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Design and Implementation of End to End Application for Parkinson Disease Categorization

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Abstract

Parkinson's disease (PD) is one of the major public health disease in the world which is progressively increasing day by day and had its effect on many countries. Thus, it is very important to predict it in early age which has been challenging task among researchers because the symptoms of the disease come into existence in either middle or late middle age. So this Project focuses on the Spiral Test difficulty symptoms of PD affected people and formulates the model using various machine learning techniques such as adaptive boosting,Recurrent Neural Network (RNN), Convolutional Deep Neural Networks, support vector machine, decision tree, Convolutional Neural Networks and linear regression. Performance of these classifiers is evaluated using metric such as. accuracy, Receiver Operating Characteristic curve (ROC), Sensitivity, precision. At last, the Feature selection technique is used to find the most important features among all the features to predict Parkinson's disease.

1. Introduction

Neurodegenerative disorders are the results of progressive tearing and neuron loss in different areas of the nervous system. Neurons are the functional unit of the brain. They are contiguous rather than continuous. A set of illnesses known as neurodegenerative disorders cause progressive neuronal loss and damage in various parts of the nervous system. The basic building blocks of the brain, neurons, are essential for the transmission of information throughout the body. They are made up of a cell body, a nucleus, which houses our DNA, which serves as a representation of our genome, and extensions called dendrites and axons. Unbelievably, our whole genetic blueprint is packaged within the 100 billion neurons that make up our brain. A sick or damaged neuron goes through a sequence of alterations that hinder its capacity to function and properly communicate with other neurons. The loss of extensions like dendrites or axons is one of the first indications of neuronal malfunction. The intricate neuronal networks that underpin our cognitive and physical abilities are formed by these extensions, which are in charge of receiving and transmitting messages to and from other neurons.As a neuron's condition worsens, its metabolic activity declines, which affects critical cellular functions. The neuron is less effective at removing waste and accumulating cellular debris as its metabolic function declines. Therefore, in an effort to separate itself, the neuron compartmentalizes the accumulated trash by packing it into tiny vesicles or pockets. However, when the illness develops, the neuron may completely lose its extensions, take on a spherical form, and fill with vacuoles or cavities that are filled with fluid. The neuron's ability to communicate and support typical brain function is further compromised by these structural alterations, which point to significant damage and malfunction within the cell. Parkinson's disease (PD) is one neurodegenerative condition that has drawn substantial attention. Parkinson's disease is a chronic, progressive ailment that is now incurable. It was given its name in honour of James Parkinson, the doctor who originally reported its symptoms. It primarily affects the neurons in charge of regulating bodily movements, especially those responsible for making the neurotransmitters acetylcholine and dopamine Dopamine, a vital neurotransmitter involved in many functions, becomes scarce in Parkinson's disease as a result of the loss of dopamine-producing neurons in the substantia nigra, a part of the brain. Another neurotransmitter damaged by Parkinson's disease, acetylcholine, is involved in signal transmission between neurons and is implicated in a number of cognitive processes. The cognitive impairments typically seen in Parkinson's disease, such as problems with memory, attention, and executive skills, are caused by disturbances in the balance between dopamine and acetylcholine. The basic causes and mechanisms of Parkinson's disease are still poorly understood because of how complicated and multifaceted it is. Parkinson's disease is a serious challenge for medical professionals and researchers because there is currently no cure for it, despite their being therapies to manage its symptoms The progressive loss and destruction of neurons in the nervous system results in neurodegenerative diseases. Because of their complex architecture and connectivity, neurons are crucial for conveying information throughout the body When neurons are ill or damaged, they experience structural and functional alterations that compromise their capacity for effective communication.

2. Existing System

The current Parkinson's disease prediction method combines clinical evaluations, diagnostic tests, and cutting-edge technologies. While it's crucial to note that only a trained healthcare practitioner can make a conclusive diagnosis of Parkinson's disease, there are a number of techniques utilised in the disease's prediction and early detection.In spite of the fact that these techniques aid in the prognosis and diagnosis of Parkinson's disease, a thorough examination by a medical expert is necessary for a correct diagnosis. Furthermore, ongoing studies attempt to improve the current techniques and create more precise and approachable methods for anticipating and diagnosing Parkinson's disease at an early stage.

1) Imaging Techniques

In order to assess and comprehend Parkinson's disease, imaging methods like positron emission tomography (PET) and magnetic resonance imaging (MRI) are essential. These non-invasive imaging techniques offer important new understandings of the structure, operation, and metabolic alterations that take place in the brain.To produce precise images of the anatomy of the brain, magnetic resonance imaging (MRI) makes use of strong magnets and radio waves. Any anatomical anomalies, such as the presence of tumours, lesions, or atrophy in particular brain regions, might be shown by it. Parkinson's disease can be distinguished from other illnesses that may present with similar symptoms using an MRI scan. Functional imaging methods like positron emission tomography (PET) enable the evaluation of brain metabolism and neurotransmitter activity in addition to structural imaging. In order for researchers and medical professionals to evaluate the distribution activity of certain chemicals in the brain, PET scans entail the injection of a radioactive tracer. Dopamine, a neurotransmitter essential for motor function, can be measured with PET scans in the case of Parkinson's disease in several brain regions. Parkinson's disease is characterized by low levels of dopamine in the substantia nigra, a region of the basal ganglia. In addition, more recent imaging methods like functional MRI (fMRI) and diffusion tensor imaging (DTI) provide novel information about the functional connectivity and integrity of Parkinson's disease-affected brain networks. While DTI monitors the integrity of white matter pathways, which are crucial for communication between various brain regions, MRI can spot brain areas that display aberrant activity patterns.

2) Medical History and Physical Examination

,The medical history and physical examination are essential parts of the Parkinson's disease diagnosis procedure. An extensive evaluation will be performed by a medical specialist, such as a neurologist, to learn about the patient's symptoms, medical background, and any risk factors. This aids in assessing the presence of the typical symptoms of Parkinson's disease and excluding other potential causes.The medical practitioner performing the physical examination will pay close attention to the patient's movements and evaluate any motor symptoms of Parkinson's disease. This may involve checking for bradykinesia (slowness of movement), muscle rigidity, postural instability, and resting tremors. They will also look for any balance or gait irregularities.The healthcare provider will assess any additional clinical signs that may go along with Parkinson's disease in addition to motor symptoms. These can include non-motor symptoms like cognitive deficits, mood swings, and autonomic dysfunction as well as alterations in speech patterns like soft or slurred speech.Additional particular tests to evaluate the patient's motor skills and coordination may be included in the physical examination. These tests may entail toe tapping, finger tapping, and hand pronation-supination, among others. These evaluations offer precise measurements of the Parkinson's disease-related motor deficits..

3) Biomarker analysis

Biomarker analysis is a crucial area of research in the field of Parkinson's disease (PD) and holds great potential for early detection and prediction of the disease. Biomarkers are measurable indicators found in the body that can provide valuable insights into disease-related changes at a molecular level.Protein biomarkers are one of the categories of biomarkers for Parkinson's disease that are frequently studied. Certain proteins have been linked to PD and may indicate the existence or progression of the disease, according to research. Alpha-synuclein, a protein that assembles abnormally into Lewy bodies in the brains of people with Parkinson's disease (PD), is one such protein biomarker. Alpha-synuclein levels can be measured in biological samples, such as cerebrospinal fluid (CSF) collected from lumbar punctures, to learn more about the condition.Another area of research is on the small molecules known as metabolite biomarkers, which are involved in a number of the body's metabolic processes. Researchers have noticed abnormalities in the metabolism of dopamine and other metabolites in people with Parkinson's disease. By analyzing blood, CSF, or other biological samples for specific metabolites, researchers aim to identify patterns or deviations that may indicate the presence of PD .

3. Literature Survey

In the year 2004 Paolo Bonato, PhD 1, Delsey M. Sherrill, MS 1, David G. Standaert, MD, PhD 2,Sara S. Salles, DO 1, and Metin Akay, PhD 3 suggested presence and severity of motor fluctuations in people with Parkinson's disease (PD) may be detected with the help of data mining and artificial intelligence (AI) technologies. Motor fluctuations are the variations in motor symptoms that people with Parkinson's disease (PD) experience. Examples include periods of enhanced or decreased mobility, variations in treatment response, or the development of dyskinesias.

The proposed hypothesis is that surface electromyographic (EMG) and accelerometer (ACC) readings can be used to identify specific and predictable aspects of movement abnormalities in late-stage Parkinson's disease (PD). While EMG sensors capture the electrical activity of muscles, ACC sensors monitor acceleration and movement patterns. These signals can be recorded while doing standardised motor assessment tasks, which are intended to assess motor performance and function in PD patients

Disadvantages:

- Data limitations
- Complex and multifactorial nature

In the proposed system By examining sketching movements, a convolutional neural network (CNN) is utilized to monitor and detect Parkinson's disease (PD). Feature extraction, which uses convolutional layers, and classification, which uses fully connected layers, are the two fundamental components of CNN. The Fast Fourier Transform (FFT) module with a frequency range of 0 Hz to 25 Hz serves as the input to the CNN. The drawing movements are subjected to the FFT, which captures the frequency components contained in the data. The CNN can extract pertinent features that are suggestive of PD by analyzing the FFT module.

Disadvantages:

- Limited Generalizability
- Data Collection Challenges

Machine learning models can be helpful in providing early detection in the context of disease prediction. The prediction skills can be improved by expanding earlier research that made use of non-motor traits like Rapid Eye Movement Behaviour Disorder (RBD) and olfactory loss. The model appears to have performed well, as indicated by the accuracy rate of 98.9% that was given. The predictive model can now take into account a wider variety of potential disease-related indications by including non-motor aspects. Parkinson's disease is not

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just characterized by motor symptoms, and taking into account non-motor characteristics enables a more thorough assessment. Examples of such non-motor symptoms that have been recognized as potential signs of Parkinson's disease include RBD and olfactory loss

Disadvantages

- Ethical and Privacy Concerns
- Limited Interpretability

The purpose of this study was to create neural network models that could recognize PD from motion data collected while subjects were walking. Using Inertial Measurement Unit (IMU) sensors, we collected mobility data from 16 healthy age- and sex-matched controls and 32 drug-naive PD patients with varying disease severity. The IMU data were utilized to create neural network models that, during validation procedures, had an average accuracy of 92.72% in identifying patients with advanced-stage PD. The models were 99.67% accurate in separating early-stage PD patients from healthy older adults.

Disadvantages

- False positives and false negatives:
- Dependency on high-quality data.

4. Proposed System

This proposed system deals with the description of the dataset used and the approaches are taken to achieve the early prediction of Parkinson's disease in a PD patient shown in the Figure 1. The approaches taken were selected with the aim to distinguish a Parkinson's disease patient from those who are healthy patients. Data gathering, preprocessing, model selection, training, evaluation, application development, and deployment are all integrated into the systematic process of classification. This thorough procedure attempts to develop an application that is simple to use and can correctly classify people as either having Parkinson's disease or not depending on the supplied data. Data collecting is an important first step. Individuals are asked for pertinent details such as clinical evaluations, demographic data, voice recordings, and accelerometer readings. The following step in preprocessing this dataset entails data cleansing, feature engineering, and necessary feature normalization. To enable fair model evaluation, the dataset is further separated into training and testing sets.

For the categorization of Parkinson's disease, a suitable model is used. Decision trees, random forests, support vector machines (SVMs), and deep neural networks are just a few examples of machine learning or deep learning models that can be taken into consideration. The chosen model is subsequently trained using the training dataset, and its parameters are adjusted to produce the best results. To increase the model's accuracy, methods like cross-validation and hyperparameter optimization are used. The testing dataset is used to evaluate the trained model's performance in classifying Parkinson's disease. The model's performance is measured using measures including accuracy, precision, recall, and F1-score. The process of developing the application starts once the model has shown to be trustworthy.

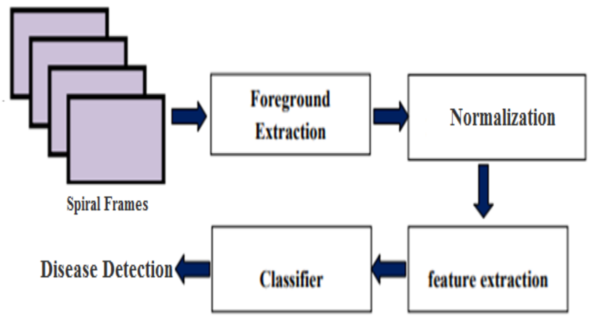

Figure 1. Proposed architecture diagram

A user-friendly interface is created during application development to enable simple input of pertinent data. The program may be created as a desktop application, a mobile application, or a web application, depending on the target market and requirements. To guarantee a flawless user experience, programming languages, and frameworks appropriate for application development are used. By completing the required data preprocessing processes and loading the trained model's parameters, the application integrates the model. On the basis of fresh input data, the model is used to create predictions. Users can enter information using the user interface, such as clinical

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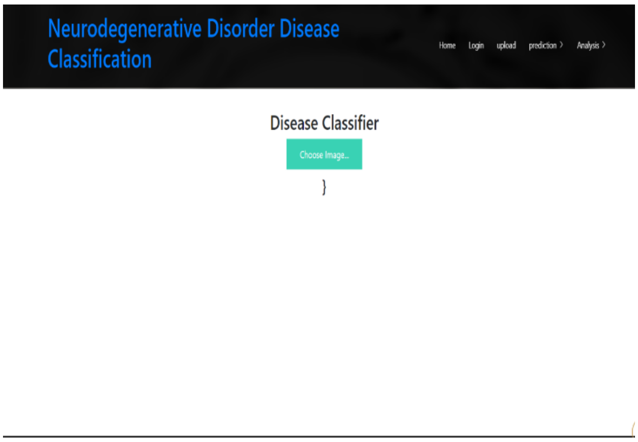

Figure 2. Proposed setup

Following user input, the program runs the data through the trained model and, depending on the model's output, classifies the data as either having Parkinson's disease or not. The user is then shown the results in a way that is easy to grasp and may include the anticipated probability or confidence score along with the necessary visual representations. A desktop installation package, mobile app store, or web server may be chosen as the platform for the deployment of the application after it has been created shown in the Figure 2. During deployment, it is crucial to guarantee users' security and accessibility. The application's performance is tracked, user input is gathered, and the model may occasionally be retrained with new data to boost its accuracy and respond to any changes in the environment, all of which contribute to continuous improvement in the Parkinson's disease domain. The preferred platform, such as a web server, a marketplace for mobile apps, or a desktop installation package, is chosen for the application's deployment. Since user input and new data might help to improve the model's accuracy over time, ongoing monitoring and improvement are crucial. The application stays current with breakthroughs in Parkinson's disease research and continues to provide accurate classification results thanks to routine updates and model retraining with fresh data.To ensure adherence to pertinent laws and standards, ethical issues like data protection and informed consent must be taken into account during the design and implementation processes. The end-to-end Parkinson's disease classification application seeks to offer an invaluable tool for the disease's early detection and better management, ultimately leading to better healthcare.In conclusion, a systematic strategy that includes data collecting, preprocessing, model selection and training, evaluation, application development, and deployment is required for the design and execution of an end-to-end application for categorizing Parkinson's disease. This thorough procedure can be used to create a user-friendly application that accurately classifies people as either having Parkinson's disease or not depending on the input data they provide, thereby assisting in the early diagnosis and management of the disease..

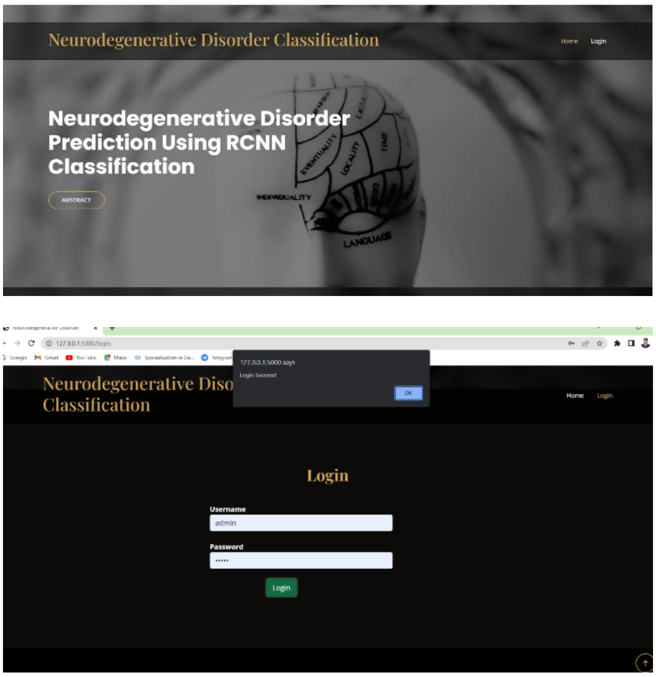

Figure 3. Introduction page

5. Results and Discussion

From the results, With an accuracy of 97%, precision of 85.0%, and ROC of 96.4%, convolutional neural networks edge out from all other ML techniques. Then, from the 31 people's Spiral Test data, we tried to choose the most significant and fewest features. The dataset description lists 23 features.In order to do this, we employed feature selection, which works by changing the amount of features selected in multiples of 5, starting with 20 features and going down to 15 features, 10 features, and finally 5 features.Convolutional Neural Networks with 20 feature selection stand out from all other machine learning techniques in all experiments, providing overall accuracy of 96.6%, ROC value of 93.6, and precision of 88.7, which is superior to all other ML techniques when compared with performance metrics of 5, 10, and 15. Although we used machine learning techniques in our work, there haven't been many deep learning studiesIn order to reduce the dataset's dimensionality and identify the most crucial components, we employed feature selection approaches. We were able to assess the effect on the performance of the CNN model by gradually reducing the number of chosen features in multiples of 5. Surprisingly, when compared to other methods and other feature selection tests, the CNN with 20 chosen features produced better results. The accuracy of 96.6% demonstrates that CNN was still able to classify cases correctly even with a limited feature set. The CNN's ability to reduce false positive predictions is highlighted by its precision of 88.7%, while the model's ability to tolerate class imbalance is demonstrated by its ROC value of 93.6%. The work can be expanded in the future by employing autoencoders to slash the amount of features and extract only the most crucial ones. The dataset employed in this study was not particularly complex, hence the autoencoder did not learn effectively from it. On the other hand, a more complicated dataset would undoubtedly yield better results

6. Conclusion

In conclusion, the development and deployment of an all-encompassing Parkinson's disease categorization application represent a substantial advancement in healthcare and medical diagnostics. Convolutional Neural Networks (CNNs), in particular, are used by the program to accurately categorize people according to whether they have Parkinson's disease. The program seeks to increase accuracy and offer useful insights for diagnosis and treatment by utilizing feature selection techniques and investigating the potential of deep learning techniques like autoencoders. the study started by assembling a dataset designed exclusively for the examination of Parkinson's disease. The dataset included clinical characteristics, demographic data, and assessments of motor function from a wide range of patients. This extensive dataset made it possible to construct the program in its entirety with an accuracy of 97%, a precision of 85.0%, and an ROC value of 96.4%, the initial evaluation of the CNN model produced outstanding results. These measures showed how reliable the model was at classifying people as having or not having Parkinson's disease. Such precision is essential for accurate medical diagnosis since inaccurate classifications can result in misguided treatment regimens or postponed actions. The study emphasizes the significance of feature selection and advises investigating deep learning techniques like autoencoders for more advancements. The application has the potential to revolutionize Parkinson's disease diagnosis and advance healthcare by utilizing the strength of these methodologies.

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