Pre-thesis - 1 Report
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Deep learning approach for early detection of Parkinson's disease using spiral and wave drawing

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Chapter 1

Abstract

1.1 Abstract

Parkinson’s disease (PD) is a neurological disorder. Due to the nature of the disease, both motor and non-motor manifestations of PD significantly influence a person’s movements, and may cause tremors, slowness of movement, muscle stiffness, and imbalance. The estimated global population affected by PD has more than doubled from 1990 to 2016 (from 2.5 million to 6.1 million), which is a result of the increased number of elderly people and age-standardized prevalence rates of around 1% in the population above 60 years old, affecting 1–2 people per 1,000 (Tysnes and Storstein). We propose an efficient deep learning approach to detect Parkinson's disease at the early stage using spiral drawing and wave drawing performance of a patient. The dataset is composed of two clinical exams of spiral drawing and wave drawing. Several deep learning architectures such as VGG 19, Resnet 50, Resnet101, Efficient Net V2, and Inception V3 are applied and analyzed to classify Parkinson's disease and normal conditions. Moreover, an ensemble method and explainable artificial intelligence are used in the proposed model. The proposed system allows efficient detection of Parkinson's disease using wave drawing and spiral drawing performance analysis of a patient applying deep neural network architectures.

Chapter 2

Introduction

2.1 Introduction

Parkinson's disease is a condition in which a portion of your brain deteriorates, resulting in increasingly severe symptoms over time. While this condition is best known for affecting muscle control, balance, and movement, it can also affect your senses, thinking ability, mental health, and other areas. Parkinson's disease develops naturally with age, and the average age at which it begins is 60 years old. It is slightly more common in men or people born male than in women or people born female. While Parkinson's disease is usually associated with old age, it can strike adults as young as 20, though this is extremely rare and often people have a parent, full sibling, or child with the same condition. Globally, PD-related disability and death are increasing faster than any other neurological disorder. In the last 25 years, the prevalence of Parkinson's disease has more than doubled. According to 2019 estimates, there are over 8.5 million people worldwide who have Parkinson's disease. According to current estimates, PD caused 5.8 million disability-adjusted life years in 2019, an increase of 81% since 2000, and 329 000 deaths, an increase of more than 100% since 2000. Our motivation for this paper is early detection of PD as well as convenient detection.

It is critical to correctly diagnose Parkinson's disease so that patients can receive appropriate treatment and care advice. Furthermore, early PD diagnosis is critical because treatments such as levodopa/carbidopa are more effective when started early in the disease. Non-pharmacologic treatments, such as increased exercise, are also easier to implement in the early stages of Parkinson's disease and may slow disease progression. Another reason for early detection is purely economical. Although it is difficult to estimate, one assessment puts the number of currently diagnosed US patients at over 645,000, which does not include the many undiagnosed cases. If those cases were included, the number of people with Parkinson's disease in the United States rises to approximately 849,000. The annual costs of Parkinson's disease in the United States are estimated to be nearly $11 billion, including $6.2 billion in direct costs. The majority of PD costs are incurred in the later stages of the disease when symptoms are at their worst. Thus, from a purely economic standpoint, any strategy that maintains PD symptoms in the early stages of the disease is likely to be very beneficial in terms of limiting expenditures.

In our society, it is very rare to think of being conscious of PD at the family level. Due to which early detection is far-fetched, treatment is often delayed. This is why one of our motivations was the easy early detection of PD. We wanted everyone to be able to test at home whether they are diagnosed with PD or not through this project.

2.1.1 Research Problem

Parkinson's disease is a progressive neurodegenerative disorder that affects the motor features of the body due to which the patient's normal movement is disturbed. This makes it difficult for potential Parkinson's disease patients to visit the physician periodically, a further issue is that the information gleaned by the physician is limited to a brief session every few months. One of the problems with existing models for the early detection of Parkinson's disease is the inability to distinguish between Parkinson's disease subjects and unaffected controls. This is due to the late effect capture between subjects and the specific spiral drawing, for healthy people, drawing a specific spiral drawing can be difficult. They will sometimes draw like Parkinson's disease patients, which will have an effect on the outcome. Lack of sample data and sufficiently varied forms of spiral drawing, as well as lack of modified features, are some of the problems of the existing models. Many models advocate cross-sectional group studies for early detection but these studies are primarily observational and are classified as descriptive research rather than relational research, which means they cannot be used to determine the cause of something, for instance, disease. In M. Shaban et al.(2020) [1], they have used Electroencephalography (EEG) but it does not extract enough numerous special high-level features. Thus even if Dynamic Spiral Test (DST) is introduced in a model, it is not entirely proven effective because in the model Static Spiral Test (SST) is required later. Moreover, the majority of the models studied are based on spiral and voice datasets rather than scan reports. Another essential thing to consider is which field of machine learning is used in the model because it requires extensive execution and precise outcomes to illustrate the method. Model validation requires an understanding of the processes used for early detection as well as the hardware devices used. In some models, the inability of the software to be accessed from anywhere is also a constraint because it was not designed for a web platform. For instance, a hardware-related issue is the use of a digitized graphics tablet.

With the aim of solving the issues of pre-advised models, this paper employs some unique models. For instance, training the VGG 19 model on millions of images improves its precision while decreasing the computational task. Likewise, EfficientNet models outperform existing CNNs in terms of accuracy and efficiency, and they reduce FLOPS by an order of magnitude. Moreover, The extensive empirical evidence for the RESNET 121 model shows that the residual networks used in this model are easier to optimize and can gain accuracy from significantly increased depth. DENSE NET 121 which was also used requires fewer parameters and allows feature reuse, resulting in more compact models with state-of-the-art performance. Inception v3 has been able to reduce the number of parameters through transfer learning thereby reducing the computational complexity.

2.1.2 Research Objective

The goal of this study is to discuss a deep learning-based CNN architecture for Parkinson's disease detection. People are not aware of the risk of this disease. The focus of this research is to increase public awareness about Parkinson's disease and to make it easier for patients to understand the disease's future. People will put more priority on diagnosing this illness once they are aware of it and realize how important it is to do so. Our research will be a handy application so that people can detect the disease by staying at home.

- To develop a model for early-stage detection and segmentation of Parkinson's disease.
- To better understand deep learning architecture's features and detection system.
- To try to attain the best possible accuracy by using different deep learning architectures with fewer error rates.
- To try to achieve improved performance by using ensemble modeling techniques and XAI.
- The system should have consistent performance and enhanced patient variation robustness, as well as the capability to implement credible out-puts.

2.1.3 Literature Review

In the paper, author M.Shaban present a model where Convolutional Neural Network (CNN) model was trained on the preprocessed dataset [1]. PD is a neurodegenerative disorder. The signs include tremors and slowness of movement in addition to non-motor symptoms such as changes in cognition, anxiety, and sleep issues. To preserve an adequate quality of life for PD patients utilizing suitable medical therapies, early diagnosis of PD is essential. CNN approach was utilized to identify PD patients. The preprocessed dataset was used to train a convolutional neural network (CNN) model, which was then cross-validated 4-fold and 10-fold. When 10-fold cross-validation was conducted, the CNN model had an accuracy of 88%, 89%, and sensitivity of 89%, and 87% on the wave and spiral patterns, respectively. The CNN Model's confusion matrix was used for 4-Fold and 10-Fold Cross Validation. And for the wave and spiral datasets, the accuracy of AUC was roughly 93%, 94% (4-fold), 89%, and 92% (10-fold), respectively. Sensitivity, specificity, and accuracy were used to assess how well the CNN model performed.

The technique of electroencephalography (EEG) measures brain activity. Analysis of the EEG signals' frequency and power may reveal important details about the motor and non-motor disorders of PD. In order to discover the early biomarkers of the disease, a deep learning approach will be used to automate EEG analysis and extract a variety of distinctive high-level features. Validation accuracy, sensitivity, and specificity were used to examine the CNN model's performance. The research is more accurate when deep learning methods (such as convolutional neural networks) are used since they can pick up features without requiring human engagement.

Convolutional neural networks (CNN) were utilized in the paper [2] to analyze the drawing patterns and detect PD. One of the most prevalent neurodegenerative disorders affecting adults over 65 is Parkinson's disease (PD). It has been established that handwriting impairment in people with Parkinson's disease (PD) is inversely correlated with disease severity. The symptoms of movement problems, such as rigidity, instability in posture, and tremor, are typically seen in PD patients at various stages. Patients with Parkinson's disease also tend to write or draw at significantly lower speeds and pressures than healthy individuals. Convolutional neural networks (CNN) are the technique utilized in this study to examine the drawing patterns of spiral and wave sketches, respectively.

Furthermore, an ensemble voting utilizing a meta classifier was carried out in order to impose a combinatory judgment based on both image categories. Logistic Regression and Random Forest Classifier were the two machine learning algorithms used by the meta classifier. The prediction probabilities derived from the CNN Models were fitted to each of the algorithms separately. The entire model has a 93.3% overall accuracy after being trained on the data of 55 patients. The findings of the model were also tested using a 5 Fold cross-validation on the entire dataset. The original null hypothesis proposed that small misclassifications may predict Parkinson's patients from healthy patients. And because Parkinson's patients had 2 and 3 misclassifications in the spiral and wave, respectively, the CNN models did not accept this particular hypothesis. The method put out in the article appears to be quite good at clearly separating the sketches created by Parkinson's patients from healthy people.

Khatami, Pedram; Canturk, Ismail; Ozyilmaz, Lale proposed the Deep Learning method for diagnosing PD from handwritten dynamics. [3]. Parkinson's disease (PD) is a chronic, neurodegenerative condition brought on by a decrease in the neurohormone dopamine, which the hypothalamus releases. This illness impairs stamina, slows down speech and movement, decreases motor impulse levels compared to normal reflexes, and affects the ability to write owing to tremors in the hands. Convolutional Neural Network (CNN) approach has been applied. CNN is widely used and advantageous for image processing and classification. The work also investigates a newly developed medical test called Dynamic Spiral Test (DST). There are three types of handwriting tests: Static Spiral Test (SST), Dynamic Spiral Test (DST), and Stability Test on Certain Points (STCP). The research gives 80% accuracy. The dataset contains healthy people and PD patients. The dataset includes 72 individuals, 57 patients, and 15 controls (healthy people). This study chose 90%, 75%, and 50% of the data for training, and 10%, 25%, and 50% of the data for testing, respectively, for SST, and DST. The accuracy of using spirals and extracted images is higher than the 10-fold cross-validation of the SST and DST tests. Future efforts based on this study intend to apply several Deep Learning CNN architectures, such as LeNet or ImageNet, to the dataset. Additionally, it aims to use 1D CNN and several classifiers to analyze dataset signals rather than images. This work's primary objective is to extract feature images from the HW dataset and demonstrate how well CNN can learn features from them. This CNN model effectively handles the classification of extracted feature images. This CNN model's classification results demonstrate that we were successful in obtaining high accuracy for DST.

The techniques employed in the article [4] include feature extraction and image processing to diagnose Parkinson's disease (PD). It is a degenerative, chronic, and progressive condition that can affect the nervous system and result in tremors, muscle rigidity, slowness of movement, and impairments in speech and writing abilities. Parkinson’s disease occurs when nerve cells that produce dopamine are destroyed, a process that is performed slowly, thus characterizing the progression of this disease. The signs include anxiety, insomnia, memory loss, and abnormalities of the autonomic nervous system. The handwriting tests of 92 people were divided into two groups, the control group, and the patient group. The patients make up 80.44% of the dataset, whereas controls make up 19.56% of it. Image preprocessing and feature extraction are the methods used. It develops a method that will automatically distinguish the handwritten trace (HT) from the exam template (ET), taking spirals and meanders into account. In order to assess the "amount of difference" between the two images, the feature extraction stage aims to describe both HT and ET before comparing them. Naïve Bayes (NB), Optimum-Path Forest (OPF), and Support Vector Machines with Radial Basis Function (SVMRBF) for result analysis. NB obtained the best global results concerning the Spiral dataset, while SVM achieved the best results over the Meander dataset. Add more samples from the control group to the dataset and create new characteristics that can more effectively discriminate between patients and controls. The research paper dealt with the problem of Parkinson’s Disease recognition by combining machine learning and computer vision techniques.

Pre-clinical markers of Parkinson’s Disease are needed and should be quantifiably abnormal in early disease, Which is discussed in [5]. UPDRS-III is the most widely used and accepted rating scale in PD, so it is used in this study. There are many available methods to assess neurodegenerative disease, but this study uses a digitizing tablet to facilitate computerized spiral analysis. Depending on this model's specificity for disease, there is the potential that it could be capturing a late effect that is not abnormal in all PD subjects, and/or may be absent in early disease.138 PD subjects and 150 controls drew spirals on a digitizing tablet. Analyses were conducted using the Statistical Analysis System SAS version 9.1 and STATA12. A model using all the indices, including indices from both hands as well as variation between hands, had good classification accuracy in discriminating PD from unaffected control subjects (AUC = 0.875 / 87.5%). The variability between both hands was significantly greater among cases for DoS, 2ndSm, T, and SWVI. Spiral analysis accurately discriminates subjects with PD and early PD from controls supporting a role as a promising quantitative biomarker. Further assessment is needed to determine whether spiral changes are PD specific compared with other disorders and if present in pre-clinical PD.

Article [6], talks about monitoring Parkinson's disease at regular intervals is costly and inconvenient, so self-administered and non-invasive telemonitoring applications are now popular among PD patients. In this study, we propose a dynamic spiral test (DST) that can only be performed with the use of a computer. We present the comparative results of DST and show that it can be used along with traditional tests in telemonitoring applications. The handwriting dataset was constructed using Wacom Cintiq 12WX graphics and special software was designed for recording handwriting drawings and testing the coordination of the PD patients using the recordings. In this study, we used two different kinds of tests, Static Spiral Test (SST) and Dynamic Spiral Test (DST). The SST and DST recordings of 25 PD patients and 15 control subjects are analyzed based on the speed and acceleration of their drawings. The control subjects are expected to show similar performances in SST and DST, as opposed to the PD patients. The difference in DAH scores of control subjects and PD patients are found to be statistically significant (p-value <0.002). The analysis of the obtained drawing tests demonstrates that the acceleration of SST is statistically closer to that of DST for control subjects when compared to PD patients. It can be concluded that the SST and DST tests can be applied together in order to measure the cortical and motor performance of the subjects and can find use in diagnosis and telemonitoring applications of PD and some other similar neuropathological conditions.

Parkinson's Disease is a neurodegenerative disease produced by the loss of dopaminergic function and characterized by motor disorders and it affects more than 1% of people over 60 years old. Article [7] shows that there is currently no objective test for PD and the rate of misdiagnosis is high. In this study, we used a pen-and-tablet device to study differences in hand movement and muscle coordination between healthy subjects and Parkinson's disease patients. After evaluating several classification algorithms, obtaining the best results accuracy of 88.63% and an Area Under the ROC Curve of 93.1%. We used a public dataset which was the Digitised Graphics Tablet dataset. This dataset includes spiral drawings from 77 people, 62 with PD, and 15 healthy people in the control group. After the experiment the two most informative signals were the coordinates X and Y. When using all the signals, the system reported an accuracy of 96.5%, an F1 score of 97.7%, and an AUC (%) of 99.2%. An interesting research line for future work is to evaluate other architectures of deep neural networks like Recurrent Neural Networks (RNNs). RNNs have shown interesting improvements when modeling patterns in time series.

Early Parkinson’s disease affects the size of writing, kinematics, and pen pressure. The handwriting of a person gets influenced by a number of factors, this is why in this article [8], the patient’s drawing abilities, especially recording the dynamics while the patients draw a spiral was used. The goal of this study was to find the best writing tasks and handwriting features where the difference between severity groups is significant. The dynamics of handwriting were recorded using a Wacom A3 size digital tablet with an ink pen with a pressure sensor. The study included 62 age-matched volunteers ranging from UPDRS=0 (control group) to severely affected patients (UPDRS > 24). AUC for all the four tasks used in this study was roughly in a similar range (range 0.67 to 0.79), the 4th task's accuracy was significantly better, with AUC= 0.933. This study has two major limitations. It did not study patients in their "Off" state, and it is a cross-sectional group study. This study compared different writing tasks to determine the differences between groups based on the severity of Parkinson's disease.

A tough and sophisticated coordinated motor activity is spiral drawing. The important work is done in analyzing speech and handwriting samples to assess tremors and the severity of PD using the traditional techniques of regression and neural networks. In terms of forecasts and diagnostics, feature engineering and machine learning models perform better, disclosing more specifics about the symptoms. Moreover, here the coordinate dataset and picture dataset is transformed to kinematic features datasets for both healthy and sick people. Finding relevant kinematic cues and using machine learning to support PD prediction are the goals. Drawing samples and digital records of 25 Parkinson's disease patients and 15 healthy persons make up the spiral drawing dataset, which may be obtained from the UCI machine learning repository. On the digital tablet, three different kinds of drawings are made. These tests include the Static Spiral Test (SST), Dynamic Spiral Test (DST), Stability Test on Certain Points (STCP), and the Circular Motion Test. The information from the drawing is recorded by specialized software created with API and C# during the test. The dataset also includes text files (in CSV format) and drawings, such as png pictures showing SST and DST. Using the graphics table from the Wacom Cintiq 12WX, a handwriting dataset was created. There are other works related to this research Convolutional neural networks are a new image analysis method recently introduced (Martin, Monteros, and Segundo, 2019) for identifying Parkinson's disease (PD) utilizing spiral drawings discussed in this article [9].

Furthermore (Thomas, Lenka, and Kumar, 2017) have provided an overview of the methods and technologies used today in handwriting analysis for movement disorder diseases. Throughout this literature there is consistent authentication that spiral drawing is an effective way of detecting PD and using digitized drawing makes it simpler and more possible to observe the time of behavioral change. This task can also be used to also follow up on PD. However, in this continuously changing world, there is always a better solution. The PD patients are challenged and if they are asked to draw a spiral diagram on a digitized tablet this will be hard for them also drawing on a digitized tablet is not an easy task. This paper assures that the three types of spiral drawing tests have significant effects. Furthermore, there were four ML models that were implemented on processed datasets. Moreover, comparing four machine learning methods to prior work on a small sample of spiral drawing images, the authors achieve 91.6% accuracy and 98.1 AUC.

Globally one of the most critical health issues is Parkinson's disease. In this work, pattern recognition techniques were used to examine the spirals created during the diagnosis of Parkinson's disease. For each drawing, 123.066 characteristics were thus collected. The feature selection procedure with genetic algorithms was used as a pre-step to get over this issue. For the categorization method, decision trees and k-nearest neighbors were employed. A leave-one-out cross-validation technique is used to verify the results. By typing with such a unique electronic pen that monitors pressure and hand motions in three coordinate axes, Unlu et al. attempted to identify Parkinson's disease[10]. Moreover, this research clearly shows us that the used method produces a successful outcome. In particular, the decision tree classification accuracy value was calculated to 1.00 by using the genetic approach to choose the feature. These findings demonstrated the applicability of the suggested technique for the diagnosis of Parkinson's disease. Spiral drawing and dynamic spiral drawing data from 62 Parkinson's disease patients and 15 healthy controls were obtained from the UCI Machine Learning Repository data set and used to construct a new data set for this study. Drawings were taken in this data set using static and dynamic methods, respectively. On the tablet, the spiral image that must be produced for static drawings is visible. The figure is displayed in dynamic graphics by blinking. Firstly, Parkinson’s disease diagnosis is particularly challenging in the early stages of the disease. In this research, Static Spiral Test (SST) drawing of a Parkinson’s patient, Dynamic Spiral Test (DST) drawing of a Parkinson’s patient, SST drawing of a healthy person, and DST drawing of a healthy person were used. The GA-DT method produced the most successful condition, based on spiral drawings. It may be claimed specifically that feature selection procedures considerably influence the categorization success rate. In addition, it is observed that all samples are appropriately predicted without an inaccurate estimate when GA-DT classification success rates are taken into account. This literature makes it quite evident that analysis of the Parkinson's spiral test was used to diagnose Parkinson's disease. When the outcomes are taken into account, it is clear that they were effective. The early PD detection and follow-up on PD is a huge benefit for the challenged Pd patient so this research will be very effective for them. On the other hand, in this modern world collecting drawings and then it is classified them should not be an appropriate solution.

A Parkinson's disease diagnosis system has been developed by this research after it examined the kinematic properties that were taken from the handwritten spirals created by patients. The raw form time-series dataset was used to extract kinematic characteristics. The suggested approach may be employed as an early-stage Parkinson's diagnostic screening test. A graphical tablet was used to construct the dataset used in this study from 77 people, including 62 Parkinson's sufferers. For data collection, three different tests were devised. The static spiral test (SST) is the first test, followed by the dynamic spiral test (DST) and the third test is the stability test on tough points (STCP) The prime focus of this paper is to detect and treat PD patients using handwritten spiral drawings. There are various other research papers that share the same focus in this article [11] which demonstrates how Parkinson's patients may be classified using kinematic and pressure parameters that were derived from handwriting samples. Kotsavasiloglou et al. explored the use of machine learning to distinguish Parkinson's disease patients from healthy people using just a few horizontal lines drawn by a person. The authors of this article came to the conclusion that kinematic characteristics were the most significant for categorizing Parkinson's patients. Moreover, throughout the lecture, it is also proven by showing a comparison with other recent work. AdaBoost, XGBoost, Random Forest, and Support Vector Machine's performance on entire feature sets and reduced feature subsets have all been examined. The best results, with an accuracy rate of 96.02%, are produced by the combination of the mutual information gain feature selection approach with AdaBoost classifiers. In this era of evaluation and new opportunities using digitized graphics tablets will not be the genuine solution as drawing in graphics tablets is very difficult for PD patients so this needs further improvement.

Spiral drawing has been utilized for years as a clinical tool in the assessment of different movement disorders, such as PD. This test in the article[12], is traditionally conducted on pen and paper and analyzed and observed by medical persons. The main idea of this research paper is to perform this test conducted digitally. There will be two drawing tasks: first the spiral drawing task, and the traditional task. This drawing process uses fingers which makes the spiral drawing task hard so there will be another predictable task called the square drawing task. There are a few steps of drawing tasks after landing on the smartphone app an instruction and template are given below then drawing feedback is given. The drawing tasks were tested by 14 test subjects in the local Parkinson’s Association meeting. There were eight participants with PD their mean age were 71.5. There were six without PD mean age of 72.3. All participants conducted three spiral and three square drawings using the same device Time logged touch X, and Y coordinates, and a screen capture of the final drawing was collected.

Parkinson’s disease is the second most prevalent neurodegenerative disease in the world. It is characterized by the loss of neurons in a region of the brain known as substantia nigra and it affects almost 10 million people in the world. This research [13] is based on asking the patients to draw using software developed to detect Parkinson’s disease. The drawings will then be passed through a series of image methods to reduce noise and extract the characteristics of 11 metrics of each drawing. Additionally, these 11 metrics will be stored. Moreover, machine learning techniques such as optimum-path forest (OPF), support vector machines (SVM), and Naive Bayes use the dataset to search and learn the characteristics for the process of classifying individuals distributed into two classes which are: sick and healthy. These three algorithms (OPS, SVM, and Bayesian classifier) were used to obtain the best result regarding the classification of individuals. The study was conducted for three months, which allowed the collection of data from 10 individuals diagnosed with Parkinson’s disease and aged between 40 and 80 years. Nine out of these patients exhibited the disease in the advanced stage while one was found to be in a mild stage. For the control group, 10 random individuals of different ages were used to evaluate the algorithm and the chosen attributes. In the test, the SVM classifier obtained better precision. On the other hand, the OPF and the Bayesian classifiers presented similar results in the patterns, presenting results inferior to the SVM. From the patterns used, the Archimedes cube and spiral patterns presented a greater precision than the triangle pattern, which indicates that the cube and spiral patterns provide a better response to identifying individuals with PD according to the attributes and data used. Based on the results, it can be seen that amongst all the three algorithms used, SVM obtained a better response to the presented data set. This algorithm, used in the patterns of the cube and Archimedean spiral obtained a 100 % accuracy with a sensitivity of 100 % during the classification stage of the two classes in which the data sets presented in this work were divided.

Parkinson’s disease begins with symptoms that may not be noticeable at the early stages and gradually worsen over time and cause permanent movement disorders. Parkinson’s disease also causes symptoms that progressively worsen the patient’s mental health. In this research, the experiment is performed in R studio and Jupyter notebook. The Parkinson’s speech dataset with various recordings was taken from the UCI Machine Learning Repository. The dataset in this article [14] included 20 voice data with Parkinson’s disease and 20 voice data from healthy people, and the result was compared for the people with Parkinson’s disease and normal people. In this research, the parameters for detecting Parkinson's disease from the spiral drawing were the average of pen-pressure, weighted average speed, and average Composite Index of the Speed as well as Pen pressure(CISP) of sketching. The pen pressure is recorded using the pen. This is having the range of [0,1024]. The speed is calculated using the time taken to complete one spiral. The PCA algorithm is used to find patterns from the spiral database. It was found that the values of all three parameters were lower for people with Parkinson’s disease compared to normal people. The median of the normalized spiral values has a range of 0 to 1 where 0 is worst and 1 is best. The model can be further developed as a hybrid version of MRI or PET scans along with the spiral and voice datasets to further increase accuracy.

To detect the severity of Parkinson’s disease, a change in handwriting can be an early marker. The symptoms of Parkinson’s disease affect the sketching ability and writing abilities of the patients causing three changes which are; the size of writing, pen pressure, and kinematics. This research [15] has investigated the group differences in the dynamic features between PD and control subjects while sketching in order to create a precise approach for diagnosing PD patients. In this research, for 206 samples obtained from 62 subjects (31 Parkinson’s and 31 controls), dynamic handwriting features were calculated. To ascertain group differences, they were examined depending on the severity of the disease. Moreover, to assess the degree of relationship between the various features, the Spearman rank correlation coefficient was calculated. Also, to capture the dynamics of the handwriting, a Wacom A3 size digital tablet (Wacom Intuos Pro Large) with an ink pen having a pressure sensor was used. When applying dynamic features to various writing and spiral drawing activities, the maximum area under the ROC curve (AUC) ranged from 0.67 to 0.79. AUC increased to 0.933 when angular features (φ and pn) and the count of direction inversion during sketching of the spiral were utilized. For φ and pn, the Spearman correlation coefficient was maximum. It has been demonstrated that the most effective way to distinguish between the PD and Control groups was to use the angular(φ and pn) and direction change features for the Archimedean-guided spiral.

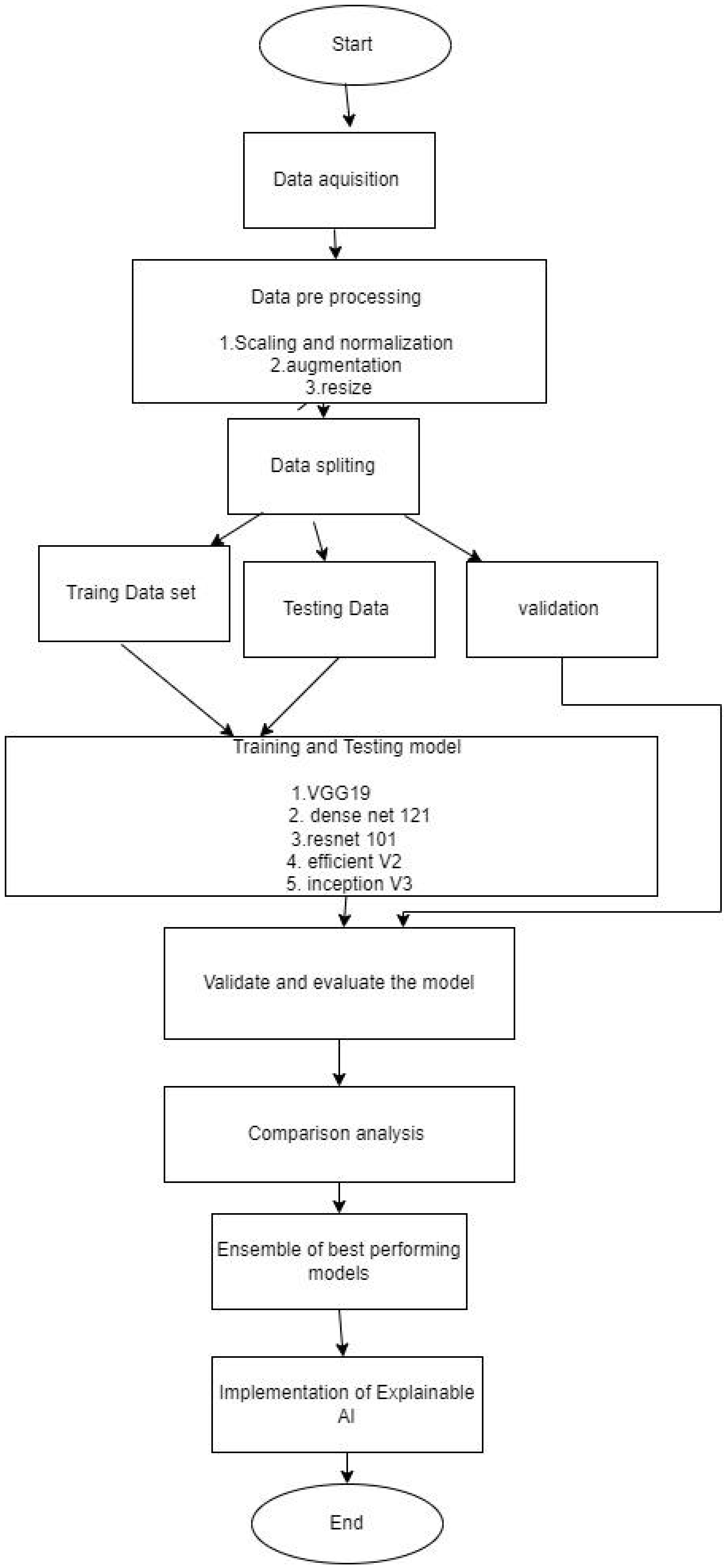
Chapter 3

Proposed Work Plan

3.1 Work plan

The purpose of our paper is to detect Parkinson's disease at an early stage. At first, it will collect the data from spiral and wave drawings. Then these images need to be pre-processed by doing scaling and normalization, augmentative and resizing. Furthermore, the data need to be split. It will be divided into 3 parts and they are training data set, testing dataset, and validation. The training data set contains 70%, the testing data set contains 20% and validation contains 10% of the whole dataset. The training and testing models are VGG 19, Resnet 50, Resnet 101, efficient net

V2, and Inception V3. Then data will validate and evaluate the model. Then it will show the result analysis or comparative analysis. After that, it will reveal the ensemble of best-performing models. Lastly, it will implement explainable AI.


Start
Data aquisition
Data pre processing
1.Scaling and normalization
2.augmentation
3.resize
Data spliting
Traing Data set
Testing Data
validation
Training and Testing model
1.VGG19
2. dense net 121
3.resnet 101
4. efficient V2
5. inception V3
Validate and evaluate the model
Comparison analysis
Ensemble of best performing models
Implementation of Explainable AI
End

3.2 Methodology

3.2.1 VGG19 Model

The extremely deep VGG19 has been trained on a massive number of different pictures for challenging classification tasks. The ImageNet database, which has one million photos in 1000 categories, is used to train the VGG19 algorithm. The usage of a fine-tuned VGG-19 for screening [16] Parkinson's disease (PD) based on a Kaggle handwriting dataset can be explored and experimented with in this work. To assess and categorize spiral and wave handwriting datasets into controls and PD in an automated fashion, a pre-processing step followed by a tuned VGG-19 can be used.

3.2.2 Inception V3

The third version of Google's Deep Learning Convolutional Architectures is called Inception V3. The model makes considerable use of batch normalization, which is also applied to the activation inputs. Using Softmax, the loss is calculated. Deep networks containing repeated blocks known as the Inception blocks—which are highly tunable—make up the inception. They are made up of several convolutional filters [18], ranging in size from 5x5 to 1x1, each of which produces results that are cascaded. While maintaining the overall fundamental elements of the image under review, they make sure that specific localized information is not lost. The number of parameters that must be trained is reduced by the inception model. Due to the decomposition of bigger convolution layers into smaller ones and other techniques, Inception-v3 has a lower number of parameters. A variety of modifications to the original framework produce a quicker, more precise architecture that also functions with smaller datasets.

3.2.3 Res-Net 101 model

A convolutional neural network with 101 layers is called ResNet-101. Higher accuracy on harder tasks may be the outcome of the deeper network. There are 101 layers in the network. Faster convergence can be made possible by the usage of skip connections [18] in the resnet. Even the far deeper resnet layers show to train more quickly than earlier models. In order to avoid overfitting, this model also used batch normalization efficiently. To reduce the number of training parameters[18], both of the aforementioned models abandon the conventional fully connected layers.

3.2.4 EfficientNetV2

The convolutional neural network of the EfficientNetV2 type performs better than other models in terms of parameter efficiency and training speed. In the initial layers, EfficientNetV2 makes considerable use of both MBConv and the recently introduced fused-MB Conv. Parkinson's disease detection method can be proposed using EfficientNetV2. To determine the suggested method's detection effectiveness[19], a series of experiments can be run. The performance of the suggested method can be evaluated using the dataset of spiral and wave drawings.

3.2.5 Densenet-121

One of the models in the DenseNet family created for picture classification is the densenet-121 model. (DenseNet), which establishes feed-forward connections between every layer. DenseNets offer a variety of compelling benefits, including the elimination of the vanishing-gradient issue, improved feature propagation, enhanced feature reuse, and much fewer parameters. When tested for classification using the prominent ImageNet datasets, the DenseNet is recognized for having a convolutional neural network design that is state-of-art [20].In the model architecture, each layer accepts the target input and a concatenation of the feature maps from the layers that came before it. It can execute nonlinear operations such as ReLU, batch normalization, pooling, or convolution. Following the computation of the non-linear function, the resultant feature maps of each layer are sent as inputs to the succeeding connected layers. The concatenation technique fails if the size of the feature maps varies. As a result, as the size of the feature maps varies, the necessity for pooling operations becomes crucial.

3.2.6 Ensemble Modeling

In ensemble modeling, many distinct base models are employed to predict a result. The goal of employing ensemble models is to lower the prediction's generalization error. When using the ensemble model, the prediction error lowers as long as the basic models are varied and independent. This method of data mining makes use of numerous decision trees, a form of the analytical model created to forecast results based on many inputs and rules. Ensemble Learning is a NN training method [21], where the prediction from various trained networks are merged to solve a problem. Three ensemble network architectures can be examined in this research. Proposed ensemble architectures include:

1) Stacked Ensemble Model- M7, which concatenates the outputs of all constituent models, followed by a Dense Layer.
2) Average Ensemble Model- M8: All of the constituent models' expected outputs are averaged in this model architecture.
3) Majority Voting - M9: The majority of the models' predictions are calculated by M9 utilizing mode. The final result is calculated using the hard voting method,

in which each constituent model votes for one of the output classes, and the prediction that receives the most votes is selected as the final prediction.

Chapter 4

Conclusion

4.1 Conclusion

Parkinson's disease is not a direct killing disease but it is a progressive disorder. Early detection of this disease is important. Early treatment can slow disease progression. There is no approved medication to prevent or stop Parkinson's disease development. Deep learning applications have recently become very popular in medical image analysis. We analyzed the most recent research on deep learning methods used for Parkinson's disease detection and diagnosis. To make the results more understandable, we divided them into categories such as data collection, pre-processing, data splitting, evaluating model result analysis, and so on. We studied each category and collected ideas about the algorithms used in different tasks. The suggested approach employs explainable artificial intelligence and the ensemble method. To sum up we can say that, with the help of deep neural network architectures and wave and spiral drawing performance evaluations, the suggested approach enables effective Parkinson's disease identification.

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