EMERALD

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Issue #7

The latest news, views, and announcements - Issue #7

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GitHub repository

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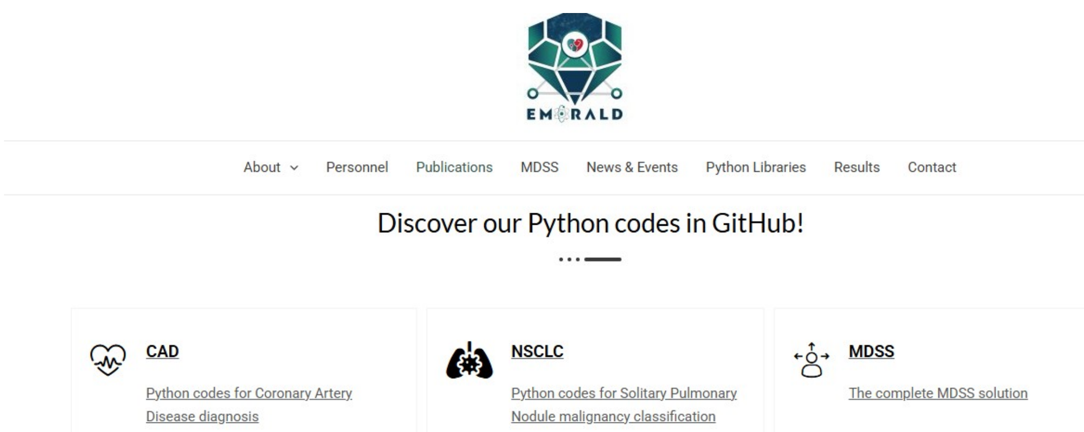
Welcome to the seventh edition of the EMERALD newsletter.

Dear readers,

We are pleased to announce the release of the seventh edition of the EMERALD newsletter. This issue covers significant developments from July 2024 to December 2024. We aim to inform you about noteworthy events and updates during this period.

Enjoy,

The EMERALD Team



Progress catch-up

Since July 2024, the EMERALD has had exciting news to share, since we presented our results to the IISA conference about the development of a Medical Decision Support System (MDSS), which has been built to employ the classification algorithms towards the effective diagnosis of Coronary Artery Disease (CAD) and NSCLC, while providing interpretability and transparency of the results. Furthermore, the EMERALD team has published articles in journals for CAD and NSCLC diagnosis.

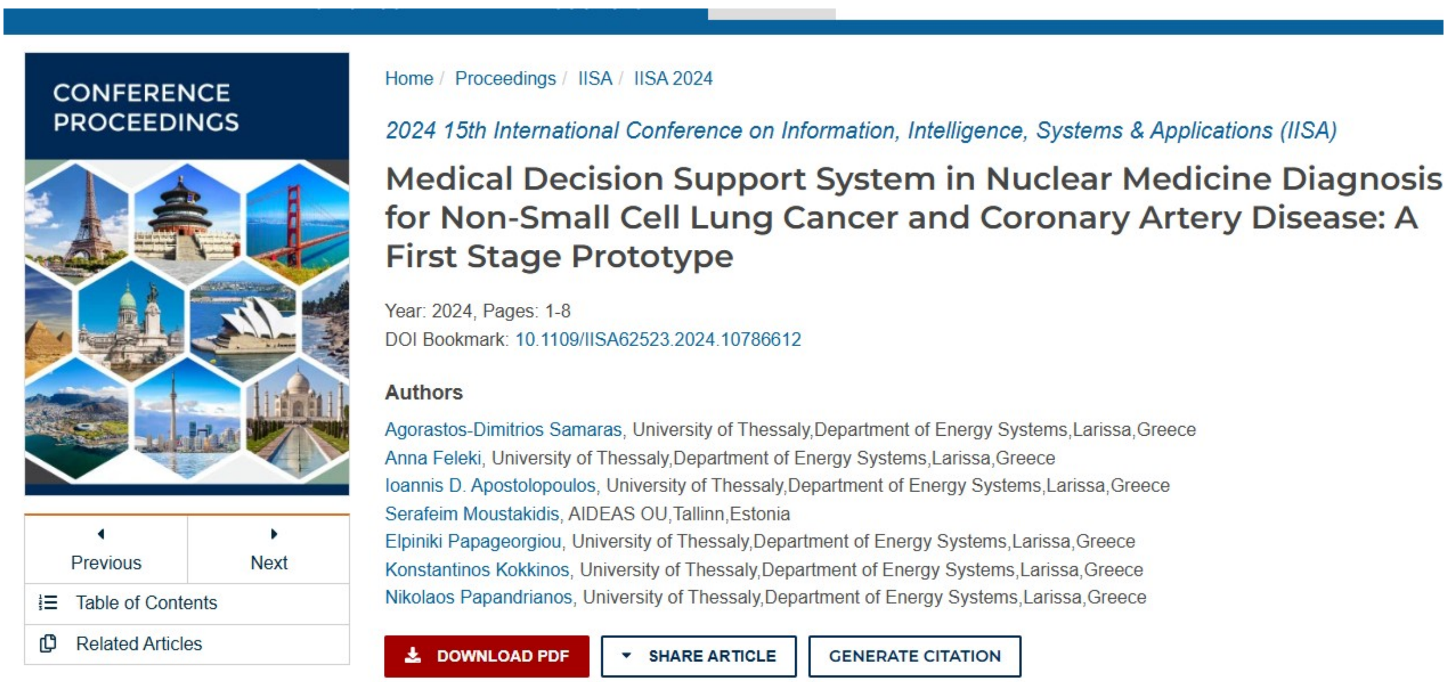
A DICOM viewer has been integrated into the MDSS, enabling the visualization of DICOM files from CT and PET scans. Users can interactively crop the region of interest, specifically focusing on the solitary pulmonary nodule (SPN), and then forward it directly for further analysis within the MDSS pipeline. This feature connects manual image review with automated, AI-driven diagnostics in a streamlined workflow. In parallel, a dedicated GitHub repository has been developed, featuring the open-source library PyXAI–DeepFCM, along with implementations of machine learning (ML), convolutional neural networks (CNNs), DICOM tools, and natural language generation (NLG) techniques. This infrastructure supports transparency, reproducibility, and collaborative development.

Presentation on July 17-19, 2024, in Grand Arsenali, Chania, Crete, Greece

Ioannis Apostolopoulos (Postdoctoral Researcher and Faculty member of EMERALD) attended the Fifteenth International Conference on Information, Intelligence, Systems and Applications (IISA 2024) presenting two articles titled "Medical Decision Support System in Nuclear Medicine Diagnosis for Non-Small Cell Lung Cancer and Coronary Artery Disease: A First Stage Prototype" and "Investigating the agreement with human readers and generalization capabilities of a transfer learning approach for predicting the malignancy of Solitary Pulmonary Nodules in CT screening"

New Article in IISA Conference 2024

DOI: 10.1109/IISA62523.2024.10786612, Date: 18 December 2024



The first out of two presented studies titled "**Medical Decision Support System in Nuclear Medicine Diagnosis for Non-Small Cell Lung Cancer and Coronary Artery Disease: A First Stage Prototype"** introduces the Medical Decision Support System (MDSS) developed to support the diagnosis of Coronary Artery Disease (CAD) and Non-Small Cell Lung Cancer (NSCLC). The system integrates Machine Learning (ML), Deep Learning (DL), and Fuzzy Cognitive Map (FCM) models to assess CAD risk and identify malignant Solitary Pulmonary Nodules (SPNs). By combining clinical and imaging data through a hybrid approach—using DeepFCM and ML techniques—the MDSS offers explainability through graphical concept maps, SHAP analysis, Grad-CAM for interpreting CNN predictions, and Natural Language Processing (NLP) to translate results into interpretable summaries. This design enhances transparency and fosters clinician trust in AI-assisted decision-making. The system achieved strong performance aligned with expert evaluations; however, maintaining its effectiveness relies on continuous data updates and regular retraining of its predictive models. Check the full article here.

New Article in IISA Conference 2024

DOI: 10.1109/IISA62523.2024.10786628 , Date: 18 December 2024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Investigating the Agreement with Human Readers and Generalisation Capabilities of a Transfer Learning Approach for Predicting the Malignancy of Solitary Pulmonary Nodules in CT Screening

Publisher: IEEE Cite This PDF

Ioannis D. Apostolopoulos ; Nikolaos D. Papathanasiou ; Dimitris J. Apostolopoulos ; Nikolaos D. Papandrianos ; Elpiniki I. Papageorgiou All Authors

Our team also presented an article at the IISA conference, titled "Investigating the agreement with human readers and generalization capabilities of a transfer learning approach for predicting the malignancy of Solitary Pulmonary Nodules in CT screening".

The authors employed the pre-trained VGG19 model and evaluated its performance on two independent lung nodule image datasets: the LIDC-IDRI dataset, comprising scans from over 1,000 patients, and a test dataset of 42 PET/CT scans containing solitary pulmonary nodules (SPNs). In Phase 1, the VGG19 network was fine-tuned and trained on the LIDC-IDRI dataset, followed by a 25-run, 10-fold cross-validation to assess its learning process and performance metrics. In Phase 2, the trained model was applied to classify nodules in the test dataset, acquired from a PET/CT scanner not included in the training data, and its diagnostic performance was compared with human-reader diagnoses. The model demonstrated high sensitivity, true positive rate (TPR), and AUC values, confirming the effectiveness of the chosen paradigm. However, a decline in reliability was observed when predicting previously unseen data, highlighting the inherent challenges in achieving perfect alignment between AI and human interpretations. Despite these limitations, the study showcased the potential of AI and transfer learning in early lung cancer detection. The LIDC dataset yielded an accuracy of 89.54%, sensitivity of 88.89%, and specificity of 90.52%, while the test set achieved 80.12% accuracy, 83.61% sensitivity, and 77.5% specificity. Further comparisons with other models, including Inception V3, Xception, Residual Network, and Dense Network, revealed varying performance, with Residual Network achieving the highest accuracy of 94.12%. Check the full article here.

New Article in Journal Big Data and Cognitive Computing

DOI: https://doi.org/10.3390/bdcc8080085, Date: 2 August 2024

big data and cognitive computing

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A Multi-Modal Machine Learning Methodology for Predicting Solitary Pulmonary Nodule Malignancy in Patients Undergoing PET/CT Examination

by Ioannis D. Apostolopoulos [1,*], Nikolaos D. Papathanasiou [2], Dimitris J. Apostolopoulos [2], Nikolaos Papandrianos [1] and Elpiniki I. Papageorgiou [1]

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Big Data Cogn. Comput. **2024**, *8*(8), 85; https://doi.org/10.3390/bdcc8080085

Submission received: 2 July 2024 / Revised: 25 July 2024 / Accepted: 31 July 2024 / Published: 2 August 2024

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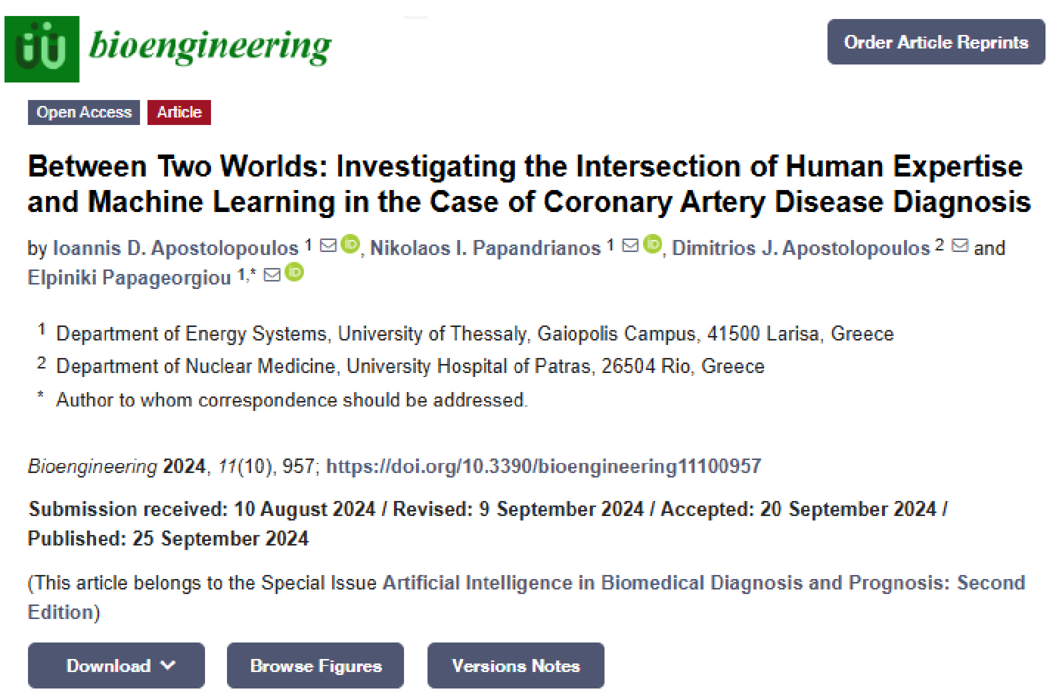
Our team published an article titled ”A Multi-Modal Machine Learning Methodology for Predicting Solitary Pulmonary Nodule Malignancy in Patients Undergoing PET/CT Examination” in the Journal Big Data and Cognitive Computing. This study presents an advanced multimodal machine learning approach for classifying SPNs associated with NSCLC as benign and malignant. Integrating CT and PET images through a VGG19 neural network, along with SPN characteristics analyzed by an XGBoost model, this methodology aimed to improve diagnostic accuracy and precision. Evaluated using 402 annotated cases and 96 histopathologically confirmed cases from the University Hospital of Patras, the model achieved a remarkable 97% agreement with experts and an 85% diagnostic accuracy rate in external validation. Key predictors identified included the VGG19 outputs, SUVmax, and nodule diameter, emphasizing the strength of merging imaging modalities with clinical data for robust diagnostic performance. Check the full article here.

New Article in BioEngineering

DOI: https://doi.org/10.3390/bioengineering11100957, Date: 25 September 2024



bioengineering

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Open Access Article

Between Two Worlds: Investigating the Intersection of Human Expertise and Machine Learning in the Case of Coronary Artery Disease Diagnosis

by Ioannis D. Apostolopoulos [1], Nikolaos I. Papandrianos [1], Dimitrios J. Apostolopoulos [2] and Elpiniki Papageorgiou [1,*]

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Bioengineering **2024**, *11*(10), 957; https://doi.org/10.3390/bioengineering11100957

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(This article belongs to the Special Issue Artificial Intelligence in Biomedical Diagnosis and Prognosis: Second Edition)

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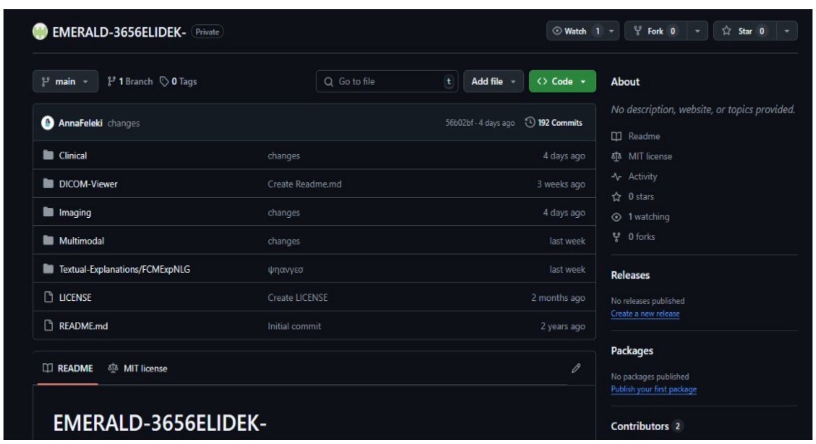
Our team published an article titled "Between Two Worlds: Investigating the Intersection of Human Expertise and Machine Learning in the Case of Coronary Artery Disease Diagnosis" in the BioEngineering Journal. This study investigated the synergy between human expertise and ML for diagnosing CAD, using data from 606 patients at the University Hospital of Patras, Greece. It compared the diagnostic accuracy of human evaluators with that of a Random Forest (RF) model in predicting CAD risk, utilizing clinical inputs such as age, sex, cardiovascular history, and known risk factors like hypertension and diabetes. Incorporating human clinical judgments into the RF model boosted its diagnostic accuracy to 80.17%, whereas its performance dropped to 73.76% when human insights were excluded. The findings highlight the value of integrating human expertise with ML algorithms, enhancing diagnostic precision, particularly in complex or ambiguous cases, and suggesting that a collaborative approach could significantly improve CAD risk assessment and management. Check the full article here.

GitHub repository (Link)



The EMERALD team developed a GitHub repository to provide open access to the implementation of EMERALD's AI methodologies. Key libraries include:

- **pyXAI-DeepFCM/FCM**: FCM models for clinical data classification, integrating various learning techniques (FCM-PSO, FCM-GA, FCM-ELM), along with Neural-FCM to adapt and refine interconnections based on historical data.
- **pyXAI-DeepFCM/DeepFCMx**: Medical image classification model that clusters feature maps extracted from CNNs and computes similarities between feature maps and cluster centroids to enhance interpretability and diagnostic accuracy.
- **pyXAI-DeepFCM/DeepFCM**: Multimodal classification models that combine clinical data with CNN-generated predictions, utilizing multiple learning techniques (DeepFCM-PSO, DeepFCM-GA, and DeepFCM-ELM) to establish interconnections for enhanced diagnostic accuracy.
- **RGB-CNN**: Custom CNN-based model for medical image classification, designed from scratch to analyze and differentiate pathological patterns in diagnostic imaging.

- **ObjDetectionMaps**: Object detection model (YOLOv8) for NSCLC diagnosis using CT/PET scans, enabling precise detection and localization of abnormalities to support clinical assessment.
- **Textual explanations**: The FCMExpNLG model was developed, and FCFExpGen was utilized to generate textual explanations, translating complex AI-driven predictions into human-readable justifications. These models enhanced interpretability by explaining key clinical and imaging features influencing the diagnosis.
- **DICOM Viewer**: A DICOM Viewer was integrated, supporting CT and PET imaging, with zoom, and pan functionalities.

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Ελληνικό Ίδρυμα Έρευνας & Καινοτομίας

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