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DEPARTMENT OF COMPUTING

Module: 5COSC009C.2

Software Development Group Project

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Parkinson's Disease Detection Application

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I. Problem Background

Parkinson's disease (PD) is known to be one of the most common progressive neurological disorders, which results from the loss of brain cells that produce dopamine (Ali *et al.*, 2019). Dopamine is a neurotransmitter that directs the smooth and coordinated muscle movements of the body therefore low production of dopamine will cause mobility problems and tremors. The exact cause of Parkinson's disease is unknown, but it is found to be related with genetic and environmental factors (Thusha Nawasiwate *et al.*, 2019). Most people who develop PD are 60 years of age or older, but some people develop the disease at younger ages. More men are prone to be diagnosed with PD than women and having a close relative with this illness will increase the chances of developing it. The typical progression of Parkinson's disease with time are defined in 5 stages as shown in Figure 1. It is vital to diagnose PD at early stages because it is identified as an incurable disease. However, it is a challenging task to diagnose it as there are no specific tests for this condition. Generally, various tests and physical exams are performed to identify the most common symptoms present in PD patients: slowness of movement, voice impairments, shaking or tremors, rigidity of the limbs or trunk, and poor balance (Ali *et al.*, 2019).

Figure 1: Five Stages of Parkinson's Disease (Steve, 2020)

In 2016, 6.1 million individuals have been identified with Parkinson's disease globally and 211 296 deaths were recorded (Ray Dorsey *et al.*, 2018). Now more than 10 million people worldwide are living with PD and there are many more undiagnosed cases

With the challenging methods of diagnosis, the need for a digitalized system in assisting the process of diagnosing PD has become a necessity (Taleb *et al.*, 2020). The deterioration in handwriting is identified as a manifest of PD therefore, it can be used as one of the means to diagnose this disease. Handwriting is one of the day-to-day activities done by any person which requires fine dexterity abilities. This involves a mix of complex convoluted combinations of cognitive, sensory and perceptual-motor factors (Rosenblum *et al.*, 2013). Preceding researchers have shown that the handwriting method has the ability to analyze and discriminate various stages of PD. Hence, methods have been proposed to automatically detect a PD patient by comparing the handwriting of a potential PD patient with a healthy person's handwriting. This is achieved by applying micrography and vision-based methods on handwritten exams.

II. Research Gap

II.I. Dataset and data extraction

For the proposing project two data sets are found which are available online. The data set is called HandPD (Pereira *et al.*, 2015), and it was developed by the Faculty of Medicine of Botucatu, Sao Paulo State University, Brazil. Both datasets combined have a total of 158 individuals, which consists of 105 Parkinson patients and 53 healthy people in the control group. The data set is rich in variety,

Healthy group:

- Age: 19 - 79 years old
- Genders: both male and female
- Dominant hand: both left-handed and right-handed

Patient group:

- Age: 38 - 78 years old
- Gender: both male and female
- Dominant hand: both left-handed and right-handed

For the extraction of the data from the dataset the method used by (Pereira *et al.*, 2015).

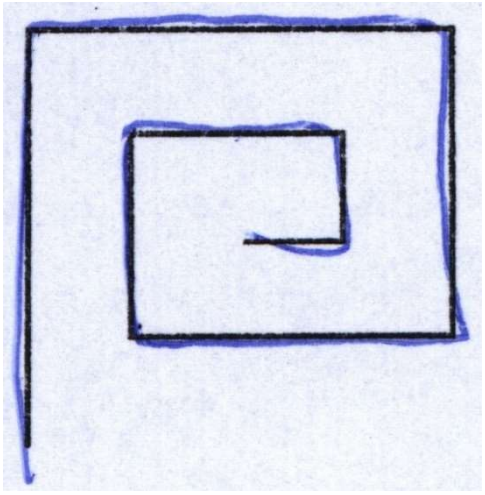

Figure 2: Healthy person control group hand-drawing example

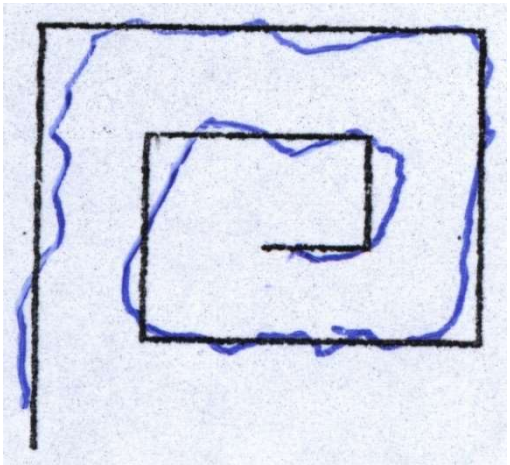

Figure 3 : PD patient hand-drawing example

II.II. Machine learning model

(Pereira et al., 2015) has carried out experiments through three supervised pattern classifiers such as Naive Bayes, Optimum path forest and support vector machines. Out of these classifiers the classifier that showed the highest accuracy percentage was Naive Bayes followed closely by Optimum path forest.

(Chakraborty *et al.*, 2020) has used Deep learning algorithms such as CNN and sophisticated computer-aided detection systems to increase the accuracy and the efficiency of the diagnosis.

(Gil-Martín, Montero and San-Segundo, 2019) has also used CNN for the detection of Parkinson's disease. First the dataset was divided into 5 subset form which four were used for training and one for testing. To train the CNN experiments were repeated five times by modifying the test and training sets and by doing so they have reached an accuracy of 96.5%.

By referring to these researches the authors have decided to use an instant based algorithm under supervised method to develop a machine learning model. By using this model authors plan to produce a binary output, whether the user has Parkinson's disease or not.

II.III. Existing solutions

Since Parkinson's disease was first discovered in 1817, researchers have attempted to give better solutions to diagnose this disease. Some of them are

- Zham and his team have proposed a study that uses speed and pen pressure to identify Parkinson's disease. To do this they have used a digital tablet in order to get the inputs from the patients, and then they have proposed a method that provides a correlation factor between the features and severity level of Parkinson's disease. This approach has a good accuracy rate and efficiency, but this approach has not considered the fact that everyone might not have the accessibility to a digital tablet.
- Naranjoa and his team have proposed a study that uses voice recordings to extract features and consider an advanced statistical approach for pattern recognition (Naranjo *et al.*, 2016). The approach that they have taken is a novel subject-based Bayesian approach. This approach has a good accuracy rate with a mean value of 0.752 and also is affordable since all it needs is a recording device (i.e. mobile phone, voice recorder) but the issue with this approach is that not every patient with Parkinson's disease develops speaking disabilities (*What Are Common Symptoms of Parkinson's Disease?*, 2017).
- In 2015, a research team proposed a study that uses voice, posture, gait, finger tapping, and response time of person which would be obtained by the user's phone through an application (Arora *et al.*, 2015). The method of classification which has been used is random forest. This approach has an average mean absolute error of 1.29 and, it is a very cost-effective idea since the user only needs a smartphone. But the issue is this process takes a lot of time that the user might not have if the user has the disease.

III. Aim

"This project aims to research on, design, and implement a system to predict and diagnose if the user has Parkinson's disease or not".

Further elaborating on the aim of the project, it introduces a mobile application with an artificial intelligence model that can diagnose whether the user has Parkinson's disease or not. The project plans to enable the application to work regardless of the region of the user or the gender. The application is going to support almost every Android phone on the market. The application is planned to be user-friendly as well as be easy to understand by any age group.

IV. Scope

IV.I. In – Scope

- User must draw on the printed meander shape which is given in the A4 sheet.
- User can only use blue color pen to draw the meander Shape.
- When taking the photograph of this drawing the camera should place directly above the image (90 degrees) and the camera must be parallel to the surface of the A4 sheet.
- The images which are taken by the camera must be 720p or above.
- All the markers should be visible.
- Application can run on android devices only. The version must be Android Jellybean, v16, 4.1.x or newer.
- Hardware requirement must be an ARM based Android device.
- Predicting the user is a Parkinson's patient or not.

IV.II. Out – Scope

- If the shape which is in the printed A4 sheet be a spiral shape.
- If the image which on the printed A4 sheet is dynamic.
- Images of drawings which are below 720p.
- Predicting the Parkinson's disease stages.
- iOS devices.
- Devices which have an older version than Android Jellybean, v16, 4.1.x.

V. Features of the prototype

Based on the current proposed prototype, the authors have decided to implement a mobile application that can detect if a patient has Parkinson's disease using an image of their handwriting.

The mobile application will be built using android and the objectives of the mobile application is to provide the user a simple interface where they can easily take a photo specified image that will determine if the individual that drew the special markings on the photo had Parkinson's disease or not .

V.I. Instructions for the users

First the app will consist of a feature where the users are given instructions on how to print a special set of markers onto a piece of paper (The application will provide a file containing the special markers to be printed).also it will include a detailed explanation on how the user should take the required images .

V.II. Inputs from the camera

The Second feature consists of a camera feature where the user is able to take image of the paper prepared by the user. This camera feature will also include an overlay in the camera screen so that the user is able to align the markings on the paper with the overlay, allowing the user to minimize the errors when using the mobile application

V.II. Insert existing images

The third feature gives the user the ability to insert an image that was taken previously using the required markers, that is in the phone memory.

V.II. Machine learning algorithm and result

The main highlighted feature of the application is to obtain the image by the user by either the inbuilt camera or that is uploaded and run the image through a machine learning algorithm that will detect and analyze the markers and hand drawings made by the user or a patient and provide the user with a result which includes if the person that made the drawing has Parkinson's disease or not.

VI. Proposed technologies to be used for the prototype

VI.I. Flutter (Framework) – Front end development

The front end of the application the authors are planning to develop will be made using Googles' open source mobile UI framework called Flutter. The programming language Flutter is written in is called Dart. Simply, Flutter allows the developers to create a native mobile application with only one code base. Features like hot reload will expedite development. Flutter's widgets incorporate all critical platform differences such as scrolling, navigation, icons and fonts to provide full native performance on both iOS and Android.

VI.II. Python (Programming language) – Machine learning and Data science

Machine learning can make connections between disparate datasets but requires serious computational sophistry and power. Python fills this need by being a general-purpose programming language. It allows developers to create CSV output for easy data reading in a spreadsheet.

Python has long been known as an easy programming language to learn, from syntax to point of view and also since it has an active community with a vast collection of libraries and resources, the authors will be using the language for the machine learning and data science components of the application. Python also enables developers to get prototypes running quickly, which will ensure fast development.

VI.III. Numpy – Python library

Numpy is the core library for scientific computing in python. It provides a high-performance multidimensional array object and tools for working with these arrays. Numpy is a powerful N-dimensional array object which is Linear algebra for python. Numpy arrays are essentially Vectors and Matrices. Vectors are strictly 1-D array whereas Matrices are 2-D, but matrices can have only one row/column.

VI.IV. Pandas – Python library

Pandas is an open source library built on top of Numpy providing high performance, easy to use data structures and data analysis tools. It allows for fast analysis and data cleaning and preparation. It enables developers to work with data from a variety of sources.

VI.V. Firebase – Serverless architecture

Firebase enables developers to use a "serverless" architecture for the back end of the application. In simple terms, Serverless architecture is a programming paradigm that focusses on coding functions for web-endpoints directly rather than going through the whole process of setting up a server, routing requests, defining REST resources and then creating methods for GET, POST and PUT.

Since the authors are using Flutter as the framework to develop the application's front end, it was decided on working with Firebase. Firebase and Flutter work hand in hand since both are integrated well. Firebase gives the developers access to backend services for mobile applications including authentication, storage, database, and hosting without maintaining independent servers.

VI.VI. Anaconda – Package manager for Python

Anaconda is a free and open-source distribution of the Python for scientific computing (data science, machine learning applications, large-scale data processing, and predictive analytics that aims to simplify package management and deployment. The distribution includes data science packages suitable for Windows.

Anaconda distribution comes with over 250 packages automatically installed, and over 7,500 additional open-source packages can be installed from PyPl as well as the Conda package and virtual environment manager. It also includes a GUI, Anaconda Navigator, as a graphical alternative to the command line interface.

VI.VII. TensorFlow – Machine learning library used with Python

TensorFlow is an open source library for numerical computation and large-scale machine learning. TensorFlow bundles together a slew of machine learning and deep learning, also known as neural networking models and algorithms. TensorFlow allows the developers to create dataflow graphs and structures that describe how data moves through a graph. Each node in a graph will represent a mathematical operation and each connection or edge between nodes is a multidimensional data array or tensor.

VI.IX. Scikit-learn - Machine learning library used with Python

Scikit-learn is another ML library used with Python. It features various classification, regression and clustering algorithms. Scikit-learn uses Numpy extensively for high-performance linear algebra and array operations. The plan is to use this library when developing the application.

VII. Feature Comparison Chart

Feature	Drawing Movements Research (Gil-Martín, Montero and San-Segundo, 2019)	Detecting and monitoring using smartphones (Arora *et al.*, 2015)	Proposed Application
Input using Graphics tablet	✓		
Input Using camera			✓
Test voice		✓	
Tap test		✓	
Posture test		✓	
Upload Image to test			✓
Detect if user has Parkinson's	✓	✓	✓

Table 1: Feature comparison chart

VIII. References

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IX. Work breakdown chart

Work done	Meraki Group Members					
	w1761764	w1761962	w1761910	w17617653	w1761909	w1761778
Problem Background	✓	-	-	-	-	-
Research Gap	-	✓	-	✓	-	-
Aim	-	✓	-	-	-	-
Scope	-	-	-	-	✓	-
Features of the prototype	-	-	-	-	-	✓
Proposed technologies to be used for the prototype	-	-	✓	-	-	-
Feature Comparison Chart	-	-	-	-	-	✓
Research on the Topic	✓	✓	✓	✓	✓	✓
Final Editing to the Project Proposal	✓	✓	✓	-	-	-

Table 2: Work breakdown chart for team Meraki