central two leaves of the multileaf collimator are positioned in a small gap, and non-coplanar arcs at different table positions and with collimator angles of 45 and 135 degrees are employed. The dose provided by the LINAC is proportional to the sine of the gantry angle, delivering a spherical dose distribution at the target volume, equal to physical cones. The aim of the current work was the evaluation of this technique.

Materials and Methods

In this study, treatment plans were developed using the VC technique in Eclipse treatment planning system (TPS), utilizing AAA Version 15.6.06 calculation model on an anthropomorphic head phantom, with a Dosimetric Leaf Gap (DLG) value of 0.36 mm and a 2.1 mm leaf gap (LG) of the two central leaves of the MLC. The plans were recalculated and delivered on the OCTAVIUS 4D phantom, equipped with 1600SRS (PTW) ion chamber array, using a 10 MV (2400MU/min) FFF beam of an Edge LINAC (Varian Medical Systems), equipped with a 120 leaf HD MLC. Thereafter, the measured dose distributions were compared to the ones calculated by the TPS, applying a gamma analysis for plan verification and deliverability of the technique. The gamma criteria utilized were 1mm distance to agreement and 3% and 5% dose difference.

Results

The gamma analysis results showed a gamma passing rate of 90.1% & 95.1% (gamma criteria 1mm/5%) and 88.3% & 84.8% (gamma criteria 1mm/3%), for 50% and 10% threshold, respectively.

Discussion

Comparing our results with the results of the gamma analysis of Brown et.al.[5] after EBT3 film irradiation, they showed a higher gamma passing rate of 99.4% (gamma criteria 1mm/2%) with 10% threshold. The difference between Brown's study and ours could originate from their use of films for verification, which offers superior spatial resolution compared to a detector array. Our future steps will involve the implementation of film dosimetry in plan verification in combination with refining various model parameters for the optimal outcome.

Conclusions

Virtual Cone technique could successfully replace the use of physical cones in clinical practice for SRS treatment of functional disorders. Further refinement is required for the implementation of the technique

References

1.Hynes PR DJ. Stereotactic Radiosurgery (SRS) and Stereotactic Body Radiotherapy (SBRT): Treasure Island (FL): StatPearls Publishing; [Updated 2023 Jul 25]. Available from: https://www.ncbi.nlm.nih.gov/books/NBK542166/.

2.Ferreira F, Akram H, Ashburner J, Zrinzo L, Zhang H, Lambert C. Ventralis intermedius nucleus anatomical variability assessment by MRI structural connectivity. Neuroimage. 2021;238:118231.

3.Yasmeh J MC, Stea B Repeat LINAC-based Stereotactic Radiosurgery for Recurrent Trigeminal Neuralgia. Cureus. 14.

4.Luxton G, et al. Stereotactic radiosurgery: principles and comparison of treatment methods. Neurosurgery. 1993;32:241-59; discussion 59.

5.Brown TAD, Ayers RG, Popple RA. Commissioning a multileaf collimator virtual cone for the stereotactic radiosurgery of trigeminal neuralgia. J Appl Clin Med Phys. 2022;23:e13562.

6.Popple RA, Wu X, Brezovich IA, Markert JM, Guthrie BL, Thomas EM, et al. The virtual cone: A novel technique to generate spherical dose distributions using a multileaf collimator and standardized control-point sequence for small target radiation surgery. Adv Radiat Oncol. 2018;3:421-30.

Keywords: Virtual Cone Technique, functional disorders, stereotactic radiosurgery

SPECT/CT WHOLE-BODY SCINTIGRAPHY WITH 131 IODINE IN THE ASSESSMENT OF RECURRENCE OF PATIENTS WITH DIFFERENTIATED THYROID CANCER

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Introduction

Planar scintigraphic imaging (PS) with I-131 remains the gold standard in monitoring patients with well differentiated thyroid cancer (DTC) after initial surgery. However, interpretation of PS is often limited by non-specific radioiodine uptake, which may lead to false-positive findings due to physiological or benign uptake in normal tissues [1-4]. Hybrid imaging systems, such as SPECT/CT, integrating functional data with anatomical localization from low-dose CT. This study assessed the added additional diagnostic value of post-therapeutic SPECT/CT+WBS in terms of assessing recurrence in patients with DTC.

Materials and Methods

This retrospective study included 205 patients with DTC who underwent post-therapeutic WBS and SPECT/CT with I-131 at the Nuclear Medicine Department of the University General Hospital of Heraklion. SPECT/CT was performed immediately following planar WBS to further evaluate equivocal or suspicious findings. Diagnostic performance, lesion characterization, and clinical impact were evaluated. Imaging datasets and reports were manually reviewed and interpreted by nuclear medicine physicians. Statistical analysis was performed using IBM SPSS Statistics 25.0 .

Results

SPECT/CT detected all lesions (N=261, 100%) of iodine uptake observed on PS, and identified 82 additional foci (23.9%). Combining WBS with SPECT/CT provided higher diagnostic value in terms of interpretation of findings, as it clarified 94 equivocal findings. The incremental diagnostic value of metastases is also undisputed, as 29 distant foci detected by PS were identified and classified. Overall, SPECT/CT classified 1 equivocal PS, confirmed 3 negative scintigraphic studies, detected and confirmed PS findings by improving anatomic localization of sites of radioiodine uptake observed on planar WBS in 98 patients, reclassified abnormal findings on planar imaging by attributing them to normal uptake in 44 patients, while in 11 patients with positive planar scintigraphy, SPECT/CT was negative. Moreover, in 27 scans the hybrid method detected more foci of abnormal uptake, while in 21 patients it detected more foci of abnormal and benign uptake.

Conclusions

SPECT/CT improved the diagnostic performance by enhancing lesion detection and reducing false-positive findings. In post-ablation scans, SPECT/CT demonstrated clear incremental value over planar imaging by accurately characterizing equivocal uptake sites. It identified unexpected sites of either neck lymph node or distant metastases and clarified the presence of residual thyroid tissue, thyroglossal duct remnants and the existence of a thymus gland. The combination of WBS+SPECT/CT offers a powerful diagnostic tool for the detection and classification of regional and distant metastases, providing better anatomical localization and interpretation of radioiodine uptake. These findings are in consistent with recent systematic reviews and meta-analyses demonstrating that the addition of SPECT/CT to WBS significantly improves diagnostic confidence, enables more accurate staging and risk classification, and influences therapeutic decision-making in a substantial proportion of patients [4,5].

References

1. Wong, Ka Kit, et al. "Incremental value of diagnostic 131I SPECT/CT fusion imaging in the evaluation of differentiated thyroid carcinoma." American journal of roentgenology 191.6 (2008): 1785-1794.
2. Shinto, Ajit S., et al. "Incremental value of 131I SPECT-CT versus planar whole body imaging in patients with differentiated thyroid carcinoma." Thyroid Research and Practice 12.1 (2015): 8-13.
3. Oh, Jong-Ryool, and Byeong-Cheol Ahn. "False-positive uptake on radioiodine whole-body scintigraphy: physiologic and pathologic variants unrelated to thyroid cancer." American journal of nuclear medicine and molecular imaging 2.3 (2012): 362.
4. Chong, Ari, et al. "Clinical implications of adding SPECT/CT to radioiodine whole-body scan in patients with differentiated thyroid cancer: a systematic review and meta-analysis." Clinical Nuclear Medicine (2022): 10-1097.
5. Xue, Yan-Li, et al. "Value of 131 I SPECT/CT for the evaluation of differentiated thyroid cancer: a systematic review of the literature." European journal of nuclear medicine and molecular imaging 40 (2013): 768-778.

Keywords:
differentiated thyroid cancer, DTC, radioactive iodine therapy, I-131, whole body scintigraphy, WBS, SPECT/CT

BLOCKCHAIN-ENABLED FEDERATED LEARNING MODELS FOR SECURE AND OPEN MEDICAL DATA SHARING: A COMPARATIVE REVIEW

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Introduction

Secure and efficient sharing of medical data across institutions is vital for advancing healthcare diagnostics, research, and treatment outcomes. However, concerns over patient privacy, data ownership, and regulatory compliance have obstructed open data exchange. Federated learning (FL) has emerged as a promising machine learning paradigm that allows institutions to collaboratively train models without sharing raw data. At the same time, blockchain technologies provide immutable, decentralized frameworks to enhance trust, traceability, and transparency. This abstract summarizes findings from a comparative review of recent approaches combining FL and blockchain in the context of health data sharing.

Materials and Methods

The review included peer-reviewed journal articles, IEEE conference papers, and case studies published between 2021 and 2025 that were identified through searches conducted on Google Scholar, PubMed and ScholarGPT, using a combination of keywords. A total of eleven papers were analyzed, including comparative models and three practical use case implementations. The rejected papers did not implement federated environment and focused on pre-trained models. The six retained covered the federated learning setting and applied blockchain technology to enhance transparency.

Results

The models varied in terms of blockchain architecture (public vs. permissioned), federated learning designs (asynchronous vs. FedAvg), and privacy mechanisms. Key findings include:

- Security Enhancements: Models like T-BFL[1] employed two-dimensional trust mechanisms, while another research work [2] used parameter masking with asynchronous learning. Another framework utilized resilience metrics against cyberattacks demonstrating significant robustness [3].
- Data Storage and Validation: Some frameworks [4] utilized IPFS and blockchain for decentralized storage; others used smart contracts oracles for trust enforcement[3].
- Use Case Effectiveness: A digital twin model that eliminates identity and raw data was proposed [5], offering privacy-preserving simulation-based collaboration.

Discussion

The integration of blockchain into federated learning provides several advantages. However, significant trade-offs exist. For instance, cryptographic techniques (e.g., homomorphic encryption) increase computational complexity. Moreover, consensus mechanisms like PBFT may not scale effectively in public blockchain environments. A notable advancement is the shift toward ”identity-less” and ”data-less” training via digital twins [5], which introduces new paradigms for privacy in medical AI. Distinct differences across the models lie in their trust architecture (reputation vs. smart contracts vs. oracles), deployment models (cloud vs. edge-based) and data contribution strategies (quality scoring, gradient auditing, masking).

Conclusions

The use of blockchain and federated learning is promising in forming a secure and privacy-aware ecosystem for medical data sharing. The reviewed models demonstrate varying strengths in scalability, security and interoperability. Future work should emphasize cross-domain operability and real-time use case validation in clinical settings.

References

1. Jiang, R., Zhang, et al., (2025). T-BFL model based on two-dimensional trust and blockchain-federated learning for medical data sharing. *The Journal of Supercomputing*, *81*(2), 378.
2. Kumar, R., Bernard, C. M., et al., (2024). Privacy-preserving blockchain-based federated learning for brain tumor segmentation. *Computers in Biology and Medicine*, *177*, 108646.
3. Myrzashova, R., Alsamhi, S. H., et al., (2024). Safeguarding patient data-sharing: Blockchain-enabled federated learning in medical diagnostics.
4. Gupta, M., Kumar, M., & Gupta, Y. (2024). A blockchain-empowered federated learning-based framework for data privacy in lung disease detection system. *Computers in Human Behavior*, *158*, 108302.
5. Wickramasinghe, N., & Ulapane, N. (2025). A Solution for the Health Data Sharing Dilemma: Data-Less and Identity-Less Model Sharing Through Federated Learning and Digital Twin-Assisted Clinical Decision

Keywords:
Blockchain, Federated learning, Health data sharing, Open data, Privacy-preserving AI

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ESTIMATION OF DOSE IN NEONATES UNDER 1kg IN INCUBATOR FROM CHEST X-RAYS

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Abstract

Purpose

The aim of this study is to estimate the typical diagnostic reference levels (DRL) of radiation exposure values for chest radiographs in neonates under 1kg in mobile imaging at a University Hospital in Greece and to compare these values with the existing DRL values from the literature.

Materials and Methods

Patient and dosimetry data, including sex, age, weight, tube voltage (kV), tube current (mA), exposure time (s), exposure index of a digital detector (S) and dose area product (DAP) were collected from a total of 80 chest radiography examinations performed on neonates (<1kg and <30 days old). All examinations were performed in a single X-ray system and all data (demographic and dosimetry data) were collected from the PACS of the hospital. Typical radiation exposure values were determined as the median value of DAP and ESD distribution. Afterwards, these typical values were compared with DRL values from other countries. Three radiologists reviewed the images to evaluate image quality for dose optimization in neonatal chest radiography.

Results

The mean value and standard deviation of DAP, from all examinations, was 0.13 ± 0.11 dGy·cm^2 (range, 0.01 – 0.46 dGy·cm^2) and ESD was measured at 11.55 ± 4.96 μGy (range, 4.01-30.4 μGy). The typical values in terms of DAP and ESD were estimated to be 0.08 dGy·cm^2 and 9.87 μGy, respectively. The results show that the DAP value decreases as the exposure index increases. This study's typical values were lower than the DRLs reported in the literature because our population had lower weight and age. From the subjective evaluation of image quality, it was revealed that most of the radiographs (over 80%) met the criteria for being diagnostic as they received an excellent rating in terms of noise levels, contrast, and sharpness.

Conclusion

This study contributes to the determination of typical dose values in a rare and sensitive category of patients (neonates weighing <1 kg) as well as information on the image quality of chest X-rays that were performed in this group.

Table 1: Comparison of typical values (median value of DAP and ESD) with literature.

Reference	Age / Weight Category	DAP [dGy·cm^2]	ESD [μGy]
This study	<1 kg	0.08	9.87
R. Gilley et al.	<1 kg	0.03	-
T.J.M. Minkels et al.	600-1000g	0.02	-
K. Alzyoud et al.	0-1 y	-	130
L. Hora et al.	<5 kg	0.09	-
G. Compagnone	0y	0.14	-
National Diagnostic Reference Levels in Japan (2020)	0-1 y	-	200
A. Schegerer et al.	<3 kg	0.03	-
RADIATION PROTECTION N° 185	<5 kg	0.15	-
B. Mohsenzadeh et al.	<1 y	-	60
A. Bouaoun et al.	<4 kg	0.23	55.2
H. Kim et al.	0y	0.5	-

References

1. European Commision. Radiation Protection No 185: European Guidelines on Diagnostic Reference Levels for Paediatric Imaging; Luxembourg Publications Office of the European Union: Luxembourg, 2018; pp. 1–122.
2. ICRP, International Commission on Radiological Protection. Diagnostic Reference Levels in Medical Imaging; ICRP Publication: Ottawa, ON, Canada, 2017.

Keywords:
Diagnostic Reference Revel (DRL), Typical Values, Radiation protection, Neonatal Radiation Dose.

ΛΙΠΟΣΩΜΑΤΑ DPPC:CHOLESTEROL ΚΑΙ DPPC:PLURONIC F-127 ΜΕ ΕΝΣΩΜΑΤΩΜΕΝΗ ΚΕΡΚΕΤΙΝΗ: ΣΥΓΚΡΙΤΙΚΗ ΜΕΛΕΤΗ ΦΥΣΙΚΟΧΗΜΙΚΩΝ ΚΑΙ ΘΕΡΜΟΤΡΟΠΙΚΩΝ ΙΔΙΟΤΗΤΩΝ

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Εισαγωγή

Τα λιποσώματα αποτελούν τα πιο ευρέως μελετημένα συστήματα μεταφοράς φαρμακομορίων. Διάφοροι τύποι φωσφολιπιδίων, ως κύρια δομικά στοιχεία, και η χοληστερόλη, ως ρυθμιστής της ρευστότητας των λιπιδικών μεμβρανών, αποτελούν βασικά βιοϋλικά για την παρασκευή τους. Ωστόσο, μόρια, όπως πολυμερή, μπορούν να τροποποιήσουν την επιφάνεια τους, προσδίδοντας φυσικοχημική σταθερότητα και βελτιώνοντας την διαπερατότητα από βιολογικούς φραγμούς [1]. Η κερκετίνη αποτελεί ένα φλαβονοειδές μόριο με ισχυρή αντιοξειδωτική δράση. Παρά τις ευεργετικές της δράσεις, η λιπόφιλη φύση της και η περιορισμένη βιοδιαθεσιμότητά της αποτελούν τους κύριους περιοριστικούς παράγοντες για την κλινική εφαρμογή της. Σκοπός της παρούσας εργασίας είναι η ανάπτυξη λιπιδικών και χιμαιρικών νανοσυστημάτων κατάλληλων για την μεταφορά κερκετίνης για πιθανή τοπική εφαρμογή.

Υλικά και Μέθοδοι

Για την παρασκευή των λιποσωμάτων χρησιμοποιήθηκαν: το φωσφολιπίδιο DPPC (1,2-dipalmitoyl-sn-glycero-3-phosphocholine), η χοληστερόλη, το τρισυσταδικό συμπολυμερές Pluronic F-127 (Poloxamer 407) και το βιοδραστικό μόριο κερκετίνη. Τα λιποσώματα παρασκευάστηκαν με ενυδάτωση λεπτού λιπιδικού υμενίου και υπερήχηση. Τα φυσικοχημικά χαρακτηριστικά των συστημάτων μελετήθηκαν μέσω τεχνικών σκέδασης του φωτός, στους 4^{o}C και στους 25^{o}C. Η διαφορική θερμιδομετρία σάρωσης χρησιμοποιήθηκε για την αξιολόγηση της θερμικής συμπεριφοράς των λιπιδικών διπλοστιβάδων.

Αποτελέσματα

Τα αποτελέσματα της φυσικοχημικής αξιολόγησης υποδηλώνουν ότι η αντικατάσταση της χοληστερόλης με το Pluronic F-127 οδηγεί στην παρασκευή λιπιδικών νανοσωματιδίων με μικρότερη υδροδυναμική διάμετρο και δείκτη πολυδιασποράς.

Στην περίπτωση των λιποσωμάτων με χοληστερόλη, η προσθήκη της κερκετίνης οδήγησε σε μείωση της φυσικοχημικής σταθερότητας. Αντίθετα, στα νανοσυστήματα με ενσωματωμένο Pluronic F-127, παρουσιάστηκε αύξηση της σταθερότητας κατά την ενσωμάτωση της κερκετίνης [2]. Η θερμοκρασία αποθήκευσης των λιποσωμιακών διασπορών δεν επηρέασε τη φυσικοχημική σταθερότητα σε καμία από τις δύο κατηγορίες λιποσωμάτων.

Τα αποτελέσματα της θερμικής ανάλυσης υποδηλώνουν ότι η ενσωμάτωση του Pluronic F-127 επηρεάζει σε μικρότερο βαθμό τη θερμοτροπική συμπεριφορά της λιπιδικής διπλοστιβάδας DPPC. Η παρούσα συμπεριφορά διατηρείται και μετά την προσθήκη του μορίου της κερκετίνης.

Συζήτηση

Στην συγκεκριμένη μελέτη, η αντικατάσταση του μορίου της χοληστερόλης από ένα πολυμερές, όπως το F-127, οδήγησε σε βελτιωμένη φυσικοχημική συμπεριφορά, γεγονός που δύναται να διευκολύνει την μεταφορά της κερκετίνης. Η θερμική ανάλυση των λιπιδικών διπλοστιβάδων πραγματοποιήθηκε με σκοπό την αρχική αξιολόγηση της ρευστότητας των λιπιδικών διπλοστιβάδων. Σε επόμενες μελέτες πρόκειται να διερευνηθεί η πιθανή χρήση των λιποσωμιακών προϊόντων για τοπική εφαρμογή.

Συμπεράσματα

Η ενσωμάτωση του τρισυσταδικού συμπολυμερούς Pluronic F-127 στη δομή των λιποσωμάτων οδηγεί σε σημαντική διαφοροποίηση και αύξηση των πλεονεκτημάτων, σε σχέση με συστήματα με ενσωματωμένη χοληστερόλη.

Βιβλιογραφία

1. D. Guimarães, A. Cavaco-Paulo, and E. Nogueira (2021) ‘Design of liposomes as drug delivery system for therapeutic applications’, International Journal of Pharmaceutics, vol. 601, p. 120571.
2. M. Johnsson, M. Silvander, G. Karlsson, and K. Edwards (1999) ‘Effect of PEO−PPO−PEO Triblock Copolymers on Structure and Stability of Phosphatidylcholine Liposomes’, Langmuir, vol. 15, no. 19, pp. 6314–6325.

Λέξεις κλειδιά:

Λιποσώματα, Χοληστερόλη, Pluronic F-127, Κερκετίνη, Σταθερότητα, Θερμική ανάλυση

REINFORCEMENT LEARNING FOR WALKING ASSISTANCE CONTROL OF A LOWER LIMB EXOSKELETON

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Introduction

Spinal Cord Injury (SCI) often leads to paraplegia, affecting both physical and mental health. Lower limb exoskeletons can aid rehabilitation and improve mobility, enhancing quality of life. Traditional models require crutches for balance, limiting upper limb freedom. Heavier, crutch-free devices offer slower mobility with minimal advantages over wheelchairs [1]. This paper presents a Deep Reinforcement Learning (DRL) approach to ensure walking balance for the Hermes exoskeleton, eliminating the need for additional external support. Developed by the HERMES Team at the University of Thessaly, this project aims to create a robotic exoskeleton that promotes hands-free, independent mobility and supports activities of daily living (ADL) for individuals with (SCI).

Materials and Methods

The proposed control system replaces the Hermes controller with an RL agent, whose policy is designed to find the optimal set of actions that maximize the cumulative reward, specifically aiming to make the exoskeleton walk in a straight line with minimal control effort. The simulation environment for this system is built using Simscape Multibody in MATLAB, which models the exoskeleton's dynamics, including the flexion and extension of the hip, knee, and ankle joints. For training the agent, both Deterministic Policy Gradient (DDPG) and Twin-Delayed Deep Deterministic Policy Gradient (TD3) are utilized [2]. These are model-free, off-policy RL methods that employ an actor-critic architecture. The actor learns the optimal policy by interacting with the environment, while the critic evaluates the actions taken by the actor.

Results

The agent underwent a total of 20 simulations, 10 for each algorithm. Table I presents the mean reward received by the agent during the entire training period with a 95% confidence interval for each of the two algorithms. The TD3 algorithm achieved a higher mean reward (177.42 ± 32.7) compared to DDPG (158.87 ± 14.35), indicating superior performance. Notably, TD3 achieved higher rewards with fewer steps, demonstrating a more efficient gait pattern. In addition to the quantitative analysis, eleven gait parameters were assessed. Each parameter was rated on a scale from 1 to 10 as shown in Figure 1. A t-test was performed to confirm statistical significance, revealing that TD3 outperformed DDPG in parameters such as Speed (GS), Walking Pattern (WP), and Stability (St), while DDPG performed better in Ground Contact (GC), Knee Angle (KA), and Frontal Inclination (FI). Despite differences in individual parameters, TD3 (7.99 ± 1.17) outperformed DDPG (6.34 ± 1.33), showcasing its superior overall performance.

Table 1: Comparison of DDPG and TD3

Algorithm	Mean Reward	Mean Steps
TD3	177.42 ± 32.7	156 ± 24
DDPG	158.87 ± 14.35	185 ± 10

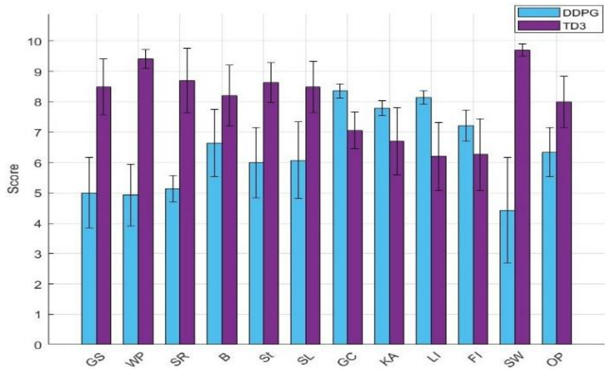

Figure 1. Gait Parameters Evaluation

Conclusion

DRL has shown promise in enhancing Hermes exoskeleton walking balance, enabling crutch-free locomotion and more natural, independent movement. The TD3 algorithm outperformed DDPG, demonstrating its capability to enhance exoskeleton control for more practical and autonomous rehabilitation use.

References

1. S. Luo, G. Androwis, S. Adamovich, E. Nunez, H. Su, and X. Zhou (2023) Robust walking control of a lower limb rehabilitation exoskeleton coupled with a musculoskeletal model via deep reinforcement learning, Journal of NeuroEngineering and Rehabilitation, 20:34.
2. S. Fujimoto, H. van Hoof, and D. Meger (2018) Addressing Function Approximation Error in Actor-Critic Methods, arXiv:1802.09477.

Keywords:
Lower limb exoskeleton, Deep reinforcement learning, Human-exoskeleton interaction, Walking control, Spinal cord injury

DESIGNING A WEARABLE LOWER BODY DISTRIBUTED SENSOR SYSTEM USING DATA FUSION FROM SEMG AND MARG

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Introduction

A large part of the human population is experiencing health complications in regards to movement that are caused by damage of the nerve tissue**.** Neuroplasticity can be induced with the help of wearable robotics, in order to aid in rehabilitation [2]. This work focuses on the kinematics and dynamics of lower limb motion, and how its analysis [1] can provide a greater understanding of the impact of the pathology to the user's movement. Through the real-time acquisition of surface Electromyography (sEMG) and Inertial sensor (IMU) measurements, in combination with a musculoskeletal kinematic model in OpenSim, we aim to optimise rehabilitation outcome through a detailed evaluation of the user's kinematic status.

Materials and Methods

The system consists of a wearable sensor modality of sEMG and MARG sensors, which gather kinematic and muscle activation data from stroke patients. This data is collected and processed by a Robot Operating System (ROS) package, enabling efficient sensor data management and distribution. The combined data is then forwarded to OpenSim, a software platform for biomechanics simulation which generates detailed musculoskeletal models and can describe the error factor in lower body movement. The proposed system, as well as a serious game application made in Unity, are combined to provide real-time biofeedback to the end user, and refine their use which results in increased immersion and engagement by the patients. [2]

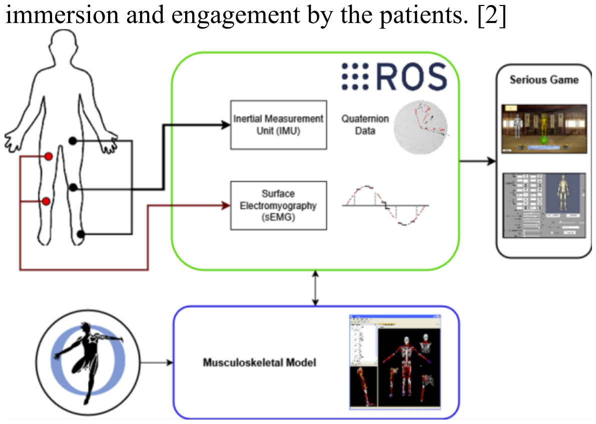

Figure 1. The ROS - OpenSim System Architecture

Discussion

It is important to consider the challenges of optimizing sensor placement and calibration methods to minimize interference while ensuring high data quality and real-time transfer without sacrificing accuracy. Looking ahead, research should focus on enhancing sensor positioning, improving fusion algorithms, and validating performance using established motion capture systems. These advancements should contribute to enhance the system for effective use in neurorehabilitation and its applications in real-world scenarios.

References

1. Margaritis, F., Mitsopoulos, K., et al.. (2024). Kinematic and Dynamic Analysis of Lower Limb Movement: Towards the Design of a Wearable Rehabilitation Assistant Device . Global Clinical Engineering Journal, 6(SI6), 62–67.
2. Mitsopoulos, K., Fiska, V., et al.. (2023). NeuroSuitUp: System Architecture and Validation of a Motor Rehabilitation Wearable Robotics and Serious Game Platform. Sensors, 23(6), 3281.
3. Athanasiou A, Mitsopoulos K, et al. Neurorehabilitation Through Synergistic Man-Machine Interfaces Promoting Dormant Neuroplasticity in Spinal Cord Injury: Protocol for a Nonrandomized Controlled Trial JMIR Res Protoc 2022;11(9):e41152

Keywords:
sEMG, MARG, data fusion, ROS, OpenSim, lower body movement, kinematics chain, burden of disease, wearable sensors, sensor system

Acknowledgement

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ENERGY HARVESTING SYSTEMS FOR SELF-POWERED PROSTHESES

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Introduction

Powered prosthetic limbs enhance autonomy for individuals with limb loss, yet battery limitations remain a key barrier. Frequent recharging, weight, and bulkiness reduce usability and comfort. Energy harvesting systems—specifically Triboelectric Nanogenerators (TENGs)—offer a promising route to achieve self-powered prostheses [1,3] by reclaiming biomechanical energy otherwise lost during movement.

State of the art

Many energy harvesting techniques have been developed to date, taking advantage mainly of the inherent biomechanical energy produced by biological systems:

Pyroelectric nanogenerators (PYENGs) work by utilizing the pyroelectric effect

Piezoelectric nanogenerators (PENGs) work by converting mechanical stress or strain into electrical energy through the piezoelectric

TENGs work by harnessing the principle of triboelectricity, where two dissimilar materials come into contact and separate, causing the transfer of electrons between them and generating electrical energy as a result of the resulting imbalance in charge. [2]

Among those, TENGs appear as the most promising alternative [2,4], being able to produce higher power in lower operational frequencies, while also harvesting energy not only from normal forces, but also from shear stresses which dominate the forces exerted at the joints.

Materials and Methods

We propose a design incorporating TENGs at key locations in lower-limb prostheses (Figure 1), namely the foot (for ground reaction forces), ankle, and knee. The mechanical dynamics at these sites were simulated using OpenSim (gait2392_simbody.osim) and SCONE, modelling both generic and amputee gait.

Results

The loads at the TENG installation sites (joint reaction forces and ground reaction forces) were extracted through inverse dynamics, static optimization and joint reaction analysis algorithms.

The maximum forces reach up to 3000 N, while the shear element reaches hundreds of N (the shear part could not be effectively harnessed if PENGs were used)

This approach however does not take into consideration the fact that our model should simulate the gait of a prosthetic-bearing amputee. For this reason, the H0914M.osim3.osim model was modified accordingly in two ways and a forward simulation was performed using the SCONE software.

- Stiff leg approach:

The knee joint was "locked" simulating the first prosthetics

- No-muscles approach:

To further validate the results the simulation was performed erasing the muscles moving the shank and foot, turning it into a prosthetic.

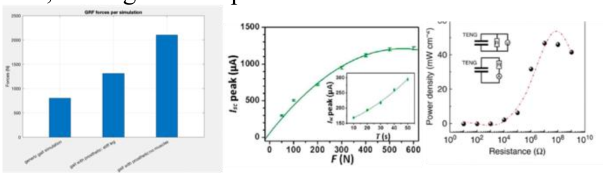

Figure 1. TENG output characteristics for different prosthetic leg configurations

We appreciate that the more accurate the simulation, the higher the exerted forces that will be transformed to useful energy, as shown in Figure 1 leading up to 18.45 W produced.

Furthermore, we suggest incorporating TENGs at more sites, such as the wheelchair the amputee uses when charging the prosthetic (Figure 2).

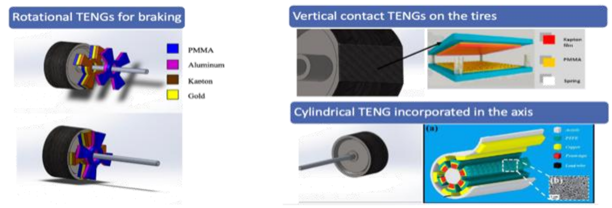

Figure 2. TENGs incorporated into wheelchairs

Discussion

This study presents a framework for integrating TENGs into lower-limb prostheses, demonstrating the potential to reclaim considerable biomechanical energy during movement. While our in silico approach provides valuable insights, it does not fully capture user-specific variations in gait or the physiological implications of energy harvesting. Notably, even slight increases in energy demand may influence user comfort and the practical efficiency of the prosthesis. As such, future work should aim to refine these designs. Experimental validation and user-centred optimization will be key to translating this approach into clinically viable applications.

References

[1] Wang Z (2013). Triboelectric Nanogenerators as New Energy Technology. *ACS Nano*

[2] Ahmed A. et al. (2020). Triboelectric vs Piezoelectric Generator Comparison. *iScience*, 23(7)

[3] Qu X. et al. (2021). Assistive Devices Powered by TENGs. *J. Phys. Mater.*, 4(034015)

[4] Zhang Z., Cai J. (2021). High Output TENGs for Human Motion. *Current Applied Physics*, 22

Keywords:
Energy harvesting, Triboelectric Nanogenerators, Prosthetics, Self-powered systems, Gait simulation

LITERATURE REVIEW OF SHORT-ARM HUMAN CENTRIFUGE REHABILITATION PROTOCOLS

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Introduction

The absence of gravity during long-term spaceflights, as well as its reduced effect on Earth due to a sedentary lifestyle, has been shown to cause similar negative effects on the human body and cause pathologies in various physiological systems [1]. The application of artificial gravity via the Short-Arm Human Centrifuge (SAHC) has been studied as a possible countermeasure against spaceflight-related dysregulation. However, hyper-gravity protocols implemented using the SAHC have also been used to treat various pathologies. We conducted a literature review to study employed protocols for mitigating related symptoms.

Materials and methods

A literature review was conducted using the PRISMA [2] framework of literature published in English since 1990 on Scopus, PubMed, and IEEE Xplore. The search was performed using "artificial gravity", "gravity therapy", "microgravity," and "rehabilitation" as keywords to identify relevant studies. Article selection and characterization were performed by two independent reviewers using pretested forms.

Results

The search identified 2445 manuscripts published from 1990 to January 2025. 2008 articles were initially screened. 60 articles met the inclusion criteria and were full-text screened, while 6 articles were not retrieved. From these articles, 5 SAHC rehabilitation studies were identified.

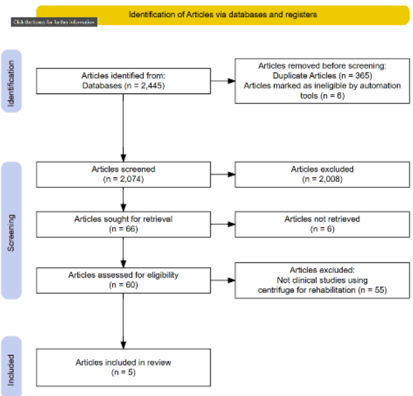

Figure 1. Article selection flowchart

The selected articles varied in terms of purpose, methodology, and detail of reporting. 2 of the selected studies investigated SAHC as a countermeasure to simulated weightlessness, 1 used healthy participants, 2 articles presented case reports where SAHC was used on a stroke and an MS patient. Study completion times varied from 3 days in one of the simulated weightlessness articles to 3 months in the case of the other 4. One of the studies employed a continuous protocol, while the other 4 (80%) used an intermittent centrifugation protocol. The magnitude of the +Gz accelerations ranged between 0,5 and 2,7. The frequency of the centrifugation varied between daily (1 article, 20%) and a three-week exposure (4 articles, 80%). Finally, while most articles (80%) recorded one session/day, one study suggested 2-3 runs/day of exposure.

Discussion

Our search for rehabilitation protocols involving SAHC in the published literature aimed to be comprehensive while balancing practicality and available resources. It was not within the remit of this literature review to assess the methodological quality of individual studies included in the analysis. Based on the characteristics, range of methodologies, and reported challenges in the included articles, we have identified a lack of comprehensive studies exploring the use of the SAHC on patients as a rehabilitation tool. Although the results from the usage of SAHC towards the mitigation of the detrimental effects induced either by disability or simulated microgravity appear promising, more research involving large cohorts, strict protocols, and a variety of outcome measures is required.

Conclusions

This literature review of SAHC-implementing research described the various protocols available in the relevant literature. We have identified that the number of protocols used for rehabilitation is limited, with only 5 being described in the literature. Furthermore, the geographic distribution of SAHC in use is limited to 3 centers. Further research in the field will unlock the benefits of SAHC in mitigating the symptoms and accelerating the rehabilitation of patients.

References

1. Sandler, H., and Vernikos, J. (1986). Inactivity: Physiological Effects. Orlando, FL: Academic Press Inc
2. Haddaway, N. R., Page, M. J., Pritchard, C. C., & McGuinness, L. A. (2022). PRISMA2020: An R package and Shiny app for producing PRISMA 2020-compliant flow diagrams, with interactivity for optimised digital transparency and Open Synthesis Campbell Systematic Reviews, 18, e1230.

Keywords:
Rehabilitation, Human centrifuge, Review

LINKING SEMANTIC MEDICAL VOCABULARIES TO 3D ASSETS FOR A CHATGPT POWERED, VIRTUAL REALITY BASED, MEDICAL EDUCATION ENVIRONMENT

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Introduction

Virtual and augmented reality (collectively referred to as eXtended Reality - XR) have both been identified as widely available three-dimensional (3D) immersive technologies for anatomy education envisioning spatial relationships between them, providing a deeper educational outcome [1]. AI successes provide promising indicators for AI as aids for medical students [2]. Integration of ChatGPT powered virtual assistants to VR faces the challenge of content relevance and discoverability. There, medical semantic vocabularies such as the Unified Medical Language System (UMLS) [3], can provide annotated information about biomedical and health related concepts. This work presents a service and messaging data flow implementation for annotating and discovering 3d assets based on the Unified Medical Language System metathesaurus.

Methods

This implementation enhances asset annotation and discoverability in a Unity3D-based VR medical education platform. A Node.js based interface queries the UMLS Search API.

Results

The user asks a question in the Unity-based VR environment, and the LLM AI response extracts key nouns. These nouns are sent to the UMLS Search API, which returns valid medical terms with Concept Unique Identifiers (CUIs). Matching terms are compared to an annotated 3D models library, ranking models by relevance. The most relevant 3D models are displayed to support the chatbot's educational response. The overall architecture supporting this solution is presented in Fig. 1.

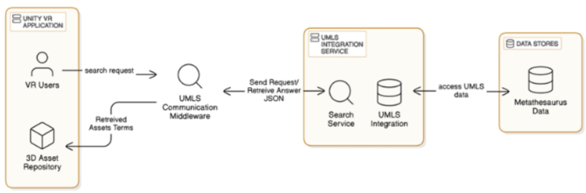

Figure 1. Simplified architecture of the UMLS – 3D anatomy models discovery framework.

Discussion and Conclusion

This implementation is currently in the prototype stage. Future evaluation plans include teacher and student quantitative and qualitative feedback. A key limitation of its performance is its implicit dependence on the robustness of the linked LLM API. A key challenge for medical education technology resources is that of content relevance and recovery. Previous endeavors have identified the importance of semantic annotation for discoverability and repurposing of resources such as virtual patients [4]. Freeform, queries to an LLM chatbot cannot be supported, even with an encyclopedic VR asset base if these assets are not discoverable through medical terms annotation. Robust communication between term repositories (e.g UMLS) and VR education assets is the necessary intermediate step towards discoverable and repurposable, versatile medical education technology resources. Developing procedural educational content and self-directed learning supporting educational platforms is the natural extension and use of this work.

References

1. Pickering JD, Antoniou PE, Ntakakis G, Athanassiou A, Babatsikos E, Bamidis PD. Assessing the difference in learning gain between a mixed reality application and drawing screencasts in neuroanatomy. Anat Sci Educ [Internet]. 2022 May 6;15(3):628–35.
2. Antoniou P.E. Tagaras K., Bamidis P.D.(2024) Enhancing Anatomy Education through an AI-Powered Virtual Reality Auditorium In S. Konstantinidis, P.D. Bamidis (eds) Conference Programme & Book of Abstracts of the 5th International Conference on Medical Education Informatics (pp. 14) ISBN: 978-960-243-750-6
3. UMLS Reference Manual at https://www.ncbi.nlm.nih.gov/books/NBK9684/
4. Dafli, E., Antoniou, P., Ioannidis, L., Dombros, N., Topps, D., & Bamidis, P. D. (2015). Virtual patients on the semantic Web: a proof-of-application study. Journal of medical Internet research, 17(1), e16.

Keywords:
Medical Education, Virtual Reality, Large Language Models, ChatGPT, Semantic Annotation.

MONTE CARLO DETERMINATION OF CORRECTION FACTORS FOR BeO-BASED OPTICALLY STIMULATED LUMINESCENCE DETECTORS IN GAMMA KNIFE RADIOSURGERY SMALL FIELDS

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Introduction

Optically Stimulated Luminescence (OSL) dosimeters have been introduced in Quality Assurance (QA) programs for clinical dosimetry in radiotherapy applications [1]. The aim of this study is to implement a Monte Carlo- (MC-) based framework for the determination of volume averaging effects and the output correction factors in the context of IAEA TRS-483 dosimetry code-of-practice [2], for commercially available BeO-based OSL radiation detectors, suitable for Gamma Knife (GK) dosimetry procedures.

Materials and Methods

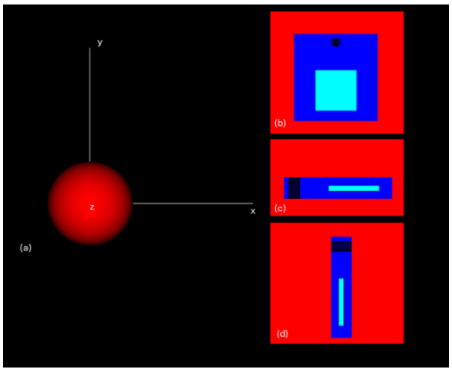

Figure 1: (a) The water spherical phantom with the OSL dosimeter in three nominal cardinal orientations: (b) axial, (c) coronal (d) sagittal.

MC simulations were performed using the EGSnrc V2019 MC software package. The commercially available myOSLchip™ dosimeter (RadPro International GmbH, Germany) was modelled based on blueprints provided by the corresponding manufacturer. The detector consists of a small plastic case (external dimensions 10x10x2mm^3) which houses the sensitive volume made of BeO (square disk of 4.65x4.65x0.5mm^3 and density ρ=2.85 g/cm^3). The active volume of the OSL dosimeter was positioned at the center of a spherical water phantom (diameter: 16cm), which coincided with the Radiation Focus Point (RFP) of the GK system. Phase space files for three collimator sizes (4mm, 8mm and 16mm) of a GK irradiation unit were used as the source models [3]. The 4mm and 8mm collimators were used as the clinical fields (f_{clin}), while the nominal 16mm collimator was regarded as the machine-specific reference field (f_{msr}). For the determination of output correction factors for relative dosimetry [2], the absorbed dose in a small water cavity with a radius of 0.25mm was calculated. The volume averaging effect for the available collimator sizes was also quantified. All calculations were performed for the three cardinal orientations of the detector: (i) axial, (ii) coronal, (iii) sagittal (Figure 1).

Results

The MC calculated correction factors are presented in Table 1. Volume averaging effect was found to have a significant impact on dose measurements, reaching up to 26% for the 4mm collimator.

Table 1: MC calculated $k_{Q_{clin},Q_{msr}}^{f_{clin},f_{msr}}$ correction factors [2] in a water phantom for the GK-PFX irradiation unit. The 16mm collimator corresponds to f_{msr}. Corresponding overall combined uncertainties at the confidence 68% level are shown in the parentheses.

	$k_{Q_{clin},Q_{msr}}^{f_{clin},f_{msr}}$ correction factor [2]	
OSLD orientation	**f_{clin}: 8mm collimator**	**f_{clin}: 4mm collimator**
axial	1.008 (5)	1.134 (6)
coronal	1.011 (5)	1.186 (6)
sagittal	1.010 (5)	1.184 (6)

Conclusion

$k_{Q_{clin},Q_{msr}}^{f_{clin},f_{msr}}$ correction factors for the BeO-based OSL detectors and all cardinal orientations were determined, contributing to data availability for relative dosimetry in GK radiosurgery.

References

1. Kry S F et al 2020, Med. Phys. 47 e19–51.
2. Palmans et al 2017, IAEA TRS-483, Vienna
3. Pappas E P et al 2016, Phys Med. Biol. 61 1182–203

Keywords:
dosimetry, OSL, small field, correction factors, Gamma Knife, radiosurgery

Acknowledgements
RadPro International GmbH are acknowledged for providing detailed schematics of the corresponding OSL dosimeters.
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AGILE METHODOLOGY FOR USER REQUIREMENTS ELICITATION IN THE RAISE PLATFORM

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Introduction

The RAISE platform supports open, transparent, and reproducible biomedical research by allowing computational scripts to be executed on protected datasets, with only results returned and blockchain-registered [1]. It aligns with FAIR (Findable, Accessible, Interoperable, Reusable) principles while maintaining data security. Agile and Living Lab methodologies [2] were employed to adaptively develop a user-centered environment.

Materials and Methods

A mixed-methods Agile approach was applied:

- **Structured User Engagement:** Interviews, surveys, and usability testing identified key system needs.
- **UX and Performance Evaluation:** Task-based assessments and participatory design ensured intuitive data navigation and reproducibility.
- **Incremental Development:** Bi-monthly iterations integrated validated user feedback. Researchers interacted with RAISE (Figure 1) by searching, viewing metadata, and processing datasets securely. Quantitative and qualitative analyses identified usability trends and optimization points. Continuous two-month cycles ensured progressive adaptation.

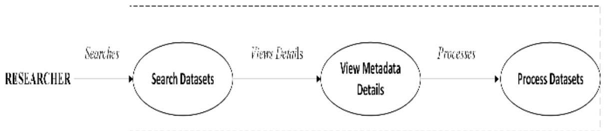

Figure 1 – RAISE Use Case Diagram

Results

Agile iterations led to refinements including improved search functionalities, interface enhancements, and real-time monitoring for computational traceability. Modular system design ensured scalability and FAIR compliance, facilitating integration with external infrastructures.

Discussion

Agile methods enabled rapid responsiveness to user feedback, addressing workflow fragmentation and integration issues. Co-creation with pilot users shaped RAISE's evolution. While resource-intensive, this iterative process minimized usability gaps and strengthened platform effectiveness.

Conclusions

Combining Agile development, real-world testing, and structured UX evaluations, RAISE delivers a scalable, FAIR-compliant platform that supports open, reproducible biomedical research. Continuous engagement ensures adaptability to future needs.

References:

1. Wilkinson, M. D., et al. (2016). The FAIR Guiding Principles for Scientific Data Management and Stewardship. Scientific Data, 3, 160018.
2. Dell'Era, C., & Landoni, P. (2019). Living Lab: A Methodology Between User-Centered Design and Participatory Design. Creativity and Innovation Management, 28(3), 380–395.

Keywords:
FAIR principles, Biomedical data processing, Research accreditation, Data security, Open Science

Acknowledgement
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ΠΡΌΣΦΑΤΕΣ ΕΞΕΛΊΞΕΙΣ ΣΤΗ ΝΑΝΟΪΑΤΡΙΚΉ ΓΙΑ ΤΗ ΣΥΝΔΥΑΣΤΙΚΉ ΑΝΤΙΚΑΡΚΙΝΙΚΉ ΘΕΡΑΠΕΊΑ ΜΕ ΑΚΤΙΝΟΘΕΡΑΠΕΊΑ ΚΑΙ ΦΩΤΟΘΕΡΜΊΑ

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Introduction
Η ακτινοθεραπεία (RT) και η φωτοθερμική θεραπεία (PTT) αποτελούν καθιερωμένες αντικαρκινικές θεραπείες, οι οποίες τα τελευταία χρόνια έχουν ενισχυθεί σημαντικά χάρη στην πρόοδο της νανοϊατρικής. Η ενσωμάτωση μεταλλικών νανοσωματιδίων (NPs) υψηλού ατομικού αριθμού (Z) σε αυτές τις μεθόδους επιτρέπει την ανάπτυξη συνεργιστικής δράσης, συνδυάζοντας την ακτινοευαισθητοποίηση με την τοπική παραγωγή θερμότητας και ενισχύοντας την καταστροφή των καρκινικών κυττάρων.

Discussion
Η παρούσα ανασκόπηση συνοψίζει τις πιο πρόσφατες εξελίξεις στον συνδυασμό RT–PTT με τη μεσολάβηση νανοσωματιδίων, δίνοντας έμφαση στον διττό τους ρόλο: ενίσχυση της ακτινοπροκαλούμενης βλάβης και αύξηση της φωτοθερμικής απόδοσης. Συζητούνται διάφοροι τύποι νανοσωματιδίων – όπως χρυσός, λευκόχρυσος, βισμούθιο, χαλκός, καρβίδιο ζιρκονίου και πολυλειτουργικά υβριδικά συστήματα – ως προς τις φυσικοχημικές τους ιδιότητες, τους μηχανισμούς στόχευσης και τα θεραπευτικά τους αποτελέσματα in vitro και in vivo. Παράλληλα, αναδεικνύονται βασικές προκλήσεις όπως η τυποποίηση των θεραπειών, η μακροχρόνια τοξικότητα και στη μεταφραστική ιατρική. Τέλος, εξετάζονται οι μελλοντικές προοπτικές της θεραπείας RT–PTT με νανοσωματίδια, θέτοντας τις βάσεις για την ανάπτυξη της επόμενης γενιάς πολυλειτουργικών νανοσυστημάτων.

Λέξεις Κλειδιά:
Νανοσωματίδια Μετάλλων, Νανο-ογκολογία, Ακτινοθεραπεία, Φωτοθερμική Θεραπεία

THE IMPACT OF COMPUTED TOMOGRAPHY ITERATIVE RECONSTRUCTION IN RADIATION DOSE REDUCTION

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Introduction

Iterative Reconstruction (IR) techniques in Computed Tomography (CT) imaging have demonstrated potential in obtaining high quality images with reduced radiation dose [1-3]. IR algorithms such as Sinogram Affirmed Iterative Reconstruction (SAFIRE) and Adaptive Statistical Iterative Reconstruction (ASIR) have been tested in clinical-based, as well as in phantom-based studies. The current phantom-based study investigates the impact of IR parameters in image quality and radiation dose in head CT.

Materials and Methods

To simulate patient head, a Mini CT QC acrylic phantom (diameter: 15.25 cm) was utilized, that includes tissue equivalent inserts (bone-equivalent and soft-tissue materials) and a high resolution insert. Image acquisition was performed using a 128 slice CT scanner (Somatom go.Top, Siemens). Vendor default exposure settings for head CT considered tube voltage of 100kVp and tube current of 212mA. A range of tube current values was further exploited (180-61 mA) for radiation dose reduction (CTDIvol). Reconstruction parameters considered varying SAFIRE strength values (S1, S2,S3,S4,S5) and two reconstruction kernels (Hr40f and Hr60f). Image quality was assessed quantitatively [Noise, Contrast-to-Noise Ratio (CNR), Signal-to-Noise Ratio (SNR)] and qualitatively (spatial resolution).

Results and Discussion

Increasing SAFIRE strength from S1 to S5, noise was reduced, while CNR (Figure 1) and SNR (Table 1) were increased. Images reconstructed by high SAFIRE strength (S4 and S5) were smoother, without degradation of spatial resolution. Sharper reconstruction kernel (Hr60f) provided improved spatial resolution as compared to smoother kernel (Hr40f). Increased value of radiation dose (CTDIvol) resulted in improved SNR and CNR values. Low dose images (current=151mA, CTDIvol=32.36mGy) reconstructed with SAFIRE strength S4 demonstrated similar image quality (SNR and CNR without compromising spatial resolution) as compared to the reference protocol (current=212mA, CTDIvol=45,50mGy).

Conclusions

SAFIRE iterative reconstruction allows for reduced radiation dose, maintaining CT image quality and can be used for pediatric imaging and low-dose protocols.

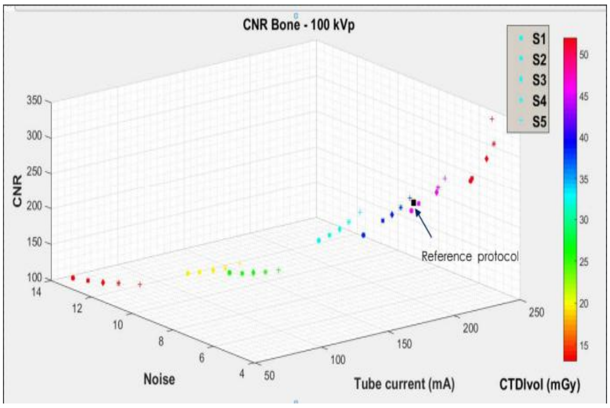

Figure 1. 4D diagram illustrating CNR and Noise for bone-equivalent material with respect to SAFIRE Strength (S1-S5) and Radiation Dose (CTDIvol) at 100kVp.

Table 1: Signal-to-Noise Ratio (SNR) for the bone-equivalent material with respect to Iterative Reconstruction (IR) Strength for two reconstruction kernels (exposure conditions: tube voltage 100kVp and tube current 121mA)

IR Strength	Kernel Hr40f	Kernel Hr60f
S1	88,67	23,02
S2	90,58	25,75
S3	92,59	29,05
S4	94,55	33,66
S5	97,02	39,66

References

1. M.J. Willemink and P.B. Nöel (2019) The evolution of image reconstruction for CT – from filtered back projection to artificial intelligence, Eur Radiol, 29:2185-2195
2. J. Greffier, F. Macri, A. Larbi et.al. (2015) Dose reduction with iterative reconstruction: Optimization of CT protocols in clinical practice, Diagn Interv Imag, 96:477-486
3. W. Stiller (2018) Basics of iterative reconstruction methods in computed tomography: A vendor independent overview, Eur J Radiol, 109:147-154.

Keywords:
Computed Tomography, Iterative Reconstruction, Radiation Dose, Image Quality, Optimization

Η ΡΑΔΙΟΜΙΚΗ ΩΣ ΒΑΣΙΚΟ ΕΡΓΑΛΕΙΟ ΓΙΑ ΤΗΝ ΠΡΟΒΛΕΨΗ ΚΑΙ ΤΗΝ ΔΙΑΓΝΩΣΗ ΝΕΩΝ ΕΣΤΙΩΝ ΣΚΛΗΡΥΝΣΗΣ ΚΑΤΑ ΠΛΑΚΑΣ

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Εισαγωγή- Σκοπός

Η σκλήρυνση κατά πλάκας (ΣΚΠ) είναι μια φλεγμονώδης νόσος που προσβάλλει περίπου 2,9 εκατομμύρια άτομα παγκοσμίως Η ραδιομική αποτελεί ένα πολλά υποσχόμενο εργαλείο για την ποσοτική ανάλυση εικόνων Μαγνητικής Τομογραφίας (ΜΤ) στη ΣΚΠ. Η παρούσα ανασκόπηση εξετάζει τη χρήση ραδιομικών χαρακτηριστικών για τη διάγνωση και πρόγνωση νέων εστιών ΣΚΠ.

Μέθοδος και Υλικά

Η βιβλιογραφική αναζήτηση πραγματοποιήθηκε στο PubMed για το χρονικό διάστημα από το 2011 έως 2024.

Αποτελέσματα

Μία σημαντική παράμετρος στη διαχείριση της ΣΚΠ είναι η έγκαιρη αλλά και η έγκυρη διάγνωση της. Οι Loizou et al. [1] διερεύνησαν τη συμβολή των χαρακτηριστικών υφής των εικόνων ΜΤ Τ2 κλινική αξιολόγηση και πρόγνωση της ΣΚΠ. Τα αποτελέσματα της μελέτης έδειξαν σημαντικές διαφορές στα χαρακτηριστικά υφής μεταξύ φυσιολογικής λευκής ουσίας και αλλοιώσεων, καθώς και μεταξύ ασθενών με διαφορετικά επίπεδα αναπηρίας. Επιπλέον, ορισμένα χαρακτηριστικά υφής φάνηκαν να σχετίζονται με την εξέλιξη της αναπηρίας, υποδεικνύοντας πιθανή προγνωστική αξία. Αντίστοιχα, Οι Arkadani et al. [2] χρησιμοποίησαν Γραμμική Διαχωριστική Ανάλυση και τον αλγόριθμο 1-Nearest Neighbor, καταδεικνύοντας την ικανότητα του μοντέλου να διακρίνει με ακρίβεια τις αλλοιώσεις της ΣΚΠ από τη φυσιολογική λευκή ουσία. Αντίστοιχα, οι Shao et al. [3] εξέτασαν αν οι υπερεντάσεις λευκής ουσίας μπορούν να προβλεφθούν σε πρώιμα στάδια, αναλύοντας την υφή σε εικόνες ΜΤ FLAIR σε ηλικιωμένους. Τα αποτελέσματα έδειξαν υψηλή ακρίβεια για το μοντέλο πρόβλεψης (AUC 0.967). Παρόμοια ακρίβεια παρουσίασε το μοντέλο των Loizou et al. [4], αναδεικνύοντας έτσι την δυνατότητα των ραδιομικών χαρακτηριστικών στην πρόβλεψη εμφάνισης βλαβών ΣΚΠ. Αντίστοιχα, οι Khajetash et al. [5] με την εργασία τους ανέδειξαν την αποτελεσματικότητα ενός μοντέλου μηχανικής μάθησης με βάση την ραδιομική στην πρόβλεψη της εξέλιξης των ενεργών πλακών των βλαβών της ΣΚΠ με χρήση εικόνων FLAIR πετυχαίνοντας μέγιστη τιμή AUC 0.85. Τέλος, η μελέτη των Lavrova et al. [6] έδειξε ότι τα χαρακτηριστικά από ποσοτική ΜΤ στη φυσιολογικά εμφανιζόμενη λευκή και φαιά ουσία προσφέρουν αξιόπιστες διαγνωστικές πληροφορίες, ενώ τα χαρακτηριστικά από συμβατική ΜΤ (Τ1) μπορούν να συμβάλουν σε έναν γρήγορο και αυτοματοποιημένο έλεγχο ανωμαλιών στη λευκή ουσία.

Συμπεράσματα

Η βιβλιογραφική ανασκόπηση έδειξε ότι η χρήση της ραδιομικής μπορεί να αποτελέσει ένα βασικό εργαλείο για την πρόγνωση και τη διάγνωση της ΣΚΠ. Ωστόσο, παρόλη την υψηλή ακρίβεια που παρουσιάζουν τα μοντέλα αυτά υπόκεινται σε αρκετούς περιορισμούς. Οι περισσότερες μελέτες είναι μονοκεντρικές, χωρίς να λαμβάνουν υπόψη την ανομοιογένεια μεταξύ πρωτοκόλλων ΜΤ. Επιπλέον, απαιτείται μεγάλος όγκος δεδομένων για την ανάπτυξη αξιόπιστων προγνωστικών μοντέλων. Τέλος, αν και τα χαρακτηριστικά παρουσιάζουν υψηλή συσχέτιση, ο παθοφυσιολογικός μηχανισμός της ΣΚΠ παραμένει ασαφής.

Αναφορές

1. Loizou, Christos P., et al. "Quantitative texture analysis of brain white matter lesions derived from T2-weighted MR images in MS patients with clinically isolated syndrome." Journal of neuroradiology 42.2 (2015): 99-114.
2. Ardakani, Ali Abbasian, et al. "Application of texture analysis in diagnosis of multiple sclerosis by magnetic resonance imaging." Global journal of health science 7.6 (2015): 68.
3. Shao, Yuan, et al. "Predicting the development of normal-appearing white matter with radiomics in the aging brain: a longitudinal clinical study." Frontiers in Aging Neuroscience 10 (2018): 393.
4. Loizou, Christos P., Marios Pantzaris, et al. "Normal appearing brain white matter changes in relapsing multiple sclerosis: Texture image and classification analysis in serial MRI scans." Magnetic Resonance Imaging 73 (2020): 192-202.
5. Khajetash, Benyamin, et al. "Introducing radiomics model to predict active plaque in multiple sclerosis patients using magnetic resonance images." Biomedical Physics & Engineering Express 9.5 (2023): 055004.
6. Lavrova, Elizaveta, et al. "Exploratory radiomic analysis of conventional vs. quantitative brain MRI: toward automatic diagnosis of early multiple sclerosis." Frontiers in neuroscience 15 (2021): 679941.

Λέξεις-κλειδιά

Σκλήρυνση κατά Πλάκας, Ραδιομική, Μοντέλα Πρόβλεψης, Τεχνητή Νοημοσύνη, Μηχανική Μάθηση

A REVIEW OF THE TECHNOLOGICAL ADVANCEMENTS AND TECHNICAL CHALLENGES OF FLASH RADIATION THERAPY

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Introduction

FLASH radiotherapy (FLASH-RT) is a new paradigm of radiation therapy, featuring ultra-high Dose rate (UHDR) irradiation of tumours, with Dose rate of 40 Gy s^{-1} or higher. While maintaining its anti-tumour effect, FLASH-RT is characterised by a transient hypoxic state of the healthy tissue, which results in its extended sparing, when compared to conventional radiotherapy methods [1].

Materials & Methods

A comprehensive review of literature on FLASH-RT has been conducted, focusing on technological advancements in UHDR-radiation delivery in various modalities. Special attention has been paid to novel methods and proposed structures dedicated for FLASH.

Results

Numerous technological advancements have been made in the past decade to accommodate the production and transmission of various modalities of UHDR radiation. The implementation of existing electron LINACs has been shown to enable FLASH-RT for superficial tumours, while there have also been various studies regarding the employment of Bremsstrahlung-target- and synchrotron- produced X-Rays for FLASH [2-3].

Furthermore, focused Very-High-Energy Electron beams have been shown to enable the production of a Spread-Out Electron Peak, resembling the Dose distribution of the Spread-Out Bragg Peak of hadrons [4]. Last, but not least, existing hadron radiotherapy systems have been shown to be, in principle, compatible with FLASH-RT, with cyclotrons and synchrotrons presenting both strengths and weaknesses on the production and delivery of UHDR beams [5].

Discussion

Despite its promising potential, several technological challenges remain to be addressed before additional pre-clinical and clinical trials, and widespread adoption. Technological advancements should also facilitate biological experiments and aid in the understanding of the, currently unclear, conditions for the induction of the FLASH effect, which should, in turn, facilitate the devisement of treatment plans. Additionally, development of real-time dosimetry methods and of beam diagnostics equipment to ensure dose and dose rate optimisation is crucial for the accurately monitored delivery of UHDR radiation.

Conclusions

Advancements in accelerator technology, beam control and real time dosimetry are vital in the successful implementation of FLASH radiotherapy. Overcoming these challenges requires further research and is expected to significantly optimise cancer treatment methods.

References

1. C. Limoli and M.-C. Vozenin (2023) Reinventing Radiobiology in the Light of FLASH Radiotherapy, Annual Review of Cancer Biology, 7:1-21
2. M.-C. Vozenin, *et al.* (2024) FLASH: New intersection of physics, chemistry, biology and cancer medicine, Reviews of Modern Physics, 96:035002
3. P. G. Maxim, S. G. Tantawi and B. W. Loo Jr. (2019) PHASER: A platform for clinical translation of FLASH cancer radiotherapy, Radiotherapy and Oncology, 139:28-33
4. J. Fischer, *et al.* (2024) Very-high energy electrons as radiotherapy opportunity, EPJ Plus, 139:728
5. A. Koutsostathis - FLASH Radiation Therapy: A Review on the Ultra-High Dose Rate Paradigm of Radiotherapy, Hadron Therapy Symposium (Thessaloniki 19.-21.10.2024) at https://indico.cern.ch/event/1470161/#143-flash-radiation-therapy-a

Keywords:
FLASH, UHDR, X-Rays, Particle Therapy, PHASER, VHEE, Dosimetry

REHABOTICS: AN INTEGRATED REHABILITATION SYSTEM FOR ASSESSING AND TREATING UPPER LIMB SPASTICITY AFTER STROKE

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Introduction

Limb spasticity resulting from stroke, traumatic brain injury, multiple sclerosis, or various central nervous system disorders such as brain tumors, leads to loss of hand function, joint stiffness, and severe pain. According to [1], stroke incidents worldwide have been recorded at 12.2 million, with 6.55 million deaths from stroke, and 143 million disability-adjusted life years, while upper limb impairment is the most common disability affecting 77.4% of patients. In clinical practise, the primary rehabilitation method involves a stretching program and the patients must visit their physiotherapist daily. This poses significant challenges for both the patients and their families considering their reduced motor function. Also, traditional methods for assessing upper limb spasticity are susceptible to variations influenced by the clinician's expertise.

Materials and Methods

The automation of traditional evaluation methods presents an emerging area, with robot-aided systems being one of the most promising approaches. This paper introduces the REHABOTICS integrated rehabilitation system to deliver highly personalized assessment and treatment for upper limb function in patients with spasticity following a stroke. The REHABOTICS exoskeletal system consists of two functional elements: (i) the passive (soft) exoskeletal aid (PEA), and (ii) the active exoskeletal aid (AEA). PEA refers to the part of the system responsible for measuring and acquiring the data through a glove with specialized sensors. The data monitoring and storing takes place in real time, extracting useful metrics and conclusions. The system includes an interactive virtual environment using machine vision and augmented reality technologies able to acquire, interpret and evaluate the spatial information of the user's hand from either the PEA or a computer camera or a combination of the above. The AEA is an exoskeleton for managing finger movements by utilizing the rotational motion of servo motors (Dynamixel AX-12A, Corona, CA, USA). An articulated structure has been developed with specially designed rings which guide a wire in order to transfer the motion of the servo motor to the finger components converting rotational motion into linear.

Results

The assessment tests which are performed using the PEA are based on: (i) the Ashworth Scale (AS), which is the most universally accepted clinical tool used to measure the increase of muscle tone, (ii) the Passive Range of Motion (PROM), (iii) the Active Range of Motion (AROM), and (iv) Free Session (Fig. 1a). The AEA offers an interactive interface which allows users (patients and physiotherapists) to adjust parameters like finger extension speed, set the maximum extension angle, and control the speed of return to the starting position (Fig. 2b). Using an intuitive navigation menu, the selected exercise is executed, prompting the servo motors to begin moving the fingers. The movement angles for each servo motor are displayed in degrees on the graphical interface.

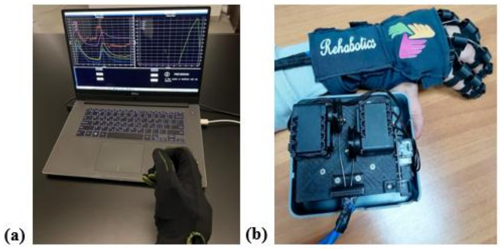

Figure 1. The REHABOTICS: (a) PEA, (b) AEA.

Discussion

The REHABOTICS exoskeletal system based on the PEA and AEA components is a novel robot-aided system for the assessment and treatment of upper limb spasticity after stroke. Although further clinical research is required, the REHABOTICS solution is designed to: (i) provide an affordable and easy-to-use system for both patients and clinicians, (ii) deliver quantitative data to clinicians through specialized assessments (e.g. Box and Block test, AS scale, PROM, AROM), and (iii) motivate patients to enhance their motor skills.

References

1. V. Feigin *et al.,* Global, regional, and national burden of stroke and its risk factors, 1990–2019: a systematic analysis for the Global Burden of Disease Study 2019, The Lancet Neurology 20 (10), 795 – 820, 2021.

Keywords:

Upper limb spasticity, stroke, rehabilitation, passive exoskeletal aid, active exoskeletal aid.

Acknowledgement

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CPR ASSIST: A WEARABLE AND MOBILE APP SYSTEM FOR REAL-TIME CPR FEEDBACK AND TRAINING

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Introduction

Out-of-hospital cardiac arrest (OHCA) has a survival rate below 10%, with high-quality chest compressions being critical for improving outcomes [1]. However, even trained professionals struggle to maintain proper cardiopulmonary resuscitation (CPR) technique due to fatigue, incorrect hand placement, and lack of real-time feedback [2]. Traditional CPR training relies on sensor-equipped mannequins, which, while effective, are bulky, expensive, and not practical for continuous practice [2]. More recently, wearable CPR assistance devices have been developed to offer real-time feedback in a more portable form. Despite these advancements, many still suffer from rigidity, discomfort, and lack of emergency response integration, limiting their effectiveness in both training and real-world scenarios [3,4].

CPR Assist Glove and App

The CPR Assist Glove is a wearable device designed to improve CPR technique by providing real-time feedback and emergency response support. It is equipped with sensors to measure compression depth, frequency, and other metrics, ensuring users follow proper guidelines. It connects wirelessly to a mobile application, which acts as the main interface for monitoring performance and tracking CPR quality. The app has two main modes: *Emergency Mode* – When activated, the system prompts the user with an option to call emergency services (112). The app includes an AED Locator which shows the nearest defibrillator and provides real-time navigation directions. Additionally, it provides live compression feedback by analyzing sensor data in real-time and issuing corrective prompts to guide effective CPR. *Training Mode* – This mode helps users improve their CPR skills by offering real-time feedback on compression depth, frequency, and effectiveness. After each session, the app stores performance data, allowing users to review previous sessions, track progress over time, and analyze detailed insights for skill improvement. This system assists in real-time emergencies while also acting as a CPR training tool. By integrating wearable technology and real-time analytics, it ensures precise CPR execution and supports continuous skill improvement in both clinical and public settings.

Conclusion

This work presents the CPR Assist Glove, a wearable solution aimed at improving CPR quality through real-time feedback, emergency response integration, and structured training. Future work will focus on enhancing sensor accuracy, improving glove comfort for extended use, and conducting real-world testing to evaluate its effectiveness in both training and emergency situations.

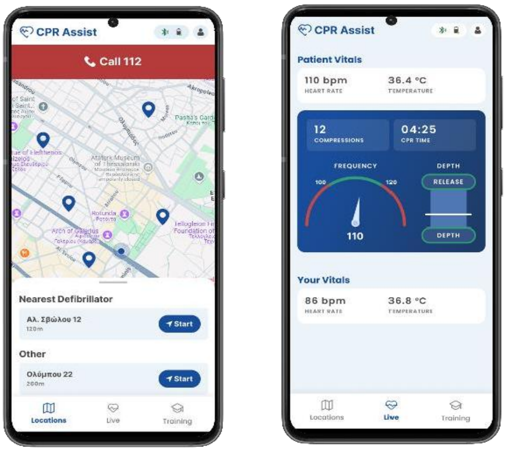

Figure 1. Screenshots of the app in Emergency Mode (left) and Training Mode (right).

References

[1] Li S, et al. Survival after out-of-hospital cardiac arrest before and after legislation for bystander CPR. JAMA Netw Open. 2024 Apr 26;7(4):e247909.
[2] Xie J, Wu Q. Design and evaluation of CPR emergency equipment for non-professionals. Sensors. 2023 Jun 27;23(13):5948.
[3] Guridi S, et al. A proof-of-concept study on smart gloves for real-time chest compression performance monitoring. IEEE Access. 2024; 12: 22331–44
[4] Zhang J, et al. Wearable inertial and pressure sensors- based chest compression quality assessment to improve accuracy and robust- ness. IEEE Sensors J. 2024 Feb 1;24(3):3774–87.

Keywords
assistive glove, cardiopulmonary resuscitation, m-health
Acknowledgments
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SEARCHING FOR BIOMARKERS IN CEREBRAL PALSY: AN IN-SILICO ANALYSIS

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Introduction

Cerebral palsy (CP) comprises a group of non-progressive neurodevelopmental disorders that impact posture, coordination, and motor control. While spasticity, hypertonia, and muscle weakness are hallmark symptoms, therapeutic decisions—particularly the initiation and timing of botulinum toxin (BoNT-A) injections—are largely empirical, lacking quantitative guidelines. This project investigates the use of digital twins and predictive modelling to derive kinematic biomarkers that can guide therapeutic intervention, offering a framework for objective and personalised clinical decision-making.

Materials and Methods

To simulate CP-related motor dysfunction, a planar 9-degree-of-freedom musculoskeletal model was constructed using OpenSim and SCONE, incorporating 18 lower-limb muscles. Literature-derived alterations in reflex delay, constant baseline activation (C_0), and feedback gain (K_F) were used to simulate both full-blown and intermediate stages of the disease. A model of BoNT-A-treated CP was created by applying a 62.5% attenuation to C_0 and K_F and eliminating reflex delays. We developed five classes of digital patients: healthy control, untreated CP, post-BoNT treatment, and intermediate states representing 50–80% disease progression and 40–80% treatment efficacy decay. Forward dynamic simulations were run to assess balance under each condition, and joint kinematic profiles (ankle, knee, and hip angles) were extracted for analysis. Two primary phases of motion were studied: the dynamic phase leading to balance and the postural steady-state phase. Metrics included absolute and normalized joint angle differences, standard deviation, interquartile range, and—most importantly—the average joint angle after balance. These were evaluated as potential biomarkers for disease state classification. A linear discriminant analysis (LDA) classifier was trained to detect the threshold at which patients transition from "normal" to "diseased," informing optimal treatment initiation and reinjection timing.

Results

Simulated balance tasks revealed unique joint angle trajectories for each clinical state. Notably, the average hip and ankle joint angles post-balance robustly discriminated between normal, CP, and post-treatment cases. The classifier identified ~70% disease progression as the threshold for initiating BoNT-A therapy, and ~60% efficacy loss as the point for reinjection. The knee angle was found to be supportive but insufficient as a standalone biomarker due to non-unique mappings across conditions. Characteristic regression curves were fitted for each joint across disease and treatment progression stages, yielding clear visual decision boundaries. While the ankle and hip angles were monotonic and suitable for direct clinical use, the knee angle showed ambiguity in intermediate states. When used in combination, however, these joint-based metrics offered high diagnostic and prognostic resolution.

Discussion and Conclusions

This study demonstrates the feasibility of using digital patient simulations to derive non-invasive, easily measurable kinematic biomarkers for CP. These biomarkers—average joint angles after balance—can be obtained from basic video recordings and computed with minimal post-processing, aligning with standard clinical workflows. Their application spans diagnostic screening, treatment planning, and therapy monitoring. We propose a novel methodology for managing cerebral palsy using joint angle-based biomarkers derived from validated in silico models. Hip and ankle angles post-balance provide reliable diagnostic and prognostic information and can inform the initiation and repetition of BoNT-A therapy. These findings support a shift toward quantitative, simulation-driven, and patient-specific medicine in pediatric neurorehabilitation. Experimental validation and calibration with wearable motion capture systems are essential next steps. Scaling the simulation to 3D models, incorporating contractures and tendon transfer scenarios, and refining the classifier with larger datasets will further enhance its translational potential.

References

1. Granata KP et al., Electromechanical Delay in Spastic CP, 2000
2. Lidbeck C et al., Muscle Strength and Standing Ability, 2015
3. Kainz H et al., Muscle Force Scaling in CP Models, 2018
4. Multani I et al., BoNT in CP, 2019
5. Chen YT et al., BoNT and Motor Performance in Stroke, 2020

Keywords

Cerebral palsy, Biomarkers, Botulinum toxin, Joint kinematics, SCONE, Musculoskeletal modeling

STUDY OF SPINAL MUSCULAR ATROPHY USING GRAPH THEORY

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Introduction

Graph theory is examined as a powerful tool for understanding and analyzing Spinal Muscular Atrophy (SMA), a genetic disorder that affects spinal cord neurons and causes progressive muscular weakness and atrophy [1]. By modeling neurological mechanisms and gene interactions as graphs, researchers can obtain a computational and visual framework of the disease [2], enhancing understanding and enabling therapeutic interventions.

Disease

Spinal Muscular Atrophy (SMA) is a neurodegenerative and neuromuscular disease, genetically determined, that impacts the central and peripheral nervous system, as well as voluntary muscles. It is classified as a motor neuron disease and is primarily caused by mutations in the SMN1 gene [1]. The severity of SMA varies, with forms ranging from mild to life-threatening

Graph Theory and Modeling

Graphs, consisting of nodes and edges, are widely used to represent complex biological systems [2]. In SMA, genes are modeled as nodes and their interactions as edges, forming protein networks and gene expression graphs. These models can simulate motor neuron apoptosis and synaptic disruptions, contributing to the understanding of impaired neural function.

Expected outcomes

Recent advances in genetic screening and gene therapy have improved outcomes for SMA patients. However, instability of therapeutic proteins remains a challenge. Through sub-graphs and network motifs, gene interactions can be better visualized, allowing prediction of novel biological pathways and regulatory relationships [4].

Limitations

Despite its promise, graph-based modeling has limitations. Biological systems are highly dynamic and context-dependent, which simple graph structures may not fully capture. Moreover, the accuracy of graph inference depends on data quality and completeness, and large-scale graphs may require significant computational resources [3].

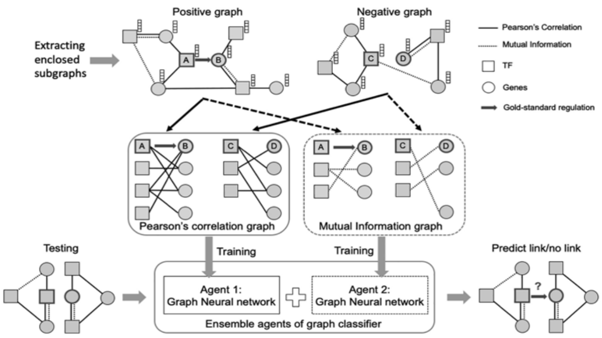

Fig. 1. End-to-end framework gene regulatory graph neural network (GRGNN), proposed by Wang et al. (2020) [4].

Conclusions

Graph theory offers valuable insights into SMA at molecular and genetic levels. Further development of graph-based algorithms may support early diagnosis, individualized therapies, as well as prediction of SMA's progression.

References

1. Muscular Dystrophy Association (MDA) https://www.mda.org/disease/spinal-muscular-atrophy
2. Barabási AL. Network science. Philos Trans A Math Phys Eng Sci. 2013 Feb 18; 371(1987): 20120375. doi: 10.1098/rsta.2012.0375. PMID: 23419844.
3. Nikolaou C., & Chouvardas, P. (2015). Compitional Biology. Kallipos, Open Academic Editions. https://hdl.handle.net/11419/1577
4. Wang J., Ma A., Ma Q., Xu D., Joshi T.. Inductive inference of gene regulatory network using supervised and semi-supervised graph neural networks. Computational and Structural Biotechnology Journal, Elsevier 2020, https://doi.org/10.1016/j.csbj.2020.10.022

Keywords

Spinal muscular atrophy, graph theory, gene expression, biological networks

LIGHT-BASED NANOMEDICINE APPROACHES IN OCULAR CANCER MANAGEMENT: FUTURE PERSPECTIVES

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Introduction

Current treatments for ocular cancers often face limitations such as suboptimal delivery of pharmaceutical ingredients, limited specificity and severe side effects. Nanomedicine aims to address these challenges by enhancing conventional methods, including light-based therapies, namely photothermal therapy (PTT) and photodynamic therapy (PDT).

Methods

A comprehensive literature review was conducted to evaluate recent advancements in nanoparticle-based therapies for the most common ocular cancers, retinoblastoma (RB) and uveal melanoma (UM), with a focus in PTT/PDT. Relevant preclinical and clinical studies were systematically analyzed.

Results/Discussion

PTT uses light-sensitive heating agents which, after being delivered to the tumour site, are irradiated by a NIR laser and convert light energy into heat to induce cell death via hyperthermia. PDT on the other hand employs photosensitizers that, upon activation with specific light wavelengths produce reactive oxygen species (ROS) to induce tumor cell apoptosis or necrosis.

Nanoparticles can be employed directly as photothermal agents, as in the case of gold nanoparticles, which efficiently convert light energy into heat due to their optical properties, or iron-oxide nanoparticles, which can be used for magnetic hyperthermia. Similarly, TiO_2 NPs have demonstrated effectiveness as photosensitizers in PDT. A different approach is to conjugate NPs with conventional photothermal agents (e.g. ICG) or photosensitisers (e.g.porphyrins), in order to create formulations with improved pharmacokinetics and bioavailability. Recent advances include thermoresponsive nanogels that allow controlled drug release upon irradiation. Surface functionalization with targeting ligands, such as EpCAM antibodies or FA, further enhances specificity and uptake by cancer cells.

A major achievement of nanomedicine is the lipid nanoformulation of the photosensitiser verteporfin, Visudyne®, which is approved for PDT in excudative AMD. It is currently being investigated in clinical trials for both RB and UM, with particularly promising results for UM. Another noteworthy nanoformulation is AU-011, a virus-like nanoparticle conjugated with a fluorescent dye, that targets the heparan-sulfate proteoglycans overexpressed in cancer cells. When light activated, it induces immunogenic death, and it has advanced in phase 2 trials for UM.

A revolutionary aspect of nanotechnology in photo-based therapies is its potential for multimodal applications. For instance, AuNPs can act as enhancers for OCT, fluorescent or PA imaging, allowing in vivo tracking and image-guided PTT, while they have also been used as dose enhancers in radiotherapy. Another treatment often combined with PTT or PDT is chemotherapy, leveraging the increased susceptibility of treated cells to chemotherapeutic drugs. PTT and PDT can also benefit from each other. For example, PTT increases local blood flow and oxygenation, mitigating the oxygen dependency limitations of PDT. Overall, NPs enable the co-deliver of a variety of molecules (light-activated, imaging-enhancing, chemotherapeutic), allowing several combinations between chemotherapy, PDT, PTT and radiotherapy, along with imaging, to maximise their synergetic effects.

Conclusion

The integration of nanotechnology in photo-based therapies can offer treatment precision and optimised administration, with some nanoformulations already in clinical trials and several others in preclinical studies. Given the ability to combine them with other therapeutic methods, such as radiotherapy and chemotherapy, as well as multiple imaging modalities, nanomedicine holds the potential to transform the ocular oncology landscape.

References

1. Lara-Vega, I.; Vega-López, A. Combinational Photodynamic and Photothermal - Based Therapies for Melanoma in Mouse Models. Photodiagnosis Photodyn. Ther. 2023, 43, 103596.
2. Russo, E.; Spallarossa, A.; Tasso, B.; Villa, C.; Nanotechnology for Pediatric Retinoblastoma Therapy. Pharmaceuticals 2022, 15 (9), 1087.

Keywords:
Nanomedicine, PTT, PDT, Retinoblastoma, Uveal Melanoma, Nanoparticles

REVIEWING CLINICAL USE OF FLUOROPHORES IN ENDOSCOPE ASSISTED RESECTION OF INTRAPARENCHYMAL BRAIN TUMORS

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Introduction

Intraoperative use of fluorophores aims in better visualization of the tumoral tissue [1]. Its use in combination with microsurgical technique is well established in achieving greater resection with lower neurological complications. Endoscopes capable of inducing fluorescence have been gaining traction in the recent years hoping to maximize the extent of resection in the margins of a tumor where visualization only by microscope has technical limitations.

Materials and Methods

A literature review in PubMed database of the last 5 years was conducted in March of 2025, using the search term “fluorescent use in endoscopic neurosurgery” retrieving 62 results. Only articles about nonvascular intraparenchymal tumors were included. Case reports were also excluded. Eight articles were reviewed comparing florescence-enhanced endoscopic and endoscope-assisted resection of intraparenchymal brain tumors against microscope only resection.

Results

The Fluorescent agents used by the researchers were 5-aminolevulinic acid (5ALA), Indocyanine Green (ICG) and Fluorescein (FNa). When compared with microscope, the visualization of the tumoral tissue by endoscope under fluorescent lighting was more intense and in some of the cases where the administration of the agent was characterized “unhelpful” under microscope view the endoscope achieved to show sufficient contrast [2]. Furthermore, after mass excision under microscope when inspecting the cavity with an endoscope it was possible to identify residual malignant tissue due to better viewing angles and closer proximity to the surgical field. This advantage is reinforced by using endoscopes with 30^{o} cameras [3]. Better and more extensive visualization is also supported by a greater percentage of gross total resection achieved when the use of endoscope is implemented [5].

Discussion

The treatment of brain tumors remains a challenge, with complete excision of lesions being a center point of the therapeutic course. The implementation of fluorescent agents during surgery has improved patients’ outcome and the use of endoscopes seems to further enhance the extent of resection. Specialized gearing is necessary both for microscopes and endoscopes capable of capturing the wave lengths emitted by fluorophores (ICG:820-860nm,5-ALA:640-710nm, FNa:540-690nm), with the latter not being widely available yet due to extra cost and additional training required.

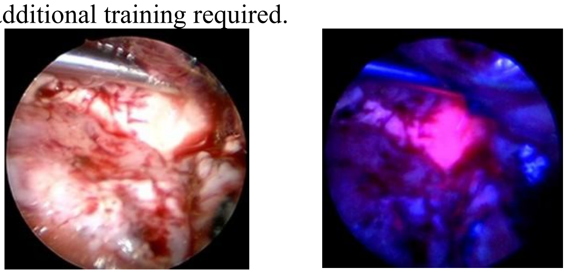

Figure 1. 5-ALA guided endoscopic resection [4]. Endoscope view of the surgical cavity under white light (left) and blue light (right)

Conclusion

Data so far is promising for using florescence-enhanced endoscopy treating intraparenchymal tumors. Additional high-quality studies are needed to clarify the superiority of combined endoscope/ microscope technique against their use separately. More research is needed in the field of fluorophores, development of novel substances and exploring multiple agents use during surgery, analyzing technical challenges, interference and toxicity

References

1. Xu Y, et al. (2025) Fluorescence Endoscopy with Second Window Indocyanine Green for Surgical Resection of Malignant Brain Tumors. World Neurosurg. 6;196:123766
2. Bettag C, et al. (2022) Endoscope-assisted visualization of 5-aminolevulinic acid fluorescence in surgery for brain metastases. J Neurosurg. 29;137(6):1650-1655.
3. Ma R, et al. (2024) Endoscopic 5-Aminolevulinic Acid-Induced Fluorescence-Guided Intraparenchymal Brain Tumor Resection-Can the Endoscope Detect More Fluorescence Than the Microscope? World Neurosurg. 185: e1268-e1279.
4. Ruzevick J, et alt. (2022) From white to blue light: evolution of endoscope-assisted intracranial tumor neurosurgery and expansion to intraaxial tumors. J Neurosurg. 11;139(1):59-64..
5. Bettag C, et al. (2023) Endoscope-enhanced fluorescence-guided microsurgery increases survival in patients with glioblastoma. Acta Neurochir (Wien). 165(12):4221-4226.

Keywords:
5-ALA, Neuroendoscopy, Fluorescence-guided surgery, Endoscope, Fluorescein, Indocyanine Green

KNOWLEDGE-BASED TREATMENT PLANNING MODELS IN RADIOTHERAPY FOR PROSTATE PATIENTS

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Background

Knowledge-Based Planning (KBP) in radiotherapy is used to improve treatment plan quality and to reduce both plan variability among users and the treatment planning time. A commercial KBP software which is used to create estimates of dose-volume histograms (DVHs) for new patient's organs at risk (OARs). This study aims at the creation of three KBP models for prostate cancer patients by expanding the pre-existing models.

Materials and Methods

Three *RapidPlan*™ (Varian Medical Systems, Palo Alto, CA) prostate models were created using 143 high quality, clinically acceptable VMAT plans. The models created were based on the dose prescribed to the Planning Target Volume (PTV) for the successive prostate irradiation phases; namely low-risk, intermediate and high-risk phase. During the verification of each model, the DVH's (*Figure 1-LEFT*) and the regression and the residual plots of each structure were examined for potential outliers (*Figure 1-RIGHT, Figure 2-LEFT, Figure 2-RIGHT*). The statistical parameters of the new models were analyzed.

Results

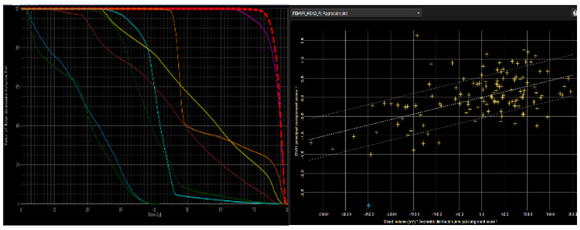

Figure 1. (LEFT) Dose Volume Histogram from a prostate treatment plan, including OARs and PTV. (The y-axis represents the Ratio of Total Volume (%) and the x-axis represents the dose (Gy)). (RIGHT) The influential point (blue crosshair) drives the regression plot of Femoral head. The y-axis represents the DVH principal component score 1, and the x-axis represents the geometric distribution principal component 1.

Training and verification results showed improved results for the three new models. Specifically, the low-risk irradiation phase 2 out of 6 trained OARs achieved a coefficient of determination above 0.7, denoting a coherent model. Likewise, in the intermediate and high-risk irradiation phase, 3 out of 6 trained OARs achieved a coefficient of determination above 0.7.

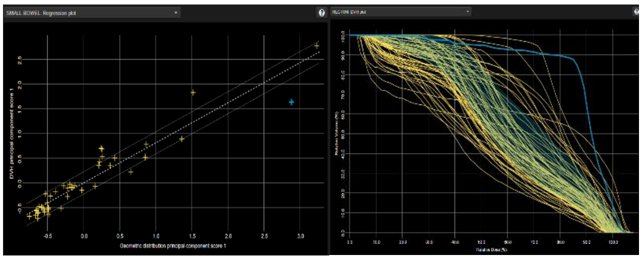

Figure 2. (LEFT) Regression plot of the small bowel; the treatment plan in blue is a potential geometric outlier. Each crosshair in the graph corresponds to a different treatment plan included in training set. (RIGHT) Rectum: Negative dosimetric outlier (Clinical DVH is worse than the predicted DVH Estimate from RapidPlan).

Conclusion

The training and the verification of the three models showed favorable results and set the correct basis for the final step of models' validation.

References

1. Anna-Maria Fanou, 2022, Study and introduction of knowledge-based planning (KBP) models for VMAT treatment plans into clinical use

2. W. Schlegel, P. Kneschaurek, 1999 May, Inverse radiotherapy planning, 175(5):197-207.

3. A. Fogliata, L. Cozzi et al., 30 October 2019, RapidPlan knowledge-based planning: iterative learning process and model ability to steer planning strategies, volume 14: article number 187.

Keywords: Knowledge-Based Planning, RapidPlan, VMAT, prostate cancer.

PERSONALIZED REAL-TIME DOSIMETRY FOR ANAESTHESIOLOGISTS: ASSESSING RADIATION EXPOSURE ACROSS FLUOROSCOPIC GUIDED SURGICAL PROCEDURES

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Introduction

Ionizing radiation is a key component of many surgical procedures across specialties such as vascular surgery, orthopedics, and urology [1]. Anaesthesiologists play a crucial role in these interventions, often requiring their continuous presence throughout the procedure [2]. Consequently, their occupational exposure to radiation can be significant and varies with the type of procedure, highlighting the need for systematic monitoring. Each surgical procedure presents distinct exposure patterns, necessitating a tailored approach to radiation protection [3]. This study aims to quantify the effective radiation doses received by anaesthesiologists during fluoroscopy-guided procedures, emphasizing the importance of procedure-specific exposure assessment to enhance personalized real-time dosimetry and improve radiation safety for healthcare staff [3,4].

Materials and Methods

ALMAR+ HERADO real-time, active personal dosimeters that recorded exposure every minute were employed for dose monitoring. A statistical analysis was performed to assess the impact of procedural variables, including surgical procedure, anaesthesiologist positioning, irradiation duration, and patient Dose Area Product (DAP). Additionally, the data were utilized to evaluate compliance with radiation protection guidelines and established exposure limits.

Results

The findings of this study reveal that radiation dose varies based on procedure type, irradiation time, and patient DAP. Neurointerventional procedures showed the highest effective dose, with prolonged irradiation and elevated DAP. ERCP procedures had the lowest exposure, featuring short irradiation and minimal DAP. Urological procedures showed high DAP despite shorter irradiation time, suggesting that the anaesthesiologist's position in the operating room may significantly influence exposure, regardless of patient DAP.

Discussion

Radiation exposure among anaesthesiologists varies by procedure emphasizing the need for personalized dosimetric monitoring. Real-time dosimetry enables tailored protection strategies, optimizing shielding, positioning and exposure management to enhance occupational safety.

Conclusions

The comparison of surgical procedures reveals substantial variations in anaesthesiologists' radiation exposure, largely dependent on irradiation time, and positioning. The findings highlight the necessity for procedure-specific monitoring and adaptive radiation protection strategies to ensure optimal occupational safety as well as the benefits of real time dosimeters use.

References

1. N. Frane and A. Bitterman (2023) Radiation Safety and Protection, StatPearls Publishing. Available from: https://www.ncbi.nlm.nih.gov/books/NBK557499/
2. R. Verma, et al. (2015) Anaesthesiologist: The silent force behind the scene, Anesthesia: Essays and Researches, 9: 293-7. Available from: https://pmc.ncbi.nlm.nih.gov/articles/PMC4683484/
3. A.M. Sailer, et al. (2017) Real-Time Patient and Staff Radiation Dose Monitoring in IR Practice, Cardiovascular and Interventional Radiology, 40: 421-429. Available from: https://pubmed.ncbi.nlm.nih.gov/27942927/
4. P.G. Lu, et al. (Year) Real-Time Dosimetry Measurements Reduce Surgeon Radiation Exposure During Endovascular Procedures, Journal of Vascular Surgery, 75: e94. Available from: https://www.jvascsurg.org/article/S0741-5214(22)00567-5/fulltext

Keywords: Dosimetry, Radiation protection, Anaesthesiologist's exposure, Fluoroscopy guided surgery.

ΚΑΛΥΤΕΡΕΣ ΕΡΓΑΣΙΕΣ
ΒΡΑΒΕΙΑ

BEST PAPER
AWARDS

ΒΡΑΒΕΥΣΗ ΚΑΛΥΤΕΡΩΝ ΕΡΓΑΣΙΩΝ ΠΟΥ ΠΑΡΟΥΣΙΑΣΤΗΚΑΝ ΣΤΟ 11Ο ΠΑΝΕΛΛΗΝΙΟ ΣΥΝΕΔΡΙΟ ΒΙΟΪΑΤΡΙΚΗΣ ΤΕΧΝΟΛΟΓΙΑΣ ΚΑΙ ΣΤΟ 2Ο ΠΑΝΕΛΛΗΝΙΟ ΣΥΝΕΔΡΙΟ ΦΥΣΙΚΩΝ ΕΠΙΣΤΗΜΩΝ ΣΤΗΝ ΥΓΕΙΑ

Στα βραβεία καλύτερης προφορικής ανακοίνωσης της ΕΛΕΒΙΤ (Κώστας Γκιόκας 2025 award), καλύτερου poster και καλύτερου φοιτητικού άρθρου η ΕΛΕΒΙΤ προσφέρει κάλυψη εξόδων για συμμετοχή σε συνέδριο (ως 500 ευρώ) διοργάνωσης ΕΛΕΒΙΤ, EAMBES, IFMBE, GCEA το 2025 ή το 2026.

Στο βραβείο καλύτερης προφορικής ανακοίνωσης της ΕΛΕΝΕΠΥ, η εταιρεία προσφέρει κάλυψη εξόδων για συμμετοχή σε συνέδριο (ως 500 ευρώ) σε οποιαδήποτε εκπαιδευτική δράση ή συνέδριο επιλέξει ο λαμβάνων το βραβείο.

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1) ΚΑΛΥΤΕΡΗ ΠΡΟΦΟΡΙΚΗ ΑΝΑΚΟΙΝΩΣΗ ΕΛΕΒΙΤ – ΒΡΑΒΕΙΟ «ΚΩΣΤΑΣ ΓΚΙΟΚΑΣ» 2025 (best oral award – ELEVIT)

Filip Ivanis, Georgia Beleli, Vasiliki Fiska and Alexander Astaras

“A Novel Soft-Robotic Glove for Physical Rehabilitation Featuring Adjustable Agonist/Antagonist Muscle Assistance”

ΕΥΦΗΜΟΣ ΜΝΕΙΑ (honorable mention)

Dimitrios Petrolekas, Anastasios Raptis, Efstratios Karavasilis, Konstantinos Moulakakis, Ioannis Kakisis and Christos Manopoulos

“4D Flow MRI-Enabled Patient-Specific Computational Hemodynamics of Thoracic Aorta: CFD Predictions Vs. In Vivo Imaging Data”

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2) ΚΑΛΥΤΕΡΗ ΑΝΑΡΤΗΜΕΝΗ ΑΝΑΚΟΙΝΩΣΗ (best poster award)

Despoina Markoglou and Konstantinos Ampountolas

“Reinforcement Learning for Walking Assistance Control of a Lower Limb Exoskeleton”

ΕΥΦΗΜΟΣ ΜΝΕΙΑ (honorable mention)

Georgios Parisis, Parmenion Tsitsopoulos, Panagiotis Bamidis and Alkinoos Athanasiou

“Source-Level EEG Functional Connectivity Analysis in Schizophrenia Patients”

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3) ΚΑΛΥΤΕΡΟ ΑΡΘΡΟ ΣΤΟ ΦΟΙΤΗΤΙΚΟ ΔΙΑΓΩΝΙΣΜΟ (best student paper)

Alexandros Moraitopoulos, Niki Pandria, Konstantinos Mitsopoulos, Panagiotis Bamidis and Alkinoos Athanasiou

"Enhancing Household Objects into Smart Health Monitoring Devices: An Unobtrusive Remote Health Monitoring System to Assist Healthy Aging"

ΕΥΦΗΜΟΣ ΜΝΕΙΑ (honorable mention)

Aliki Zilidou, Alexandros Moraitopoulos, Vasiliki Zilidou and Panagiotis Bamidis

"Development of an Exergames Platform for Physical Assessment Using Depth Sensors and Unity: A Gamified Approach to Human Motion Analysis"

4) ΚΑΛΥΤΕΡΗ ΠΡΟΦΟΡΙΚΗ ΑΝΑΚΟΙΝΩΣΗ ΕΛΕΝΕΠΥ - (best oral award - ELENEPY)

Kalliopi Natalia Tzaneti, Dimitris Zantzas, Efstathios Sidiropoulos, Konstantinos Zisis, Anestis Kalfas and Kyriaki Papadopoulou Pappas

"Hemodynamic and Anatomic Effects of the Anterior Cerebral Artery in Aneurysm Formation"

ΕΥΦΗΜΟΣ ΜΝΕΙΑ (honorable mention)

Dimitrios Samaras, Georgios Agrotis, Alexandros Vamvakas, Maria Vakalopoulou, Marianna Vlychou, Aikaterini Vassiou, Vasileios Tzortzis and Ioannis Tsougos

"Investigating the Stability of Radiomic Features Across Different MRI Field Strengths and the Impact of Harmonization Techniques"

Editors: Αλκίνοος Αθανασίου, Βασιλική Ζηλίδου, Παναγιώτης Μπαμίδης (Συντ.)

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