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Application of Deep Learning Models for Parkinson Disease Detection: An Overview

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ABSTRACT: Over 6 million individuals throughout the world are living with Parkinson's disease (PD), making it the second most prevalent neurodegenerative ailment. There are therapies for the symptoms of the disease, which may raise the likelihood of surviving the illness, but there are no medicines that completely cure the sickness. The prevalence of Parkinson's disease (PD) as well as disability-adjusted life years continue to rise at a steady rate, which places an increasing burden not only on patients but also on their families, society, and the economy. When administered in the early stages of Parkinson's disease, dopaminergic medicines have the potential to considerably decrease the disease's development. On the other hand, the advancement of the illness often causes these therapies to become less effective. A timely diagnosis of Parkinson's disease is essential for initiating prompt treatment, which in turn enables patients to maintain their independence for the greatest amount of time feasible. Unfortunately, diagnoses are often delayed owing to a number of causes, including a worldwide dearth of neurologists experienced in early identification of Parkinson's disease (PD). The use of computer-aided diagnostic (CAD) tools, which are capable of performing automated diagnosis of Parkinson's disease and are founded on techniques of artificial intelligence, is attracting attention from healthcare services. In this article, we discuss deep learning models for the automated diagnosis of Parkinson's disease (PD), making use of a variety of diagnostic modalities, such as brain analysis and motion symptoms. We emphasise the present restrictions that are preventing the widespread use of computer-aided design (CAD) tools in the healthcare industry and select the top performing deep learning model that has been reported for each modality based on these research. Finally, we offer new paths to extend the research on deep learning in the automated identification of Parkinson's disease in the hopes of boosting the usability, applicability, and effect of such tools to enhance the early detection of Parkinson's disease around the globe.

KEYWORDS: Parkinson's disease (PD); deep learning; computer-aided diagnosis, feature extraction, machine learning

I. INTRODUCTION

Parkinson's disease (PD) is a neurological condition that cannot be cured; it causes the central nervous system to deteriorate over time and leaves sufferers with incapacitating neurological symptoms [1]. The underlying cause of the neurodegeneration that occurs in Parkinson's disease is still only partially understood; however, key pathophysiological features include the gradual loss of dopaminergic neurons in a part of the midbrain known as the substantia nigra pars compacta (SNpc), as well as the accumulation of misfolded alpha-synuclein protein in 'Lewy bodies' within the cytoplasm of neuronal cells in several different brain regions [Movement control depends on the nigrostriatal route, which is a dopaminergic network connecting the SNpc and the dorsal striatum. This pathway is also known as the nigrostriatal pathway. Therefore, when the nigrostriatal pathway is disrupted, afflicted persons with PD experience motor abnormalities such as tremors, stiffness, and bradykinesia [3]. In addition to motor symptoms, affected people may also have non-motor symptoms, such as constipation, melancholy, sleeping difficulties, and a diminished sense of smell [1,3].

This study's objectives are to (1) provide a comprehensive review of automated Parkinson's disease (PD) detection utilising deep learning models; and (2) promote deep learning models as a potential computer-aided diagnostic (CAD)-based tool for clinical decision support systems. The review will be conducted using a systematic research design. In the first section of this paper, we discussed the history of Parkinson's disease (PD), the limitations of the currently used technique of diagnosis, and the CAD tool as a potential solution to reduce the workload of neurologists. After that, we elaborated on the benefits of deep learning models over machine learning models as a CAD tool and illustrated the mechanics of the two most popular types of deep learning models, which are the convolutional neural network (CNN) and the long short-term memory model. Both of these models are used to train computers to recognise images (LSTM).



In Section 2, we discuss the implementation of the PRISMA model for the purpose of conducting a systematic evaluation of automated PD detection studies that make use of deep learning models. In order to construct the systematic review, a total of 63 research were selected after the irrelevant studies were methodically eliminated one by one. After that, these investigations were separated into two distinct groups for discussion in Section 3: brain analysis and motor symptoms. After that, an analysis of the data as well as a visualisation of it were carried out for each category. In Section 4, we also discussed the current trend that was observed from the 63 research studies, the limitations of deep learning models for CAD detection, and presented the proposed directions for future work that can increase the adoption of deep learning models as a CAD tool. All of these topics were covered within the context of increasing the use of deep learning models as a CAD tool. The review is brought to a close in the fifth and final section, which provides a summary of the most important results, as well as their limits and the promise of deep learning models as a CAD tool to assist clinical choices.

II. LITERATURE SURVEY

The presence of core clinical features, such as bradykinesia and the absence of certain exclusion criteria, is used to diagnose Parkinson's disease (PD) at this time. The accuracy of clinical diagnosis can be improved by following standard clinical criteria, such as those established by the UK Parkinson's Disease Society Brain Bank (UKPDSBB) [8]. These clinical criteria depend on the knowledge of a neurologist, but they still have flaws. For instance, the diagnosis accuracy using the UKPDSBB is only slightly over 80 percent, even in specialised neurology institutes, when compared to post-mortem pathological testing as the gold standard [9]. In addition, there is a severe lack of neurologists all over the world, which is particularly problematic in nations where the population is becoming older and where there is a high incidence of neurological illnesses [10]. This results in a lengthened period of time before afflicted persons may get a diagnosis of Parkinson's disease. As a direct result of this, by the time a diagnosis is made, generally sixty percent of the dopaminergic neurons have been destroyed [2].

There is interest in the possibility of using CAD tools based on artificial intelligence methods, specifically machine learning (which may potentially involve the more conventional pattern recognition approaches) or deep learning (which may involve sophisticated multi-layered neuronal systems), to perform an automated diagnosis of PD [11–13]. This is an effort to meet the demands for healthcare, and there is interest in the possibility of using these tools. These CAD tools are able to carry out automated detection by utilising the biomarkers of PD, such as signals from an electroencephalogram (EEG), posture analysis during the gait cycle, voice aberration, or imaging techniques for the brain, such as magnetic resonance imaging (MRI) and positron emission tomography (PET) [14]. To train a traditional machine learning model, it is necessary to first extract features from the biomarkers and then choose the features that are most relevant to the task at hand [15–19]. This process must be repeated several times. This is a necessary step due to the fact that machine learning models on their own are unable to learn from high-dimensional data in its raw form. If this step is skipped, the model is likely to overfit the dataset [20]. In addition to this, the selection of the characteristics that are the most relevant must be done by a skilled and experienced expert system that is familiar with a variety of different methods for feature selection [15,16]. This has led to the somewhat poor adoption of machine learning models as the future CAD tools as feature extraction and selection can be complicated procedures that are comprehensible by machine learning experts but not so much by the end-user of the CAD tool [21,22]. This has led to the somewhat poor adoption of machine learning models as the future CAD tools. These end-users might be healthcare professionals like practising physicians, health researchers, or consumers of other domain apps.

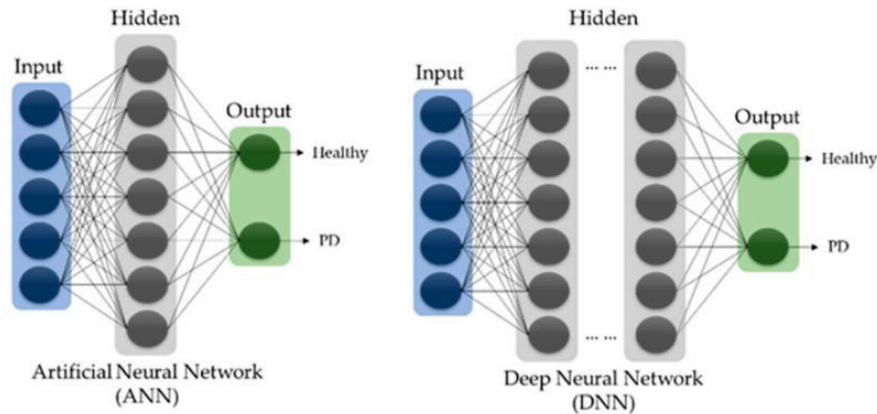


Figure 1. Basic architecture of ANN and DNN models.

Deep learning models, which are of increasing interest with big data and can resolve some of the limitations of machine learning models by eliminating the need for feature selection, feature extraction tools. Such models are capable of learning the high-dimensional data, and they may function analogously to the neurons in the human brain [23]. The conventional forms of machine learning models known as artificial neural networks (ANN) consist of three main layers: the input, the hidden, and the output layer as shown in Figure 1. All three layers within a neural network contain artificial neurons that are interconnected, as denoted by the black lines. As the neural network learns via a learning algorithm (e.g., backpropagation), the weights of the connection (black lines) between the neurons update iteratively [23]. The neurons, which act as an individual classifier, determines the output signal after processing the weights from its previous connections [23]. When an ANN model has been constructed into an architecture that has more than one hidden layer, the system is then known as deep neural networks (DNN), and such systems are then capable of learning the data with a higher degree of complexity [23] (Figure 1). In deep learning algorithms, there are often other classes of model, such as CNN, recurrent neural network (RNN), and LSTM, that utilize DNN as their basic principal architecture.

In any CNN model, the input layer of a typical DNN model is replaced by a series of convolutional and pooling layers, as also shown in Figure 2. If DNN is described as the neurons in our brain, then the CNN may be considered as the human visual system [24]. The first convolutional layer contain numerous filters which extract features from the input image to generate multiple feature maps. The subsequent pooling and convolutional layers reduce the dimension of the feature maps and further enhance the features, thereby reducing the complexity of the feature map and the likelihood of overfitting [25]. This could be considered as analogous to the human visual system, where the visual cortex attempts to break down images into simpler representations for the brain to perceive the image with ease [24].

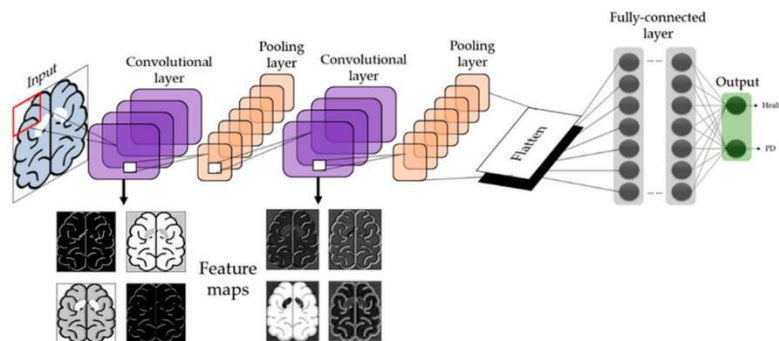


Figure 2. Basic architecture of the CNN model.

At the flatten layer, which comes immediately after the final pooling layer, the feature maps are transformed into single-list vectors (Figure 2). After that, the neurons in the neural networks, which are also referred to as the fully connected layers, will learn to detect the characteristics from the single-list vectors in order to carry out picture classifications [25]. Therefore, CNN models are well-known for their exceptional image identification capabilities.



Numerous research have successfully proved the effectiveness of CNN in medical imaging, including the detection of breast malignancies and eye problems using mammograms and colour fundus pictures, respectively. In addition to photographs of medical conditions, CNN has shown that it can successfully use biometric facial recognition algorithms for the purpose of human tracking.

III. ANALYSIS AND DISCUSSIONS

This review highlights many critical components of the current deep learning research being conducted for automated PD diagnosis, including the following:

- The prediction accuracy of deep learning models for the diagnosis of Parkinson's disease (PD) has been shown to be rather high by a number of different studies.
- The CNN model was suggested for use in around 57 percent of the deep learning research that were conducted for automated PD identification.
- It has been established that CNN models have a high prediction accuracy for picture classification tasks such as identifying signals.
- Our research has also shown that CNN is effective in recognising problems in one-dimensional data, such as speech and EEG, thanks to its ability to perform well in this area.
- On the other hand, gait analysis seems to function more well with either a hybrid model (CNN-LSTM), DNN, or LSTM model. However, further study is necessary to identify which model will provide the greatest results.
- In addition to the CNN model, we suggested BPNN and GONN for speech analysis and SPECT analysis respectively, and we got the greatest prediction accuracy with these models.
- Nevertheless, clinical tests are necessary in order to demonstrate that the suggested deep learning model is appropriate for each modality..

iv. limitation of this study

Despite the significant contributions that were made by a careful synthesis of the most relevant material on deep learning algorithms for clinical diagnostic purposes, this review does come with several limitations, some of which are described in the following paragraphs.

- Deep learning research for each modality (MRI, EEG, voice, etc.) may utilise separate datasets to train their model. This is because different modalities need different types of information. Studies that are interested in magnetic resonance imaging (MRI), for instance, can utilise a private dataset rather than the public dataset known as PPMI. Therefore, if two different deep learning models are not trained with the same dataset, it may be challenging to evaluate and compare their respective levels of performance.
- There may be an insufficient number of research pertaining to ultrasound imaging, tests that are connected to minor movements, and multi-model analyses that incorporate more than one modality. Because of this, it is impossible to identify which of these three models has the greatest performance overall.
- Because of the extensive number of deep learning models that have been suggested for gait analysis, it is difficult to choose the model that provides the best results; hence, it is tricky to choose between the top three models that provide the best results: The LSTM, CNN-LSTM, and DNN networks.

V. CONCLUSION

Parkinson's disease (PD) calls for an early diagnosis and treatment in order to mitigate the effects of this degenerative disorder, allowing those who are afflicted to maintain their level of independence for as long as feasible. On the other hand, clinical diagnoses are notoriously inaccurate, and there is a global shortage of neurologists who are experts in the diagnosis of Parkinson's disease. This often leads to a delayed diagnosis and inadequate therapy of the condition. In addition, early diagnosis will be a significant factor in determining the likelihood of success for sophisticated therapies such as gene therapy, which are now in the development stage. Therefore, computer-aided diagnosis (CAD) systems that are based on deep learning models should be evaluated for use in the treatment of Parkinson's disease since they have the potential to speed up and improve the accuracy of PD diagnoses. In this work, we analysed 63 previous research articles on deep learning for a variety of modalities, including brain analyses (SPECT, PET, and MRI), as well as motion symptoms (gait, handwriting, speech, EMG). We demonstrate that deep learning models are capable of achieving a high level of prediction accuracy for PD. In particular, the CNN model, which is extensively recommended by research that had focused on image classification for brain imaging and handwriting analysis, is shown to be very

effective. Additionally, the CNN model performed well in one-dimensional signal processing, including EEG and voice analysis. However, because to a lack of data on illness prediction, end-users such as neurologists and other doctors have not yet shown support for deep learning models. As a result, the purpose of this study is to suggest novel solutions for future research on deep learning, as well as maybe the incorporation of visual signals, such as the segmentation of anomalous regions, as a function in the architecture of the deep learning model. In addition, we strongly suggest that researchers keep developing deep learning models with specialised applicability to a variety of additional illness detection issues, and that they include visual inputs into their model. It is hoped that researchers will be encouraged to adopt more explainable and interpretable methods in deep learning-based CAD tools, which can then be taken up by the end-users, and improve the health care outcomes for an increasing number of individuals all over the world who are affected by Parkinson's disease.

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