CWSPI'26

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18th Cyprus Workshop on Signal Processing and Informatics

FINAL PROGRAM
AND BOOK OF ABSTRACTS

Venue:
Cyprus Marine and Maritime Institute (CMMI)
13 Plateia Vasileos Pavlou, 6023 Larnaca, Cyprus

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Passcode: Zm6zk69T

14:00-19:10, July 14th, 2026

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Preface:

It is our great pleasure to welcome you to the **18th Cyprus Workshop on Signal Processing and Informatics (CWSPI 2026)**. Building on the success of the previous seventeen editions, CWSPI continues to serve as a vibrant forum for researchers, faculty members, graduate students, and industry professionals to present and discuss recent advances in signal processing, image and video analysis, artificial intelligence, machine learning, informatics, and their broad spectrum of applications.

Over nearly two decades, CWSPI has established itself as one of the leading national scientific events in Cyprus, fostering scientific excellence, interdisciplinary collaboration, and innovation. The workshop provides a unique platform for exchanging ideas, showcasing emerging research, and strengthening collaborations among universities, research centres, industry, and governmental organizations, while supporting the development of the next generation of researchers.

CWSPI 2026 features a rich scientific programme comprising five keynote talks and ninteen research presentations. The programme reflects the rapidly evolving research landscape, spanning artificial intelligence, quantum machine learning, biomedical signal and image analysis, healthcare informatics, computer vision, digital twins, maritime technologies, wireless communications, explainable AI, multimodal data analytics, precision medicine, and intelligent maritime systems. Together, these contributions showcase both methodological innovations and practical applications that address important scientific, societal, and industrial challenges.

CWSPI 2026 is made possible through the continued support and collaboration of the **Cyprus Marine and Maritime Institute (CMMI)**, **CYENS Centre of Excellence**, **KIOS Research and Innovation Center of Excellence**, the **University of Cyprus**, the **Cyprus University of Technology**, **Arizona State University**, the **University of New Mexico**, and **3AE Health**. We also gratefully acknowledge the technical co-sponsorship and continuous support of the **IEEE Cyprus Section**, the **IEEE Engineering in Medicine and Biology Society (EMBS) Cyprus Chapter**, the **IEEE Signal Processing Society (SPS) Cyprus Chapter**, the **IEEE Computational Intelligence Society (CIS) Cyprus Chapter**, and the **Institution of Engineering and Technology (IET) Cyprus Network**.

We extend our sincere appreciation to all keynote speakers, authors, session chairs, reviewers, sponsors, and members of the organising committee for their invaluable contributions, which have made this workshop possible. We also thank all participants for their continued support of CWSPI and their commitment to advancing research and innovation in signal processing, informatics, and artificial intelligence.

We hope that CWSPI 2026 provides an inspiring scientific environment, promotes fruitful discussions, encourages new collaborations, and stimulates innovative research that will contribute to future scientific and technological advances.

We wish you a productive, enjoyable, and successful workshop.

Ioannis Kyriakides, CMMI
Andreas Spanias, Arizona State University
Andreas S. Panayides, CYENS Centre of Excellence
Constantinos S. Pattichis, University of Cyprus & CYENS Centre of Excellence
Efthyvoulos Kyriacou, Cyprus University of Technology
Christos P. Loizou, Cyprus University of Technology
Marios S. Pattichis, University of New Mexico
For the Organising Committee

July 2026

Topics:

- Digital Signal and Image Processing
- Interactive Media, Virtual Reality, and Augmented Reality Systems and Applications
- Algorithms and Systems for Marine and Maritime Environments
- Speech and Audio Processing
- Intelligent and Cognitive Systems
- Data Analytics for Water Quality
- Autonomous Systems
- Machine Learning and Deep Learning
- Generative AI for Signal, Image, and Video Processing
- Sensor Networks, IoT, and Signal Analytics
- Biomedical Signal, Image, and Video Analysis
- Medical Imaging and Healthcare Informatics
- Wireless Communications and Signal Processing
- FPGA-Based Signal, Image, and Video Processing
- Computer Vision and Pattern Recognition
- Explainable and Trustworthy Artificial Intelligence
- Multimodal Data Fusion and Analytics
- Digital Health and Precision Medicine Applications
- Data Science, Big Data Analytics, and Intelligent Information Systems
- Quantum Computing and Quantum AI

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Venue

Cyprus Marine and Maritime Institute (CMMI)

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Technical Program

TIME	SESSIONS
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14:40-15:10	**View Planning for 3D Reconstruction of Plants** Nikolaos Papanikolopoulos University of Minnesota, USA
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15:40-16:10	**From Water Monitoring to Smart Water Resilience using AI and Digital Twins** Stelios G. Vrachimis, Senior Research Associate KIOS Research and Innovation Center of Excellence, University of Cyprus
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17:05-17:10	**Automated Multiple Sclerosis Lesions Segmentation System Based on 3D Longitudinal Visualization and Joint Loss Optimization** Hongrui Lv[1], Christos P. Loizou[2], Linxi Dong[1], Marios Pantzaris[3] [1]Engineering Research Center of Intelligent Microsensors and Microsystems, Ministry of Education School of Electronic Information, Hangzhou Dianzi University, Hangzhou, China

	[2]Department of Electrical Engineering, Computer Engineering and Informatics, Cyprus University of Technology, Limassol, Cyprus [3]The Cyprus Institute of Neurology and Genetics, 2371 Nicosia, Cyprus
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17:35-17:40	**Comparative Performance Evaluation of Conventional, Neural, and Emerging Video Codecs for Medical Video Streaming** Ioanna Valiandi[1], Efthyvoulos Kyriacou[2], Venkatesh Jatla[3], Marios S. Pattichis[3] Andreas S. Panayides[1] [1] Videomics group, CYENS Centre of Excellence, Nicosia, Cyprus [2] Department of Electrical Engineering and Computer Science and Engineering Cyprus University of Technology, Limassol, Cyprus [3]Department of Electrical and Computer Engineering, University of New Mexico, Albuquerque, NM 87131-0001, USA
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18:25-18:30	**A scoping review on open-access foundation models pretrained on the MIMIC database** Charithea Stylianides[1], Efthyvoulos Kyriacou[2], Marios S. Pattichis[3], Andreas S. Panayides[1] [1] Videomics group, CYENS Centre of Excellence, Nicosia, Cyprus [2] Department of Electrical Engineering and Computer Science and Engineering Cyprus University of Technology, Limassol, Cyprus

	[3]Department of Electrical and Computer Engineering, University of New Mexico, Albuquerque, NM 87131-0001, USA
18:30-18:35	**Process-Aware Conformal Prediction for Ambulance Response Time Estimation** Stelios Mappouras[1*], Andreas Andreou[1], Efthyvoulos Kyriacou [1] [1]Department of Electrical Engineering, Computer Engineering and Informatics, Cyprus University of Technology, Limassol, Cyprus
18:35-18:40	**Development of an AI-Based Platform for Personalized Rehabilitation Using Wearable Technology** Stefani Argyrou, PT, MSc Clinical Physiotherapist Senior Lecturer, Frederick University, Cyprus PhD Candidate, Cyprus University of Technology Andri Christofi, PT, OMT Clinical Physiotherapist, Orthopaedic Manual Therapist Sport & Exercise Scientist Clinical Educator, Frederick University, Cyprus
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18:45-18:50	**A Comprehensive XAI Framework with handcrafted Speech Features for Alzheimer's Dementia Screening** Faiza Iqbal[1*], Zafi Sherhan Syed[2**], Muhammad Shehram Shah Syed[3], Abbas Shah Syed[4] [1]Department of Computer Science, SZABIST University, Hyderabad, Sindh, Pakistan [2,3,4]Mehran university of Engineering and Technology, Jamshoro, Pakistan
18:50-18:55	**UAV-LiDAR-Based High-Throughput Phenotyping for Non-Destructive Estimation of Biomass and Plant Height in Wheat** Noor Sajjad, Andreas Kamilaris SuperWorld Research Group, CYENS Centre of Excellence, Nicosia, Cyprus
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Abstracts

SESSION 1: PLENARY TALKS

Intelligent Coordination and Data Fusion for Maritime Operations

Ioannis Kyriakides, Research Director
Cyprus Marine and Maritime Institute (CMMI) Centre of Excellence, Cyprus

Abstract
Maritime operations take place in complex and dynamic environments, shaped by both human activity and natural processes. Effective monitoring and response at sea increasingly require the coordination of assets operating across land, sea surface, air, and underwater domains. These assets generate large volumes of data through diverse sensing modalities, yet they often operate under severe constraints in power, bandwidth, communication reliability, and autonomy. This talk will focus on the challenge of fusing heterogeneous data streams into a coherent operational picture and using that information to coordinate diverse platforms with different capabilities and limitations. Through this perspective, the presentation will highlight how intelligent data fusion, adaptive coordination, and cross-domain collaboration can improve situational awareness and support more resilient decision-making in constrained maritime environments.

Short Bio
Dr. Ioannis Kyriakides received his BSc degree in Electrical Engineering from Texas A&M University. He received his MSc and PhD degrees from Arizona State University. Throughout his graduate studies, he held a research associate position funded by the Integrated Sensing and Processing program and the Multidisciplinary University Research Initiatives (MURI) of the USA Department of Defence. He received the University Graduate Fellowship of Arizona State University in the final year of his PhD work. His research interests include Bayesian target tracking, sequential Monte Carlo methods and heterogeneous data fusion and heterogeneous sensing asset management. Applications of his research include localization of multiple RF sources, tracking surface vehicles using passive acoustic sensing, tracking multiple targets with constraints in motion and with heterogeneous agile sensing nodes, autonomous vehicle path planning for information acquisition, and identifying suitable areas for maritime activities such as aquaculture and renewable energy facilities. He has been an Associate Professor at the University of Nicosia. He is currently serving as the Marine Technology Research Director at the Cyprus Marine and Maritime Institute (CMMI). Dr. Kyriakides was the Project Coordinator for projects with a total budget of over €14M. Dr. Kyriakides is a Senior Member of the Institute of Electrical and Electronics Engineers (IEEE).

View Planning for 3D Reconstruction of Plants

Prof. Nikolaos Papanikolopoulos
University of Minnesota, USA

Abstract:
Active vision (AV) has been in the spotlight of robotics research due to its emergence in numerous applications, including agriculture and biomedicine, to name a few. A major AV problem that has gained popularity is the 3D reconstruction of targeted environments from multiple 2D views. While collecting and processing a large number of arbitrarily taken 2D images may become an arduous process in several practical settings, an efficient solution is to seek the optimal placement of available cameras in the 3D space to obtain the necessary visual information from fewer yet more

informative images to effectively reconstruct environments of interest. This process, termed as view planning (VP), can be markedly challenged in the presence of noise emerging in the environment, location of the cameras, and/or in the extracted images. We present an efficient and realistic VP pipeline, which aims to optimize the viewpoints of cameras and hence the quality of the 3D reconstruction of a field of row crops without the need for a given mesh model. This is achieved within four steps: (i) an initial flight to obtain a sparse point cloud, (ii) the generation of an initial simple mesh model utilizing the sparse point cloud, (iii) the planning of images via a discrete optimization process, and (iv) a second flight to obtain the final reconstruction. We demonstrate the effectiveness of the proposed VP framework against commonly used baseline methods for agricultural data collection and processing.

Bio:

Prof. Papanikolopoulos (IEEE Fellow, NAI Fellow) received his Ph.D. in Electrical and Computer Engineering from Carnegie Mellon University. His thesis was entitled "Controlled Active Vision" and focused on using computer vision in a controlled fashion to detect, track, and manipulate objects in the environment. His research work has focused on robotics, agriculture, image processing, computer vision, and intelligent transportation systems. He has received numerous honors and awards for his research and contributions. He has been a Distinguished McKnight University Professor at the University of Minnesota since 2007 and has been a McKnight Presidential Endowed Professor in Computer Science since 2016. In 2016, he received the IEEE RAS George Saridis Leadership Award in Robotics and Automation as well as the Center for Transportation Studies Research Partnership Award.

* This is joint work with A. Bacharis, H. Nelson, K. Polyzos, and G. Giannakis

Towards Efficient and Robust On-Device AI

Christos Kirkos, Research Lecturer
KIOS Research and Innovation Center of Excellence, University of Cyprus

Abstract

As AI continues to move from the cloud to resource-constrained devices, a key challenge is delivering intelligence that is not only accurate and efficient, but also resilient, and trustworthy. In high-stakes domains such as autonomous vehicles, drones, and critical infrastructure, AI systems must operate under constraints on latency, energy, and connectivity while remaining robust against failures, adversarial attacks, and evolving threats. This talk explores how next-generation on-device intelligence can be achieved through efficient AI architectures, and resilient algorithms with contextual awareness that enable real-time, dependable decision-making. Ultimately, the talk argues that the future of on-device AI lies not in larger models but in solutions that are compact, adaptive, and resilient, helping accelerate the safe and responsible adoption of AI-powered technologies.

Bio:

Christos Kyrkou is currently a Research Lecturer at the KIOS Research & Innovation Center of Excellence at the University of Cyprus. Between Jan. 2021 and Dec.2021 he held the position of Senior Research Associate at KIOS CoE. Dr. Kyrkou received his Ph.D. degree in Computer Engineering from the University of Cyprus in 2014 with a thesis entitled " Real-Time Hardware Acceleration of Object Detection for Intelligent Embedded Vision Systems". Prior to that he was awarded a full scholarship and received his M.Sc. in Computer Engineering from the University

of Cyprus in 2010. Preceding that, he graduated top of his class and received his B.Sc. in Computer Engineering in 2008 from the University of Cyprus.
He is an author/co-author of more than 50 scientific publications in international peer reviewed conferences and journals, including 2 best paper awards. His research interests lie in the areas of Computer Vision and Deep Learning with emphasis on real-time performance. In particular, efficient neural network architectures and techniques, algorithms for visual object recognition and detection, with applications in emergency management, smart cameras, autonomous vehicles, and UAVs. He serves as a reviewer for major conferences in the areas of computer vision and machine learning such as CVPR, NeurIPS, and ICML.
He has worked in several National and European funded research and innovation projects. Currently, he is working on robust visual AI for autonomous vehicles under the H2020 project CARAMEL, and traffic monitoring using UAVs under the Cyprus RIF project RONDA. In 2011 he co-founded ACC Innovations Ltd and up to December 2017 he served as Director of Technology and Operations contributing to funded proposals by the Cyprus Government and the development of embedded firmware for robotics platforms. In 2017 he graduated from the 9-month Self-Driving Car Engineering program by UDACITY. He has also received individual GPU Grants by NVIDIA in support of his research.

From Water Monitoring to Smart Water Resilience using AI and Digital Twins

Stelios G. Vrachimis, Senior Research Associate
KIOS Research and Innovation Center of Excellence, University of Cyprus

Short abstract:

Water systems are becoming increasingly complex cyber-physical infrastructures, facing growing challenges related to water losses, contamination, energy use, climate extremes, and cyber-security. This talk will present recent work on the use of Artificial Intelligence and digital twins to move from water monitoring towards smart water resilience. The focus will be on practical applications in water utilities and emergency-response contexts, showing how machine learning, computational intelligence, digital twins, and generative AI tools can support critical tasks such as leak detection, water-quality event detection, contamination-risk assessment, and real-time operational awareness. Examples using multiple sensing technologies, such as satellite data and drones, will be discussed, with emphasis on how they can be integrated for risk-based management of drinking-water networks. The talk will highlight how AI can move beyond offline analytics towards operational decision-support tools that improve the efficiency, safety, reliability, and resilience of water systems.

Bio sketch:

Dr. Stelios G. Vrachimis is a Senior Research Associate at the KIOS Research and Innovation Center of Excellence, University of Cyprus. He holds an M.Sc. in Control Systems from Imperial College London and a Ph.D. in Electrical Engineering from the University of Cyprus. His research focuses on smart water systems, using AI-based monitoring, state estimation, fault diagnosis, optimization, control, and digital twins for water distribution and water-quality applications. He has contributed to several national and European projects on smart water resilience, including digital-twin platforms for Cypriot water utilities, leakage diagnosis, contamination detection, and risk-based water-quality management. His work aims to translate advanced research methods into operational decision-support tools for water utilities.

SenSIP quantum machine learning algorithms and applications

Andreas Spanias, Professor, SenSIP center director
Arizona State University

Abstract:
The SenSIP Center has established a broad research program in quantum machine learning (QML) with applications spanning healthcare, cybersecurity, and sustainable energy. Recent efforts of PhD students include QML methods for brain tumor detection from MRI, quantum-enhanced histopathological image classification executed on quantum hardware, and hybrid quantum-classical algorithms for credit card fraud detection. SenSIP has also developed QML approaches for photovoltaic (PV) fault detection and classification, improving the reliability of solar energy systems. The seminar will also summarize NSF research experience for undergraduate projects on QML. All these activities integrate quantum feature encoding, variational quantum circuits, and noise-aware optimization while providing research opportunities for undergraduate and graduate students, advancing both practical applications and quantum AI education.

Biosketch:
Andreas Spanias is Professor in the School of Electrical, Computer, and Energy Engineering at Arizona State University (ASU), where he directs the SenSIP Center. His research spans signal processing, machine learning, quantum machine learning (QML), speech processing, and intelligent sensor systems. He has authored more than 350 publications, two textbooks, and holds 29 U.S. patents. Dr. Spanias is an IEEE Fellow, Senior Member of the National Academy of Inventors, and a Fulbright U.S. Scholar. His recent research focuses on QML for brain tumor detection, histopathological image analysis on quantum hardware, credit card fraud detection, and photovoltaic fault diagnosis. He also leads educational and research initiatives that advance practical quantum AI applications and workforce development.

SESSION 1: Biomedical Image and Video Processing and Analysis

Self-supervised Vision Representations for Quantifying Age Acceleration in *Drosophila* Intestinal Tissue from Confocal Images: Preliminary Findings

Andria Nicolaou[1], Euripides Soteriou[2], Maria Michail[2],
Constantinos S. Pattichis[1], Chrysoula Pitsouli[2]
[1]Department of Computer Science, University of Cyprus
[2]Department of Biological Sciences, University of Cyprus

Abstract
Aging is a major biological process characterized by progressive cellular and tissue-level alterations and is a significant risk factor for various diseases. The fruit fly *Drosophila melanogaster* provides a valuable in vivo model for studying aging due to its conserved genetic pathways and relevance to human disease mechanisms. The objective of this study was to quantify age acceleration from *Drosophila* intestinal tissue images using self- supervised learning and regression analysis. Adult fly midguts were collected at multiple timepoints, dissected, and immunostained for intestinal stem cells, nuclei, and cellular junctions. Confocal microscopy images were acquired using a standardized imaging protocol, followed by preprocessing. A self-supervised vision foundation model, DINOv2, was employed to extract high-dimensional image representations. Ensemble regression models were developed using the extracted embeddings to quantify tissue age acceleration. The findings showed that self- supervised vision representations may capture age-associated morphological patterns in *Drosophila* intestinal tissue and enable quantitative assessment of age acceleration.

Keywords: Aging; Confocal Microscopy; Drosophila Midgut; Regression Analysis; Self-supervised Learning.

Automated Multiple Sclerosis Lesions Segmentation System Based on 3D Longitudinal Visualization and Joint Loss Optimization

Hongrui Lv[1], Christos P. Loizou[2], Linxi Dong[1], Marios Pantzaris[3]
[1]Engineering Research Center of Intelligent Microsensors and Microsystems, Ministry of Education School of Electronic Information, Hangzhou Dianzi University, Hangzhou, China
[2]Department of Electrical Engineering, Computer Engineering and Informatics, Cyprus University of Technology, Limassol, Cyprus
[3]The Cyprus Institute of Neurology and Genetics, 2371 Nicosia, Cyprus

Abstract
Introduction: Accurate evaluation and longitudinal tracking of Multiple Sclerosis (MS) lesions are essential for effective disease management and the early detection of neurological decline. Although deep learning (DP) has made significant progress in medical image processing, current segmentation models are highly prone to missed diagnoses when identifying MS micro-lesions. Furthermore, multi-center data often leads to a decline in model generalization performance due to the heterogeneity across MRI scanners, and traditional manual tracking measurements are extremely time-consuming. To address above challenges, we developed an integrated, fully-automated MS lesions segmentation and 3D visualization system. The primary objective of this study is to establish a highly robust quantitative analysis pipeline, focusing on enhancing the system's ability to identify micro-lesions and providing intuitive visualization of longitudinal

disease progression to objectively distinguish between active and stable MS courses. **Methodology**: This study adopted an evaluation protocol for generalization across different magnetic field strengths. The model was trained on 1.5 T T2-weighted MRI scans from the training subset of the MSLesSeg dataset. This dataset contains 53 subjects with 93 multi-timepoint scans collected from various scanner models and clinical centers. For external validation, we performed lesion segmentation and longitudinal visualization on the ISBI 2015 dataset, which includes 5 subjects with 21 sets of 3T longitudinal 3D MRI scans. During the data preprocessing phase, the system sequentially executed High-Definition Brain Extraction Tool (HD-BET) skull stripping and N4 Insight Toolkit (N4ITK) bias field correction, and employed the White Stripe algorithm with Z-score for single-image intensity normalization to standardize image contrast across scanners. In the lesions segmentation phase, the system utilized a 3D Attention U-Net architecture integrated with a deep supervision mechanism, jointly optimized with Focal Tversky Loss and Boundary Loss to enhance the capture of micro-lesion edge features. In the longitudinal tracking module, after independently segmenting follow-up scans (TP2, TP3, TP4), the system rigidly registered the resulting binary masks to the baseline (TP1) space to calculate the dynamic changes in lesion volumes. Quantitative validation metrics included Lesion True Positive Rate (LTPR), Lesion False Positive Rate (LFPR), 95% Hausdorff Distance (HD95), Domain Drop in Dice Similarity Coefficient (ΔDSC), Interscan Coefficient of Variation (CV), and Absolute Volume Difference (AVD). **Results**:The results demonstrated good agreement and stable cross-scanner robustness between expert manual annotations and automated outputs. Regarding micro-lesion identification, the system achieved an LTPR=(79.2%±3.5%), with LFPR controlled around 16.8%, and an HD95=(2.45±0.50) mm, proving the practical efficacy of the joint loss function in mitigating missed diagnoses and boundary blurring of micro-lesions. In cross-scanner compatibility tests, the Interscan CV of images stabilized below 4.5%, and the ΔDSC during cross-domain testing was controlled at approximately 5.1%. Clinical volume evaluation showed that AVD remained within a reasonable error margin of 8.3%, and the automatically calculated volumes exhibited a moderate-to-high positive correlation with expert volumes (Pearson $\rho = 0.78$, $p < 0.05$). Based on the above metrics, the interactive 3D frontend enables users to select and view 3D images at specific time points and automatically compares them with the preceding time point, clearly presenting the spatial evolution of new (red), shrinking (green), and stable (yellow) lesions. **Discussion & Future Directions***:* By integrating the 3D Attention U-Net with joint loss optimization, this system effectively addressed the performance shortcomings of current segmentation models in capturing micro-lesions; meanwhile, the rational intensity normalization and registration strategies ensured the reliability of cross-domain evaluation. Future research will not only focus on the lesions themselves but also expand the analysis scope to perilesional areas (e.g., surrounding edema and microenvironmental changes). Concurrently, we will explore more advanced deep learning networks to further improve the recognition accuracy of micro-lesions. Furthermore, we plan to conduct interdisciplinary collaborations to explore and predict the potential future developmental trends of lesions after a specific time point, aiming to provide more forward-looking quantitative support for early warning and personalized intervention in neurology.

Keywords—*Multiple Sclerosis, Intensity normalization, Lesions segmentation, Micro-lesions, 3D visualization, Longitudinal tracking.*

MRI-Based Multiple Sclerosis Lesion Segmentation and Longitudinal Quantitative Analysis

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Abstract

Introduction and Innovation: Multiple sclerosis (MS) is a chronic inflammatory and demyelinating disease of the central nervous system. Magnetic resonance imaging (MRI), especially fluid-attenuated inversion recovery (FLAIR), is widely used for MS lesions detection and disease monitoring. However, current MS lesion assessment still largely depends on manual annotations, which is time-consuming, subjective, and affected by inter-observer variability. Although deep learning has shown strong potential in medical image segmentation, MS lesion analysis remains challenging because of small lesion size, severe class imbalance, scanner variability, and limited longitudinal interpretation. To address these limitations, this study proposes an MRI-based framework for MS lesion segmentation and longitudinal quantitative analysis. The main innovation is to extend conventional single-time-point lesion segmentation into a longitudinal disease progression analysis pipeline. For each patient, one scan is selected as the baseline, and follow-up MRI scans are registered into the baseline space. The corresponding lesion masks, brain masks, and brain tissue segmentation labels are transformed together, enabling spatially consistent comparison across multiple time points. This design allows the system to evaluate not only total lesion burden, but also lesion-level evolution, including new, disappeared, enlarged, reduced, and stable lesions. In addition, the framework jointly analyzes MS lesions and major brain tissues, including white matter (WM), gray matter (GM), and cerebrospinal fluid (CSF), providing a more comprehensive description of disease progression. **Materials & Methods:** The materials used in this work include the ISBI2015 MS lesions segmentation dataset consisting of five subjects, mainly using the FLAIR modality for model training, and private longitudinal MRI cases for trend analysis. SynthSeg is used for skull stripping, brain mask generation, and brain tissue segmentation. The overall workflow includes MRI import, time-point identification, baseline selection, N4 bias field correction, SynthSeg-based tissue segmentation, rigid registration of follow-up scans, transformation of images and masks into the baseline space, lesion segmentation, connected component analysis, lesion matching, quantitative measurement, and visualization. For lesion segmentation, a 2.5D U-Net model integrated with attention mechanisms and a Transformer module is adopted. Adjacent slices are used as input to provide limited inter-slice contextual information while maintaining the computational efficiency of 2D segmentation. Attention gates are used to enhance lesion-related features in the decoder, while the Transformer module improves global contextual feature fusion. Dice score (DS), focal loss, and cross-entropy-based combined losses are used to reduce the influence of severe lesion-background imbalance. A five-fold cross-validation strategy is performed to evaluate model robustness under limited-sample conditions. After segmentation, connected component analysis is applied to identify individual lesion regions. Lesion-wise matching is then conducted using spatial overlap, centroid distance, volume change (V), DS, overlap (O), Accuracy (A), Recall (R) and IoU. Based on the matching results, lesions evolution is categorized as new, disappeared, enlarged, reduced, or stable. WM, GM, and CSF volumes are extracted from SynthSeg labels to support tissue-level longitudinal analysis. The system outputs lesions volume tables, tissue volume statistics, lesion matching results, trend curves, and visual overlay images. **Results and Discussion:** In the five-fold cross-validation

experiment, the model achieved an average validation DS = 0.718 ± 0.081, IoU = 0.662 ± 0.076, R = 0.787 ± 0.066, and A = 0.9986. The DS and IoU results indicate that the model can effectively segment most lesion regions, while the recall result suggests that it can detect a large proportion of lesions voxels. However, the relatively high standard deviation across folds shows that model performance is still affected by data variation, small lesions, and limited sample size. The high A should also be interpreted carefully because lesion voxels occupy only a small proportion of the whole brain image. The longitudinal analysis of two private cases further demonstrates the potential application value of the proposed framework. In the first case, the voxel-based MS lesion V increased from 20,181 mm^3 at T1 to 22,839 mm^3 at T4, corresponding to an increase of approximately 13.17%. During the same period, GM and WM V decreased by approximately 1.93% and 1.90%, respectively, while CSF V increased by approximately 1.31%. In the second case, the lesion V increased from 26,083 mm^3 at T1 to 38,739 mm^3 at T4, corresponding to an increase of approximately 48.52%. GM and WM V decreased by approximately 1.44% and 2.06%, respectively. These preliminary results suggest that the proposed framework can capture both focal lesion burden changes and global brain tissue V trends. Overall, this project establishes an integrated workflow for MS brain MRI segmentation and longitudinal quantitative analysis. Compared with single-time-point segmentation methods, the proposed longitudinal design provides more clinically meaningful information for disease progression assessment. **Conclusions and Future Trends:** Future work will focus on expanding the dataset by increasing the number of patients, time points, and scanner variations. Multi-modal MRI data, such as FLAIR, T1, T2, and PD, will be introduced to improve lesion characterization and reduce modality-related limitations. The segmentation model will be further optimized to improve small-lesion detection and reduce false positives. The registration and lesion matching strategies will be improved by combining IoU, centroid distance, volume change, and temporal consistency. More comprehensive evaluation metrics, including DS, P, R, Hausdorff distance, lesion-wise sensitivity, and volume error, will be used to assess both voxel-level and lesion-level performance. In addition, expert review and clinical validation will be incorporated to improve system reliability. With further optimization, the proposed framework may serve as a decision-support tool for MS disease progression monitoring, longitudinal treatment response assessment, and objective clinical reporting.

Keywords—Multiple Sclerosis, MRI Segmentation, Lesion Segmentation, Longitudinal Analysis, SynthSeg, Brain Tissue Segmentation, 2.5D U-Net, Transformer.

Assesment of Multiple Sclerosis Lesion Progression using Logitudinal MRI Radiomics

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Abstract

Introduction: Multiple sclerosis (MS) is a chronic inflammatory and demyelinating disease of the central nervous system, where lesion evolution observed on magnetic resonance imaging (MRI) provides important information for monitoring disease activity and progression. Conventional image assessment mainly focuses on lesion count and lesion volume, while subtle changes in lesion heterogeneity and tissue texture may provide additional imaging biomarkers. This work presents the initial idea for a longitudinal MRI radiomics pipeline for extracting and analyzing texture features from MS lesions and brain tissue regions across multiple follow-up time points. The main

goal of this study is the construction of a reproducible patient-level longitudinal analysis framework that converts multiple lesion-level radiomics measurements into interpretable patient-timepoint summaries for progression assessment.
Methodology: The current work will be based on a dataset that contains five MS patients with four common longitudinal MRI visits. The main analysis will use preprocessed T2 images and lesion masks, while tissue-region analysis includes lesion, cerebrospinal fluid, gray matter, and white matter related regions. Three-dimensional connected component analysis will be applied to lesion masks to identify individual lesions. PyRadiomics is used to extract first-order statistics, gray level co-occurrence matrix (GLCM), gray level run length matrix (GLRLM), gray level size zone matrix (GLSZM), gray level dependence matrix (GLDM), neighboring gray tone difference matrix (NGTDM), and shape or volume features. Multiple lesion ROIs from the same patient visit are aggregated into patient-level summaries. For each ROI and feature, distribution normality will be assessed using Shapiro-Wilk testing and probability plots.
Results: The pipeline identified 367 valid three-dimensional lesion components across the five patients and four time points. These lesion-level measurements were summarized into 20 lesion patient-timepoint records for longitudinal analysis. Tissue-region analysis produced 80 ROI-level records across lesion, normal-appearing white matter, gray matter, and cerebrospinal fluid regions. A total of 107 base radiomics features will be extracted, resulting in 535 patient-level radiomics summary fields after lesion aggregation.. The target will be to use exploratory analysis in order to identify features associated with changes in lesion burden like total lesion volume, appearance and lesions count.. **Discussion & Future Directions:**.We expect that the proposed framework will enable lesion-level radiomics extraction, patient-level feature aggregation, tissue-region comparison, and visual quality control within a unified analysis pipeline.
Keywords-Multiple sclerosis, MRI, radiomics, texture analysis, lesion progression, longitudinal imaging.

Semi-automated Diaphragmatic Motion Analysis in Neonates B-mode Ultrasound Videos

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Abstract

Introduction: Ultrasound imaging is widely used in neonatal intensive care units (NICUs) because it is safe, portable, and free from ionizing radiation. Diaphragmatic excursion (DE) is an important indicator of respiratory effort and neuromuscular function in neonates and is traditionally measured using ultrasound M-mode imaging. However, M-mode acquisition is highly operator-dependent, requiring accurate probe positioning and experienced ultrasonographers, which may affect measurement reproducibility and clinical consistency. This work presents a semi-automated (SA) integrated system for analyzing diaphragmatic motion directly from neonatal B-mode ultrasound videos. It combines deep learning segmentation with automated motion analysis to provide objective and reproducible respiratory measurements. **Methodology**: The proposed system was evaluated on 10 neonatal B-mode ultrasound videos, including 5 normal (N_N) and 5 abnormal (N_{AB}) cases. Video frames were preprocessed using intensity normalization and spatial transformation to reduce acquisition variability and convert pixel displacements into millimeters. A DL U-Net model was trained using 968 manually annotated diaphragm frames extracted from 10 independent neonatal ultrasound videos with an 80/20 training-validation split. The network

employed an encoder-decoder architecture with skip connections and was optimized using the Adam optimizer with a combined binary cross-entropy and Dice loss function. The trained model was then used to segment the diaphragm in each video frame. The resulting segmentation masks were used to estimate the diaphragmatic central axis, from which 10 equally spaced perpendicular sampling lines were generated to construct M-mode images. Motion curves extracted from these images enabled automatic estimation of DE, contraction velocity (CV), inspiration time (T_{insp}), expiration time (T_{exp}), total breathing time (T_{tot}), respiratory rate (RR), diaphragmatic slope curve (DSC), and relaxation rate (RR_{relax}). SA measurements were validated against expert manual (M) measurements using the Mann-Whitney rank-sum test, Spearman's correlation coefficient, regression analysis, Bland-Altman analysis, absolute percentage error (APE), and percentage standard error of the mean (%SEM). **Results**: The proposed SA system demonstrated good agreement with M measurements for the evaluated respiratory parameters. For DE the median (±IQR) values were 2.99 (0.97) mm (M) and 3.56 (1.46) mm (SA) in the N_N group, and 2.03 (0.62) mm (M) and 2.36 (1.42) mm (SA) in the N_{AB} group. DE showed strong agreement between M and SA measurements in the N_N group ($\rho = 0.89$, $p < 0.001$) and moderate agreement in the N_{AB} group ($\rho = 0.55$, $p = 0.0002$). The proposed system achieved an APE of 19.95% and 31.18% for DE, with corresponding %SEM values of 1.71% and 4.58% for the N_N and N_{AB} groups, respectively. For the remaining respiratory parameters, close agreement between M and SA measurements was consistently maintained across both groups. Specifically, in the N_N group, M vs. SA median (±IQR) values were CV (0.73 (0.31) vs. 0.65 (0.19) cm/s), T_{insp} (0.45 (0.42) vs. 0.57 (0.20) s), T_{exp} (0.53 (0.10) vs. 0.47 (0.15) s), T_{tot} (1.07 (0.51) vs. 1.10 (0.28) s), RR (56.07 (26.99) vs. 54.38 (15.06) breaths/min), DSC (7.32 (3.08) vs. 6.49 (1.88) mm/s), and RR_{relax} (6.36 (1.75) vs. 7.81 (3.14) mm/s). Similarly, in the N_{AB} group M vs. SA median (±IQR) values were CV (0.53 (0.32) vs. 0.57 (0.31) cm/s), T_{insp} (0.35 (0.11) vs. 0.41 (0.13) s), T_{exp} (0.44 (0.14) vs. 0.33 (0.19) s), T_{tot} (0.75 (0.18) vs. 0.76 (0.26) s), RR (80.00 (17.90) vs. 79.46 (23.62) breaths/min), DSC (5.31 (3.19) vs. 5.67 (3.09) mm/s), and RR_{relax} (4.23 (2.29) vs. 6.76 (4.02) mm/s). These findings demonstrate that the proposed SA system successfully replicates expert clinical assessments across all parameters while maintaining the capacity to differentiate normal from abnormal neonatal diaphragmatic motion. **Discussion & Future Directions**: The proposed SA system demonstrates the feasibility of combining DL segmentation with ultrasound motion analysis for objective neonatal respiratory assessment. The extracted respiratory parameters, particularly DE, T_{insp}, and RR_{relax}, showed good discriminative ability between normal and abnormal neonatal respiratory motion and may support clinical decision-making in NICUs. Although the study was conducted on a limited dataset of ten ultrasound videos, the results demonstrate the potential of the proposed system as a reliable and reproducible tool for diaphragmatic motion analysis. Future work will focus on evaluating the proposed system on larger datasets, improving segmentation robustness for abnormal cases, eliminating the remaining manual interactions to achieve a fully automated pipeline, and developing real-time AI-assisted decision support tools for neonatal respiratory monitoring. Ultimately, the proposed system has the potential to provide objective, reproducible, and non-invasive assessment of neonatal diaphragmatic function in routine clinical practice.

Keywords—*Neonates diaphragm, Motion analysis, Diaphragmatic excursion, M-mode, U-Net segmentation*

Diaphragmatic Normal and Abnormal Motion Analysis in Neonates Using Real and Simulated Ultrasound Videos

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Abstract

Introduction: Accurate functional evaluation of neonatal diaphragmatic motion is essential for effective respiratory management and early detection of pulmonary complications in critically ill newborns. Ultrasound video has become the preferred bedside modality owing to its real-time, non-ionizing nature, enabling continuous monitoring without patient discomfort. However, current clinical assessment still relies on labor-intensive manual measurements (MM), which limit diagnostic throughput, introduce inter-observer variability, and hinders reproducibility across operators and institutions. To address these limitations, we developed an integrated semi-automated (SA) diaphragmatic motion analysis system. This work presents a comprehensive two-stage validation framework: first through controlled simulation using synthetic ultrasound videos, and subsequently through clinical validation on real neonatal data acquired from an intensive care setting. The key innovation lies in the systematic translation from simulated modeling to bedside application, establishing a robust quantitative pipeline for objective neonatal diaphragmatic assessment, while identifying motion parameters that reliably discriminate normal from abnormal respiratory patterns. **Methodology**: The simulation study generated 20 B-mode simulated ultrasound videos—10 normal (NN) and 10 abnormal (NA)—using the Field II ultrasound simulation software. The clinical study utilized 10 real ultrasound videos prospectively acquired from a neonatal intensive care unit (5 NN, 5 NA) using a GE Vivid iq system with an 8 MHz micro-convex transducer at 30 frames per second. Both studies followed an identical processing pipeline: intensity normalization, despeckle filtering to suppress inherent speckle noise, diaphragm location, M-mode image generation, and diaphragmatic boundary segmentation using the Williams and Shah active contour (snake) model. Ten equidistant sampling lines spanning the full diaphragm were extracted per video. Seven quantitative parameters were extracted: contraction velocity (CV), diaphragmatic excursion (DE), inspiration time (T_{insp}), expiration time (T_{exp}), total time (T_{tot}), respiratory rate (RR), and relaxation velocity (RV). Validation against expert manual measurements employed mean absolute error (MAE), percentage standard error of the mean (%SEM), linear regression, Bland-Altman plots, and Spearman correlation coefficients. Group discrimination used the Mann-Whitney rank-sum test ($p < 0.05$). The identical processing framework applied across both datasets ensures direct comparability between simulated and clinical findings. **Results**: Both studies demonstrated excellent agreement between manual and semi-automated measurements across all parameters. In the simulation study, Spearman correlation coefficients ranged from $\rho = 0.77$ to 0.99 ($p < 0.01$), with MARE between 0.01 and 0.06 and %SEM below 5%. The clinical study yielded $\rho = 0.50$ to 0.85 ($p < 0.01$), with %SEM from 2.4% to 7.3%, confirming reliability in real clinical environments where image quality is inherently more variable. Statistically significant differences between NN and NA groups were identified in DE, CV, and RV across both cohorts ($p < 0.05$), demonstrating the discriminative capacity of the proposed parameters. Bland-Altman analysis revealed minimal systematic bias,

with most differences within the 95% limits of agreement. These convergent findings establish that the SA system provides accurate, reproducible diaphragmatic motion quantification, effectively bridging the gap between simulation and bedside application. **Discussion & Future Directions***:* The parameters, particularly DE, CV, and RV, constitute a robust parameter set for distinguishing normal from abnormal neonatal diaphragmatic function and guiding clinical decision-making in respiratory care. Future investigations will scale this validated framework to larger, multi-center neonatal cohorts encompassing broader gestational ages, body weights, and diverse pathologies including bronchopulmonary dysplasia and ventilator-induced diaphragmatic dysfunction. The motion analysis modules will be integrated with deep learning architectures to enable automated feature extraction, real-time classification, and operator-independent decision support, substantially reducing manual operating. Furthermore, a comprehensive, non-invasive, point-of-care diaphragmatic evaluation platform—combining biomechanical motion analysis with AI-driven pattern recognition—holds promise for predicting weaning outcomes, longitudinal respiratory monitoring in intensive care, and objective assessment of therapeutic interventions. Expanding the simulation framework to more complex physiological models will further enhance generalizability and clinical relevance.

Keywords—*Neonate's diaphragm, Ultrasound video, Respiratory Rate, Motion Simulation, Motion analysis, Relaxation velocity.*

Automated Right Ventricular Segmentation from Apical Four-Chamber Echocardiographic Videos

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Abstract

Right ventricular (RV) systolic function is a key indicator of cardiovascular status, particularly in critically ill patients. However, quantitative RV assessment in echocardiography remains challenging due to the complex geometry of the right ventricle and variability in image quality. Automated segmentation methods could improve the reproducibility and efficiency of RV evaluation.

In this study, we propose a deep learning framework for automated segmentation of the RV cavity at end-diastole (ED) and end-systole (ES) from apical four-chamber echocardiographic videos. The model is trained on the EchoNet-Dynamic dataset, originally developed for left ventricular analysis, and adapted to the RV domain using transfer learning and expert-annotated ED/ES frames.Using a DeepLabV3 architecture with a ResNet-50 backbone, the model achieved a mean Dice score of 0.8467 on the EchoNet-Dynamic dataset and 0.804 on an independent, private ICU clinical dataset, demonstrating consistent performance.

Overall, the results indicate that transfer learning from large echocardiographic datasets can support reliable automated RV segmentation and provide a basis for future automated estimation of clinically relevant RV functional parameters.

Keywords: Right ventricular segmentation, Echocardiography, Transfer learning, Deep learning, Cardiac ultrasound

Comparative Performance Evaluation of Conventional, Neural, and Emerging Video Codecs for Medical Video Streaming

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Abstract
Reliable and efficient medical video streaming is essential for applications such as telemedicine, remote diagnosis, immersive medical education, and virtual reality (VR)-based training, where both compression efficiency and encoding latency directly influence diagnostic confidence and user experience. A comparative performance evaluation of conventional, enhancement-based, and neural video coding technologies is conducted using two heterogeneous medical video datasets: low-resolution 2D carotid ultrasound sequences (560×448@40fps) and high-resolution 360° emergency simulation videos (7680×3840@30fps). Seven video encoders are evaluated, including the conventional codecs HEVC (implemented using the software encoder x265 and the GPU-accelerated HEVC_NVENC encoder), VVC, and SVT-AV1; the enhancement-based MPEG-5 LCEVC (LCEVC_HEVC); the emerging Enhanced Compression Model (ECM), a candidate reference model for the future H.267 standard; and the neural video codec DCVC-RT. Objective video quality is assessed using PSNR, SSIM, and VMAF, while encoding efficiency is evaluated using Bjøntegaard Delta Rate (BD-Rate) analysis and encoding speed measurements across the evaluated datasets and encoders. Results demonstrate that ECM achieves the highest compression efficiency on the ultrasound dataset, outperforming the competing codecs and reinforcing its potential as a candidate foundation for the emerging H.267 standard. On the high-resolution 360° dataset, the neural codec DCVC-RT delivers the best balance between compression efficiency and computational performance, achieving superior rate-distortion performance and fast encoding alongside real-time GPU-accelerated encoding. Furthermore, the GPU accelerated HEVC_NVENC implementation significantly reduces encoding time compared with software-based x265 implementation, highlighting the practical trade-offs between coding efficiency and computational complexity. Overall, the findings demonstrate the growing suitability of next-generation neural and emerging video coding technologies for real-time medical video streaming applications.

Keywords— Video Quality Assessment (VQA), 2D / 360^{O} Video Compression, Medical Video Streaming

SESSION 2: AI-Driven Sensing, Prediction and Decision Support Across Health and Communication Systems

Efficient Autonomous Hyper-Low Latency Optimization of towards 6G Mobile HetNets

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Abstract
The need to further study the huge performance and hyper- connectivity potential of the proposed Sixth generation(6G) mobile communication system, necessitates the creation of innovative processes, algorithms and systems leveraging AI/ML, to optimize and enable modern proposed 6G systems to have an excellent tradeoff of high performance, immunity against interference and attenuation; and also energy efficiency for sustainability of the network. Therefore, this work investigated, analyzed and developed algorithms at the system level for the energy efficient optimization of towards Sixth Generation (6G) and reduced user interference in mobile cellular heterogeneous networks (HetNets) via the use of Artificial Intelligence (AI) and Mathematical models. Ultimately, a proposed unique Signal Interference Reduction Energy Efficient Hybrid (SIREH) Frequency and Phase adaptive Algorithm was developed, tested, analysed and resulted in significant interference reductions, strong performance levels, power savings at serving BSs and transmitting UEs; by using intelligent AI-driven algorithms incorporating the frequency and phase adaptation of subcarrier components of the UEs and associated intelligent transmit power variations across UEs and BSs to optimize the HetNets and improve overall network energy efficiency significantly. Furthermore, this work extended the SIREH Frequency and Phase adaptive algorithm to optimize the load-balanced HetNets system to achieve an energy efficient Hyper- Low latency performance by intelligently compressing the time-duration unit of the 6G OFDM transmission subcarrier unit using integrated AI/ML cascaded-series blocks, and Frequency adaptive iterative autonomous system control; while maintaining excellent critical system performance targets and network KPIs. This study was focused on achieving Energy Efficient Hyper-Low Latency within 5G/6G HetNets.

Keywords: 6G; Energy Efficiency; HetNets; SIREH; Artificial Intelligence

Frame-to-Panorama Localization and Context-Aware Sampling for Scene-Specific Ship Detection in a Smart Marina Testbed

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Abstract
Smart maritime infrastructures provide continuous access to heterogeneous sensing streams, enabling repeated experimentation, digital-twin development, and AI-based maritime services. However, sensing hardware alone is not sufficient for scene-specific model development: historical video streams must also be spatially indexed, contextualized, and reduced to informative subsets for annotation. This paper presents a frame-to panorama localization and context-aware sampling pipeline for ship detection in historical PTZ maritime video lacking reliable pan, tilt, and zoom metadata. The method localizes frames on a reference panorama using SuperPoint and LightGlue, enriches them with weather and solar-state metadata, and applies diversity sampling to preserve variation across camera view and environmental conditions. A second context-aware stage identifies rare vessel-relevant frames near the horizon using tile-level visual embeddings and Gaussian Mixture Model clustering. Applied within the CMMI MDigi-I Smart Marina testbed, the pipeline reduces approximately 64, 000 frames to 220 images for annotation. A YOLO26-m detector fine-tuned on this subset achieves 92.69% AP50 and 70.45% AP50–95, showing that

infrastructure video streams can be converted into compact, scene-specific training sets while substantially reducing annotation effort.

Keywords: PTZ camera state recovery, ship detection, maritime surveillance, object detection

From Information-Theoretic to Learned Sensor Management for Maritime Tracking: Toward Mobile Sensing

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Abstract
We present a progression from information-theoretic to learned sensor management for maritime target tracking. First, a particle filter with entropy-based sensor selection was evaluated using real camera–LiDAR measurements from the CMMI Smart Marina Testbed. Next, in a georeferenced simulation, a reinforcement-learning policy used the particle-filter belief to select one of five fixed sensors, reaching tracking performance close to using all five sensors at once, while avoiding repeated online information-gain evaluation. Ongoing work extends the policy to joint sensing and motion control of a LiDAR-equipped unmanned surface vehicle, with longer-term application to cooperative multi-platform surveillance.

Keywords: particle filter; reinforcement learning; sensor management; information gain; maritime surveillance; unmanned surface vehicles

ZEN-OMICS: Multi-Omics Guided Personalized Drug Repurposing in Triple-Negative Breast Cancer using a Patient- Derived Zebrafish Xenograft Platform

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Abstract
Triple-Negative Breast Cancer (TNBC) is one of the most aggressive breast cancer subtypes, characterised by high molecular heterogeneity, limited targeted treatment options, and frequent therapeutic resistance [1][2][3][4]. Although advances in transcriptomics and proteomics have improved our understanding of TNBC biology, translating these findings into personalised treatment strategies remains a major challenge.
ZEN-OMICS proposes an integrated precision oncology framework that combines multi-omics analysis, bioinformatics, computational drug repurposing, and patient-derived zebrafish xenograft models to identify and functionally validate personalised therapeutic strategies. The project will integrate publicly available and patient-derived transcriptomic and proteomic datasets to identify dysregulated molecular pathways associated with tumour progression and treatment resistance. Computational analyses will prioritise existing drugs with the potential for repurposing based on pathway-level vulnerabilities and drug-target interactions.
The highest-ranked candidate compounds will subsequently undergo functional evaluation in patient-derived zebrafish xenograft models, providing rapid in vivo validation of predicted therapeutic responses. By integrating molecular profiling with functional drug testing, the project

aims to establish a reproducible translational workflow capable of supporting precision medicine approaches for breast cancer.

ZEN-OMICS is expected to generate new insights into the molecular mechanisms underlying TNBC, develop robust bioinformatics pipelines for multi-omics integration and drug prioritisation, and establish an innovative platform for personalised therapeutic discovery. The proposed framework has the potential to accelerate translational cancer research and contribute to the development of more effective, patient-specific treatment strategies for aggressive breast cancer.

Keywords: Triple-Negative Breast Cancer, Precision Oncology, Multi-Omics, Drug Repurposing, Zebrafish Xenografts

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A scoping review on open-access foundation models pretrained on the MIMIC database

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Abstract

Following the success of Transformers and the self-attention mechanism, foundation models have emerged to learn generalizable representations from large-scale data. Given the scale, multimodality, and heterogeneity of ICU data, domain-specific foundation models can provide transferable representations for downstream ICU prediction tasks. This scoping review maps 18 publicly available foundation models pretrained on the MIMIC database, a widely used open-access intensive care database.

It provides a consolidated modality-specific resource for researchers by synthesizing model availability, backbone architectures, pretraining objectives, transfer learning strategies, downstream applications, and reported performance.

Keywords: AI, Electronic Health Records, Foundation Models, Intensive Care Unit, MIMIC

Process-Aware Conformal Prediction for Ambulance Response Time Estimation

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Abstract

Background and Objective: Accurate prediction of ambulance response times is critical for emergency medical services (EMS) dispatch. Existing Machine Learning models produce point predictions that fail to communicate the uncertainty inherent in EMS data, where response times vary with fleet availability, traffic, geography, and incident conditions. This work presents a process-aware conformal prediction framework that provides distribution-free prediction intervals with finite-sample coverage guarantees for EMS response times.

Methods: The response process is decomposed into four operational phases: call processing, dispatch, crew mobilization, and travel. Conformalized Quantile Regression (CQR) is applied independently to each stage, with intervals composed via Bonferroni correction to maintain a joint coverage guarantee. Four conformal variants are evaluated on a synthetic dataset of 75,000 incidents calibrated to the Cyprus operational model, using LightGBM as the primary base model.

Results: End-to-end CQR achieves 90.4% empirical coverage with an average interval width of 7.35 minutes, 4.2% narrower than split conformal prediction. The per-stage decomposition reveals that travel contributes 41.5% and call processing 30.1% of total prediction uncertainty. Priority-stratified calibration produces 36% narrower composed intervals for urgent calls than non-urgent, with call processing uncertainty reduced by 72%.

Conclusions: CQR produces the tightest intervals and is preferred for real-time dispatch when the objective is to minimize interval width while maintaining coverage. Per-stage decomposition produces wider intervals but provides diagnostic information useful for quality assurance and process improvement. The framework is distribution-free, model-agnostic, and directly transferable to operational EMS data.

Keywords: Conformal Prediction; Emergency Medical Services; Uncertainty Quantification; Prediction Intervals.

Development of an AI-Based Platform for Personalized Rehabilitation Using Wearable Technology

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Abstract

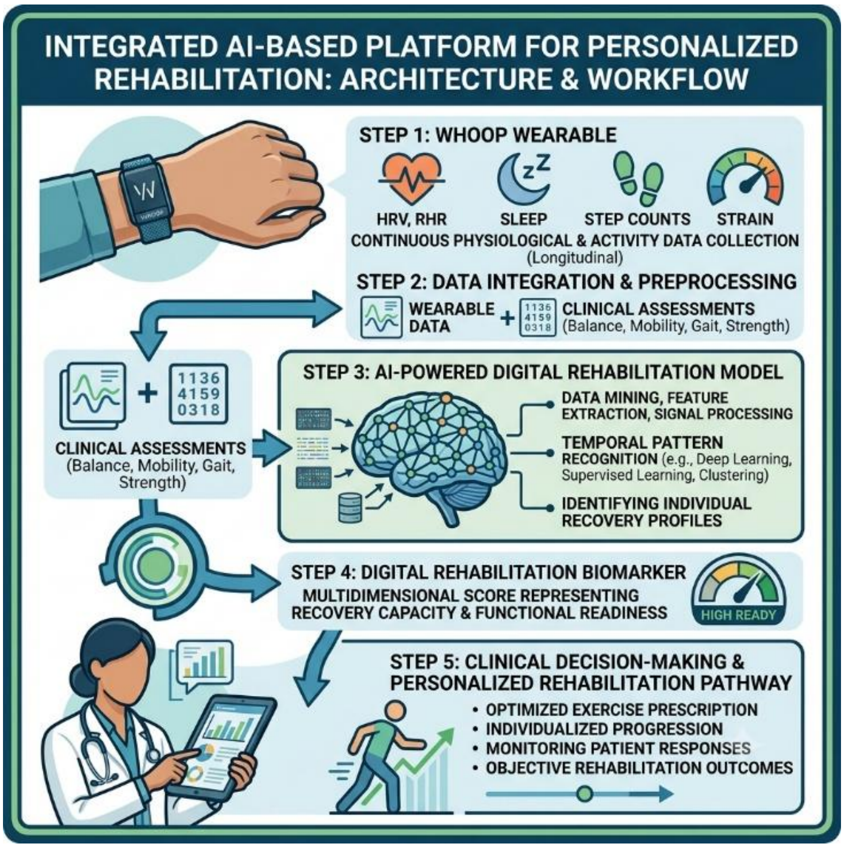
Background: The increasing demand for personalized rehabilitation approaches highlights the need for objective, continuous, and clinically meaningful monitoring of recovery and functional adaptation. Wearable technologies provide access to longitudinal physiological data, including autonomic function, sleep, activity patterns, and recovery status. However, translating these multidimensional data into clinically applicable rehabilitation biomarkers remains a significant challenge.

Objective: The aim of this conceptual study is to propose the development of an artificial intelligence (AI)-based platform for personalized rehabilitation by integrating wearable-derived physiological signals with functional performance assessments. The proposed framework aims to establish an AI-powered digital rehabilitation biomarker capable of supporting clinical decision-making and individualized rehabilitation pathways.

Methods: The proposed platform integrates continuous physiological data obtained from wearable technology, including heart rate variability (HRV), resting heart rate, sleep quality, recovery status, physical activity load, and daily strain indicators. Wearable-derived data will be combined with periodic clinical assessments, including balance evaluation, functional mobility testing, gait assessment, and lower-limb strength measures. WHOOP wearable technology will serve as a source of longitudinal physiological and recovery-related metrics. Data analysis will involve signal preprocessing, feature extraction, temporal pattern recognition, and machine learning approaches, including supervised learning, deep learning, and clustering algorithms, to identify individual recovery profiles and changes in functional readiness.

Expected Outcomes: The proposed AI-driven platform is expected to generate a personalized digital rehabilitation biomarker capable of detecting changes in recovery capacity, functional performance, and readiness for rehabilitation progression. The system aims to assist clinicians in optimizing exercise prescription, monitoring patient responses, and improving objective evaluation of rehabilitation outcomes.
Conclusions: The integration of wearable-derived physiological data, functional assessment, and artificial intelligence represents a promising direction toward precision rehabilitation. This conceptual framework provides the foundation for future validation studies aiming to develop adaptive, data-driven rehabilitation strategies and enhance individualized patient care.

Keywords: Wearable technology, Artificial intelligence, Precision rehabilitation, Digital biomarkers, WHOOP.



Digital Gamification for Cognitive Assessment in Older Adults

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Abstract
Population ageing increases the need for accessible and reliable methods to assess cognitive functioning and detect early cognitive changes. Gamified digital assessments provide a promising alternative to traditional approaches by offering engaging and objective evaluation environments. This study evaluated cognitive performance in 40 older adults using five computer-based gamified tasks assessing attention, response inhibition, visuospatial working memory, and short-term memory. Performance on selected tasks was compared with published data from 25 younger adults using measures of reaction time, accuracy, memory span, false alarm rates, and sensitivity (d′). Older adults demonstrated slower responses, particularly under higher attentional demands, while basic attentional processing and target discrimination remained relatively preserved. Greater

difficulties were observed in tasks involving visuospatial working memory and short-term memory, indicating selective rather than global cognitive decline. The gamified platform demonstrated good usability and acceptance among older adults. These findings support gamified digital assessment as a feasible approach for evaluating cognitive ageing, highlighting processing speed and memory functions as key areas of age-related vulnerability.

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A Comprehensive XAI Framework with handcrafted Speech Features for Alzheimer's Dementia Screening

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Abstract
As longevity increases, the global burden of people with cognitive impairments related to aging has also increased. This has added additional stress on social-support and healthcare service-providers. It is known that early identification of cognitive impairments can not only improve the quality-of-life of affected individuals but also enable service providers to better plan healthcare and end-of-life support. Artificial intelligence (AI) is a key enabling technology that can identify patterns from multiple signals indicating cognitive impairment. Speech communication is one such signal and is considered a promising biomarker for it. It is particularly advantageous because it is minimally invasive compared with brain imaging. In pursuit of ethical use of AI-powered speech analysis, it is essential that such technology offers explanations of its decision-making process.The framework first trains AI models using vocal and linguistic characteristics of speech that are linked with Alzheimer's Dementia (AD), then uses XAI techniques to uncover the decision-making of these AI-models. This is evaluated using the "ADReSSo", a benchmark dataset for screening AD as well as predict the MMSE score for cognitive impairment.

The proposed framework shows promising results, with an accuracy of 80.28% for AD screening using linguistic modality and 71.83% from voice alone, thereby suggesting impaired language to be the stronger biomarker. This observation is corroborated by AI-models developed for MMSE score prediction where a RMSE of 4.82 and 5.96 obtained respectively. This research contributes to the development of accurate and interpretable speech-based tools for early AD screening and supports their potential integration into responsible clinical workflows.

Keywords: speech recognition, human-computer interaction, computational linguistic

UAV-LiDAR-Based High-Throughput Phenotyping for Non-Destructive Estimation of Biomass and Plant Height in Wheat

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Abstract
High-throughput phenotyping plays a major role in selecting resilient cultivars to counter adverse effects of climate change on crops and support food security. Manual

measurements of plant height and biomass are slow, destructive and labour-intensive. This study used UAV-mounted LiDAR to non-destructively estimate plant height and fresh biomass across 80 wheat plots in Cyprus. High-density point clouds capture 3D canopy structure, combined with temporal, spectral and structural growth features from six repeated flights. ML models like Ridge, Random Forest, Gradient Boosting, and XGBoost were used to capture these trends and predict biomass, achieving R^2=0.83 for plant height, 0.72 for fresh biomass, with RPD>1.7 confirming reliable performance.

Keywords: High-throughput phenotyping; UAV-LiDAR; point cloud; canopy structure; wheat biomass

Quantum Hybrid Deep Learning Ensemble for Credit Card Fraud Detection

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Abstract

Credit card fraud remains a persistent challenge in the financial sector, leading to significant monetary losses if not effectively mitigated. In this paper, we propose a hybrid ensemble pipeline in which transformers, graph attention networks, and variational autoencoders serve as deep feature extractors over classical and quantum-enhanced representations. A tree-based meta-learner (XGBoost) aggregates these feature embeddings for the final decision. We examine and evaluate quantum circuit design strategies across different number of qubits, Pauli feature maps and data reuploading patterns under statevector simulations. We compare model configurations including tree-based models, standalone neural networks, and the proposed ensemble. Even without the quantum-enhanced features, the ensemble improves detection accuracy, achieving 2% higher averaged F1-scores over the classical tree-based baseline. Introducing quantum-enhanced features in the ensemble pipeline attains comparable performance over classical-only inputs, maintaining an AUC of approximately 98\% on the European Credit Card Fraud Dataset. Simulator-based quantum noise causes slight degradation in averaged F1-scores, while averaged AUC is maintained relative to the statevector baseline across varying noise types and levels.