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Neurosage: Predictive Modeling For Parkinson's Progression

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Abstract: In The Parkinson's disease (PD) is a progressive neurodegenerative disorder that affects movement, muscle control, and balance. Early diagnosis of PD is essential for timely intervention and management of the disease. This project proposes a novel PD detection system that leverages spiral drawings and convolutional neural networks (CNNs) for accurate and efficient diagnosis. The proposed system consists of two main components: data collection and analysis. Patients are instructed to draw spirals using a digital pen or touchscreen device, capturing the subtle motor impairments characteristic of PD. These drawings are then pre processed and fed into a CNN model for feature extraction and classification. The CNN model is trained on a dataset of spiral drawings from both PD patients and healthy individuals. Transfer learning techniques are employed to fine-tune a pre-trained CNN architecture, enhancing the model's ability to detect subtle patterns indicative of PD. The developed system is implemented using Python and Flask, providing a user-friendly web interface for data collection and analysis. The system aims to improve the accuracy and efficiency of PD detection compared to existing methods, offering a non-invasive and cost effective solution for early diagnosis and monitoring of PD patients.

Keywords: Parkinson, CNN, Deep learning, Spiral Drawings.

I. INTRODUCTION

Parkinson's disease (PD) is a neurodegenerative disorder that affects the central nervous system, leading to a gradual loss of muscle control and movement coordination. Early diagnosis of PD is critical to initiate timely treatment and interventions to slow down the progression of the disease. Therefore, accurate and efficient methods for detecting PD are essential in clinical practice. This project proposes a PD detection system that utilizes spiral drawings and convolutional neural networks (CNNs) developed using Python and Flask, a web framework. Spiral drawings are commonly used in clinical assessments to evaluate motor function in PD patients. The proposed system aims to improve the accuracy and efficiency of PD detection compared to existing systems.

The project involves several steps, including data collection of spiral drawings from PD patients and healthy individuals, data preprocessing to clean and prepare the data for analysis, feature extraction from the spiral drawings to obtain relevant features, and model development using CNNs, a popular deep learning technique known for its ability to automatically learn complex patterns from data. Flask, a Python web framework, is used to develop a user-friendly interface for the PD detection system.

II. METHODOLOGY

This method designs an advanced Convolutional Neural Network (CNN) based deep learning algorithm to predict Parkinson's disease using image. Traditional machine learning algorithms like SVM and Random Forest do not filter data multiple times, resulting in lower prediction accuracy. In contrast, the CNN algorithm filters data multiple times using neuron values, leading to improved prediction accuracy.

2.1 Preprocessing

Data pre-processing involves preparing raw data to make it suitable for a machine learning model. It is a critical initial step in creating a machine learning model. Often, the data encountered in a project is neither clean nor well-organized. Therefore, cleaning and formatting the data is essential before performing any operations on it. This is where data pre-processing comes into play.

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2.2 DL-CNN

Training and testing a CNN involves passing the source data through a series of layers including convolution layers with a kernel or filter, Rectified Linear Unit (ReLU), max pooling, fully connected layers, and a SoftMax layer for classification. The convolution layer is essential for feature extraction from the source image, maintaining the relationship between pixels by learning image features through small blocks of the input data. It uses a mathematical function with two inputs: the source image $I(x,y,d)$ where x and y are the spatial coordinates (number of rows and columns), and d is the image dimension (d=3 for an RGB image), and a filter or kernel $F(kx\ ,ky\ ,d)$ of similar size.

The output from the convolution process, called the feature map, has a size of C((x−kx+1),(y−ky+1),1). For example, if the input image is 5x5 and the filter is 3x3, the feature map is obtained by multiplying the input image values by the filter values.

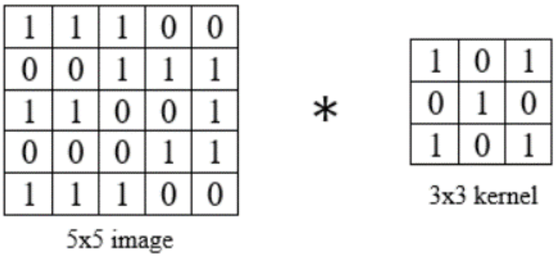

Fig. 1 convolution layer process of an image with size 5×5 is convolving with 3×3

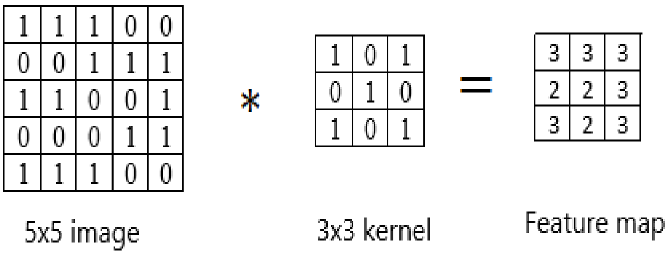

Fig. 2 convolution layer process of Convolved feature map.

2.2.1 ReLU layer

Networks that use the rectifier operation for hidden layers are known as Rectified Linear Unit (ReLU) networks. The ReLU function $G(*)$ performs a simple computation: it returns the input value directly if it is greater than zero; otherwise, it returns zero. Mathematically, this can be represented using the max function over the set of 0 and the input x as follows: $G(x)$=max{0, x}.

2.2.2 Max pooing layer

This layer reduces the number of parameters when dealing with larger images. Known as subsampling or downsampling, it decreases the dimensionality of each feature map while retaining the essential information. Max pooling selects the maximum element from the rectified feature map.

III. MODELING AND ANALYSIS

3.1 Problem Analysis

The problem analysis involves understanding the complexities of accurately diagnosing Parkinson's disease (PD) at an early stage. PD is a neurodegenerative disorder characterized by motor function impairments, and early detection is crucial for initiating effective treatments. Traditional diagnostic methods can be subjective and inconsistent, often leading to delayed or inaccurate diagnoses. This project aims to address these challenges by utilizing spiral drawings, which are commonly used in clinical assessments to evaluate motor function in PD patients.

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The analysis involves examining the variability and features in these drawings that differentiate PD patients from healthy individuals, ensuring the data collected is representative and suitable for training a deep learning model. Additionally, the problem analysis includes evaluating the technical requirements for implementing a convolutional neural network (CNN) to analyze the spiral drawings. This involves understanding the nuances of CNN architecture and its ability to automatically extract relevant features from complex data. The project also needs to ensure that the system is user-friendly and accessible to clinicians, which involves using Flask, a Python web framework, to develop an intuitive interface. Challenges such as data preprocessing, feature extraction, model accuracy, and system integration are identified and addressed in this phase, providing a clear roadmap for developing an effective PD detection system. This thorough analysis ensures that the project is well-equipped to tackle the intricacies of PD diagnosis and create a reliable and efficient tool for clinical use.

3.2 Proposed Model

The Proposed Model illustrates Parkinson's disease prediction using Convolutional Neural Networks (CNNs). The process commences with a dataset comprising images relevant to the disease. These images undergo preprocessing, which involves tasks like resizing, formatting, and normalization to prepare them for analysis. Subsequently, the images are fed into a CNN model capable of automatically extracting essential features from the image data. This feature extraction process is crucial as it allows the model to learn patterns associated with Parkinson's disease. Once the model has been trained on a dataset of images and their corresponding labels (indicating the presence or absence of Parkinson's), it's subjected to rigorous testing using a separate set of images. The ultimate goal is to create a model that accurately predicts whether a new, unseen image represents a person with or without Parkinson's disease. This pipeline, combining image processing, feature extraction, and deep learning, holds promise for aiding in the early detection and diagnosis of Parkinson's disease.

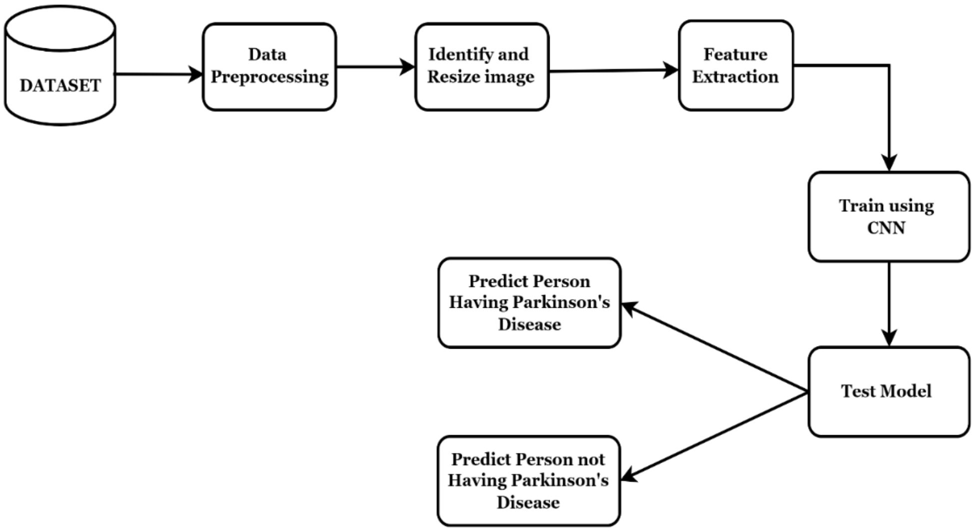

Fig. 3 Proposed Model of the System

3.3 Dataset

The dataset for Parkinson's disease detection consists of labelled spiral drawings from individuals diagnosed with the condition as well as from healthy people. Each drawing in the dataset represents a spiral pattern created by participants under controlled conditions, and these drawings are used to assess motor function and cognitive coordination. The dataset is designed for use with Convolutional Neural Networks (CNNs), which can analyze the intricate patterns in the spiral drawings to differentiate between healthy individuals and those with Parkinson's disease.

By training CNN models on this dataset, automated systems can be developed that can accurately detect and monitor the progression of Parkinson's disease based on subtle variations in drawing patterns that may be indicative of motor impairments associated with the condition. Dataset found in https://www.kaggle.com/datasets/kmader/parkinsons-drawings.

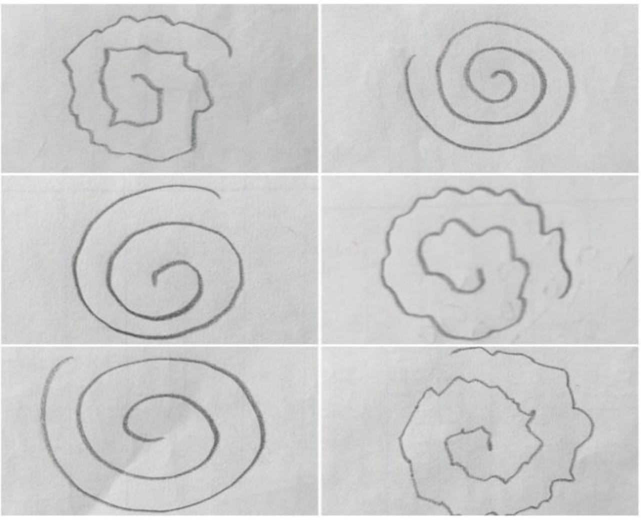

Fig. 4 Spiral Drawings Dataset

IV. CONCLUSION

The Parkinson's disease is a progressive neurological disorder that hinders the brain's ability to control movement. While there is currently no cure, early detection is essential for effective management. To facilitate early diagnosis, we have employed advanced deep learning techniques. These methods are proficient at analyzing complex data patterns, allowing them to accurately detect early symptoms of Parkinson's disease. Our approach involves extracting critical information from various datasets to create highly predictive deep learning models. By harnessing the capabilities of deep learning, we aim to greatly enhance the early detection and management of Parkinson's disease, ultimately improving patient outcomes and quality of life.

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