

# An Approach to Differential Evaluation and Early Detection of Parkinson's Disease using Image Processors, and Machine Learning

Authors: Yashvardhan Mayur Verma <sup>(1)</sup>; Reetu Jain <sup>(2)</sup>

<sup>(1)</sup> Doon school, Location Hyderabad.

Email id: yashvardhan.376.2025@doonschool.com

<sup>(2)</sup>Supervisor, 1018/909, B Wing, Samarth Aishwarya, New Link Road, Lokhandwala, Oshiwara, Mumbai-400053, Maharashtra, India.

Email-id: [reetu.jain@onmyowntechnology.com](mailto:reetu.jain@onmyowntechnology.com)

## ABSTRACT

Parkinson's disease is a disorder affecting the motor capabilities of the individual. The typical symptoms include freezing of gait, bradykinesia, deterioration of handwriting, and impaired voice and speech abilities. The early detection of Parkinson's Disease allows patients to begin therapy and management strategies at stages of the disease that are not too severe and irreversible. This is to prevent the effects of advanced stages of Parkinson's that can severely degrade the quality of life of the patient. Several measures can be taken to prevent this and come to a conclusive diagnosis. After this, therapy to reverse the effects, or decrease further progression of Parkinson's can be expedited. There can be several factors that can support the diagnosis and these factors can be tested using several methods, such as speech processing, handwriting image processing, and body acceleration during day-to-day movements.

For this research our dataset includes handwriting samples from 36 subjects. In this work we have researched on the application of Deep learning architectures using handwritten images of 0 and 1. In this paper, an attempt has been made to diagnose Parkinson's disease by analyzing these hand-drawn images of 0 and 1 and training a Convolutional Neural Network (CNN) to do a binary classification for different drawing patterns giving an accuracy score close to 60%. Our methods use machine learning techniques and can give conclusive results and aid clinicians in the diagnostic process.

**Keywords:** Convolutional Neural Network (CNN), Machine Learning

## 1. Introduction

Parkinson's disease (PD) is a neurodegenerative disorder affecting the motor capabilities of the patient. It is affecting hundreds of thousands of aged people, considerably degrading their first-rate lives. PD is a complex sickness characterized by several motor and non-motor signs that worsen over time. In advanced degrees of PD, medical analysis is clear-cut.[7]. But, in the early tiers, when the symptoms are frequently incomplete or subtle, the analysis will become difficult and at times, the subject might also continue to be undiagnosed. For example, a huge-scale epidemiological examination of a European cohort confirmed that a massive proportion of previously undetected topics have been diagnosed with PD, after screening them with a symptom questionnaire accompanied by way of bodily exam and scientific intervention.[8]. Tremor, the maximum not unusual symptom in PD, may also in no way show up in a few sufferers and the affected person might also display different applicable signs and symptoms consisting of bradykinesia (slower and smaller handwriting, reduced arm swing and leg stride while taking walks, reduced facial features, and reduced amplitude of voice) to begin with. The difficulty in early detection of PD is a strong motivation for computer-primarily based assessment gear/selection aid gear/check contraptions that can be a useful resource within the early prognosis of PD. Timely detection, preferably at a stage

earlier than presently feasible, and subsequent intervention could be hugely beneficial in a manner that the affected person could have got admission to sickness modifying remedy to gradual down the path of PD progression.[9] Early detection is the aim of our project and optimizing the ways that we can detect PD as early as possible is the way forward. There is no conclusive test for PD, but many tests can be conducted to gradually support the initial diagnosis. The further we progress with the reliability of these tests, the more we can get closer to a perfectly accurate diagnosis. So even if there is no real conclusive test, the variety of reliable tests that we can make available can come to an almost perfectly accurate diagnosis.[10]. This diagnosis that we want is in the early stages of suspected Parkinson's so that we can also begin the necessary therapy and medical intervention at the earliest.

Parkinson's disease, in its advanced stages, has a clear-cut recognizability, but we want to conduct early diagnosis for the most effective prevention of degradation of the quality of life of the patient.[11]. Over the past few years, people around the world have come up with solutions pertaining to the Early Detection of PD. With phenomenal developments in tests pertaining to mainly, voice & speech analysis, gait analysis, and questionnaires, the rise of early detection of PD has begun.[12]. To further this development, my contribution to this topic lies in evaluation through the combined methods including Accelerometers and Image Processing of actions pertaining to handwriting. The process flow is shown in the below figure.

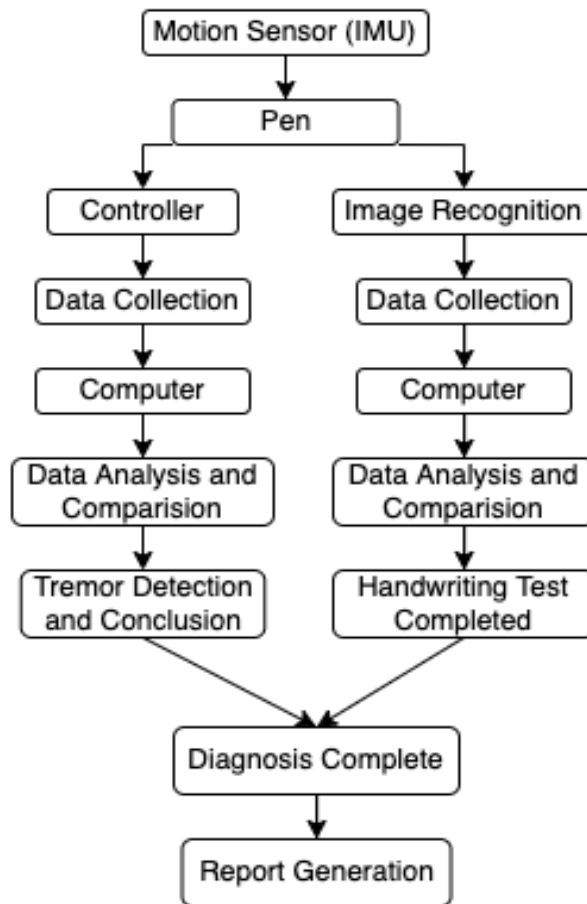


Fig 1. Process flow

## 2. literature review

Early detection of Parkinson's ailment (PD) is vital which could enable early initiation of therapeutic interventions and management techniques. but, strategies for early detection still continue to be an unmet clinical want in PD. in this look, they use the affected person Questionnaire (PQ) element from the widely used motion disorder Society-Unified Parkinson's disorder rating Scale (MDS-UPDRS) to expand prediction models which could classify early PD from healthful every day using device gaining knowledge of strategies which can be turning into famous in biomedicine: logistic regression, random forests, boosted trees and help vector system (SVM).[1]. We

completed both problem-wise and file-wise validation for evaluating the device studying techniques. We take a look at how those techniques perform with excessive accuracy and high regions below the ROC curve (each >ninety-five%) in classifying early PD and wholesome regular. The logistic model established statistically considerable in shape to the facts indicating its usefulness as a predictive version. It's far inferred that those prediction models can resource clinicians within the diagnostic manner via becoming a member of the items of a questionnaire through gadget mastering.[2].

When diagnosing Parkinson's ailment (PD), scientific professionals usually assess numerous scientific manifestations of the PD patient and price a severity stage in step with mounted criteria.[3] This scoring technique is particularly dependent on medical doctors' information, which is subjective and inefficient. In this paper, we advise a device learning based totally approach to mechanically rate the PD severity from gait statistics, specifically, the sequential records of Vertical ground reaction force (VGRF) recorded by using foot sensors.[3]. We evolved a two-channel version that mixes lengthy quick-time period reminiscence (LSTM) and a Convolutional Neural network (CNN) to analyze the Spatio-temporal patterns in the back of the gait information. The model became trained and tested on 3 public VGRF datasets. Our proposed method outperforms the present ones in terms of prediction accuracy of PD severity degrees. We trust the quantitative assessment supplied through our method will gain clinical prognosis of Parkinson's ailment.[4]. Monitoring Parkinson's Disease in Smart Cities.[5]. In this paper, they propose a PD tracking framework to be used in clever towns. With the usage of this framework, town residents can have their fitness constantly monitored and get feedback on their PD situation.[5]. Early PD signs and symptoms can, therefore, be detected and the proper remedy provided. In this framework, we use speech alerts from clients captured from diverse sensors and transmitted to the cloud for processing. Within the cloud, decisions are made about the usage of an assist vector device-based total classifier.[6]. decisions, together with the signal capabilities, are dispatched to registered medical doctors, who then prescribe positive medicines to the purchaser. Several experiments were performed, with the consequences demonstrating that the proposed framework can gain 97% accuracy in detecting PD.[6].

### **3. Preliminaries and methodology**

This section of the paper briefly describe the preliminary concept required to analyze the images and subsequent development of the DL model. The concept used to create the DL model and to analyze the images and classify them into two classes viz. Healthy and Parkinson are Convolutional Neural Networks

#### **3.1 Deep Learning (DL)**

Deep learning (DL) allows multi-layer processing computational models to recognize the pattern in the data with multiple levels of abstraction.[13]. The DL methods have greatly improved AI utilization and are extremely applied in the field of speech recognition, object recognition, facial recognition, and many other intricate domains. The DL algorithm recognizes the pattern among the different parameters of the dataset by using the backpropagation algorithm.[14]. CNN is a DL model that has brought about breakthroughs in processing images, video, speech, and audio.

In the study, the CNN model is applied to detect and categorize the drawing done by a person into two classes namely Healthy and Parkinson's. The categorization is done on the basis of the pixel values and based on the pixel value it will give the prediction to which class the image of the drawing belongs and the drawings taken as data are having two classes namely spiral and wave where the person draws wave and spiral drawings as shown in the figure below.

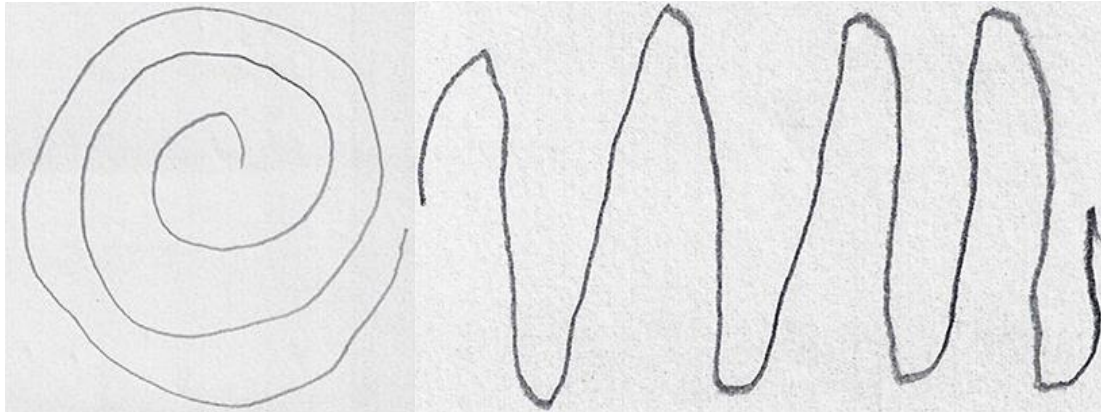


Fig 2: Spiral Drawing and Wave drawing

The CNN Model is trained separately on both datasets to understand the accuracy of the model for both drawings individually further CNN has two parts. The first part is training and the second part is testing. In the training part, the model is determined for all good values of weights and the bias from labeled examples. In the second part, the model formed during the training is tested for a sample dataset. The predicted label is then compared with the actual label to determine the accuracy and preciseness of the model created. The different operations involved in CNN prediction are as follows:

### 3.1.1 Convolution operation

The convolution operation of CNN is used to extract the features from the training images and exclude the irrelevant noises. The convolution operation divides an image into tiny and smaller fragments so that the features of the images could be easily extracted, and the irrelevant noises could be dropped down. This fragmented image is termed an image matrix ( $Im$ ). [14]. The layer containing the  $N$  filter matrix ( $Fi$ ) is slid over the image matrix throughout its width and height. Matrix multiplication of the image and filter matrix gives the resultant matrix ( $Re$ ) termed as convolution matrix. Mathematically,

$$Im \times Fi = Re \quad (1)$$

### 3.1.2 Activation operation

In neural networks, the activation operation of a node defines the output of that node for a given input or set of inputs. In this paper, a rectified linear unit (ReLU) is used as the activation operator. The ReLU is mathematically expressed as

$$y = 0, \text{ if } x < 0 \quad (2a)$$

$$y = x, \text{ if } x \geq 0 \quad (2b)$$

ReLU, compared to sigmoid function or similar activation functions, allow faster and effective training of deep neural architectures on large and complex datasets.[14].

### 3.1.3 Pooling operation

The pooling operation reduces the number of learning parameters and thereby the amount of computational work to be performed is reduced. This operation is useful to summarize the feature present in a region of the feature map generated by the convolution layer. Pooling operation in CNN is done mostly by average pooling and maximum pooling.[15]. In the Average Pooling operation, the average value for patches of a feature map, and uses to create a downsample. However, the major disadvantage of using average pooling is that if there is more

than one outlier it does not give an accurate result. This can be overcome with the use of maximum pooling where the maximum value for patches of a feature map is used. [15].

### 3.1.4 Layer stacking

In layer stacking operation, the convolution operation, activation, and pooling operation are repeated until the output obtained is a minimized matrix of the input image.

### 3.1.5 Fully connected layer

This is the last layer of a CNN model. This layer comprises neurons that are fully connected to the neurons from the previous layers. Therefore this layer is called a fully connected (FC) layer. This layer is responsible for classifying and predicting the output or label of the input class.

### 3.1.6 Classification and Prediction

Classification is the categorization, and each neuron of the FC layer is mapped with a label. The FC layer predicts the label of the input class that has a maximum number of features like the testing images. In this study, the SOFTMAX activation function is used to classify the label. The SOFTMAX activation function is used for predicting a multinomial probability distribution. The mathematical expression for the SOFTMAX activation function is

$$\sigma(z_i) = \frac{e^{z_i}}{\sum_{j=1}^K e^{z_j}} \quad (3)$$

## 3.2 Performance of the CNN model

The CNN model is built using the Keras and Tensorflow library which is coded in python 3.10 and runs on a 64-bit windows 11 system with 8 GB RAM and i5, 1.6GHz processor. The parameters of the CNN model are optimized using Adam optimizer. The Adam optimizer inherits the positive attributes of the “Gradient Descent with Momentum” and “Root Mean Square Propagation” algorithms. Figure 3 shows the model summary for both the wave drawings model and the spiral drawings model.

Layer (type)	Output Shape	Param #
conv2d_4 (Conv2D)	(None, 28, 28, 20)	1520
activation_8 (Activation)	(None, 28, 28, 20)	0
max_pooling2d_4 (MaxPooling2D)	(None, 14, 14, 20)	0
conv2d_5 (Conv2D)	(None, 14, 14, 50)	25050
activation_9 (Activation)	(None, 14, 14, 50)	0
max_pooling2d_5 (MaxPooling2D)	(None, 7, 7, 50)	0
flatten_2 (Flatten)	(None, 2450)	0
dense_4 (Dense)	(None, 500)	1225500
activation_10 (Activation)	(None, 500)	0
dense_5 (Dense)	(None, 2)	1002
activation_11 (Activation)	(None, 2)	0

Fig 3: Model Summary

The proposed CNN model is executed for 8 epochs with 3 steps per epoch and 1 validation step. The epoch that showed the least loss value is selected as the optimal model. The training accuracy and training loss graph obtained from the CNN model for detecting and classifying the spiral drawing into healthy and Parkinson is shown in figure 4.

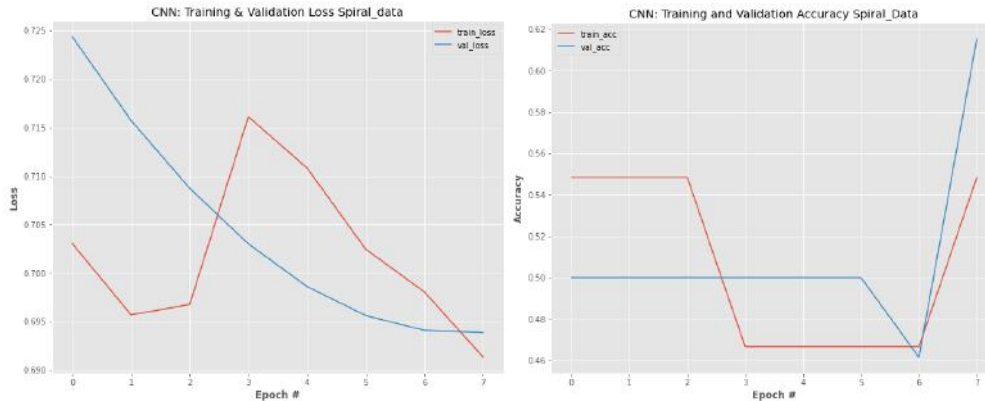


Fig 4.: accuracy and loss of the Spiral drawing Model

The training accuracy and loss computed for the 1st epoch of the spiral drawing CNN model is 0.5036 and 0.7006 respectively. However, the training accuracy and loss values computed for the 8th epoch is 0.6166 and 0.6989 respectively.

The training accuracy and training loss graph obtained from the CNN model for detecting and classifying the wave drawing into healthy and Parkinson's is shown in figure 5.



Fig 5.: accuracy and loss of the wave drawing Model

The training accuracy and loss computed for the 1st epoch of the Wave drawing CNN model is 0.45 and 0.69 respectively. However, the training accuracy and loss values computed for the 8th epoch are 0.56 and 0.68 respectively.

#### 4. Conclusion

In this study, we trained and evaluated a Deep Learning based CNN and conducted a reader study. In summary, the presented CNN has the potential for smart detection of Parkinson's disease by viewing the drawing made by

a person which can be either spiral or wave if the accuracy for both the models is compared then the spiral model shows better accuracy. CNN makes the diagnosis of Parkinson's disease quite easy and user-friendly, which is an advantage over other techniques to diagnose Parkinson's. As there is still a scope for better accuracy, in future work it has to be investigated if it is sufficient to train with a larger dataset, or if an auxiliary CNN is needed to identify misclassified cases and react correspondingly. With advances in the healthcare industry, and AI world information about data may also be available in the form that a machine can read soon. Such information, stored in patient records, may be used to update CNN's decision. Furthermore, to enhance classification performance, we plan to collect and annotate more data contributing to enhanced training and improving the accuracy of both the CNN Models.

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