Guest Editorial Advanced Machine Learning Algorithms for Biomedical Data and Imaging

RESEARCHERS in machine learning including those working in computer vision, image processing, biomedical analysis, and related fields when tied with experienced clinicians can play a significant role in understanding and working on complex medical data which ultimately improves patient care. Developing a novel machine-learning algorithm specific to medical data is a challenge and need of the hour. Healthcare and biomedical sciences have become data-intensive fields, with a strong need for sophisticated data mining methods to extract the knowledge from the available information. Biomedical data contains several challenges in data analysis, including high dimensionality, class imbalance, and low numbers of samples. Although the current research in this field has shown promising results, several research issues need to be explored as follows. There is a need to explore novel feature selection methods to improve predictive performance along with interpretation and to explore large-scale data in biomedical sciences. The guest editorial team (Mohammad Tanveer, Chin-Teng Lin and Amit Kumar Singh) hopes that the articles included in this Special Issue contribute to the state-of-the-art machine learning algorithms for biomedical data and imaging applications. Our Call for Papers received an enthusiastic response with many high-quality submissions in this particular section. After a rigorous review process, we accepted 22 articles in the October issue to form the first part of the Special Section. A brief summary of each paper is introduced below.

Fetal congenital heart disease (CHD) is the most common type of fatal congenital malformation. Fetal four-chamber (FC) view is a significant and easily accessible ultrasound (US) image among fetal echocardiography images. Automatic detection of four fetal heart chambers considerably contributes to the early diagnosis of fetal CHD. In [A1], Qiao et al. proposed an intelligent feature learning detection system for FC views to detect the four chambers. A multistage residual hybrid attention module is presented, which focuses more on spatial and content information of the fetal cardiac chambers in FC views. Due to numerous hardware shortcomings, medical image acquisition devices are susceptible to producing low-quality images. In order to this, Sharif et al. [A2] proposed a learning-based method to tackle the challenge of enhancing low-quality medical images. The proposed study incorporates a deep model comprising a residual block and gatting mechanism in an encoder-decoder structure to reduce the visual artefacts. Also, this study has introduced a multi-term objective function to produce natural looking enhanced images.

Gupta et al. [A3] considered Blood Volume Pulse (BVP) extraction as an under complete problem and proposed a method resistant to motion and illumination variation artifacts. This method is based on an under complete independent component analysis, aiming to estimate the unmixing matrix using a non-linear cumulative density function that has been optimized using the customized Levenberg-Marquardt algorithm. In contrast to the conventional data-driven-based machine learning strategy, Li et al. [A4] focused on an alternative, i.e., knowledge-driven-based strategy to enhance the performance of machine learning in the diagnostic work. Specifically, the expert knowledge is incorporated and designed into a FÇN construction model. The constructed FÇN is then validated by feeding it into a TIN diagnostic model. The superior results illustrate that expert knowledge can play a quite positive role in machine learning for biomedical data.

Currently, depression has become a common mental disorder, especially among postgraduates. In order to make the recognition of depression more reliable and convenient, Shao et al. [A5] described a multimodal gait analysis-based depression detection method that combines skeleton modality and silhouette modality. Nowadays, predictive medicine begins to become a reality thanks to Artificial Intelligence (AI) which allows, through the processing of huge amounts of data, to identify correlations not perceptible to the human brain. Prezioso et al. [A6] presents a deep learning-based methodology for automatic segmentation and classification of salivary gland tumours. Furthermore, authors develop an explainable segmentation learning approach supporting the effectiveness of the proposed framework through a per-epoch learning process analysis and the attention map mechanism. The proposed methodology was evaluated with a collected CT dataset of patients with salivary gland tumours. Dry weight (DW), defined as the lowest tolerated post dialysis weight following the ultrafiltration (UF) of excess fluid volume, and is essential for any dialysis prescription for hemodialysis (HD) patients. In this direction, Yang et al. [A7], developed a reinforcement learning algorithm to optimize the DW evaluation problem that has long challenged clinicians, with the learned model achieving good calibration performance and improved HD treatment outcomes and exhibiting reasonable behaviour from the clinicians' perspective. The proposed method has potential application value in that it can dynamically support clinicians in determining a personalized and optimal DW adjustment policy.

Date of current version 5 October 2022.
Digital Object Identifier 10.1109/JBHI.2022.3204385

Dag et al. [A8] proposed a deep learning methods to improve Brain-Computer Interfaces (BCI) by detecting the P300 waveform in electroencephalography recordings. Differently from standard approaches, which usually aim at reaching better performance only, they also paid particular attention to BCI users' and practitioners' needs. BCI users are often subjects with neurological or physical impairments that can hardly bear long preparatory phases. Hence, the authors proposed methods to reduce the calibration time and explored the feasibility of reducing the number of electrodes needed in the setup. Electroencephalogram (EEG) based seizure types classification has not been addressed well, compared to seizure detection, which is very important for the diagnosis and prognosis of epileptic patients. The proposed idea suggested by Shankar et al. [A9] has been developed to distinguish five different types of seizure along with seizure free. The results reveal that the proposed idea can efficiently extract the underlining features and achieve the highest classification performance. The elimination of ocular artifacts is critical in analysing EEG data for various brain-computer interface applications. In this direction, Sawangjai et al. [A10], presents a method that can remove the ocular artifacts from the brain signal without requiring users to wear additional electrooculography electrodes around their eyes, requiring time-consuming manual inspection by the experts, or requiring an extra algorithm to detect the part to be processed. While the use of generative adversarial networks to alter images, eliminate noises, and even create whole new images has advanced rapidly in the field of computer vision, it remains relatively underexplored in multivariate time series data, particularly EEG signal.

In recent years, depression has become an increasingly serious problem globally. In this direction, Yu et al. [A11] suggested a method based on graph neural network that combines both temporal and spatial features of functional near-Infrared spectroscopy data for automatic depression recognition. Different statistical metrics of each channel were extracted as temporal features, and the coherence and correlation of each pair of channels were calculated as spatial features. Each patient's data was regarded as a graph, with 53 channels as nodes. Anterior cruciate ligament (ACL) deficiency not only reduces knee stability, but also increases the risk of more disease and impairs daily life, thus requiring efficient detection of ACL deficiency. Wang et al. [A12] developed a new method called SVM-MPA that fuses marine predator algorithm (MPA) and support vector machine (SVM) for simultaneous feature selection, hyperparameter optimization and classification. By comparing with 7 well-known meta-heuristic algorithms, this study has achieved the best average gait cycle-level ACL deficiency detection performance based on the proposed method. Sleep staging is an important step in analyzing sleep. Traditional manual analysis by psychologists is time consuming. In order to deal with this challenge, Huang et al. [A13] developed an automatic sleep staging model with an improved attention module and hidden Markov model (HMM). The model is driven by single-channel electroencephalogram (EEG) data. It automatically extracts features through two convolution kernels with different scales. Subsequently, the neural network uses an improved attention module to fuse time-frequency features. After the development of next-generation sequencing techniques, protein sequences are abundantly available. Determining the functional characteristics of these proteins is costly and time-consuming. Facing the above situations, Dhanuka et al. [A14] proposed an advanced deep-learning-based approach for protein function prediction using protein sequences. A set of autoencoders is trained in a semi-supervised manner with protein sequences. Each autoencoder corresponds to a single protein function only. Since, each function is learned by a specific autoencoder, it is very easy to extends it for large number of functions without disturbing the earlier models. Hospitals can predetermine the admission rate and facilitate resource allocation based on valid emergency requests and bed capacity estimation. The excess unoccupied beds can be determined with the help of forecasting the number of discharged patients. In this direction, Gao et al. [A15], investigates the random vector functional link network's (RVFL's) forecasting performance on Singapore hospitals' inpatient discharges data. The RVFL is popular because of its fast training algorithms and strong learning ability. The features of RVFL are randomly initialized and frozen during the training process. Finally, a linear readout layer is established based on the concatenation of input observations and random features.

Yao et al. [A16] proposed a 3D framework for unsupervised domain adaptation in medical image segmentation. Combining multi-style transformation and dual-attention modules, the framework shows impressive performance in alleviating domain shift problems. Presently, data mining from the collected single-lead ECG waves has therefore aroused extensive attention worldwide, where early detection of atrial fibrillation (AF) is a hot research topic. In this direction, Yu et al. [A17] proposed a two-channel convolutional neural network combined with a data augmentation method to detect AF from single-lead short ECG recordings. It consists of three modules; the first module denoises the raw ECG signals and produces 9-s ECG signals and heart rate (HR) values. Then, the ECG signals and HR rate values are fed into the convolutional layers for feature extraction, followed by three fully connected layers to perform the classification. The data augmentation method is used to generate synthetic signals to enlarge the training set and increase the diversity of the single-lead ECG signals. The work proposed by Li et al. [A18] focuses on the sample-based data augmentation (DA) methods in electroencephalogram (EEG) processing. In view of the limited number of sample-based DA for EEG-based classification tasks, three methods, performance-measure-based time warp, frequency noise addition and frequency masking, are proposed based on the characteristics of EEG signal. These methods are parameter learning free, easy to implement, and can be applied to individual samples. The model trained with the proposed DA methods achieved significant performance improvement over baselines in three tasks. In overall, this work provides more potential methods to cope with the problem of limited data and boost the classification performance in EEG processing.

Recently, accurate classification of brain tumors is vital for detecting brain cancer in the Medical Internet of Things. Detecting brain cancer at its early stages is a tremendous medical problem, and many researchers have proposed various diagnostic systems; however, these systems still do not effectively detect brain cancer. Motivated by this, Ul Haq et al. [A19] proposed a

new intelligent integrated model (CNN-LSTM) based on deep learning techniques to diagnose brain cancer accurately. The model uses a CNN model to extract deep features from image data and pass the features to an LSTM model for classification into tumor and non-tumor classes. Three data sets have been used for the model evaluation. The results of the experiments demonstrate that the proposed CNN-LSTM framework obtained very high performance compared to the baseline methods in the IoT industry. Nowadays, approaches based on Deep Learning have become mainstream for medical image segmentation because of their ability of automatic feature extraction. However, due to the plain network design and targets variety in medical images, the semantic features can hardly be extracted adequately. In order to deal with this challenge, Xie et al. [A20] developed an approach for 2D medical image segmentation. It utilizes self-attention distillation to extend network depth implicitly, fuses features through the multi-scale feature mixing, and is trained by deep supervision with group ensemble learning. Through the evaluation on different datasets, the suggested approach surpasses multiple state-of-the-art schemes.

Breast cancer is the most common female cancer in the world and it poses a huge threat to women's health. There is currently promising research concerning its early diagnosis using deep learning methodologies. In this direction, Liu et al. [A21] proposed a framework for breast pathology classification, called the AlexNet-BC model. The model is pre-trained using the ImageNet dataset and fine-tuned using an augmented dataset. The framework adopts the transfer learning strategy to pre-train and fine-tune this improved neural network framework. Drug-induced liver injury (DILI) describes the adverse effects of drugs that damage liver. Life-threatening results including liver failure or death were also reported in severe cases. In this direction, Zhan et al. [A22], developed a model to filter the DILI literature from irrelevant literature based on the title and abstract of publications with multiple text vectorization algorithms in NLP. This study also leveraged the ensemble learning strategy by building a logistic regression meta learner on the top of the predicted probability of different separate learners and compared the performance of the ensemble learning model with that of individual models. The model showed high classification performance and interpretable results.

The guest editors would like to thank all the authors who submitted their articles and anonymous reviewers who carefully reviewed and evaluated them. They extend their sincere thanks to the Editor-in-Chief of the IEEE Journal of Biomedical and Health Informatics, Prof Dimitrios I. Fotiadis for providing the opportunity and guidance to edit this Special Issue and the editorial staff for their continuous support in organizing the Special Section.

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APPENDIX: RELATED WORKS

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