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A Project Report on

Detection Of Parkinson's Disease Through Speech Analysis

Submitted by,

Ajinkya Kshatriya	**(Exam Seat No. T224089)**
Harshwardhan Tilekar	**(Exam Seat No. T224006)**
Piyush Bhondave	**(Exam Seat No. T224090)**
Sarthak Wakchaure	**(Exam Seat No. T224105)**

Guided by,

Mrs. Kavitha S

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CERTIFICATE

It is hereby certified that the work which is being presented in the Third Year Project Design Report entitled **"Detection Of Parkinson's Disease Through Speech Analysis"**, in partial fulfillment of the requirements for the award of the Bachelor of Technology in Computer Engineering and submitted to the **School of Computer Engineering and Technology** of **MIT Academy of Engineering, Alandi(D), Pune, Affiliated to Savitribai Phule Pune University (SPPU), Pune**, is an authentic record of work carried out during Academic Year Semester **V**, under the supervision of **Mrs. Kavitha S**, **School of Computer Engineering and Technology**

Ajinkya Kshatriya	**(Exam Seat No. T224089)**
Harshwardhan Tilekar	**(Exam Seat No. T224006)**
Piyush Bhondave	**(Exam Seat No. T224090)**
Sarthak Wakchaure	**(Exam Seat No. T224105)**

Mrs. Kavitha S
Project Advisor

Dr. Sandeep Pande
Project Coordinator

Mrs. Ranjana Badre
Dean

External Examiner

DECLARATION

We the undersigned solemnly declare that the project report is based on our own work carried out during the course of our study under the supervision of **Mrs. Kavitha S**.

We assert the statements made and conclusions drawn are an outcome of our project work. We further certify that

1. The work contained in the report is original and has been done by us under the general supervision of our supervisor.
2. The work has not been submitted to any other Institution for any other degree/diploma/certificate in this Institute/University or any other Institute/ University of India or abroad.
3. We have followed the guidelines provided by the Institute in writing the report.
4. Whenever we have used materials (data, theoretical analysis, and text) from other sources, we have given due credit to them in the text of the report and giving their details in the references.

Ajinkya Kshatriya	**(Exam Seat No. T224089)**
Harshwardhan Tilekar	**(Exam Seat No. T224006)**
Piyush Bhondave	**(Exam Seat No. T224090)**
Sarthak Wakchaure	**(Exam Seat No. T224105)**

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We would be failing in our duty if we do not thank all the other staff and faculty members for their experienced advice and evergreen co-operation

Ajinkya Kshatriya **(Exam Seat No. T224089)**

Harshwardhan Tilekar **(Exam Seat No. T224006)**

Piyush Bhondave **(Exam Seat No. T224090)**

Sarthak Wakchaure **(Exam Seat No. T224105)**

Contents

ABSTRACT

Parkinson's Disease (PD) patients' vocal alterations might be identified early on, allowing for management before physically incapacitating symptoms appear. In this work, static and dynamic speech characteristics that are relevant to PD identification are examined. The amount of articulation transitions and the trend of the fundamental frequency curve are considerably different between HC speakers and PD patients, according to a comparison of articulation transition features.The energy content in the transition from unvoiced to voiced segments (onset) and in the transition from voiced to unvoiced segments is used to calculate the dynamic speech characteristics (offset). This project proposes a method to build machine learning models using static features in terms of accuracy of PD detection under the two evaluation methods of splitting the dataset without samples overlap of one individual and 10-fold cross validation (CV).

Chapter 1

Introduction

Parkinson's disease is a neurodegenerative condition brought on by the loss of the neurotransmitter dopamine. PD is more prevalent. Gait and postural alterations in the aged population might increase the risk of falling and lead to mobility issues. It therefore affects daily activities and decreases the quality of life for patients and their families. Parkinson's illness mostly affects motor function. The signs of this movement disease include the inability to move freely, reduced and slow movement, increased muscular tonus, and shaking movement during rest. Lack of facial expression, poor coordination, and noticeable voice and speech changes are other traits. Since PD symptoms intensify as the disease advances, more sensitive diagnostic techniques are needed for PD diagnosis. An someone with, let's say, Parkinson's disease (PD) patients experience less stress, less intensity, and monotonous pitch and loudness (dysphonia). Given how easy and painless it is to gather speech data using mobile devices, the range of voice-related symptoms appears intriguing as a prospective screening approach. The early signs of Parkinson's disease are subtle, making them difficult to identify.

An intriguing research topic is the automatic detection of PD from speech since it has the potential to be used as a reliable instrument for non-invasive diagnosis. The capacity to detect PD subtly has the potential to dramatically advance medical care. Non-invasive procedures have a number of advantages, but their main advantage is that they enable diagnosis outside of a hospital environment, which reduces the inconvenience and cost of PD patients' physical travels for medical testing. Applications requiring on-the-spot screening and remote health monitoring are among the most popular choices for PD detection from speech as a result of this advantage.

Most of the time, Parkinson's disease has no identified aetiology. Pathological alterations in dopaminergic neurons and the resulting neurochemical dysfunction have been shown to be the most salient features of this illness. The bulk of the dopamine-producing neurons in the brainstem come together to produce a black substance called the substantia nigra. This anatomical region helps to produce regular bodily movement and has close links to other deep brain areas. Reduced range of motion and changes in voluntary motion are caused by a lack of dopamine production in the dopaminergic neurons of the substantia nigra. Parkinson's illness presently has no known cure. The illness progresses in different ways and at various rates. The signs of Parkinson's disease can be managed with a variety of medications.

1.1 Background

If we see the methods how Parkinson's disease was detected before Machine Learning is involved then we will get the idea of necessity of new approaches for detection of this disease. Parkinson's disease is neurodegenerative disease having progress over the time which have some unary percentage of affected people above the age sixty. Parkinson disease have mainly effect in older age group like people above the age fifty and similar. And if we see the growth rate of population and age wise growth then we can say that the crowd having danger of this disease is also increasing day by day. So, scope of this project is large enough that we need to watch it as a topic of concern.

Analyzing signs which are based on tests in clinic and the observations noted in medical are used for the diagnosis of Parkinson's Disease (PD), which includes the describing the variety of motor symptoms. But subjectivity is something with which traditional diagnostic approaches mostly suffers because they are dependent of the analyzation of movements which are mostly unclear to us and so as hard for classification, heading towards possibility of wrong classification. Most of the times early symptoms which does not include movements of PD are minor and so as we can say that there are strong chances that they are because of some other reasons or conditions. Concluding this we can say that taking decision based on these symptoms will lead us to wrong direction, making it challenging the detection of Parkinson earlier.

To find out solutions to these problems and difficulties and to make it possible to detect PD in early stage through updating procedure which had been used for detection and identification of Parkinson's disease, machine learning methods are to be used in this project to head towards diagnosis and differential diagnosis for Parkinson's Disease. With an investigation of source and type of data, aims heading towards use of ML methods and the related outcomes which mostly lead us to classification. A common method used from machine learning for detecting Parkinson's disease is classification where we classify the Parkinson's affected person and a healthy person based on voice signal from a concerned person, which is basically main aim of this project.

1.2 Project Idea

We intend to create and develop an application for finding out patient of Parkinson's disease through extracting the features of speech and its examination which will be referred for classifying Parkinson affected persons in order to achieve Parkinson disease affected and healthy person. The different characteristics taken from speech at a synchronization level of the pitch can be used to measure the quantity of abnormal functioning in the muscular structure of vocal tract caused by PD. By applying different kind of algorithms over the data set for classification purpose and comparing among them to build an efficient machine learning model in order to detect Parkinson's Disease

1.3 Proposed Solution

The primary goal is to detect PD, which will be advantageous for patients who are suffering from Parkinson's disease and will lower the disease's prevalence. The architecture diagram outlines the process flow that is used to clean up the raw data and use it to forecast Parkinson's data. The collected raw data is first preprocessed into a format that can be understood. After that, we must divide the dataset into train and test data in order to train the data. The classification accuracy of this model is determined by evaluating the Parkinson's data using a machine learning algorithm that combines SVM, KNN, and Random forest.

Chapter 2

Problem Definition and Scope

2.1 Problem statement

To design and develop an application for the detection of parkinson's disease using speech analysis.

2.2 Scope and Major Constraints

Scope of our project :

1. To validate a set of features appropriate for reviewing patient recordings with Parkinson's disease.
2. To perform preprocessing operations on speech.
3. To build an efficient machine learning model for the early detection of Parkinson's disease.
4. To evaluate the performance analysis with existing feature selection algorithms, sampling techniques, and classifiers, and compare the results.

2.3 Hardware and Software Requirements

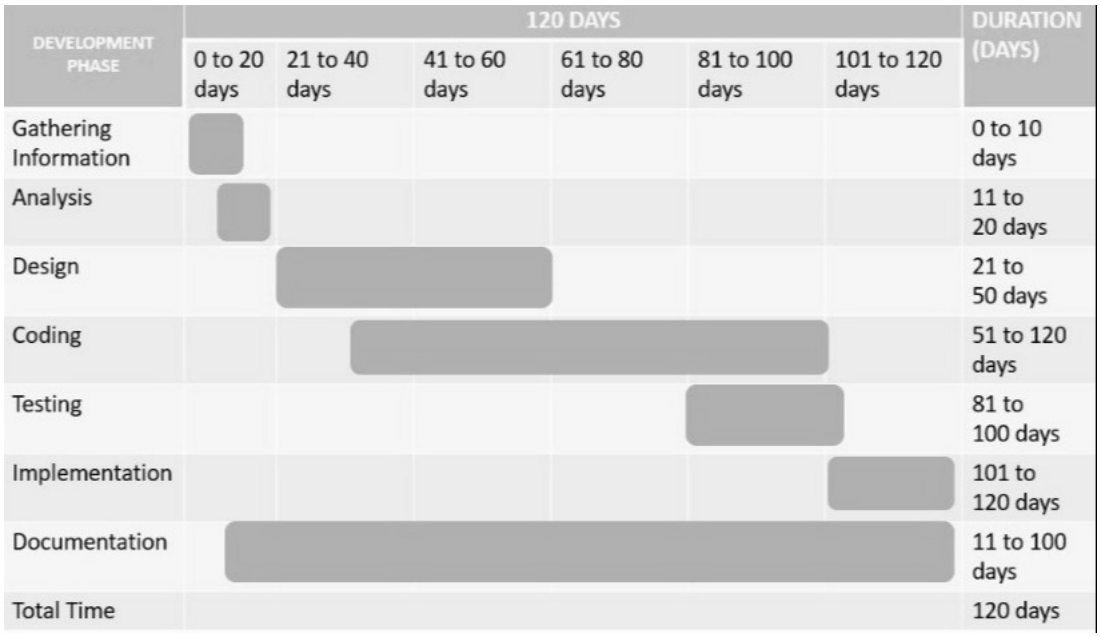
Software Requirements:

- Operating System: Windows, Linux
- Language: Python
- Libraries: Sklearn, Numpy, Pandas
- IDE: Google Colab
- Algorithm: SVM, KNN, Random Forest

Hardware Requirements:

- Device : PC or Laptop
- Equipment: Microphone

2.4 Action Plan



Chapter 3

Literature Review

Serial No	01
Title	Deep Learning-Based Parkinson's Disease Classification Using Vocal Feature Sets
Date	August 2019
Author	Hakan Gunduz
Contribution of Author	In this study, CNN and SVM classifiers are used to classify PD.
Remarks	Choose the pertinent features that best capture the inherent characteristics of the speech (audio) data.

Serial No	02
Title	On Detection Parkinson's Disease using Speech Signal of a phone call.
Date	August 2022
Author	Victor Monzon Baeza
Contribution of Author	The author has looked at a technique for utilising a phone to diagnose Parkinson's symptoms. Signal processing can be used to save costs while also enhancing patient comfort.
Remarks	Using the fact that vocal dysfunction may be among the initial PD symptoms, speech may be a good indication for identifying persons with Parkinson's.

Serial No	03
Title	A Deep learning Based Method for Parkinson's Disease Detection Using Dynamic Features of Speech Dataset: Manual
Date	July 2019
Author	Changqin quan , kang ren, and zhiwei luo
Contribution of Author	In this paper, they used Traditional ML method, Deep Learning and articulation transition of HC speaker and PD patient.
Remarks	With classification accuracy of 80, the monologue feature of speech is best for identifying early PD patients from healthy controls.

Serial No	04
Title	End-2-End Modeling of speech and gait from patients with parkinson's disease
Date	April 2021
Author	J. C. Vasquez-Correa1,2? T. Arias-Vergara1,2,3 P. Klumpp1 P. A. Perez-Toro1,2 J. R.
Contribution of Author	They were able to find that without having microphone of high quality parkinson's disease can be detected with smartphone's microphone.
Remarks	The suggested model in this study is based on CNNs and uses Mel-spectrograms as input to analyse speech signals.

Serial No	05
Title	Unobtrusive monitoring of speech impairments of parkinson's disease patients through mobile devices
Date	August 2018
Author	T. Arias-Vergara, J.C. Vasquez-Correa
Contribution of Author	In the course of casual discussions over the phone, the patients' speech is recorded.
Remarks	No need to check separately in hospitals.

Serial No	06
Title	Towards an automatic monitoring of the neurological state of parkinson's patients from speech
Date	January 2021
Author	J.R. Orozco-Arroyave, J.C. Vasquez-Correa
Contribution of Author	The correlation values found with the Spanish data are often greater than those with the other languages. It is possible that this set of speakers' higher UPDRS levels and more variability contribute to the ease with which the neurological condition may be predicted.
Remarks	What if the UPDRS scores and variability of the speakers were higher?

Serial No	07
Title	A comparative analysis of speech signal processing algorithms for Parkinson's disease classification
Date	January 2019
Author	Sakar, C. O., Serbes, G., Gunduz, A., Tunc, H. C., Nizam,H., Sakar, B. E., ... Apaydin
Contribution of Author	The author compared the various speech signal processing techniques for PD identification. In their research, a brand-new function known as the adjustable Q-factor wavelet transform was presented.
Remarks	Kernel SVM reported the best accuracy of 86 for all feature subsets. For the purpose of detecting PD, they employed a web application.

Serial No	08
Title	The Detection of Parkinson's Disease From Speech Using Voice Source Information
Date	June 2020
Author	N. P. Narendra , Björn Schuller , Fellow, IEEE, and Paavo Alku , Fellow
Contribution of Author	In this paper, author has done classification with SVM and MLP classifiers. PC-GITA database used to detect PD.
Remarks	SVM classifiers were created utilising baseline characteristics known to characterise articulation, phonation, and prosody in order to detect PD.

Serial No	09
Title	Classification of Parkinson's disease Using Pitch Synchronous
Date	January 2018
Author	Sai Bharadwaj Appakaya and Ravi Sankar
Contribution of Author	They presented a unique approach for feature extraction and analysis in this work.
Remarks	The findings demonstrate that the PD-affected vocal tract may be followed as it changes using the pitch synchronous analysis approach.

Serial No	10
Title	Effect ofacousticconditions on algorithms to detect parkinson's disease from speech
Date	November 2021
Author	J. C. Vdsquez- Correa, SerrOrozco- Arroyave. F. Vargas-Bonilla, E. Noth
Contribution of Author	In this study, the efficacy of five different techniques for detecting PD in speech was assessed. PD patients vs. HC speakers were assessed using a variety of acoustic settings, and the effects of these variables were also examined.
Remarks	Background noise most substantially affects the classification process. It must be given particular attention in order to regularly check the neurological condition. Using dynamic compression and codecs can improve the outcomes.

Chapter 4

System Requirement Specification

4.1 Overall Description

The prerequisites are explained in this chapter. outlines the software and hardware specifications needed for the programme to operate correctly.The assessment of the dissertation and its functional and nonfunctional requirements are provided in the Software Requirements Specification (SRS), which is detailed in depth.

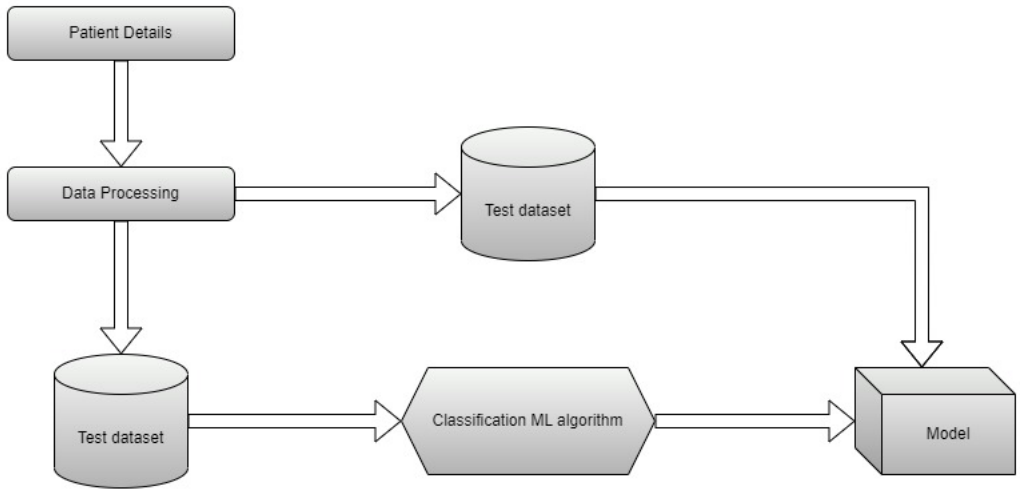
An SRS document outlines each data, functional, and behavioural requirement for software that is under development or production. The SRS is a crucial document that forms the basis of the software development process. It gives a full description of how the behaviour of the system will change. Along with a list of the system requirements, it also offers a synopsis of its main features. The aforementioned activities are a part of the systems engineering and software engineering process known as requirements analysis, which identifies the requirements that must be fulfilled for a new or modified product while taking into account the potentially conflicting requirements of various stakeholders, such as beneficiaries or users. The outcomes of the requirements analysis determine the success of a development project. Requirements should be recorded, requirement tested, tied to known business opportunities or requirements, and stated in sufficient depth to support system design.

The SRS serves as a guide for finishing the project. The SRS is sometimes referred to as a "mother" document since it serves as the foundation for all other project management

papers that come after it, including design specifications, statements of work, and software architecture. The SRS only includes functional and non-functional criteria, which is significant to notice.

4.2 Modeling

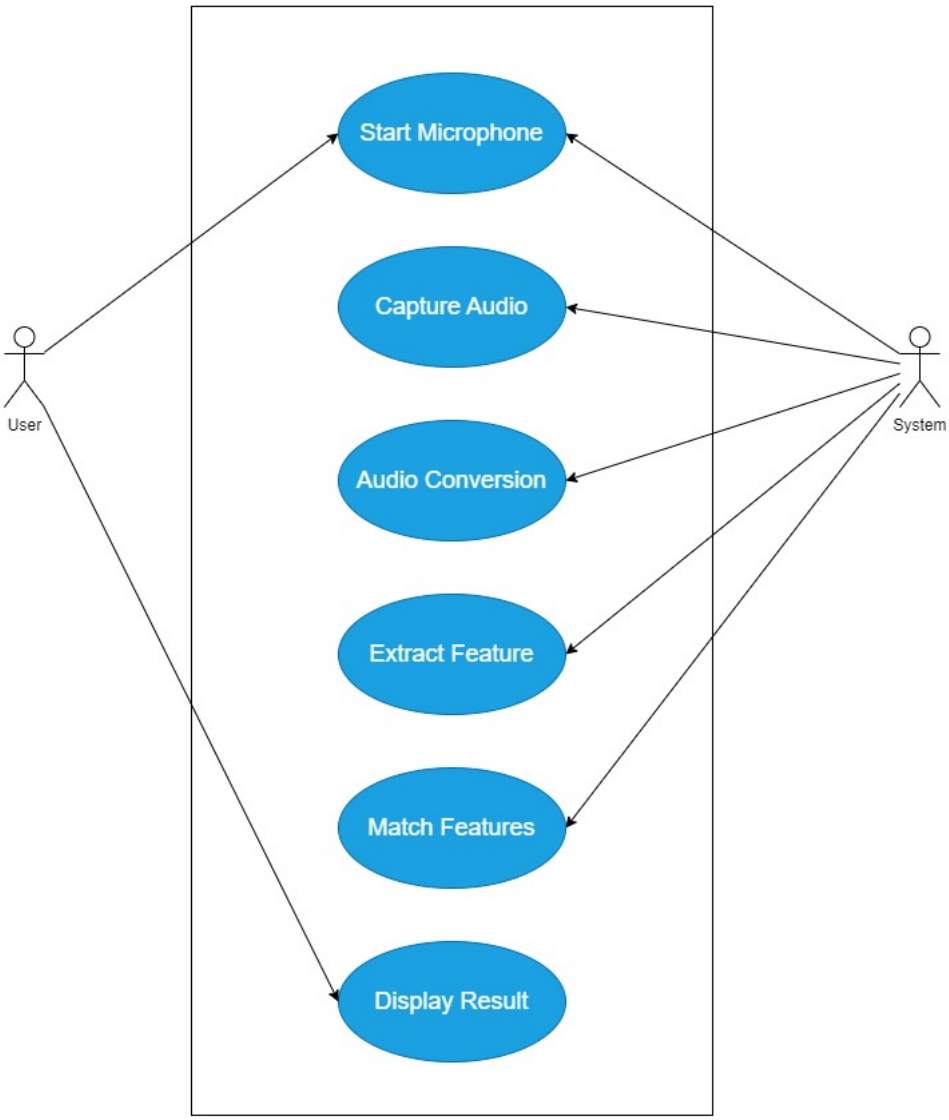
An engineering depiction of a proposed construction known as a design.The most critical part of the development process is when requirements are represented as software. The best method for faithfully converting a customer's request into a final software solution is design. The design of a new structure must be backed by software, be based on the user 's needs, and be thoroughly analyzed against the existing system. The system design is not yet complete. The end product of the design process is a representation or model that includes details on the architecture, interfaces, data formats, and other system-related components. It is necessary to make changes to the logical layout of the system, which was generated through system analysis, before creating the physical design.



Block Diagram

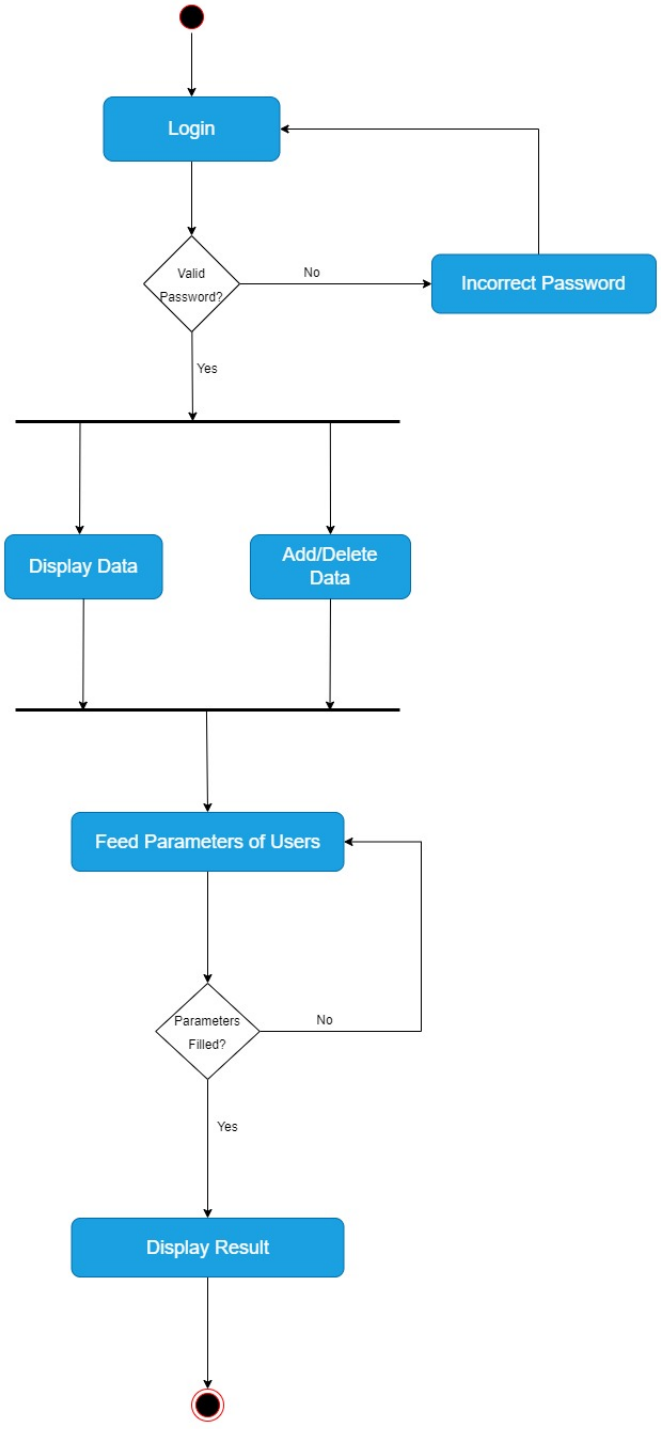
4.2.1 Use Case Diagram

An interaction between external entities and the system under study that is goal-oriented is defined by a use case. The players in the system are external entities that communicate with it. A collection of use cases that can be graphically labelled describes the whole capabilities of the system in great detail.



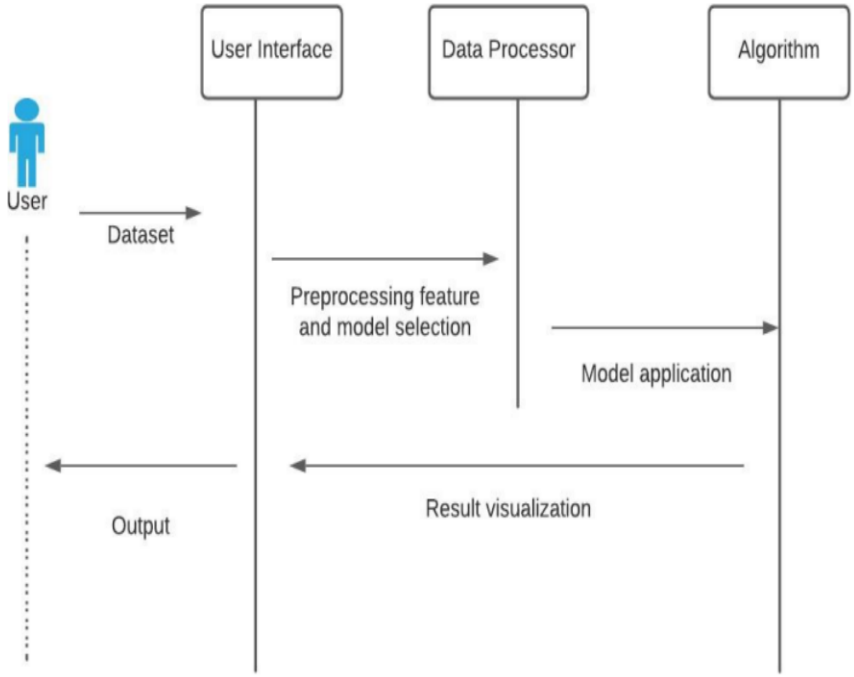
4.2.2 Activity Diagram

An activity diagram displays the order in which a complicated process's various steps must occur. The name of the operation is presented in a round box that represents the activity. The transition signalled by completion is indicated by the designed arrow added to the end of the activity symbol.



4.2.3 Sequence Diagram

Sequence diagram illustrates how and in what order a collection of items interacts, a sequence diagram is a form of interaction diagram. Software designers and business experts use these diagrams to clarify the specifications for a new system or to record an existing procedure. The terms ”sequence diagrams” and ”event scenarios” are frequently used interchangeably.



Chapter 5

System Requirement Specification

5.1 Overall Description

The prerequisites are explained in this chapter. outlines the hardware and software specifications needed for the application to operate correctly. A detailed explanation of the Software Requirements Specification(SRS), which comprises a summary of a dissertation and its functional and non-functional requirements, is provided.

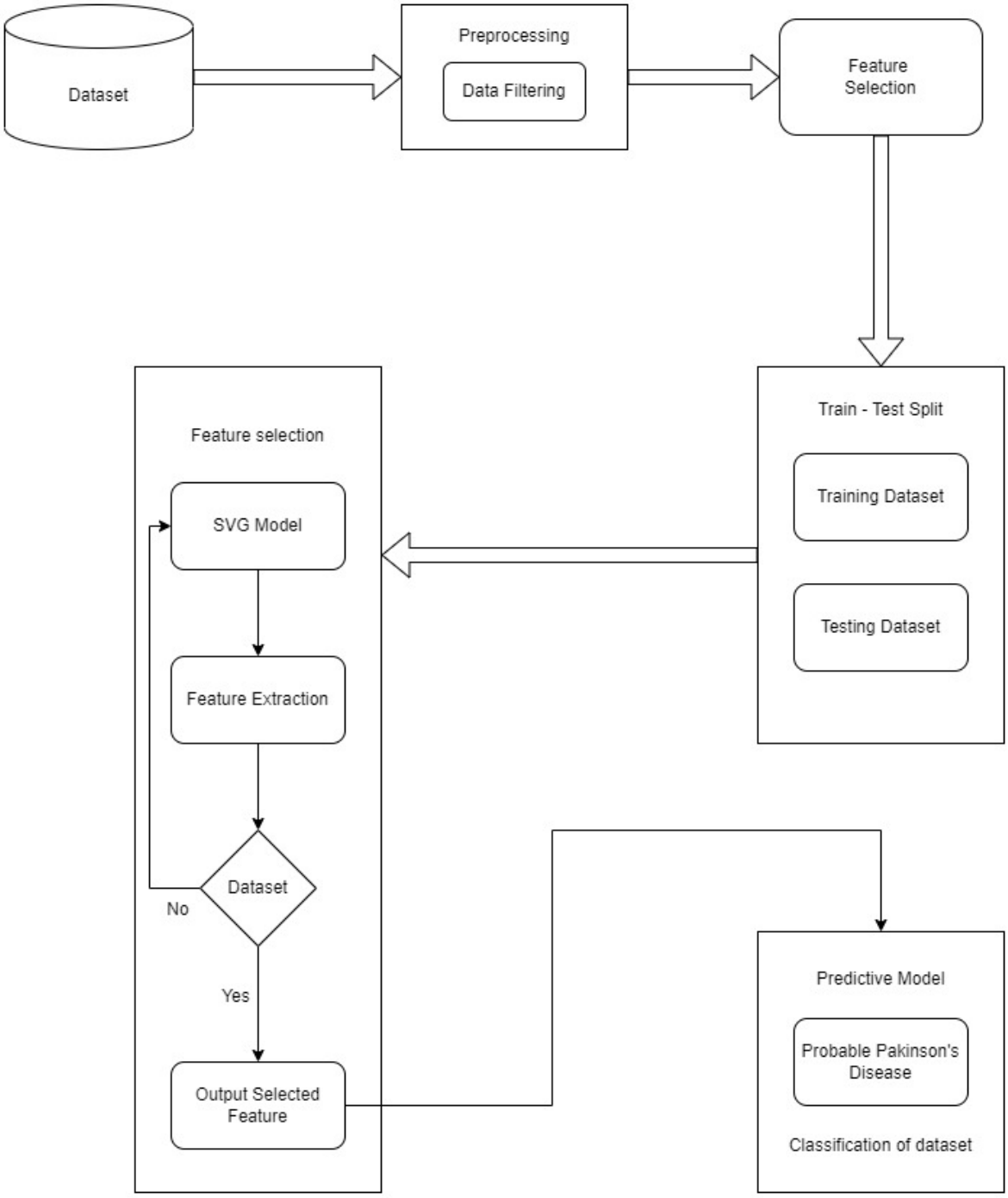
All information, functional requirements, and behavioural requirements for software that is in production or development are described in an SRS document. A key document that serves as the foundation for the software development process is the SRS. It provides a thorough explanation of how the system's behaviour will be evolved. It includes a description of its key features in addition to a list of the system requirements. These activities are a part of requirements analysis in software engineering and systems engineering, which identifies the requirements that must be fulfilled for a new or improved product while taking into consideration the potential compatibility of a subject with the other stake - holders, including such recipients or users. Success of a development project depends on the findings of a requirements analysis. The demand must be well-defined, include adequate details for system design, be measurable, testable, and linked to known business opportunities or needs.

5.2 Implementation

The following steps will be used to implement the problem statement described above.

1. The process flow that is utilised to clean up the raw data and used to forecast Parkinson's data is outlined in the architectural diagram.
2. The gathered raw data is preprocessed into a comprehensible format as the following step.
3. After that, we have to divide the dataset into train and test data in order to train the data.
4. The classification accuracy of this model is determined by using a machine learning approach that includes SVM, KNN, and Random forest to the Parkinson's data.
5. The same algorithms will be used for testing after the data has been trained using them.
6. Finally classification accuracy will be used to compare the output of these three algorithms.

Flow Chart


Dataset
Preprocessing
Data Filtering
Feature Selection
Train - Test Split
Training Dataset
Testing Dataset
Feature selection
SVG Model
Feature Extraction
Dataset
No
Yes
Output Selected Feature
Predictive Model
Probable Pakinson's Disease
Classification of dataset

Chapter 6

Conclusion

6.1 Conclusion

Research into Parkinson's disease is now of utmost importance, and an early diagnosis can enhance the quality of life for the patient. The techniques for speech analysis have lately made enormous strides. Early detection of PD is essential to better understanding the causes of the condition, launching therapy approaches, and enabling the development of efficient drugs. The study assesses how different aural environments affect various PD detection techniques. The findings show that classification work is significantly impacted by background noise. In order to frequently monitor the neurological status, it must be properly taken into consideration.

This study's major goal is to show how speech signal analysis may be used to identify Parkinson's disease. Due to the non-intrusive nature of voice measures, speech processing has long shown that it offers great potential for PD diagnosis. This study's objective is to assess how well different categorization techniques work. Several classifiers will be evaluated on a speech dataset using statistical analysis and visualisation, and different assessment criteria will be contrasted.

Chapter 7

References

[1] Sakar, C. O., Serbes, G., Gunduz, A., Tunc, H. C., Nizam, H., Sakar, B. E., ... Apaydin, H. (2019). A comparative analysis of speech signal processing algorithms for Parkinson's disease classification and the use of the tunable Q-factor wavelet transform. Applied Soft Computing, 74, 255-263.

[2] Christos Laganas , Dimitrios Iakovakis , Stelios Hadjidimitriou , Vasileios Charisis. Parkinson's Disease Detection Based on Running Speech Data From Phone Calls IEEE TRANSACTIONS ON BIOMEDICAL ENGINEERING, VOL. 69, NO. 5, MAY 2022

[3] N. P. Narendra , Björn Schuller , Fellow, IEEE, and Paavo Alku. The Detection of Parkinson's Disease From Speech Using Voice Source Information. IEEE/ACM TRANSACTIONS ON AUDIO, SPEECH, AND LANGUAGE PROCESSING, VOL. 29, 2021

[4] C. Quan, K. Ren and Z. Luo, "A Deep Learning Based Method for Parkinson's Disease Detection Using Dynamic Features of Speech," in IEEE Access, vol. 9, pp. 10239-10252, 2021, doi: 10.1109/ACCESS.2021.3051432.

[5] J. R. Orozco-Arroyave et al., "Towards an automatic monitoring of the neurological state of Parkinson's patients from speech," 2016 IEEE International Conference

on Acoustics, Speech and Signal Processing (ICASSP), 2016, pp. 6490-6494, doi: 10.1109/ICASSP.2016.7472927.

[6] J. C. Vásquez-Correa, J. Serrà, J. R. Orozco-Arroyave, J. F. Vargas-Bonilla and E. Nöth, "Effect of acoustic conditions on algorithms to detect Parkinson's disease from speech," 2017 IEEE International Conference on Acoustics, Speech and Signal Processing (ICASSP), 2017, pp. 5065-5069, doi: 10.1109/ICASSP.2017.7953121.

[7] S. B. Appakaya and R. Sankar, "Classification of Parkinson's disease Using Pitch Synchronous Speech Analysis," 2018 40th Annual International Conference of the IEEE Engineering in Medicine and Biology Society (EMBC), 2018, pp. 1420-1423, doi: 10.1109/EMBC.2018.8512481.

[8] T. Arias-Vergara, J. C. Vasquez-Correa, J. R. Orozco-Arroyave, P. Klumpp and E. Nöth, "Unobtrusive Monitoring of Speech Impairments of Parkinson'S Disease Patients Through Mobile Devices," 2018 IEEE International Conference on Acoustics, Speech and Signal Processing (ICASSP), 2018, pp. 6004-6008, doi: 10.1109/ICASSP.2018.8462332.

[9] W. Wang, J. Lee, F. Harrou and Y. Sun, "Early Detection of Parkinson's Disease Using Deep Learning and Machine Learning," in IEEE Access, vol. 8, pp. 147635-147646, 2020, doi: 10.1109/ACCESS.2020.3016062.

[10] H. Gunduz, "Deep Learning-Based Parkinson's Disease Classification Using Vocal Feature Sets," in IEEE Access, vol. 7, pp. 115540-115551, 2019, doi: 10.1109/ACCESS.2019.2936564.