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Parkinson's Disease Detection Using Deep Learning

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Abstract

Parkinson Disease(PD) is a long term neurological disorder. Dopamine is a monoamine neurotransmitter. It performs communication messages between nervous cells in the brain. Person with Parkinson's has low levels of Dopamine so the communication message between cells is tough. Person with Parkinson disease has one symptom of tremor which is hand shaking. We consider the dataset Spiral and Wave images drawn by healthy and Parkinson's people. So, the subject with Parkinson's disorder will have a tough task to draw these diagrams. As this is an image Dataset we are Using two models one is Convolutional Neural Network and Other is Densenet 201. These models will examine the drawing style of spiral and wave drawings. Hence our Project motive is to detect whether a Person has Parkinson Disease or not.

Keywords: CNN, DenseNet201, Deep Learning, Hand Writing Impairment, Parkinson Disease Detection.

1. Introduction

Person with Parkinson's has low levels of Dopamine so the communication message between cells is tough. Person with Parkinson disease has one symptom of the symptom tremor which is hand shaking. We consider the dataset Spiral and Wave images sketched by healthy and Parkinson's people. So the Person with Parkinson disorder will have a tough task to draw these diagrams. As this is an image Dataset we are Using two models one is Convolutional Neural Network and Other is Densenet 201. These models will examine the drawing style of spiral and wave drawings. Hence our Project motive is to detect whether a Person has Parkinson Disease or not.

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2. Literature Survey

"Parkinson’s Disease Diagnosis Based on Spiral Analysis Using Machine Learning" by T. A. Fernandes et al. (2017) [1] In this study, a spiral analysis-based model for Parkinson's disease identification is proposed. The spiral drawings are divided into healthy and Parkinsonian categories by the authors using an SVM radial basis function kernel. With this strategy, they obtain an accuracy of 87.5%.

The paper "A Comparative Analysis of Speech Signal Processing Algorithms for Parkinson's Disease Classification and the Use of the Tunable Q-Factor Wavelet Transform" by M. P. Nolan et al. (2018) [2]reports an overall classification accuracy of 86.67% for the proposed tunable Q-factor wavelet transform (TQWT)-based approach on a dataset of speech signals recorded from healthy people and people with Parkinson's disease. The TQWT-based approach outperforms other algorithms such as linear predictive coding, and perceptual linear prediction in terms of classification accuracy.

"Parkinson's disease detection from spiral and wave Drawing through convolutional neural networks : A Multistage Classifier Approach" by Sabyasachi Chakraborty et al. (2020)[3]

This paper proposes a multistage classifier approach. Authors used Spiral and Wave hand written image. The Spiral and wave drawings are examined by CNN which is first stage classification. The Output of the Convolutional NN model is assessed by Random Forest and Logistic Regression models. These models are used as meta classifiers. They obtain accuracy of 93.3%

"Tremor assessment using spiral analysis in time-frequency domain" by Decho Surangrirat al. (2013) [4].This paper examines the tremor analysis using spiral analysis in real time. The authors have developed an android application where a person is asked to draw a spiral on the template in that application with dominant and non-dominant hand.

"Parkinson’s Disease Diagnosis Using Machine Learning and Voice" by Timothy J. Wroge et al. (2018) [5].This research article is about identification of PD using DNN. Voice(Features extracted) Dataset is used as the classification tool. The data is gathered through audio recording from each participant for 10 seconds. They have applied DNN to diagnose the disease. They acquire an accuracy of 85%.

"Parkinson's Disease Diagnosis Using a Combination of Wavelet Transform and SVM" by M. Elazab et al. (2019) [6].This paper proposes a mixed method of wavelet transform and SVM for identifying Parkinson's disease using spiral drawings. The authors use discrete wavelet

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transform (DWT) to decompose the spiral drawings into frequency subbands and extract features from each subband. They achieve an accuracy of 94.7% using this approach.

"Detection of Parkinson's Disease Using Magnetic Resonance Imaging Based on Deep Convolutional Neural Networks," by X. Jia et al. (2021) [7]. The paper proposes a detection approach using deep CNN with MRI images. The proposed approach achieved an accuracy of 94.86%.

3. Problem Identification

The recent report of the World Health Organization shows a visible increase in figures of PD patients growing exponentially. In China, the (PD)disease is spreading so fast and estimated that it will reach half of the population in the next 10 years. It is caused mainly by the breaking down of cells in the nervous system. Parkinson’s can have both (movement) and non-mobility signs. The signs of the motor system include stiffness, rigidity, balance problems, and tremors.

If this disease continues, the patients may have difficulty walking and talking. The non-motor symptoms include anxiety, breathing problems, depression, loss of smell, and change in speech. This can hardly be treated in its starting stages with the right medication. For the benefit of the patients, it is necessary to identify PD at an initial stage. Here we consider the images dataset and this data is used for knowing if the patient has PD or not.By using deep learning algorithms we can solve this problem.

4. Proposed Methodology

By reviewing previous research work concluded that deep learning models succeeded in extracting the features. The given solution says two different convolutional neural networks (CNN), for analysing the drawing patterns. Similarly for DenseNet201.So, in order to know persons suffering with parkinson or not, this framework contains developed model CNNand DenseNet201. The proposed system is developed with five stages which include Data collection, Data Augmentation ,pre-processing, Training and Testing. Loading the data to models and finally selecting the best model for detection.

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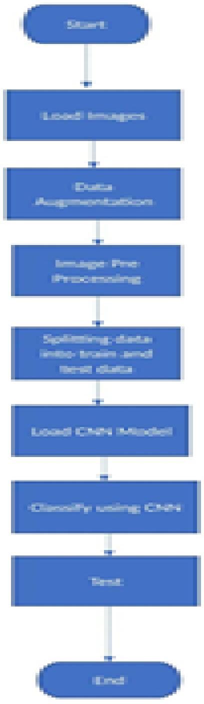

Fig 1: Flow chart of CNN

By our given solution we will classify the given set of data into binary classification that determines if the person is diagnosed with PD or not PD group people. The model which gets higher accuracy will be used for detecting PD.

For our dataset it is important to augment the images so that the size is increased and gives a large database for the detection. Below one is Densenet201.

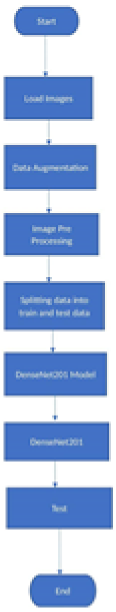

Fig 2: Chart of DenseNet201 model

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4.1 Data Collection

The data gathered from Kaggle data repository, which shared with the public by Zham P [8]. The RMIT University in Melbourne, Australia, handled the data collection process. A total of 55 individuals were assembled to participate in the process of collecting data including 27 from the Parkinson Group and 28 from the Non PD group. The researchers used different tests to assess each participant. They used a commercially available tablet to draw the spiral images, placing a sheet of paper on top and using an ink pen to draw. They also used the same process to draw the wave images. They obtained a selection of photos during the data gathering procedure are shown in below Figures.

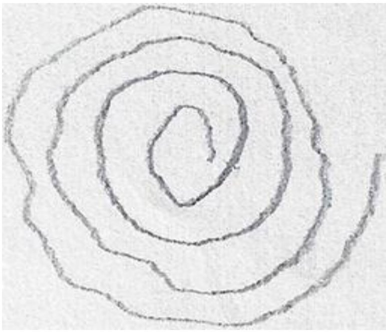

Fig3 : Spiral image of PD person

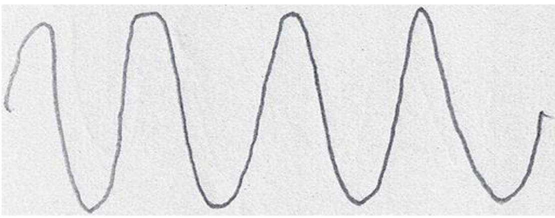

Fig 4: Spiral image of Non PD person

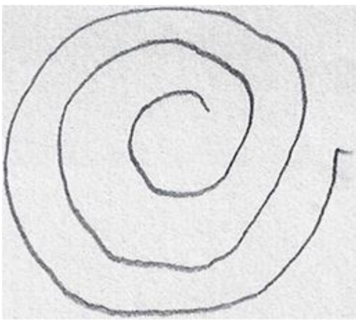

Fig 5: Spiral image of Non PD person

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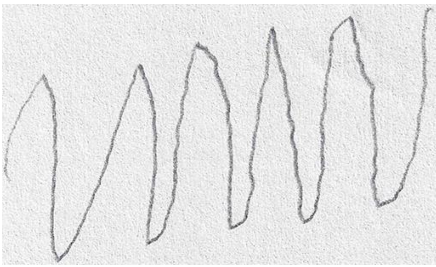

Fig 6: Wave image of PD person

4.2 Data Augmentation

The images are Augmented so that the data will be increased. All of the pictures were given to static policy-based augmentation in order to prepare them for training.(True-T)

Parameters used	Values
Flip horizontally	T
Flip vertically	T
Shift Range-Width	0.1
Shift Range-Height	0.1
Brightness	(0.5,1.5)
Rotation	60
Zoom	0.1

TABLE 1. PARAMETERS FOR DATA AUGMENTATION SPIRAL IMAGES

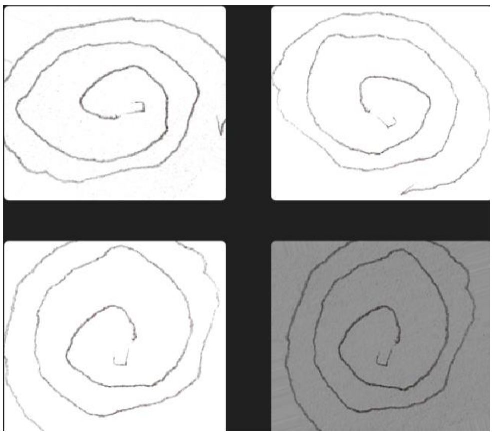

Fig 7: Comparison of Augmented images

Parameters used	Values
Flip horizontally	T
Flip vertically	T
Shift Range-width	0.1

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Shift Range-height	0.1
Brightness	(0.3,1.8)
Rotation	5
Shear	0.1
Zoom	0.2

TABLE 2. PARAMETERS FOR DATA AUGMENTATION WAVE IMAGES

The dataset has a relatively small collection of images, making it challenging to apply deep learning algorithms like CNN's. Thus, picture augmentations were carried out to add replica images to the original images as well as to broaden its divergence. The data Augmentation is done by following the below parameters. Image data generator is used from keras for the augmentation of images. As per the specified parameters the duplicates for the images given are produced and by using openCV they are stored.

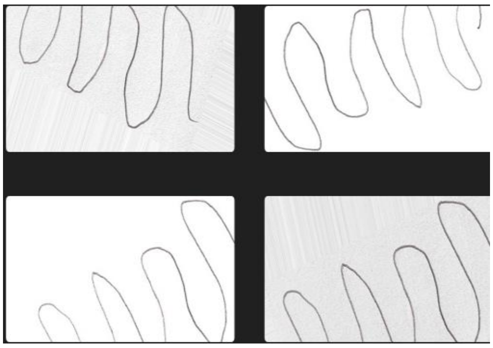

Fig 8: Comparison of Augmented images

4.3 Data Preprocessing

The augmented data is subjected to resize and reshape. Initially the data of spiral images are of 256,256,3 they are resized to 128,128,1.The wave images are 265,512,3 to 128,128,1.The images are resized so that the computational efficiency, memory efficiency, consistency are increased and images are standardized.

5. Implementation

The implementation is done by using the models DenseNet201 and CNN. Here, a model is made to analyse the images of spirals drawings and waves drawings from people suffering from PD and normal individuals. The both models we developed trained by the dataset prepared. The model that gets high accuracy is used for the detection of disease.

5.1 DenseNet201

Densenet201 is a very deep neural network that consists of 201 layers. It has a densely connected architecture, which means that each layer is connected to other layer in a dense block. This enables feature reuse and encourages the movement of gradients throughout the network.

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The model uses convolutional layers with small 3x3 filters, and it includes a bottleneck layer with 1x1 convolutions to decrease the number of input channels. It also includes a transition layer with 1x1 convolutions and 2x2 average pooling to decrease the spatial dimensions of the feature maps.

Input Layer:

The image is given in RGB format of 224x224 pixels.

Convolutional Layer:

The input image is given through a convolutional layer with 7x7 filters and a stride equals 2, which reduces the spatial resolution of the input image and extracts low-level features.

Pooling Layer:

The obtained value of the before layer given through the 3x3 max-pooling layer of stride equals 2, which further reduces the resolution of the feature maps.

Dense Blocks:

The Densenet201 model consists of four dense blocks, each consisting of several convolutional layers with 3x3 filters. Each dense block is densely connected, meaning that every layer is connected to every other layer within the block.

Transition Layers:

Between the dense blocks, there are transition layers that consist of a 1x1 convolutional layer followed by a 2x2 average-pooling layer. The purpose of these transition layers is to decrease the number of feature maps and the resolution of the extracted features.

Global Pooling Layer:

The result is then processed via a global average pooling layer, that average the image features across the spatial dimensions, after the last dense block.

Fully Connected Layer:

After passing with a softmax activation function to get the final classification probabilities for the given input, the output of the global pooling layer is final output.

5.2 CNN(Convolutional Neural Network)

A Convolutional Neural Network (CNN) is a type of neural network (NN) that can take an image data as input and differentiate between different objects or features in the image. Compared to other classification methods, CNNs require less pre-processing of data. The architecture of CNN consists of the following layers.

Convolution Layer:

By applying a set of filters on the image input data, this layer learns features from smaller sections of the image.

Max Pooling:

During input processing, the pixel with the highest value is chosen and given to the output.

Fully Connected Layer (Dense):

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The Dense layer, located near the end of Network, is capable of identifying features that are highly relevant to the output class. It produces a one-dimensional vector by flattening the results obtained from the pooling layer.

Dropout Layer:

This technique is utilized to address the issue of model overfitting by randomly eliminating a subset of neurons within a layer, which is typically linked to the Dense layer.

SoftMax Layer:

The last layer of the network aids in categorizing individual input image data from the dataset into multiple classes.

Output Layer:

The ultimate classification outcome is held by the output layer. The below figure 9 shows the working of CNN

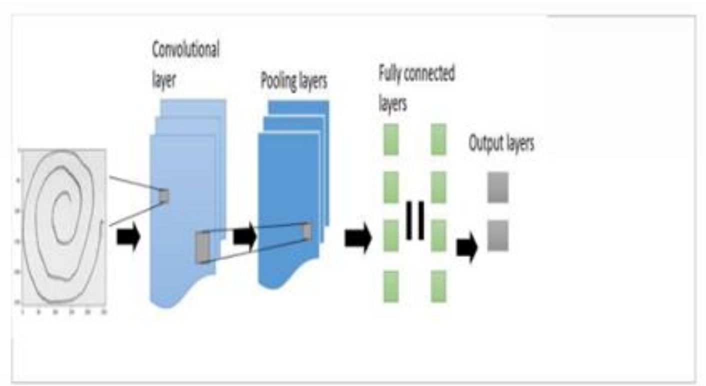

Fig 10:CNN Architecture to classify PD

6. Results and Conclusion:

Several experiments were carried out by dividing the complete dataset into varying ratios of training(80) and testing(20) sets. The proposed CNN model, which was the best among the two models evaluated, exhibited a classification accuracy of 83% and 84% for spiral and wave images respectively whereas Densnet201 obtained accuracy 73% and 73% for spiral and wave images respectively. The below graph shows the accuracy and loss for wave images.

Fig 11: DenseNet201Training Accuracy and Loss for Spiral images

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The accuracy is compared for both spiral and wave images. These are the results and these are calculated by using metrics.

For our dataset CNN model is more feasible than compared to other Deep Learning models.

Fig 12: DenseNet201 Training Accuracy and Loss for Wave images

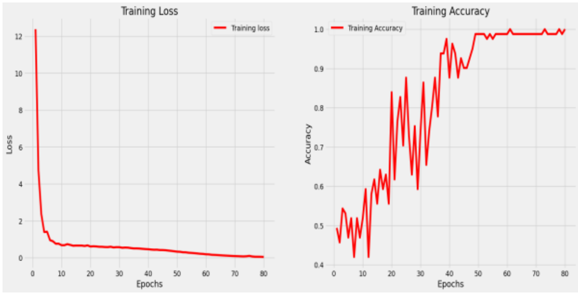

Fig 13:CNN Training Accuracy and loss for Wave images

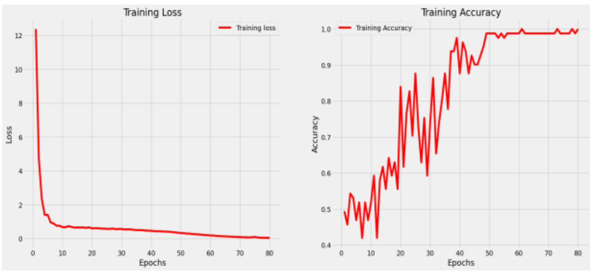

Fig 14:CNN Training Accuracy and loss for Spiral images

Above Figures show the training accuracy of the DenseNet201 and below graphs show the training accuracy of CNN models.

Below Figure 15 shows the Confusion Matrix of CNN .

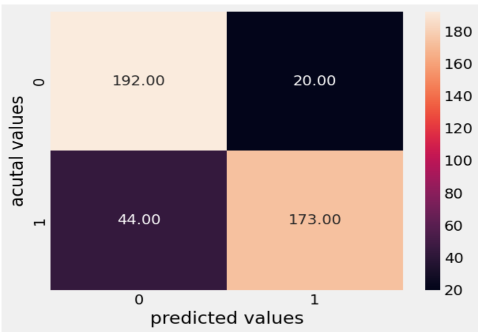

Fig 15: Confusion Matrix for CNN

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