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Parkinson's Disease Handwriting Detection Using FCNN

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Parkinson's Disease Handwriting Detection using Fully Convolutional Neural Network

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Abstract Detection of Hypo-kinetic Rigid Syndrome handwriting patterns is productive for the diagnosis of Hypo-kinetic Rigid Syndrome. Nowadays, a little computer-aided method based on computer vision points out the Hypo-kinetic Rigid Syndrome handwriting. This paper proposed a computer vision-based recognition system to recognize the handwriting patterns of Hypo-kinetic Rigid Syndrome. We trained a fully convolutional neural network to classify the high-resolution images in the NITS of the Federal University of Uberlândia training set into two different classes. Our fully convolutional neural network is simple, accurate, efficient, and works on challenging computer vision tasks. The result of the analysis of the primary objectives is to classify between normal patient and Parkinson's disease patient is done very effectively than previous research. Numerical information about the above analysis, such as in terms of accuracy, recall, precision & F1 score is done completely. Our suggested system can detect Parkinson's patients with an accuracy of 92.43%. Our study found that the Fully Convolutional Neural Network is more effective than other methods on all outcome measures to detect Parkinson's Disease. A likely explanation is that the proposed system used a different type of deep learning approach, which increases the accuracy.

Key words: Handwriting analysis . Parkinson's Disease . Computer Vision . Fully Convolutional Neural Network

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1 Introduction

Parkinson's disease, also known as hypokinetic stiff syndrome, is a long-term degenerative disorder that primarily affects the motor neurons of the central nervous system. Non-motor symptoms become more prevalent as the condition progresses [1]. The most noticeable symptoms early on in the illness are shaking, stiffness, and trouble walking. Problems with thinking and conduct are also possible. Sensory and emotional issues are also common complaints. Parkinson's disease is a movement illness that affects the nerve system. With the recent growth of various diseases including Parkinson's problems, they often need so much time to diagnose. Sometimes, extreme disease problems may lead to cancer [2]. But, there are many situations where novice can't identify the real problem [3]. Hence, a computerized diagnose system [4] will help the novice doctor to diagnose and gain experience in a shorter period and specialists can diagnose the problems correctly in time. There is also increased risk in people who have had prior healing injuries, while there is a reduced risk in tobacco smokers & those who drinks coffee or tea .
Doctors were trying to cure this disease in recent decades. But with the growth of doctors, people suffering from Parkinson's problems have increased. In 2030, there will be 6.2 M people affected by PD, which caused about 117,400 deaths in the world [5].Parkinson's medical specialists have to treat a lot of patients every day. A lot of pictures are taken daily because it is an important diagnostic tool for Parkinson's patients. Taking an image of PD patients depends on the doctors, for that it can cause misdiagnosis to depend on personal factors. Personal factors such as tire, sentiment, and little expertise [6]. The effort commitment of doctors and the occurrences of misdiagnosis may be reduced if intelligent Parkinson's disease diagnostic systems are developed to improve the quality for detecting the Parkinson's affected people. From this perspective, automatic detection in Parkinson's Disease systems [7] is one of the important tasks for smart health care. Parkinson's disease has no established origin, however it is thought to be caused by a combination of hereditary and environmental factors. Many individuals, from teenagers to adults [8] suffer from this disease which leads to severe pain for a lifetime and even to converting cancer. Those who have a family member who has the condition are more prone to get it. So far, for Hypokinetic Rigid Syndrome, several image segmentation and classification techniques such as level set method, morphological image processing [9], machine learning (ML) based classification [10] have been improved. But they could not achieve any significant results. The key contributions to this work is, we use the FCNN model to check and verify parkinson affected patients to the utmost accuracy with image processing technique. In this paper, we develop image processing based model to detect PD early since there is still no fixed valid tests for the detection of Parkinson Disease. The new model leverages a Deep Learning Fully Convolutional Neural Network approach features to facilitate frequent and higher probability of Parkinson predictions (e.g.: accuracy) over affected patients.

2 Background Studies

Iqra Kamran et al. [11] use dynamic assessment for handwriting detection using deep learning technique. They combined different types of datasets. They suggested an image analysis system that first takes an image of a Hypokinetic Rigid Syndrome patient [12] and then analyzes it using computer vision and digital image processing. This system is divided into three sub-parts. Those are (1) image preprocessing, (2) model training, (3) patient detection.
Moises Diaz et al. [13] proposed a computer vision-based Hypokinetic Rigid Syndrome patient's handwriting-based analysis system. Their system use image for classifying the Hypokinetic Rigid Syndrome patient from normal people. This process can be done during the time of extracting the image or after the process is being complete because it is mainly based on the patient's handwriting features.
Pereira et al. [14] suggested an automatic system that detects Hypokinetic Rigid Syndrome patients by handwriting analysis. Their system is divided into two subparts. The first one is the medical image processing of Hypokinetic Rigid Syndrome patients and the second one is feature extraction from the digital image. From spiral template (ST) the proposed system extracts the handwritten trace (HT) because the images are not linked between them [15]. The system takes handwriting and measures some individual points in the spiral center which is shown in Fig 1.

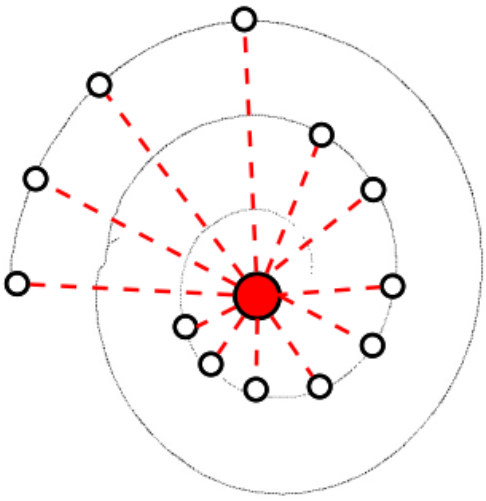

Fig. 1: The connection between the spiral's center point is represented by Some random points and the straight lines

Image segmentation of the medical image such as Hypokinetic Rigid Syndrome is important cause digital image processing and pattern recognition process are both used in the area. If we use a deep learning model such as CNN or FCNN in the medical area such as skin cancer, phthisis, or high blood glucose levels of people [16], we will get a better result. Hypokinetic Rigid Syndrome accelerates with time. So far, for Hypokinetic Rigid Syndrome, several image segmentation and classification techniques such as level set method, morphological image processing, machine learning (ML) based classification methods have been improved. But they could not achieve any significant results. Recently, one condition of AI and ANN that is called Fully convolutional neural networks (FCNNs)-has given a better result in the computer vision field containing tracking, object recognition, three-dimensional mapping, facial recognition, and activity recognition. PD is divided into five different phases [17] that are given below:

1. **Phases I:** Just a little handshaking in the time of handwriting or walking is seen in this stage. Symptoms will be seen on only one side of the body. Daily life will not be challenging at this stage.
2. **Phases II:** Symptoms will be seen on both sides of the body. Patients may not be able to do daily tasks.
3. **Phases III:** Patients keep losing balance at the time of the walk. They need someone to help to perform various tasks. A patient cannot live alone.
4. **Phases IV:** The patient can not do any daily work. They need the help of others.
5. **Phases V:** In this stage, the patient cannot walk or run. For that, they have to use a wheelchair. They could experience hallucinations.

3 Proposed Methodology

In this paper, a new model has been proposed for the detection of Hypokinetic Rigid Syndrome using different types of deep learning approach. This model is consists of a Fully Convolutional Neural Network (FCNN). Image pre-processing is done to improve the features of the image dataset. Image segmentation can usually be used for object detection, pattern recognition, acquiring relevant information from the image. Then, we have extracted features from two individual data set of Parkinson's Disease.

Deep neural network takes different types of features from training images. Later, we pass it to the convolutional network which is more efficient to classify the images with more accuracy. Hidden layers of a Fully Convolutional Neural Network (FCNN) mean adding more neurons in the middle of the input and output layers. Here, we design an FCNN so that the network can train from the difference between the expected output and actual output and then forward a signal back to the weights and propose the weights to adjust themselves.

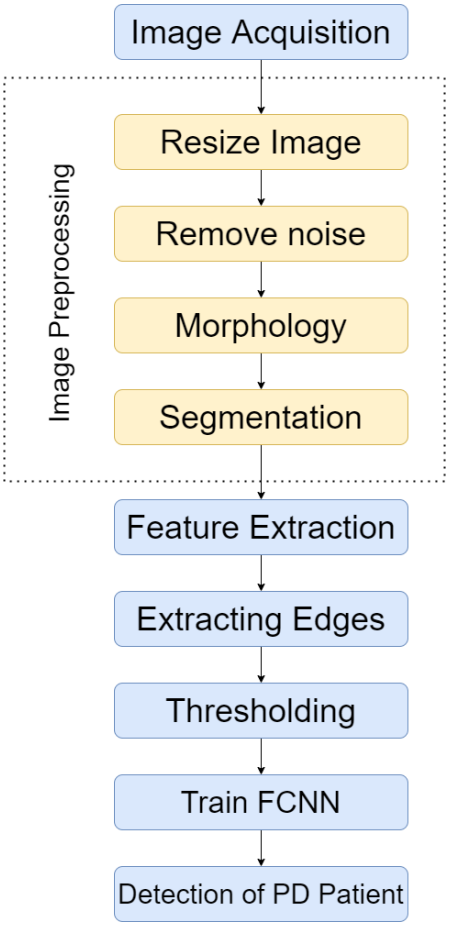

Fig. 2: Proposed Methodology

3.1 Image Acquisition

This is the very beginning level for detecting Parkinson's disease with the Spiral/Wave Test. A dataset is an assembly of group data that can be gained one by one organized as a unit. The proposed model is trained with a dataset for supervised classification using a deep learning algorithm. The dataset used here curated by Adriano de Oliveira Andrade and Joao Paulo Folado from the NIATS of Federal University of Uberlandia..Segment of dataset is appeared in Fig 3 given below:

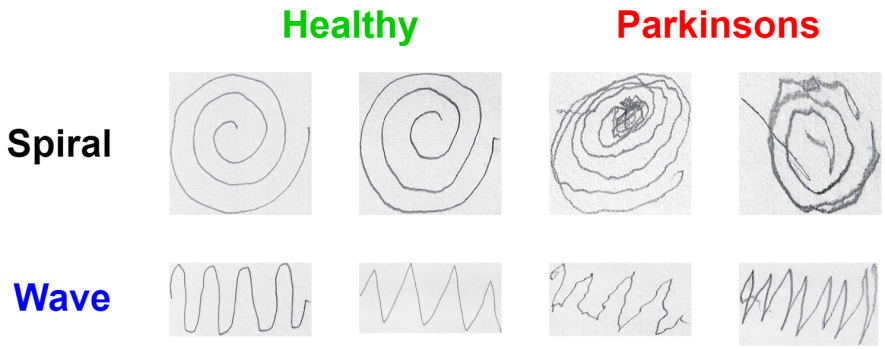

Fig. 3: Segment of Dataset

3.2 Image Pre-processing

The main reason for Image Preprocessing in fully convolutional neural networks (FCNN) is to find features from training images of the FCNN method. Generally, real-world data is mixed with so many errors. Sometimes human error or sometimes machine error. Image preprocessing makes the raw image for further processing. In that case, we have investigated the image resize and 192×192 for image preprocessing. Additionally, an observation's feature values will be merged as they proceed through single units.

3.2.1 Resize Image

FCNN's are a kind of neural community which builds regularly higher-stage capabilities out of companies of pixels typically located withinside the photos. Progressive resizing is a method for constructing FCNNs that may be green for schooling the CNN. It also can lessen the stages of a deep mastering algorithm. Properly tuned gradient descent certainly favors sturdy results, well-supported capabilities in its decision-making. In the photograph category for Perkinson's disorder case, this interprets into capabilities occupying as many pixels in a few of the pattern photos as possible. One of the processed images is shown in Fig 4.

3.2.2 Remove noise

A raw input image can be filled with garbage or noisy data. We need to remove this noise from the input image. For this, we use the Gaussian Blur (GB) algorithm. If we use this algorithm then every image has to go through the Gaussian function. It has a huge effect on computer vision or digital image processing. Generally, this algorithm removes image noise. This algorithm works on visual effects. It removes

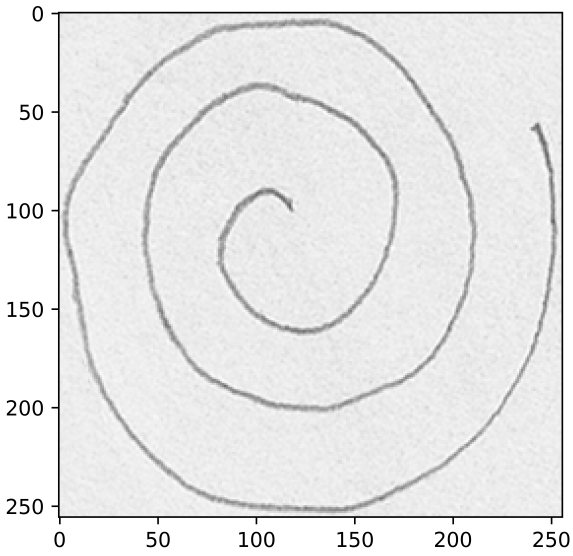

Fig. 4: Resizing Image

the blur resembling the input image. This blur can be seen by a translucent screen. It is different from the Bokeh Effect (BE). Generally, BE works on natural illumination. This BE algorithm is based on the shadow produced by the out of focus length. Her GB or BE is used as one of the effective image processing steps. It strengthens image structures in different ways in digital image processing or computer vision.

3.2.3 Morphology

After gaining an image from the previous step, we need to structure the features of the raw image. For this, we need morphological image processing instructions. It will not work with the numeric pixel value. This process depends on the nearest pixel value of a specific pixel in an image. In this step, the input image must convert into a binary image. This step can be used in a grey-scale or black-white image. In this kind of image, the pixel value of lighting is unknown. Here the pixel values of an image can be ignored. The image morphological process dissects an image into some smaller part known as pixels. This algorithm mainly targets the nearest pixel of the specific pixels. It also ignored specific pixel values. Some pixels can be "fits" with the nearest and the others will be "hits" with the nearest. The main target of this process is the non zero values in a binary image when the algorithm works properly. It is the last step of image pre-processing step in this dissertation. After that the input image is send in the main system of the suggested methodology.

3.3 Segmentation

The image segmentation technique is like the dissection of an image that divides an image into multiple subparts. It usually used for object detection, acquiring relevant information from an image, etc. Image segmentation can be done using various types of algorithms such as the thresholding method like the Otsus method, Color-based segmentation such as K-means clustering, modify algorithms such as watershed segmentation, consistency algorithm for the roughness filters. Now more recently neural network approaches also work significantly in this field, Deep learning has brought this one step ahead.

3.4 Feature Extraction

One of the most important steps of this research is to extract features from images in computer vision or image processing process. Whenever an input image is given, the proposed system creates a standard outline. This standard outline is gained before the feature extraction step from the raw input image. In the standard outline, the proposed system extract some features. The suggested Hypokinetic Rigid Syndrome patient's handwriting detection technique depends on a neural network that gained features from images. The system must find important features to sent it into the FCNN. The input image can't use in the FCNN because this image will be noisy.

3.4.1 Extracting Edges

Edge detection consists of different types of statistical functions that design to examine the pixel value of a test image at which the image illumination transforms clearly. Pixel values where image illumination is transformed completely into edges. Edges obtained from a multidimensional image of a cube-shaped image can be allocated for either vantage point reliant or vantage point self-reliance. A vantage point self-reliant margin generally emulates the fundamental attributes of the cube-shaped objects. A perspective reliant margin changes as the perspective changes, which changes the shape of the image. The border between a block of white and a block of black, for example, is an example of a typical edge. A line, on the other hand, can be a few pixels of a distinguishing hue on an otherwise endless backdrop. One of the edge detection applied on an image from dataset is shown in Fig 5.

3.4.2 Thresholding

Thresholding is a straightforward way of subdividing pictures. From a black-white image, thresholding is always used to convert the original image into binary images. Thresholding is a technique this is used to label the pixel price into unique lessons

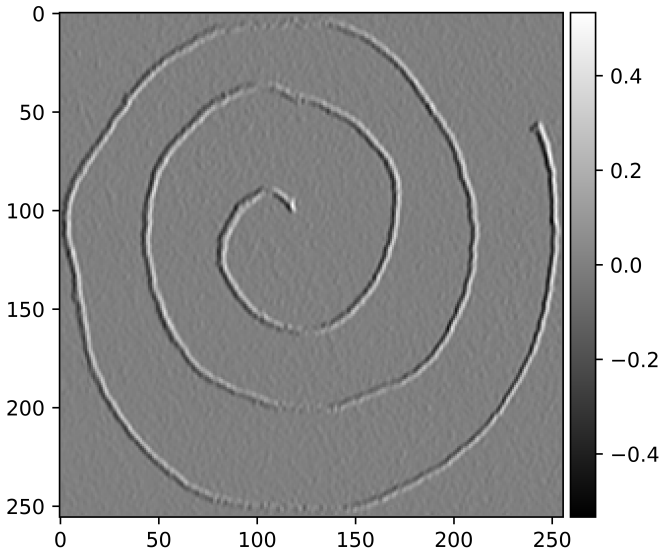

Fig. 5: Extracting edges from image

particularly foreground or history. In the Thresholding technique, we set a threshold price, and with each pixel price decrease the edge price is grouped in a single organization and pixel price is extra than the edge price is assessed in every other organization. The call of the magnificence is commonly termed as foreground with the price set to be 1 and history with the price set to be zero which paperwork the binary picture. We use computerized thresholding on these studies which is a superb manner to benefit beneficial traits encoded into pixels from entered picture at the same time as decreasing history noise. This assignment is carried out through the usage of a repercussion loop to optimize the edge price earlier than changing the schooling grayscale picture to binary.

3.5 Train Fully Convolutional Neural Network

A two-step procedure is used to train neural networks: The forward propagation stage calculates the different activation values by passing the training data down the network; the back propagation step reverses the process and changes the trainable parameters. In earlier sections, the forward pass was discussed. We'll look at how backward propagation works and the optimization strategy that was employed for this project. A section on batch-normalization is also included.

3.5.1 Backpropagation and optimization method

Gradient descent has historically been used to train fully connected neural networks. In order to minimize the cost function, this calculates the gradient of the cost function with respect to the current values of the parameters and updates the parameters in the opposite direction as the gradient. Using the chain rule, parameters are changed in order from the last to the first layer:

$$W = W - \alpha \frac{\partial \mathscr{J}}{\partial W} \tag{1}$$

$$b = b - \alpha \frac{\partial \mathscr{J}}{\partial b} \tag{2}$$

The pace of learning The hyper-parameter α determines how much the parameter is changed in the opposite direction of the gradient. If α is too tiny, it will take several iterations for the network to converge. If α is set too high, however, learning may overshoot and even diverge. The software of a completely linked neural community gradient descent set of rules wherein all of the education records are first processed earlier than any replace of the parameters is probably now no longer efficient. This is due to the fact one most effective wishes a great estimate of the gradient, which won't require the complete dataset.

3.5.2 Batch normalization

Batch normalization is a technique for speeding up learning by normalizing network activations. Batch normalization's major promise is that it reduces "covariate lag," in which each level strives to minimize its own contribution to the cost of its own inputs. However, the distribution of these inputs varies as learning continues. As each layer tries to learn an input-output mapping as its inputs change, this might slow down training. Normalization aids the function's learning of the right mapping by stabilizing the so-called passing of variables from batch to batch.

3.6 Classification

Classification is a set of categories a new perception belongs to a training data set containing experience whose classification is known. A category version tries to attract a few consequences from skilled values. Given one or greater inputs, a category machine will try and are expecting the fee of 1 or greater consequences. Outcomes are tags that may be implemented to a dataset.

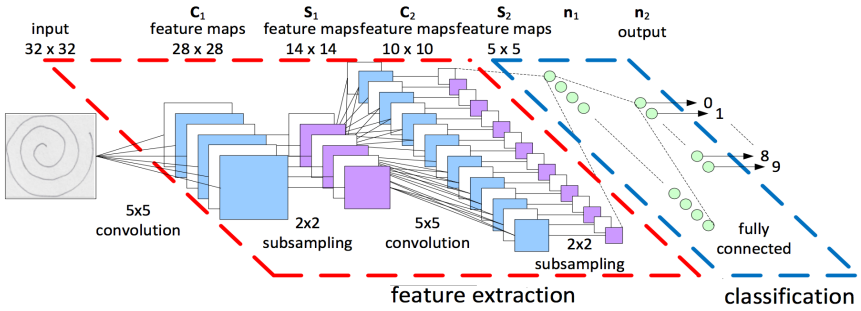

Fig. 6: Proposed Fully Convolutional Neural Network (FCNN) for Classifying Pattern

3.6.1 Input layer

The input layer, additionally referred to as a dense layer, is the principle thing of conventional neural community architectures, such withinside the Multilayer Perception illustrated in Figure 6. As defined above, it connects all of the inputs of a layer to every of its neurons with the aid of using making use of the linear aggregate accompanied with the aid of using the activation function. The wide variety of trainable contentions of this accretion relies upon at the wide variety of devices and the scale of the enter to this accretion.

3.6.2 Convolutional layer

Convolutional layers of an FCNN system were suggested to limit the number of neurons or layers for their better accuracy in characteristics (structural dimension) in the training dataset. It uses a convolution filter from the result of the previous layers of the neuron. Later, it leads to a single layer where output is calculated by the activation function. Here, the systems finally give the output of a single neuron. FCNN is a bit different neural network. At first, the layers of the neural network are organized in 3 dimensions: diameter, altitude, and chasm. After that, the neurons in the FCNN system of one layer do not connect to all the neurons in the next layer. They are connected only in a little number of neurons of the next layer, which is described in Fig 6.

3.6.3 Output layer

A previously unseen Perkinson Disease image can be classified by filtering it in a feed-forward layer in the network. The output of the last convolutional layer, after softmax, consists of the possibility of classification for background and foreground.

The pixel having a higher probability (> 0.5) to belong to the foreground than to the background.

4 Simulations and Results

This section demonstrates the simulation and results of the suggested classification system. It also shows the performance relative to existing works using the FCNN classifier. Fully connected networks tend to memorize training data entirely given enough time. Training an FCNN to "convergence" is not really a meaningful criterion because the FCNN will always keep training until it gets the specific result.
At the very beginning, we give an input image into the FCNN system that convolves, pool, flatten, and then passes through the ANN. In the end, the FCNN gives an output or prediction. After that, the FCNN network gives an output over the prediction that PD patients' handwriting image by a probability of 75%, yet the image actually of a healthy patient. An error needs to be calculated in this case.
The performance matrices of the final classification results for spiral test are shown in Fig. 7 and wave test are shown in Fig. 8 based on FCNN.

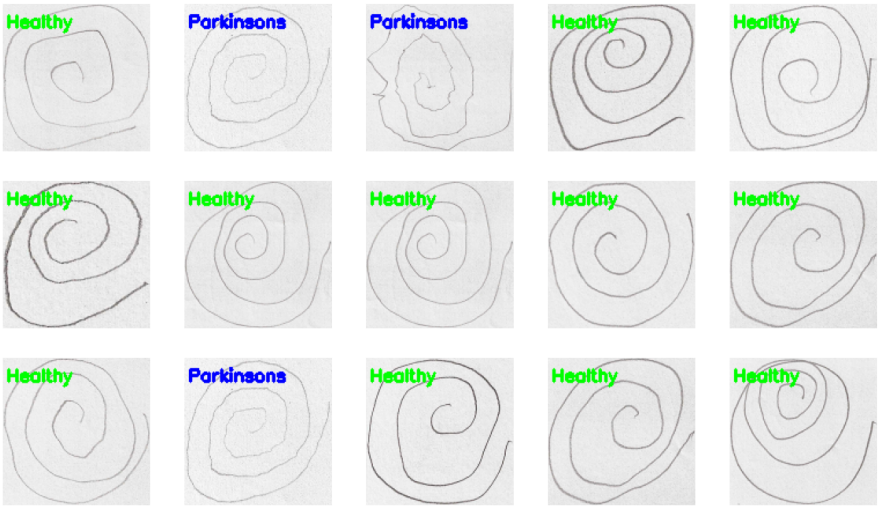

Fig. 7: Spiral test detection

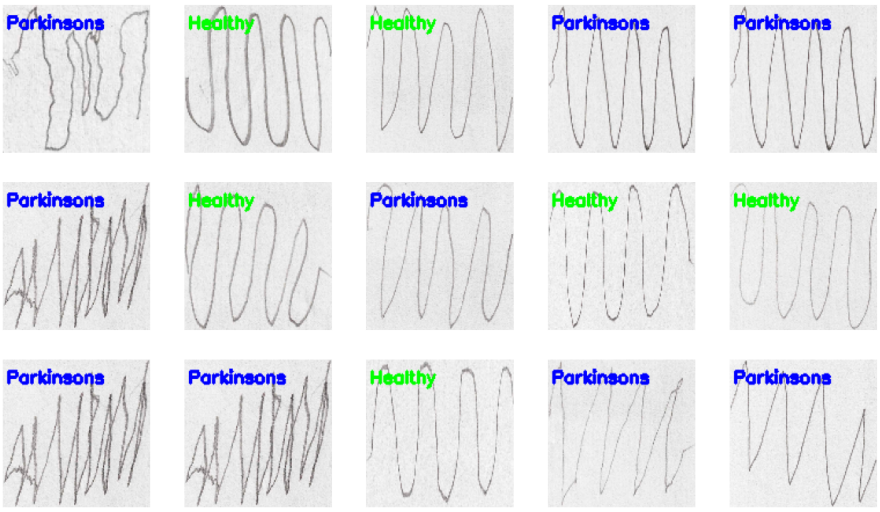

Fig. 8: Wave test detection

The result shows that the proposed methodology can find out 92.43% accurate PD patients with an inaccuracy of 7.57%. The results comparing the proposed method with three others are shown in Table. 1. It shows that the precision and inaccuracy of FCNN is better than the earlier results.

		ANN	CNN [7]	Our Study (FCNN)
	Accuracy (%)	75.8	78.9	92.43
3*Spiral	F-score	0.38	0.23	0.64
	Precision	0.24	0.25	0.57
	Recall	0.89	0.24	0.43
3*Wave	F-score	0.47	0.81	0.62
	Precision	0.94	0.82	0.51
	Recall	0.36	0.83	0.39

Table 1: Trial results for different types of method

The analogy of the proposed technique with three others methods are shown in Fig. 9. It indicates that the accuracy and percentage of error of FCNN (that achieved 92.43% and 7.57%) is preferable to the other technique.

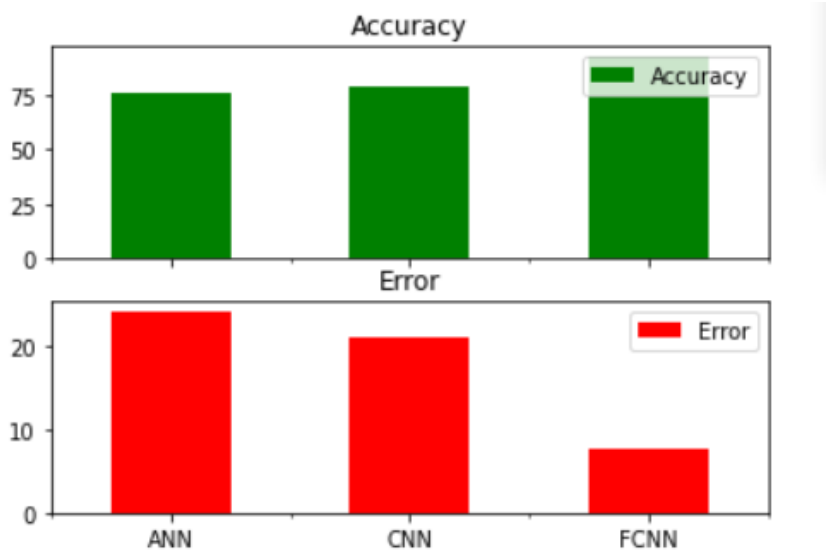

Fig. 9: Comparision Graph

5 Conclusion

Hypokinetic rigid syndrome or PD is a type of widespread illness that affects millions of humans every year. Males are extra regularly affected than girls at a ratio of around 3:2 When it's far visible in human beings earlier than the age of 50, it's far referred to as early-onset PD The average existence expectancy following prognosis is among 7 and 15 years. Treatment of PD is essential for the neuroscience field. Here we have introduced an FCNN framework for detecting Perkinson's disease using the handwriting method. This suggested technique's main characteristic is the utilization of a fully convolutional neural network to computational cost and representation of power. So, we can say this research benefits both expert systems and medical science. Using this framework requires little experience from users. Hence, young clinicians will have greater opportunities at gaining experience and diagnosing dental diseases more accurately in less time. Experts will not have any problem with misdiagnosis. The detection will be of great help for the advancement of diagnosis support systems, recognition tools, and other expert systems.

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