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Editorial

Editorial Note to the Special Issue: “Applications of Deep Learning in Electrical and Electronic Engineering”

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DEEP learning (DL) is an emerging technique in artificial intelligence (AI) in which machines can learn how to process data in a similar way to the human brain. In recent years, methods and algorithms based on DL have been of great interest and have achieved significant success in many areas of machine learning such as image processing, speech recognition, and brain pattern recognition [1], [2], [3]. Because of their success in recognizing and analyzing complicated patterns, they are making their way into almost all fields. One of the areas that allocated a large volume of DL algorithms is the field of electrical and electronics engineering (EEE). Despite the fundamental challenges such as the need for a large amount of data to train deep network coefficients as well as the complexity of designing different structures for various applications, it has been widespread in this field.

Biomedical, communication, power, control, and electronics engineering are outstanding sub-fields among the EEE areas in which DL algorithms are frequently employed.

EEE in the field of biomedical engineering focuses mostly on the fields of medical image analysis, cardiovascular health monitoring, brain-computer interfaces (BCI), robotics, and surgical assistants. DL models are used to segment medical images (e.g., Magnetic Resonance Imaging (MRI), Computed Tomography (CT) scans, and ultrasound) for the classification and identification of tumors, abnormalities, organ boundaries, and other anatomical structures in medical imaging [4],[5],[6], [7]. In BCI systems they are utilized to process and interpret brain signals (e.g. functional MRI (fMRI), Electroencephalography (EEG)), enabling control of prosthetic devices, communication aids, and other assistive technologies for patients with severe disabilities. They are also utilized in robotic-assisted surgeries by improving precision and reducing human error. In addition, DL models are instrumental in the development of predictive analytics for patient monitoring, allowing for real-time assessment of vital signs and early identification of potential health issues [3], [8], [9], [10], [11], [12].

DL has significantly enhanced various applications in communication systems by improving the efficiency and reliability of systems. DL models are employed to improve noise reduction, signal detection, and modulation recognition, thereby enhancing the quality of transmitted data [13]. In wireless communication, DL algorithms help in optimizing network resource allocation and managing interference in dense environments to ensure efficient data transmission. They are also utilized in smart antennas and adaptive beamforming to dynamically adjust the signal direction, improving signal quality and coverage [14]. Furthermore, DL enhances the performance of channel estimation and prediction, enabling more robust communication links in uncertain environments. In the development of next-generation communication networks, such as 5G and beyond, DL accelerates the improvement of data routing, traffic analysis, and resource management, paving the way for more intelligent and responsive communication systems [15], [16].

Power engineering is another field in which DL models play a significant role in enhancing various applications related to power generation, distribution, and management. In smart grid technologies, they are utilized for predicting energy demand and optimizing load management, which helps to balance supply and demand in real time [17], [18]. They can also facilitate fault detection and diagnosis in electrical distribution systems by analyzing historical data and identifying patterns associated with failures, thus minimizing downtime and maintenance costs [19]. DL algorithms enhance renewable energy integration by forecasting the

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output of solar and wind energy systems, which is crucial for effective grid management [20]. Additionally, DL contributes to the dispatching through intelligent monitoring and control of power consumption in industrial and commercial settings, leading to significant cost savings and reduced environmental impact, [21].

In control systems, DL algorithms are utilized to model dynamic systems and improve system identification, leading to more accurate predictions and optimal control strategies[22]. They are particularly effective in the development of adaptive control systems that can learn from past performance and adjust to changing conditions in real time [23]. Another application of DL models is in robotics for motion planning and trajectory optimization, enhancing the capabilities of autonomous systems in complex environments [24], [25]. Additionally, DL techniques facilitate advanced predictive maintenance in industrial automation by diagnosing equipment correctness through data-driven insights, reducing downtime, and enhancing operational efficiency [26]. Moreover, in transportation systems, DL is used for intelligent traffic management and autonomous vehicle control, improving safety and efficiency in increasingly busy urban environments [27], [24], [28].

DL is revolutionizing the field of electronics engineering, introducing innovation across various applications ranging from device design to manufacturing processes. In electronic circuit design, DL models are employed to optimize circuit topologies and predict performance based on specific design parameters, significantly reducing the time required for prototyping and testing. Additionally, DL techniques are utilized in semiconductor manufacturing for defect detection and classification, thus enhancing yield rates and ensuring higher quality of fabricated components. Furthermore, DL is applied to enhance image and video processing capability in consumer electronics, enabling features such as speech emotion recognition, facial recognition, image enhancement, and augmented reality [29], [39]. Beyond these areas, DL aids in the development of smart devices, allowing for real-time data analysis and decision-making that increase user experiences in smart homes and Internet of Things (IoT) applications [30], [31], [32], [33], [34].

This Special Issue entitled “Applications of Deep Learning in Electrical and Electronic Engineering”, aims to address the application of DL and novel machine learning methods to diverse the problems involved in electrical and electronics engineering and provide practical guidance. These methods include useful approaches that may improve predictive performance and enhance the functionality of the applications using deep network algorithms. A summary of the published papers in this Special Issue is provided below.

Salehin et al. [35] emphasized the importance of abnormal activity detection for video surveillance and security systems, which aims to identify behaviors that deviate from normal patterns, indicating potential threats like theft or aggression. Their study focuses on detecting both violent and non-violent human activities using a YOLOv9-based deep learning model. A diverse dataset of 9,341 images was created and pre-processed through augmentation, resizing, and annotation.

In [36], Moreno et al. introduced a virtual robotic system designed to supervise physical training exercises in a closed environment, requiring only a computer and a webcam. The system employs deep learning algorithms, including convolutional networks and long short-term memory (LSTM) networks, to recognize voice commands and video actions of the user. A predefined dialogue template guides the training cycle for exercises such as push-ups, sit-ups, jumps, and squats. The main contribution of their work lies in integrating deep learning techniques to personalize virtual robotic assistants for everyday tasks.

In [37], Hadjaissa et al. addressed the growing need for photovoltaic emulators (PVEs) to test and compare control strategies like Maximum Power Point Tracking (MPPT) as solar photovoltaic power generation becomes more widespread. PVEs enable consistent testing by accurately simulating PV panel behavior without external influences such as irradiance and temperature variations. This study develops a PVE model using deep learning techniques, specifically a Multi-Layer Perceptron (MLP) Artificial Neural Network (ANN) with backpropagation. The ANN is integrated with a DC-DC push-pull converter controlled by a Linear Quadratic Regulator (LQR) strategy, effectively emulating the nonlinear characteristics of PV panels to generate precise reference currents. In addition, by using a single voltage sensor and estimating the current via a Luenberger observer, the emulator minimized hardware requirements and enhanced the control signal accuracy.

Jahantab et al. [38] highlighted the critical role of Global Positioning System (GPS)-based positioning in daily life. They propose a spoofing detection method utilizing the Cross Ambiguity Function (CAF) and introduce a dimension reduction algorithm to enhance the speed and performance of the detection process. In addition, the reduced-dimensional images are trained using a modified Convolutional Neural Network (CNN) model as Transformed-CNN (TCNN), to improve the accuracy.

Herrera-Benavidez et al. [39], explore the design and implementation of a deep learning algorithm for robotic manipulation in object handling tasks within a simulated industrial environment. Utilizing the V-REP simulation tool, the study models a production line featuring a conveyor belt and a SCARA robot manipulator. A key innovation of this work is the integration of a depth camera mounted on the robot, enabling the computation of gripping coordinates by identifying and locating three distinct object types situated randomly on the conveyor belt, achieved through a Faster R-CNN architecture.

D'Souza et al. [40], addressed the increasing incidence of heart-related illnesses, primarily linked to factors such as high blood pressure, diabetes, and poor lifestyle choices. This study utilizes machine learning-based prediction methods on audio recordings of heartbeats, known as phonocardiograms (PCG), to differentiate between normal and abnormal heart sounds. Features extracted from the data are up-sampled and applied to logistic regression and random forest classification models. Additionally, ANN and deep learning networks were trained to enhance the performance.

In [41], Moradi introduced a robust artificial neural network classifier (RANNC) aimed at improving the prediction of coronary heart disease (CHD) by addressing the complications arising from imbalanced and outlier-rich clinical datasets. The efficacy of the RANNC was assessed in comparison to six other artificial intelligence algorithms: Logistic Regression Classifier (LRC), Decision Tree Classifier (DTC), Random Forest Classifier (RFC), K-Nearest Neighbors Classifier (KNNC), Support Vector Classifier (SVC), and ANN. Evaluation metrics included precision, accuracy, recall, F1-score, and Matthews Correlation Coefficient (MCC).

Yamini et al. [42], addressed the challenges of extracting relevant information from the rapidly growing unstructured data on the Web and social networks, highlighting the need for automated summarization systems. The development of machine learning-based summarization systems relies heavily on datasets, which must be evaluated for their effectiveness in data retrieval. The paper introduces the first abstractive text summarization corpus for the Sorani Kurdish language, developed with human evaluation and an automated summarization model. They have developed a customized and simplified version of the mT5-based transformer to evaluate the corpus. This pioneering Sorani Kurdish corpus and automated summarization model hold promise for advancing summarization systems in low-resource languages.

In [43], Bayat Rizi et al. explored the potential of Visible Light Communication (VLC) as a reliable, high-bandwidth, and secure optical wireless technology, particularly in medical applications. Despite its advantages, VLC faces challenges in medical environments due to signal strength fluctuations caused by patient movement. This research investigates the performance of adaptive modulation within a medical body sensor network utilizing VLC, focusing on various medical scenarios and employing machine learning algorithms based on supervised learning and reinforcement learning. Their study revealed that both approaches significantly enhance spectral efficiency and highlight the importance of link adaptation in VLC-based medical networks. Also, the implementation of the Q-learning algorithm in adaptive modulation facilitates real-time training, allowing the system to adapt to changing conditions without prior environmental knowledge.

Moharam et al. [44] addressed the high peak-to-average power ratio (PAPR) challenge associated with Filter Bank Multicarrier (FBMC) systems in 5G technology. The research focuses on evaluating PAPR reduction techniques for the FBMC system, employing four methods: classical tone reservation (TR), tone reservation combined with sliding window (SW-TR), tone reservation with active constellation extension (TRACE), and a deep learning approach (TR-Net). They have emphasized the deep learning-based TRNet technique as a groundbreaking solution for efficient, distortion-free signal processing.

In another work, Babu et al. [45] investigated the early detection and identification of tuberculosis (TB), a severe disease caused by mycobacterium that can lead to mortality. The study employs machine learning techniques, specifically a Support Vector Machine (SVM) and a Modified CNN, to enhance the accuracy of TB diagnosis from the chest X-ray (CXR) images. This research indicates that the proposed system outperforms existing methods, aiding radiologists and public health professionals in diagnosing and screening for tuberculosis.

Amirfathiyan et al. [46], explored the application of deep learning in computer graphics for 3D shape matching, particularly focusing on models with non-isometric deformation. They proposed an efficient method that organizes intrinsic and directional attributes in a structured manner, utilizing a hybrid feature derived from Diffusion-Net and spectral features. The approach involves extracting features from Diffusion-Net, computing two maps via functional map networks to obtain intrinsic and directional features, and combining these to resolve symmetry ambiguities on models with high deformation.

In [47], Razavi et al. proposed a descriptor-based approach integrated with deep learning for recognizing facial emotions to enhance driving safety. Their study aims to develop a Facial Emotion Recognition (FER) system that identifies emotions and provides real-time safety assistance. Initially, the Viola-Jones algorithm detects the facial region, followed by Butterworth highpass filtering to enhance the features of the eyes, nose, and mouth. The Local Binary Patterns (LBP) feature descriptor extracts features from these regions, which are then fed into the ResNet-50 and EfficientNet deep learning models. The outputs of both classifiers are combined using ensemble maximum voting and ensemble mean methods.

Merrikhi et al. [48] investigated the role of robots in modern society, particularly focusing on vision-based grasping tasks essential for handling objects. With advancements in depth camera technology, the paper presents a system that detects graspable parts of objects, crucial for effective robotic manipulation. They enhanced the Dynamic Graph CNN (DGCNN) network to identify these graspable areas, training it on the compiled database.

Yessad [49] introduced the CTDRCepstrum, a novel feature extraction technique aimed at differentiating human activities using Doppler radar classification. Their analysis focuses on Doppler signatures using time-frequency reassignment, highlighting its benefits for improved component separability. The CTDRCepstrum utilizes various window functions to transform each echo signal into three forms of Short-Time Fourier Transform reassignments: time RSTFT (TSTFT), time derivative RSTFT (TDSTFT), and reassigned STFT (RSTFT). A convolutional neural network (CNN) model was trained using the feature vector generated from the cepstral analysis of each RSTFT form.

In conclusion, this Special Issue highlighted the remarkable potential of deep learning techniques across various applications within electrical and electronics engineering, demonstrating its capacity to solve complex challenges through advanced computational techniques. Therefore, the continued integration of deep learning techniques will be pivotal in addressing complex challenges and advancing cutting-edge technologies.

Conflict of Interest

The authors declare no conflict of interest.

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