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EDITORIAL

Special issue on deep learning and big data analytics for medical e-diagnosis/AI-based e-diagnosis

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1 Background

The field of medical diagnosis is currently undergoing a remarkable transformation with the emergence of artificial intelligence (AI) techniques, particularly deep learning and big data analytics. These leading-edge computational methods, combined with the abundance of medical data, present unprecedented opportunities for accurate and efficient e-diagnosis. However, several challenges need to be addressed to ensure the effectiveness and reliability of medical e-diagnosis. The vast and diverse nature of medical data, encompassing electronic health records, medical imaging, and genomic information, necessitates scalable and interpretable computational techniques. Robust algorithms capable of handling noise, missing values, and class imbalance are required for the integration and analysis of this diverse data. Additionally, there is a need to revamp conservative hospital infrastructures in the industry.

Advancing medical e-diagnosis through AI techniques, especially neural computing, holds immense importance. Timely and accurate diagnosis is crucial for effective treatment planning, patient management, and improved healthcare outcomes. By harnessing the power of deep learning and big data analytics, AI-based e-diagnosis has the potential to revolutionize healthcare delivery. It enables early disease detection, personalized treatment recommendations, and proactive intervention strategies. This transformative approach can significantly enhance patient care, reduce healthcare costs, and ultimately save lives.

This special issue aims to illuminate the challenges faced in this domain, underscore the significance of AI algorithms and neural computing, and showcase recent contributions from the AI research community in leveraging this technology for medical e-diagnosis.

We the editors hope that by collaborative research efforts via this journal the challenges are addressed and the full potential of AI-based e-diagnosis is unlocked. We are pleased to see that an overwhelming number of papers were received from researchers around the world which contribute their findings to this special issue, driving advancements in the field.

2 Papers in this special issue

Over 60 papers were submitted covering a broad range of artificial intelligence in medical e-diagnosis. Each paper was reviewed by at least three experts during the review process. After multiple rounds of quality evaluations, screened by each guest editor and the invited reviewers, 16 papers were selected for inclusion in this special section. The selected papers present in-depth studies of practical solutions and certain intellectual novelty in meeting the challenging problems in AI-based e-diagnosis. The individual contributions are summarized in alphabetic order as follows.

A convolution neural network approach for fall detection based on adaptive channel selection of UWB radar signals
(Wang et al.)

The authors proposed an adaptive channel selection algorithm and fusion features for fall activity detection using ultra-wideband radar. The algorithm separates

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activity signals from the background, and the fused features of frequency- and time-domain images are fed into a lightweight convolutional neural network for detection and recognition of fall activities. The experimental results demonstrate that the method achieves high recognition accuracy (up to 95.7%) in distinguishing three types of fall activities. The paper also highlights the potential for future work, including expanding the sample size and developing algorithms for detecting and recognizing activities in multi-residential environments. The proposed approach provides a promising solution for detecting and predicting falls in indoor environments, contributing to the safety and well-being of the elderly population.

A deep learning based system for handwashing procedure evaluation
(Greco et al.)

The contribution of this paper is the proposal and development of an embedded system that utilizes a depth camera and a convolutional neural network (CNN) to automatically analyze handwashing procedures in real-time. The system evaluates the compliance of medical staff with the handwashing guidelines defined by the World Health Organization (WHO). The paper explores different deep neural network architectures, optimizers, loss functions, and weight initialization approaches to determine the best performing configuration. The experimental analysis was conducted using a dataset of 74 video sequences, capturing over 131,000 frames. The proposed method achieved valuable performance in classifying handwashing gestures, with an F1 score of 0.957 by aggregating the classification outputs. The paper also discusses future improvements, including expanding the dataset and exploring more sophisticated network architectures, such as recurrent neural networks (RNNs), to enhance performance and extend the system's applicability beyond surgical handwashing.

A novel sample and feature dependent ensemble approach for Parkinson's disease detection
(Ali et al.)

The paper investigates the integration of feature selection with deep neural networks (DNN) and compares its performance with conventional DNN and other similar integrated systems. Additionally, a new ensemble model called EOFSC (Ensemble model with Optimal Features and Sample Dependent Base Classifiers) is developed, leveraging the sensitivity of different voice phonations to different subsets of features and models. The experimental results demonstrate that feature selection integration with DNN improves performance, outperforming conventional machine learning models. The EOFSC ensemble model improves PD detection accuracy by 6.5%, surpassing previous methods for PD detection based on multiple types of speech and voice data. The proposed ensemble approach represents a significant advancement in automated PD detection.

AI-based medical e-diagnosis for fast and automatic ventricular volume measurement in patients with normal pressure hydrocephalus
(Zhou et al.)

The contribution of this paper is the establishment of a multimodal and high-performance automatic ventricle segmentation method for efficient and accurate measurement of ventricular volume in normal pressure hydrocephalus (NPH) patients. The method utilizes machine learning techniques on CT and MRI images, extracting features and establishing a segmentation model. The results demonstrate high accuracy and reliability, with Dice similarity coefficients, intraclass correlation coefficients, and Pearson correlations indicating strong agreement between automatic and manual segmentation. The process is fast and capable of handling images from different scanners and varying slice thickness. The proposed method provides valuable support for clinicians in diagnosing NPH, follow-up procedures, and surgical evaluation.

AI-driven rehabilitation and assistive robotic system with intelligent PID controller based on RBF neural networks
(Xiao et al.)

The contribution of this paper is the development of a cooperative bilateral upper-limb rehabilitation robotic system that combines mirror therapy and virtual stimulation for hemiplegia rehabilitation training. The system utilizes a robotic arm to assist the affected limb in tracking the healthy limb, enabling mirror motions and personalized adjustment of joint movements. A game-based human–computer interaction system provides visual stimulation and biofeedback training. An adaptive PID controller based on RBF neural networks enhances the tracking performance of the affected side. Experimental results validate the effectiveness of the system, and future work focuses on algorithm optimization, incorporating physiological signals for better feedback, and exploring AR or VR technology for enhanced human–computer interaction. The proposed system offers a novel approach to hemiplegia rehabilitation and shows potential for further improvement and expansion.

Artificial intelligence with big data analytics-based brain intracranial hemorrhage e-diagnosis using CT images
(Mansour et al.)

This paper presents an AIBDA-ICH model for e-diagnosis of intracerebral hemorrhage (ICH) using CT images. The model integrates artificial intelligence (AI) and big data analytics, utilizing IoMT devices for data acquisition and Hadoop ecosystem for managing big data. The proposed model incorporates a graph cut-based segmentation model to identify affected brain regions, a CapsNet model for feature extraction, and a fuzzy deep neural network (FDNN) for classification. Experimental results demonstrate the superior e-diagnostic performance of the AIBDA-ICH model with precision and accuracy of 94.96% and 98.59%, respectively. The study highlights the potential of AI and DL models in successfully diagnosing ICH in remote patients and suggests future improvements through hyperparameter tuning and DL-based segmentation techniques.

CariesNet: a deep learning approach for segmentation of multi-stage caries lesion from oral panoramic X-ray image
(Zhu et al.)

This paper presents a novel deep learning architecture called CariesNet for the segmentation of different caries degrees from panoramic radiographs. The proposed CariesNet utilizes a U-shape network with a full-scale axial attention module to accurately delineate shallow caries, moderate caries, and deep caries lesions. The study includes the construction of a high-quality dataset and compares the segmentation performance of CariesNet with other baseline methods. Results demonstrate that CariesNet achieves a mean Dice coefficient of 93.64% and an accuracy of 93.61% in segmenting the three different levels of caries. The automated system developed in this research offers a promising approach for accurate caries diagnosis using deep learning techniques.

Classification of Covid-19 chest X-ray images by means of an interpretable evolutionary rule-based approach
(De Falco et al.)

The contribution of this paper lies in proposing a new general-purpose method for interpretability in medical image classification using Deep Learning. The approach combines a filtering scheme with an evolutionary algorithm to generate IF–THEN rules that provide explicit knowledge and explanations for the decision-making process. The method is tested on a set of chest X-ray images for diagnosing the presence of COVID-19. The novelty of the paper is in addressing the need for interpretability in AI-based medical diagnosis, allowing clinicians to critically assess and evaluate the trustworthiness of the results. The proposed method offers potential for improving confidence in clinical decisions by providing interpretable outputs in the form of explanations or visualized information.

Deep learning-based multidimensional feature fusion for classification of ECG arrhythmia
(Cui et al.)

The authors proposed an effective ECG feature extraction method, Covn1d + DWT, for arrhythmia classification. The method combines traditional approaches with 1D-CNN and discrete wavelet transform to extract optimal features from ECG signals. The classification accuracy of the proposed method is evaluated using the MIT-BIH arrhythmia benchmark database, achieving an average accuracy of 98.35%, which outperforms the latest methods. The paper also discusses the use of the proposed architecture for real-time applications and its potential in diagnosing heart diseases using ECG signals. The proposed method provides a valuable tool for arrhythmia classification and has the potential for integration into wearable devices and real-time monitoring systems.

Establishment of a mindmap for medical e-Diagnosis as a service for graph-based learning and analytics
(Mohammed et al.)

This paper introduces a novel modeling strategy for organizing and integrating medical information in the context of service-oriented healthcare. The research focuses on leveraging microservices and knowledge graph APIs, with a particular emphasis on GraphQL technology, to enable the development of effective microservice-based care systems. The proposed mindmap approach aims to facilitate rich clinician interaction and improve knowledge extraction and navigation within large healthcare databases and services. By utilizing GraphQL's flexibility and efficiency, the ecosystem enables the integration of new services and dynamic changes. The paper also discusses the potential extension of the ecosystem to incorporate graph-based machine learning and analytics using a full stack API, which brings together GraphQL, Apollo, React, and Neo4j. The proposed approach offers promising possibilities for enhancing healthcare diagnostics, prognosis, and analytics.

Improving sEMG-based motion intention recognition for upper-limb amputees using transfer learning
(Fan et al.)

This paper proposes a CNN-based transfer learning solution to improve motion intention recognition in transradial amputated subjects using multi-channel surface electromyography (sEMG) signals. Due to the scarcity and signal quality deterioration of sEMG signals from amputees, the study leverages knowledge learned from intact subjects to enhance classification performance. The results

demonstrate that the proposed transfer learning method significantly improves accuracy in motion classification for amputees, with a particular focus on the mDWT and RMS features. The study also explores the correlation between classification accuracy and amputation information, such as the percentage of remaining forearm and the number of years since amputation. The findings highlight the feasibility of utilizing deep transfer learning to benefit upper limb amputees in prosthesis control, rehabilitation, and human–computer interaction, addressing the data scarcity challenge in prosthesis development.

Inverted bell-curve-based ensemble of deep learning models for detection of COVID-19 from chest X-rays
(Paul et al.)

This paper presents a novel approach for the detection of COVID-19 from chest X-ray (CXR) images using an inverted bell-curve-based ensemble of deep learning models. The study utilizes transfer learning to retrain models pretrained on the ImageNet dataset with COVID-19 CXR datasets. The trained models are then combined using the proposed ensemble method, where each classifier's output is assigned a weight and a weighted average is performed to obtain the final prediction. The proposed method achieves high accuracy, F1 score, and AUC ROC on two publicly available datasets, surpassing existing ensemble methods. The results demonstrate the effectiveness of transfer learning and the ensemble approach for improved COVID-19 detection in CXRs.

Joint optic disc and cup segmentation based on multi-scale feature analysis and attention pyramid architecture for glaucoma screening
(Sun et al.)

The contribution of this paper is the proposal of ResFPN-Net, a unified convolutional neural network for simultaneous segmentation of the optic disc (OD) and optic cup (OC) in color fundus images. The network incorporates a multi-scale feature extractor, multi-scale segmentation transition, and attention pyramid architecture to capture boundary representations, retain features of different scales, and learn rich representations and mutual connections between OD and OC. The proposed method achieves superior performance in OD and OC segmentation, outperforming other competitive methods on public datasets. The introduced multi-scale loss function improves convergence speed and accuracy. Additionally, the proposed network demonstrates effectiveness in glaucoma screening and shows potential for other biomedical image segmentation tasks.

Multilevel depth-wise context attention network with atrous mechanism for segmentation of COVID19 affected regions
(Qayyum et al.)

This paper introduces a successful deep learning model for the detection of COVID-19 using medical imaging analysis. The proposed model demonstrates excellent scores on two datasets and outperforms existing state-of-the-art networks in terms of accuracy and efficiency. This has significant implications for clinical practice and public health globally, as it has potential in aiding the early detection and management of COVID-19 particularly in countries with limited testing kits and overwhelmed healthcare systems.

Pima Indians diabetes mellitus classification based on machine learning (ML) algorithms
(Chang et al.)

The authors developed an e-diagnosis system based on machine learning algorithms for diagnosing type 2 diabetes in the Internet of Medical Things (IoMT) environment. To address the lack of transparency and trust in machine learning models, the research employs interpretable supervised ML models, namely Naïve Bayes classifier, random forest classifier, and J48 decision tree models. These models are trained and tested using the Pima Indians diabetes dataset, and their performance is analyzed in terms of accuracy, precision, sensitivity, and specificity. The experimental results demonstrate that the random forest classifier achieves the best overall performance, while the Naïve Bayes and J48 models exhibit strengths in different evaluation metrics. The study highlights the potential of these interpretable ML models in electronic diagnostic systems within the IoMT context.

VIRFIM: an AI and Internet of Medical Things-driven framework for healthcare using smart sensors
(Khowaja et al.)

The contribution of this paper is the proposal of the VIRFIM (VIrus Resistance Framework using the Internet of Medical Things) framework, which utilizes smart sensors integrated with the Internet of Medical Things to automate and cover various good practices for combating the spread of viruses, such as physical healthcare monitoring, personal hygiene, mental healthcare, and contact tracing. The framework presents hypothetical modules for each practice and provides case studies on physical activity monitoring and stress detection services to validate its implementation. The paper emphasizes the importance of integrated technologies in dealing with current and future pandemics until vaccines are widely available. The VIRFIM framework has the potential to assist individuals in

preventing the contraction of viruses while promoting the adoption of good practices and encouraging support from statuary bodies, governments, and industries.

3 Final thoughts

We hope that this special issue will serve as a valuable resource and a source of motivation for researchers venturing into the challenging aspects of this field. The guest editors express sincere gratitude to the authors for their valuable contributions to this special issue. We would also like to extend our appreciation to all the reviewers who dedicated their time and expertise to meticulously review each manuscript, contributing to its overall improvement.