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Parkinson Disease Detection from Spiral and Wave Drawings using Machine Learning Algorithm

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Abstract: Research in biometrics has experienced significant growth in recent years, leading to a wide range of applications. One prominent area where biometrics has proven invaluable is healthcare. In the field of healthcare, identifying relevant biomarkers specific to certain fitness issues and detecting them accurately is crucial for improving medical decision assistance systems. Parkinson's Disease (PD) is a condition where impairment in handwriting has been observed to correlate directly with disease severity. Additionally, individuals with Parkinson's disease tend to exhibit lower velocity and pressure while using a pen for sketching or writing. Detecting such biomarkers accurately and precisely at the early stages of the disease can greatly enhance medical diagnosis. Consequently, a system has been designed to analyse spiral and wave drawing patterns of individuals affected by Parkinson's disease. By leveraging various machine learning algorithms, it becomes possible to analyse these patterns and determine whether a person is suffering from Parkinson's disease or not.
Keywords: Parkinson's Disease, Spiral Drawings, Wave Drawings, CNN, Deep Learning, Django

I. INTRODUCTION

Parkinson's Disease is a progressive neurodegenerative disorder that causes weakness in the muscles and uncontrollable shaking of the arms and legs. It is a chronic condition that worsens over time, significantly affecting the lives of those diagnosed with it. With a prevalence rate of around 1% among individuals above 60 years old, Parkinson's Disease has become a global health concern.

In recent years, there has been a growing interest in using machine learning techniques and algorithms to address the challenges associated with diagnosing Parkinson's Disease. Traditional diagnostic tests often fall short in providing accurate and objective assessments, as they heavily rely on subjective interpretation of motor signs and symptoms. These symptoms can be subtle and difficult to detect, making early diagnosis challenging.

Fig. 1. Parkinson's Disease Symptom

To overcome these limitations, researchers have turned to machine learning methods to enhance the diagnostic and evaluation processes for Parkinson's Disease. By analysing a diverse range of data modalities, including patterns in handwriting, machine learning models can effectively differentiate between individuals with Parkinson's Disease and healthy controls or patients with similar medical presentations.

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By leveraging the power of machine learning algorithms, these models provide a more objective and reliable approach to diagnosing Parkinson's Disease. They enable healthcare professionals to detect and classify the disease with greater accuracy, minimizing misclassification and improving early diagnosis rates. This, in turn, allows for more timely intervention and tailored treatment strategies, ultimately improving the quality of life for individuals living with Parkinson's Disease.

The integration of machine learning techniques into healthcare holds immense promise, not only for Parkinson's Disease but also for various other medical conditions. As technology advances and datasets continue to expand, machine learning algorithms are expected to play an increasingly significant role in revolutionizing medical diagnostics and decision-making processes.

II. LITERATURE SURVEY

In a study by Anastasia Moskova et al. [1], a system was developed to detect Parkinson's Disease by capturing hand movements using a Leap Motion Sensor. They applied machine learning algorithms such as KNN, SVM, Random Forest, and Decision Tree to the obtained data, achieving an overall accuracy of 95.3%.

In another research paper by Shrihari K Kulkarni et al. [2], various machine learning algorithms including XGBoost, CNN, ANN, Logistic Regression, Random Forest, SVM, Boosted Trees, and RNN were employed to detect Parkinson's Disease. The study reported an overall accuracy of 94.5%.

Jaichandran R et al. [3] utilized K Mean Clustering and Decision Tree algorithms to detect Parkinson's Disease, achieving an overall accuracy of 85%.

Sabyasachi Chakraborty et al. [4] focused on analyzing spiral and wave drawings of healthy and Parkinson-affected patients. They applied Logistic Regression, Random Forest Classifier, and CNN algorithms, resulting in an overall accuracy of 93.3%.

Ferdib-Al-Islam and Laboni Akter [5] employed various machine learning algorithms such as Decision Tree, Gradient Boosting, KNN, Random Forest, HOG feature descriptor, and Logistic Regression on hand-drawn images of healthy and affected individuals. Their research yielded an overall accuracy of 89.33%.

Md. Sakibur Rahman Sajal et al. [6] conducted tremor and voice analysis of individuals with Parkinson's Disease. They utilized KNN, SVM, Naïve Bayes, and MRMR Feature Selection algorithms, achieving an overall accuracy of 99.8%.

In the study by Priyadharshini et al. [7], voice analysis of Parkinson-affected patients was performed, and the XGBoost algorithm was applied, resulting in an accuracy of 92.76%.

Basil K Varghese et al. [8] investigated speech datasets and utilized machine learning techniques such as SVR, Decision Tree Regression, Linear Regression, and SVM. Their research reported an overall accuracy of 92.9%.

Timothy Wroge et al. [9] analyzed voice datasets of both healthy individuals and those with Parkinson's Disease. They employed machine learning algorithms including CNN, SVM, Decision Trees, Random Forest, and Artificial Neural Network, achieving an overall accuracy of 86%. In summary, these studies have demonstrated the effectiveness of machine learning algorithms in detecting Parkinson's Disease using various data modalities such as hand movements, speech, and voice analysis. Each study utilized different algorithms and achieved promising overall accuracies, highlighting the potential of machine learning in improving diagnostic capabilities for Parkinson's Disease.

III. METHODOLOGY

A. Data Collection

The data was taken from a Kaggle repository which was originally published in the paper [10] by: Zham P, Kumar DK, Dabnichki P, Poosapadi Arjunan S and Raghav S (2017). This data collection process was performed at RMIT University Human Research Ethics Committee. All participants were informed about the experiment and gave oral and written informed consent prior to the start of the experiment. All subjects were given two tests i.e., Spiral test and Wave Test. These tests were conducted on A3 sized paper and an ink pen was used for drawing. Below is the figure of collected data sample.

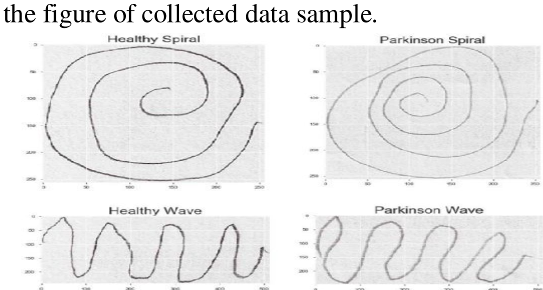

Fig. 2. Spiral test and Wave Test

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B. Data Augmentation

Data augmentation is a technique commonly used in Deep Learning to artificially increase the amount of available data by generating additional data points. This approach involves applying geometric transformations, such as flipping and rotation, to the original images to create augmented versions.

The accuracy of deep learning models heavily relies on the quality, quantity, and contextual relevance of the training data. However, acquiring a sufficient amount of high-quality data can be a challenging task. It often requires substantial resources in terms of time and cost.

To address this limitation, manual image augmentation techniques were employed in our study. By applying flipping and rotating operations, we aimed to enhance both the quantity and quality of the data used to train our Convolutional Neural Network (CNN) model. This approach allowed us to artificially expand the dataset, providing the model with more diverse samples for improved learning and generalization.

C. Model Creation

We will utilize a Convolutional Neural Network (CNN) for training our model, which is a type of deep learning neural network capable of processing various types of data. CNNs are particularly effective in detecting patterns such as lines and gradients from input images.

In the case of Parkinson's disease, there exist several biomarkers that can be used to detect the disease. One such biomarker is the Spiral/Wave Drawing. Individuals with Parkinson's disease typically exhibit difficulty in drawing smooth and accurate spiral or wave diagrams. To train our model, we have gathered a dataset comprising both healthy and Parkinson's drawings. The dataset includes 98 Spiral Drawings for training, 28 for validation, and 14 for testing. Additionally, we have 91 Wave Drawings for training, 26 for validation, and 13 for testing. Prior to training, we pre-processed the images by resizing them to a resolution of 256x256.

For the prediction of results, both the spiral and wave models consist of 8 neural layers. These neural layers play a crucial role in analysing the input data and generating predictions based on the trained model

D. Model Training and Testing

During the model training and testing phase, the input images were fed to the model in batches. In the case of the Spiral Model, each batch contained 14 images, while for the Wave Model, each batch contained 13 images. A total of 7 batches were used for training, 2 batches for validation, and 1 batch for testing.

For the training process, a sequential CNN model was employed with an input shape of (256,256,1), indicating the size and channels of the input images. The model utilized the sigmoid activation function and the Adam optimizer for optimization. The model was trained for 15 epochs, allowing it to learn from the data and update its parameters accordingly.

After training, the Spiral Model achieved an accuracy of 98% and a loss value of 0.0027. This indicates that the model performs highly accurately in classifying and predicting whether an input image belongs to a healthy or Parkinson's affected individual based on their spiral drawings. On the other hand, the Wave Model achieved an accuracy of 84.61% with a loss value of 0.4070. This demonstrates the model's ability to distinguish between healthy and Parkinson's affected individuals based on wave drawings, although with a slightly lower accuracy compared to the Spiral Model.

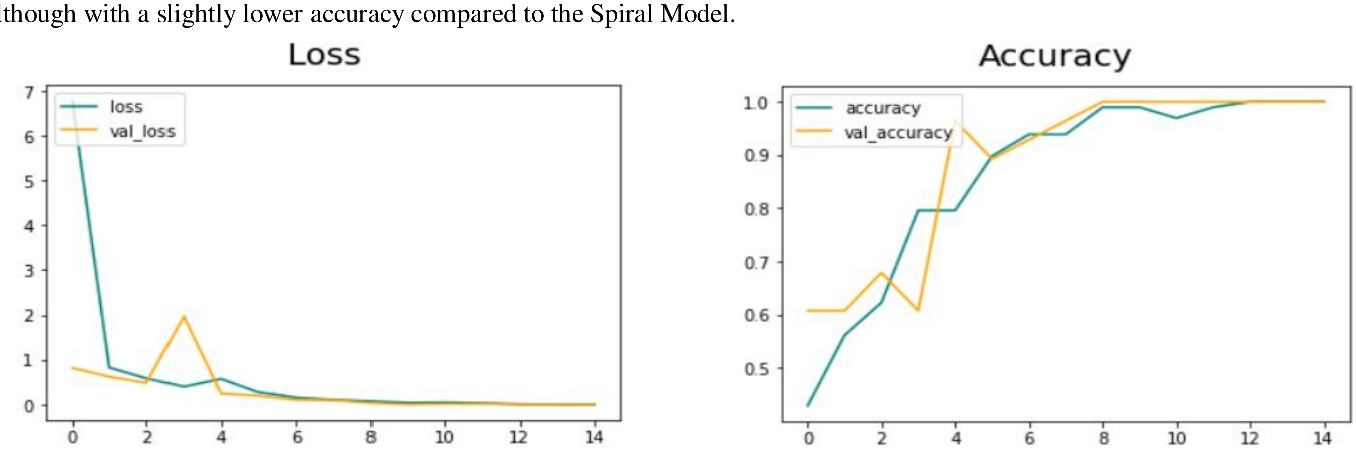

Fig. 3. Spiral Model's Accuracy & Loss

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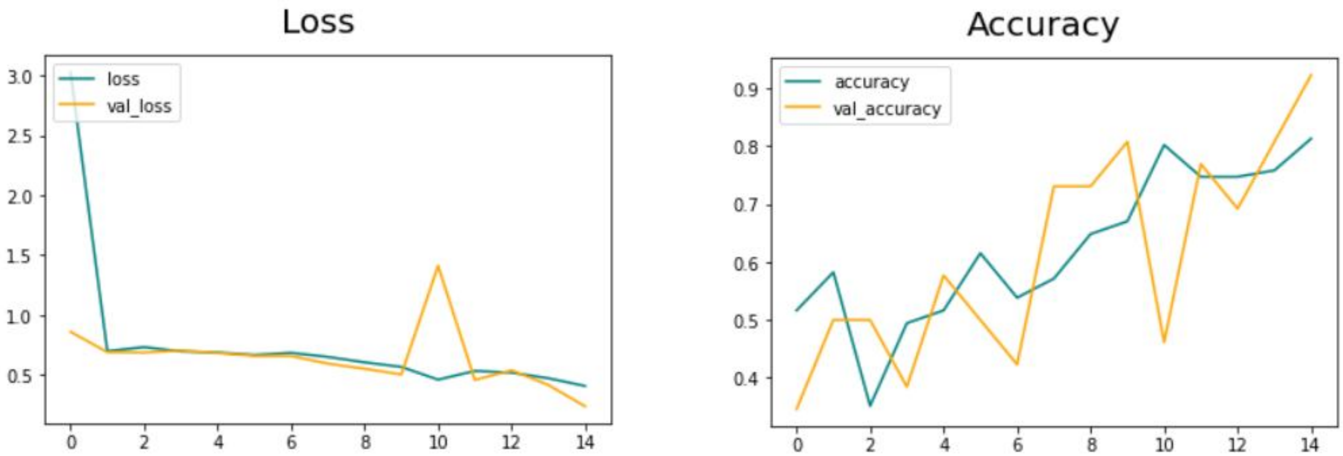

. Fig. 4. Wave Model's Accuracy and Loss

IV. RESULTS

In our research project, we successfully developed a system for Parkinson's Disease detection using machine learning algorithms and hand movement signals. We trained Convolutional Neural Network (CNN) models on a dataset of spiral and wave drawings to differentiate between healthy individuals and those affected by Parkinson's Disease. The Spiral Model achieved an accuracy of 98%, while the Wave Model achieved an accuracy of 84.61%.

We also created a user-friendly front-end interface, allowing users to easily submit their hand-drawn spiral and wave images for analysis. The system processed the images using the trained CNN models and provided real-time diagnostic results. The outcome was displayed on a result page, indicating whether the drawings exhibited characteristics associated with Parkinson's Disease.

To facilitate result management, we integrated an admin panel in Django to store and organize the diagnostic outcomes. This centralized hub enables authorized personnel to efficiently review and monitor the results.

Overall, our research demonstrates the effectiveness of our system in detecting Parkinson's Disease. The combination of accurate CNN models, a user-friendly interface, and result storage in the admin panel contributes to a comprehensive and practical solution for early diagnosis and intervention in Parkinson's Disease.

V. CONCLUSIONS

In conclusion, our research demonstrates the effectiveness of machine learning algorithms and hand movement signals in detecting Parkinson's Disease. The developed models, trained on spiral and wave drawings, showcase high accuracy rates and provide valuable insights for the early diagnosis of Parkinson's Disease.

The integration of our models into a user-friendly web interface using Django enhances the practicality and accessibility of the system. Overall, our research contributes to the development of non-invasive and objective diagnostic tools for Parkinson's Disease, potentially aiding in early intervention and improving patient outcomes.

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