Problem Statement :

Parkinson's disease is a progressive neurological disorder caused by the death of dopamine-producing cells in the brain. Symptoms of the disease include tremors, slow movement, stiffness, and difficulty with balance and coordination. There is no cure for Parkinson's disease, but medications and therapies can help to manage the symptoms and slow the progression of the disease.

Patients with Parkinson's disease are frequently dependent on their caretakers; even doctors, when examining patients, prefer to trust the caretaker's assessment of the patient's improvement with treatment. Currently, there is no way for a Parkinson's sufferer to thoroughly follow his or her own health. The primary goal of our project is to give patients with a mechanism for tracking their development, as well as to provide doctors with a trustworthy source of data to provide appropriate medicine.

Further, we are also exploring the avenues of the parkinson disease detection system using vocal data of a parkinson disease suspect. Aiming to provide doctors with a tool to make quick measurements for a probable Parkinson disease.

Research:

As suggested by our ILGC faculty mentor Prof. Shashikant Pawar, we looked into the statistics of Parkinson's patients in India, their age distribution, etc. we learned that there are approximately 10 million people with Parkinson's disease who are actively ill, and that only 1% of them are over the age of 60. The research paper was also very helpful in helping us create the

algorithm for our application by providing information on the risk factors, clinical characteristics, motor symptoms, genetic effects, brain connections, and other distinguishing characteristics of Parkinson's patients. We started by working on understanding the disease better so that we could figure out the real loophole in early stage diagnosis and the tools to keep the track of the Parkinson's Disease:

Research in Parkinson's disease in India: A review - PMC

The technological gap in the market for the Parkinson's symptoms measurement needs to be resolved. There are several ways to track the progression of Parkinson's disease and we went through some of the research papers based on the following ways before finalizing the idea behind our project:

1. Clinical assessments: A healthcare provider will perform a physical examination, review the patient's medical history, and assess the patient's symptoms to determine the severity of the disease.

   We got the following paper on the clinical assessments of Parkinson's disease.

   Optimizing Clinical Assessments in Parkinson's Disease Through the Use of Wearable Sensors and Data Driven Modeling

2. Laboratory tests: Blood and urine tests can help rule out other conditions and provide additional information about the patient's overall health.

   We got the following paper on the Laboratory Tests for Parkinson's disease.

   Parkinson's Disease: A Review from Pathophysiology to Treatment

3. Imaging tests: Magnetic resonance imaging (MRI) or computed tomography (CT) scans can show changes in the brain caused by Parkinson's disease.

   We got the following paper on the Imaging Tests for Parkinson's disease.

   Functional imaging studies of dopamine system and cognition in normal aging and Parkinson's disease - ScienceDirect

4. Quality of life assessments: Patient-reported outcome measures, such as the Parkinson's Disease Questionnaire (PDQ-39), can help assess the impact of Parkinson's disease on a patient's daily life.

   We got the following paper on the Quality of life assessments for Parkinson's disease.

   Measuring the impact of Parkinson's disease with the Parkinson's Disease Quality of Life questionnaire. | Age and Ageing | Oxford Academic

5. Motor symptom severity scales: The Unified Parkinson's Disease Rating Scale (UPDRS) and the Hoehn and Yahr scale are two commonly used tools to assess the severity of motor symptoms, such as tremors, rigidity, and bradykinesia (slowness of movement).

   We got the following paper on the Motor symptom severity scales for Parkinson's disease.

   Motor symptom severity scales

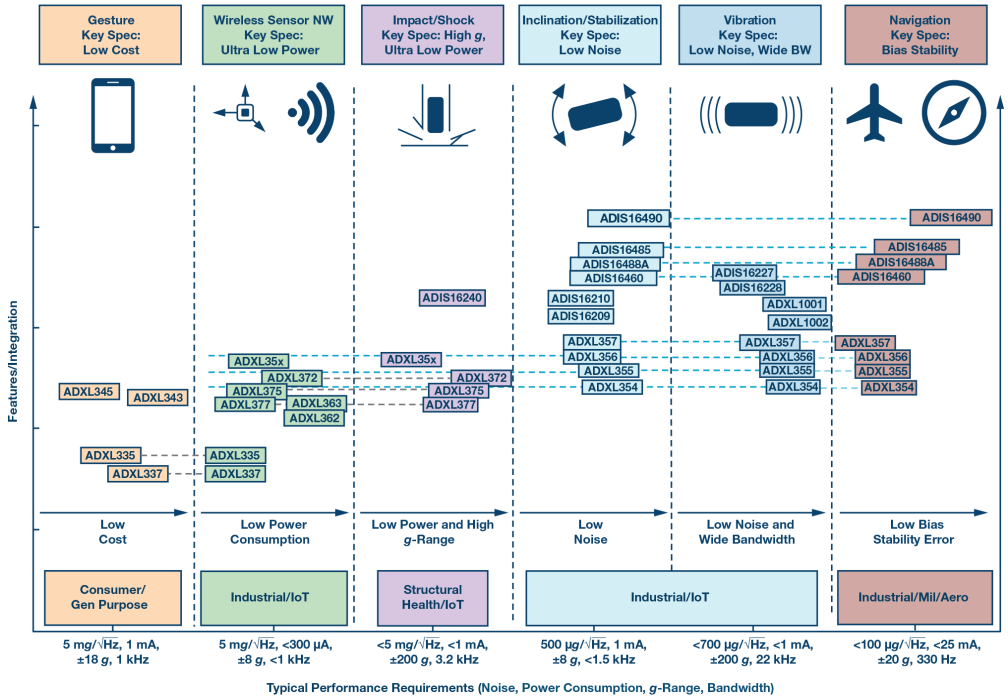
It is important to regularly monitor the progression of Parkinson's disease to help determine the best course of treatment and to ensure that the patient is receiving the most appropriate care.

Now after going through all of the research papers we got a clear picture and direction that we could work on for monitoring the progression of parkinson's disease, what else would be better other than keeping the track of the disease from the comfort of being home. Therefore, we

decided to work on a way where the patient himself/herself could perform some physical examination and could get some real time feedback, which could be later be shared with their respective doctor.

On brainstorming on the potential solutions which could help us in keeping the track of the disease over a certain period and that too without any additional cost to the patients. We wanted to make our product very accessible and therefore chose to use the sensors available in the smartphones. But one major question that we faced was that were the readings from these sensors accurate and reliable? Upon researching on the topic, we found out in a research study that the outcomes of a mobile accelerometer and a laboratory-grade accelerometer came very close and therefore making a smartphone app seemed a reasonable solution to the problem at hand. Most current solutions include wearing a heavy glove all day long, which is understandably a hassle to maintain along with being an expensive investment.

[Validity and Reliability of Mobile Applications for Assessing Strength, Power, Velocity, and Change-of-Direction: A Systematic Review]



The accuracy of a mobile accelerometer depends on several factors, including the quality of the accelerometer itself, the device it is installed in, and the environment in which it is being used.
In general, modern smartphone accelerometers are quite accurate and have a resolution of around 1-2 milli-g's (1-2 thousandths of the acceleration due to gravity). However, the accuracy of the accelerometer can be affected by external factors, such as temperature, humidity, and vibration, as well as the device's orientation and position. There are also some limitations to the accuracy of accelerometers in general. For example, they are not able to accurately measure acceleration in all three dimensions simultaneously, and they can be affected by gravitational forces. In summary, while mobile accelerometers are generally accurate, it is important to consider the potential sources of error and to test the device in a variety of environments to ensure that it is providing reliable data.
Gait identification using accelerometer on mobile phone

Moreover, while looking for the research and the existing market for projects we came across a research paper on the diagnosis of Parkinson's disease through voice samples of the patients. After analysis, we decided to integrate with our application. The link for the research material is :

Parkinson’s Disease Data Set | Kaggle

Therefore, we decided to use that data to analyze whether we could find a noticeable difference between healthy people and Parkinson’s patients. After looking at the data set we could see a clear difference between the healthy people and the Parkinson’s patients. Since there is clearly a noticeable difference, we proceeded to build a machine learning model which could then analyze the voice sample and determine whether the user is healthy or not using the Support Vector

Machine algorithm. However, we would like to clarify that this model would, by no means, serve as a substitute for consulting a doctor but just as a preliminary test that the user could take if he was worried about symptoms but not sure if they should visit the doctor just yet.

Working Brief:

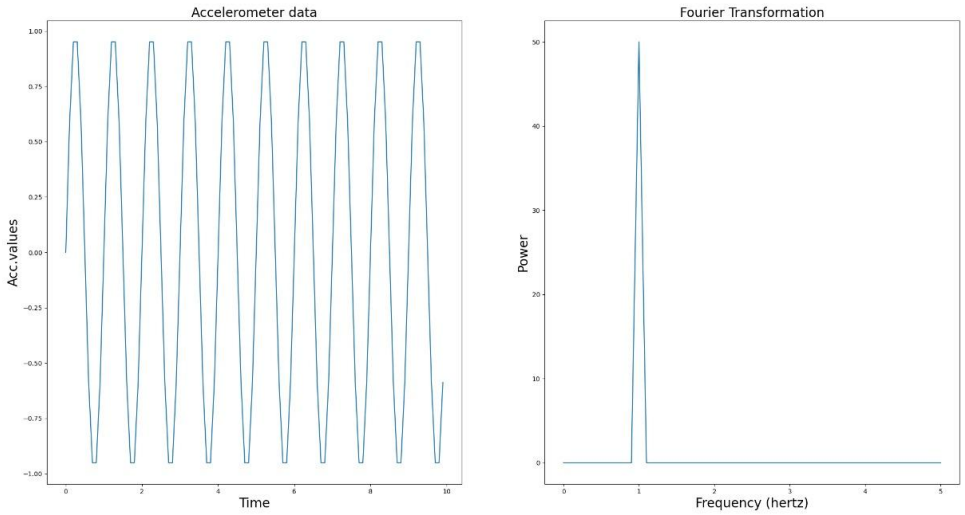
The initial stage in designing the application prototype was determining the ideal software stack. According to the research we conducted, we immediately discovered that the Flutter Framework worked well with our type of product. The main rationale for selecting Flutter was that it enables developers to create apps for numerous platforms using a single codebase, which saves time and resources as compared to designing separate apps for each platform. We then began creating the programme, merging features one by one. We encountered several issues and failures along the process, which caused some aggravation, but we eventually succeeded in creating an usable UI for the app.

The next phase in the process was to build the backend, which needed not just coding ability but also a solid understanding of mathematical principles such as Fourier Transformation. We studied mathematical ideas and created a dependable algorithm that would offer us with a final index for assessing Parkinson's illness. The previously described technique was evaluated using raw accelerometer data obtained from a third-party app.

We tried to run the built algorithm within the flutter framework but it proved to be insufficient. This was mainly because the algorithm was written in python which wasn’t fully supported by flutter. Hence, we found an alternative to host it on heroku (third party server provider) and

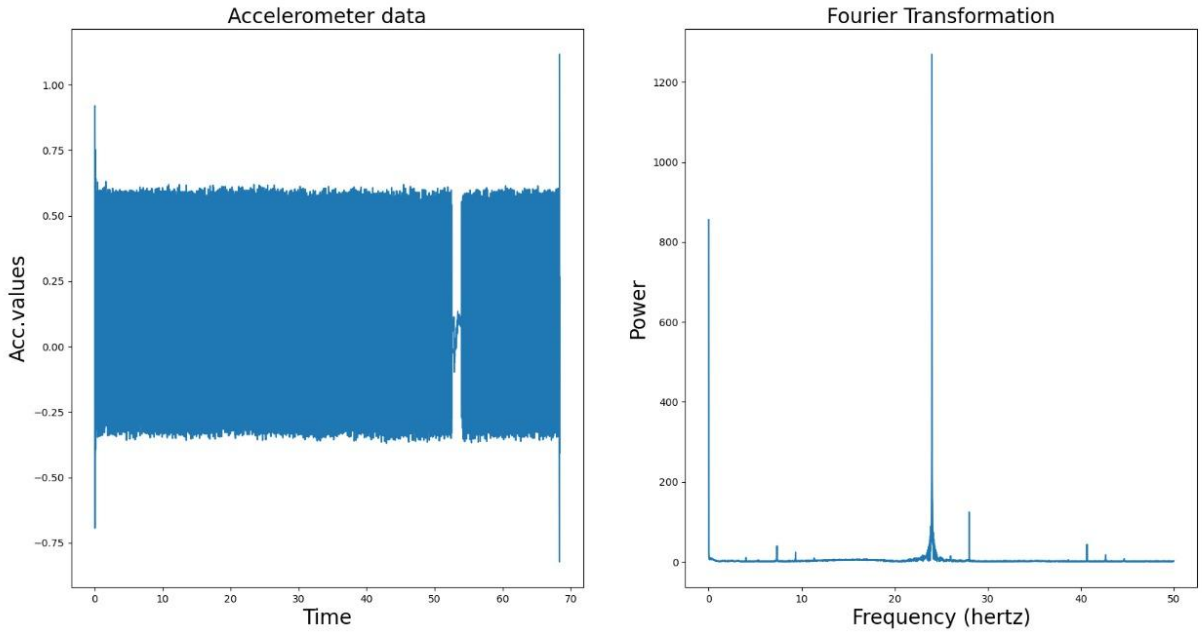
make https requests to get and feed data into the algorithm. The second portion of the backend algorithm was to gather the phone's local sensor data, store it in the right format, and feed it to the algorithm as needed. While executing the aforementioned activity, we encountered a difficulty with data storage and access. But, in the end, we completed the work successfully.

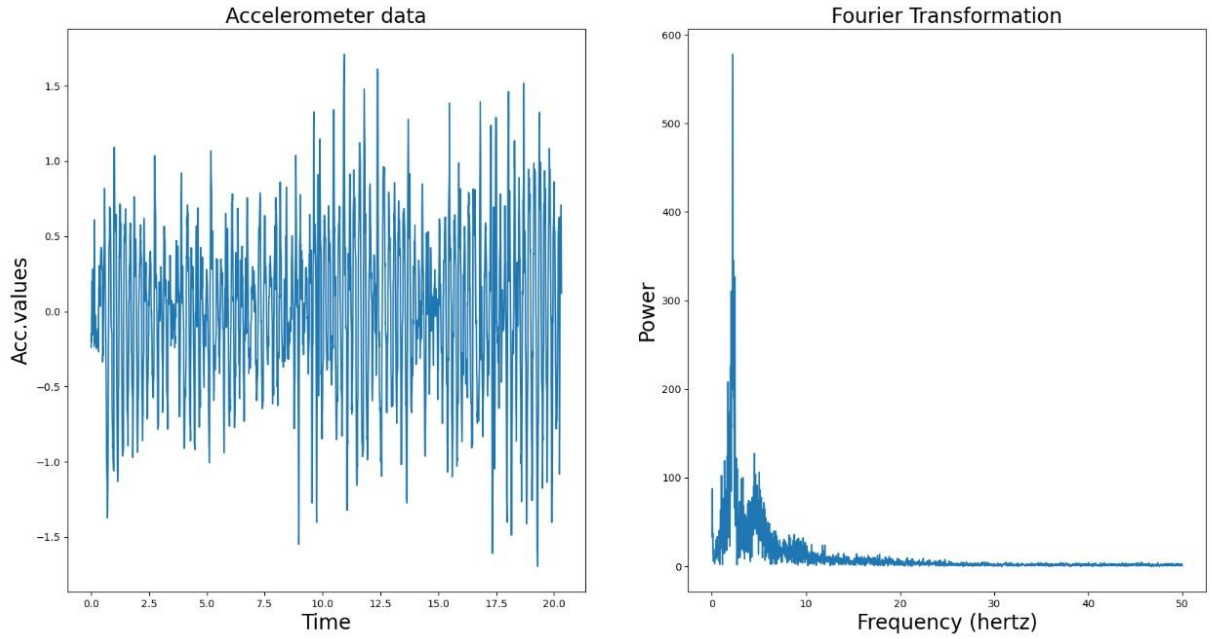
Once, we were completed with our complete mobile app to test the proper working of our algorithm. We passed a perfect sine wave generated using a computer into the algorithm and it was successful to detect the correct frequency.



We wanted further assurance that our programme would operate perfectly in a real-world situation because there are several things that may go wrong. For example, unwanted noise could be added to the data which can cause the entire system to fail. As a result, we devised an experiment that will use the membrane of a 75-watt speaker to imitate the vibration of a patient's hand. The speaker was connected to a device which would generate waves of particular frequencies.

Again we collected the data and ran our algorithm. The graph seen below represents the data collected on the left side and output on the right side.

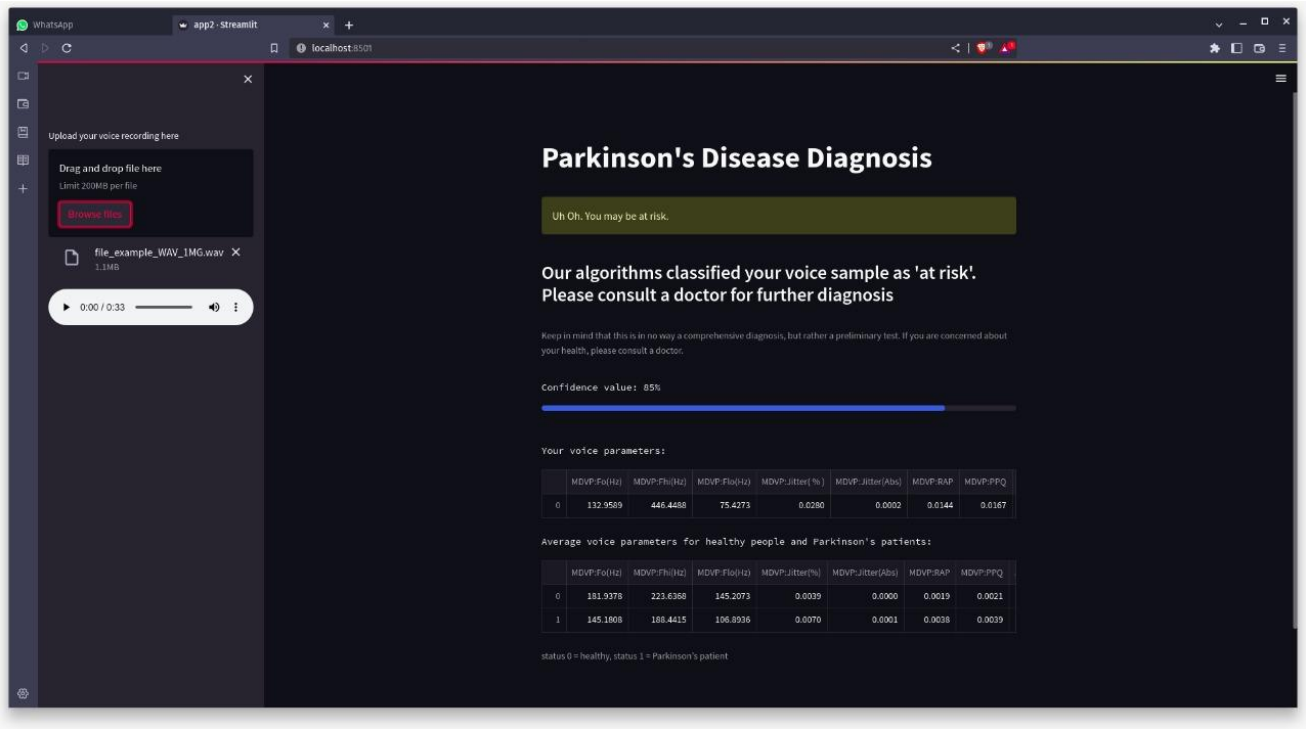


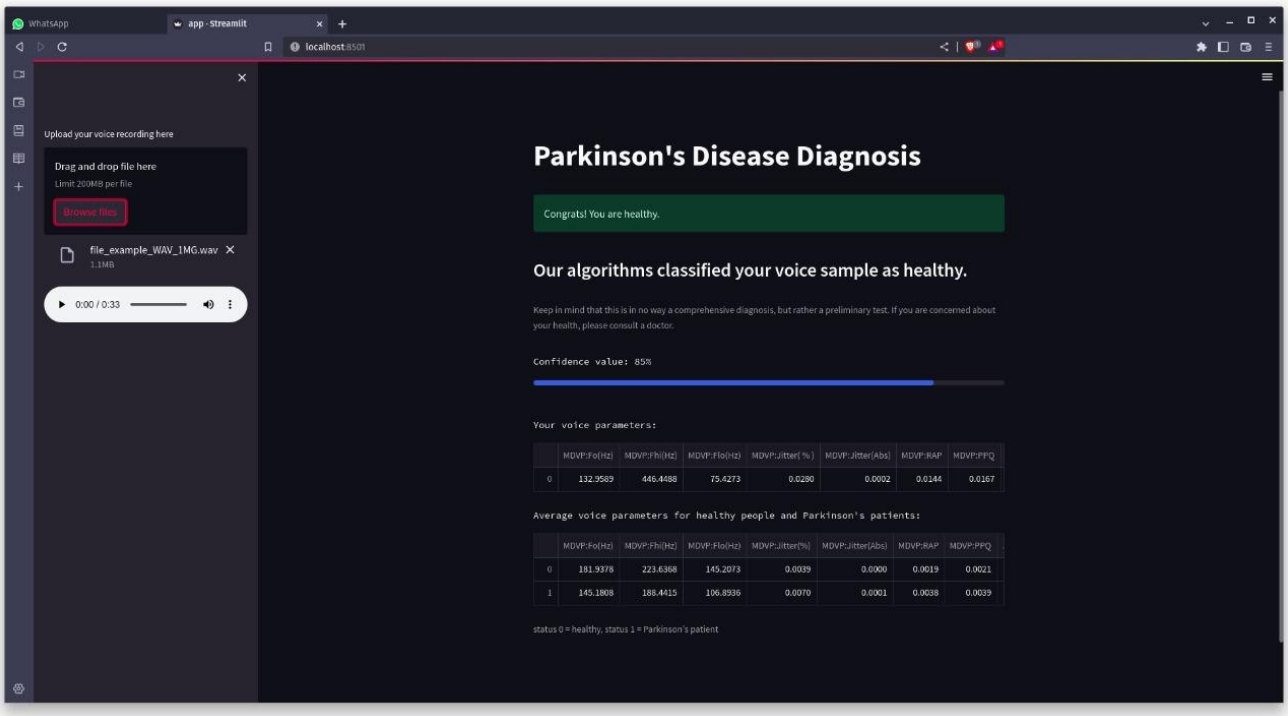


As one can observe in the experiment setup we imputed 25 hertz frequency and after processing we receive output peaking around 25 hz as well. We did the similar test for 4hz as well. This was a great achievement for our team as we proved that our data collection and algorithm were even reliable in unreliable real world conditions.

As our initiative progressed, we continued to investigate new technologies and constantly monitor the health-care sector. One of our team members uncovered an incredible resource - a database on Kaggle proving data to distinguish between Parkinson's positive and negative persons. We conducted some study on Machine Learning methodologies that would be appropriate for this use case and began testing with various classifier algorithms. Python was used to create machine learning with libraries such as sklearn, pandas, numpy, and others.

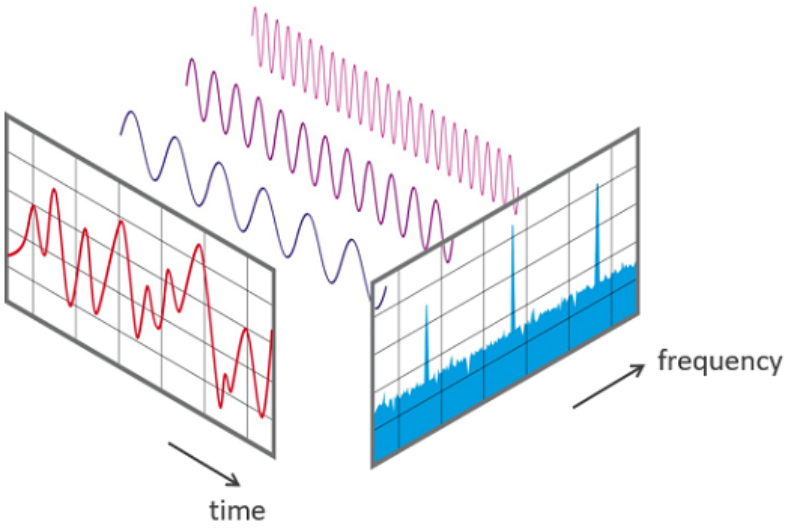
To distinguish the groups, we employed the SVM (Support Vector Machine) technique which was able to beg up to 82% accuracy in validation tests. We moved on to host the model using Streamlite to create the website's frontend.





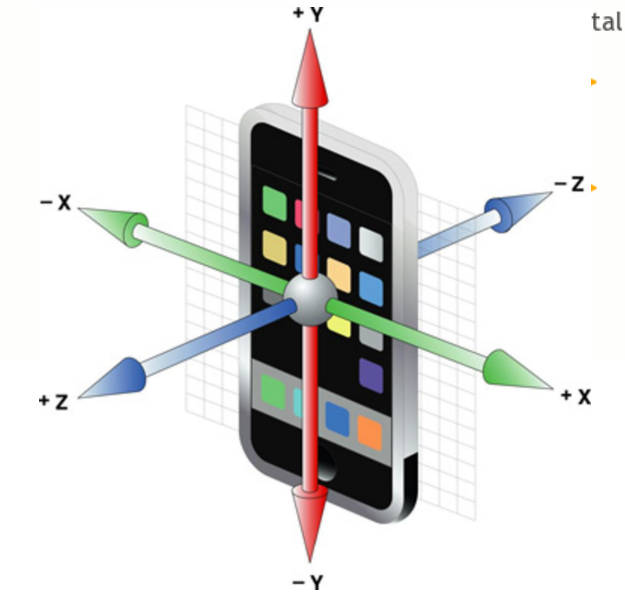
Concept

To find the frequency from a waveform, we used a technique called spectral analysis. This involves taking the Fourier transform of the waveform, which decomposes the signal into its individual frequency components. The frequency of the waveform is then equal to the frequency of the dominant component in the Fourier transform. The Fast Fourier Transform (FFT) is an algorithm for efficiently and quickly calculating the discrete Fourier transform (DFT) of a signal. The Fourier transform is a mathematical operation that decomposes a signal into its individual frequency components, which can be used to analyze the frequency content of the signal. The FFT is a fast and efficient way to calculate the Fourier transform, and it is widely used in a variety of applications, including spectral analysis, signal processing, and image processing.



The FFT works by dividing the signal into smaller segments and using a set of pre-computed weights and sums to calculate the Fourier transform of each segment. The weights and sums used in the FFT are derived from the coefficients of a polynomial equation, which can be computed in advance and stored in a lookup table for efficient use in the FFT algorithm.

An accelerometer is a device that measures acceleration, which is the rate of change of velocity. It can be used to measure the acceleration of an object in one, two, or three dimensions, depending on the specific type of accelerometer. Accelerometers are commonly used in a variety of applications, including inertial navigation, structural health monitoring, and motion sensing.



An accelerometer consists of a mass suspended on a flexible support, such as a spring or a piezoelectric crystal. When the accelerometer is subjected to acceleration, the mass is displaced, causing a change in the electrical resistance, capacitance, or other physical property of the device. This change in the physical property can be measured and used to calculate the acceleration of the device.

A gyroscope is a device that measures angular velocity, which is the rate of change of orientation. It can be used to measure the rotational movement of an object around an axis. Gyroscopes are commonly used in a variety of applications, including navigation, robotics, and motion sensing.A gyroscope consists of a spinning mass, typically a spinning wheel or disc, that is mounted on a gimbal or other support system. The spinning mass is free to rotate around one

or more axes, and the rotational movement of the mass can be measured and used to calculate the angular velocity of the device.

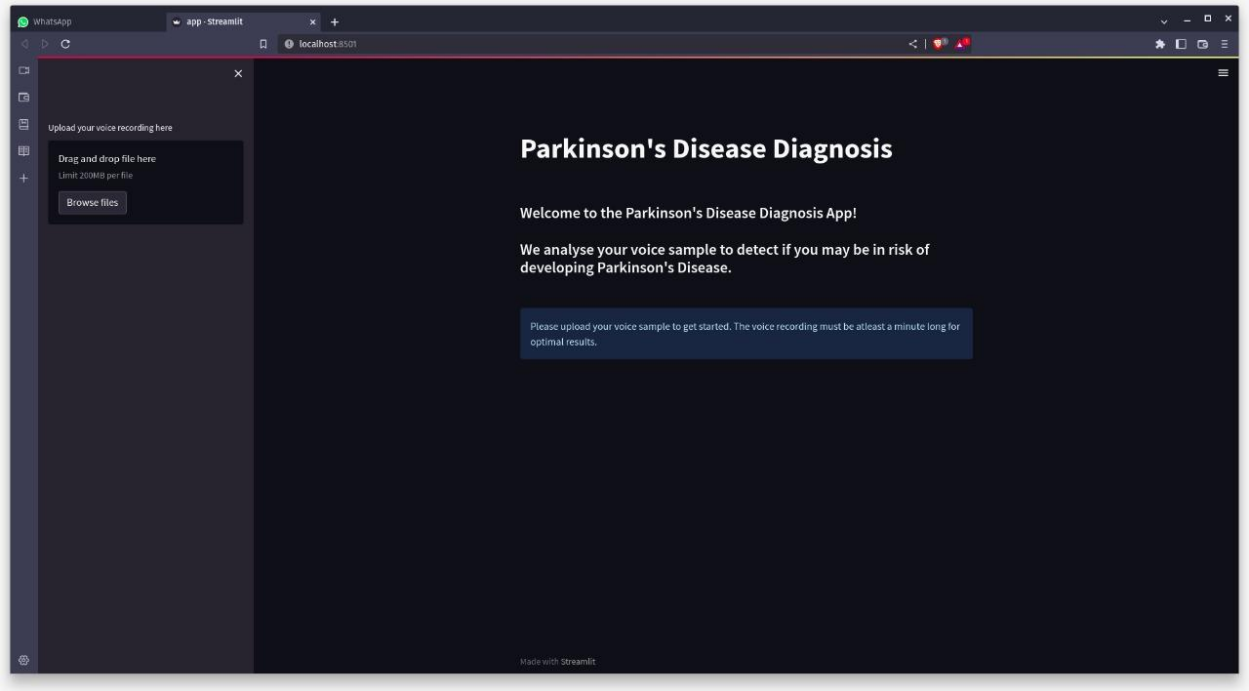
Both accelerometers and gyroscopes are commonly used in combination with other sensors, such as magnetometers and GPS, to provide more accurate and comprehensive measurements of movement and orientation. They are also often used in conjunction with microcontrollers or other processing units to analyze and interpret the sensor data in real-time.

Prototype – Explain your prototype

As we were working on a Saas product, therefore our prototype as of now is the mobile application, where we have tried to integrate two primary features:

1) The first one lets the user to monitor his/her existing condition of Parkinson over a period so that the report could later be shared to a doctor, which helps not only the patient to get the real time progression graph but even helps the doctors so that they could just go through the reports generated by our application instead of going through the laborious tests done in the laboratories, however some tests can be recommended by doctor if there is some need. But we have tried to reduce the number of tests significantly, done just to keep track of this disease and that too with the comfort of being home.

2) Secondly, we have designed an algorithm that could be used to diagnose Parkinson's disease in early stages, through voice samples. Where the user is just supposed to record a 30s voice sample and then we would feed it to our machine learning systems designed using Support vector machines which would diagnose if the person has any symptoms of Parkinsons with an accuracy of around 82 percent.



Next steps – Future directions/future scope of this project

We now plan to integrate the diagnosis through voice samples tool in the mobile application and the goal of our project is to make these tools easily accessible to as many Parkinson's disease patients as possible. Eventually, we hope to create an iOS version of this application as well as a version for smart watches. Even if our application becomes extremely successful, we are in favor of not turning this service into a for-profit SAAS (Software as a Service) because most Parkinson's patients would lose access to the idea of monitoring the progression of their condition, after the success of our software service we plan to make a band for the patients so that the data gathering could be more continuous and uniform, which will improve the accuracy of our service by a large extent. We aim to build trust within our user base while increasing its number. We plan to modify our app's algorithm to perfection and make Therapia the go to option

for taking readings of the patients and giving them a detailed analysis of their progress over the period of their treatment. We plan to collaborate with the doctors so that the patients are given a personalized treatment routine to help suppress the intensity of these tremors. We hope to see a network of doctors who trust in the credibility of our methods and patients that have been benefiting from using our app. This would require us to work extensively in collaboration with doctors and patients to improve upon the app and make it better at what it does. Our app doesn't have to be feature intensive, but it needs to be the best at what it does because the data that it provides could be critical to the patient's improvement.

Annexure

Engineering Thought and Action

- **Apply systems thinking to complex problems**

  Our project had a lot of complex aspects to deal with, we managed to deal with them by breaking the challenge down into smaller pieces. Complex challenges can be overwhelming, so it's important to break them down into smaller, more manageable pieces. This made it easier for our team to understand the problem and come up with plausible solutions.

- **Evaluate technical feasibility and economic drivers**

  If we look at our project we can say that our project is very feasible in technical terms because the various factors that affect the technical feasibility are : technological resources, funding, and personnel with the necessary skills and expertise. As our project is mostly SAAS therefore there is no need for huge

amounts in funding and we are confident in our skills and our will to learn and implement things that are needed for the project. There are various economic drivers are:

1) Revenue Potential : Our project also holds potential to be one of the revenue generating models because of some of the premium features that we plan to execute in the later stages of our project like: providing our own band for more accurate and prolonged data collection.
2) Cost of capital: due to being able to work on this project through ILGC we are able to say that there has been no need for capital investment in the project as we didn't even exhaust the funds that we are allocated in the ILGC every semester.
3) Market Demand : From the links given above for the data for the number of patients in India itself we can say that we will be able to have quite high market demand.

- **Examine societal and individual needs**

Knowing your customer is an important aspect of engineering, as it allows you to design products and services that meet the needs and preferences of your target audience. Analyze customer data: we can collect data on their customers through various channels, such as online purchases, customer service interactions, and social media. Analyzing this data can provide valuable insights into customer preferences and needs.

Communication

- **Convey engineering solutions in terms of value addition and salient features**

  A distinguishing feature of our product is that we do not require additional hardware, unlike most other alternatives out there. We use the phone's inbuilt sensors, which makes our solution much more affordable and accessible.

- **Convey engineering solutions in economic terms**

  We follow a freemium business model, where most features of our application would be available to the users free of cost. This also serves as a way of gaining the trust of our users, who may choose to purchase our smart band if they want more precision or advanced features.

Collaboration

- **Take initiative in working in team**

  We share our thoughts and ideas with each other and offer suggestions for how to move forward. We don't wait for someone to initiate action, if someone sees a need or opportunity to improve something, he takes the lead in addressing it. We are open to feedback and try to improve our performance.

- **Share your assets with the team and grow by learning from others**

  Our team is very supportive and try to help by sharing their knowledge with the team and try to solve a problem together. We offer to mentor each other and allow each one to lead in the aspects we are most comfortable with. By sharing our knowledge and being open to learning from others, you can not only help the team succeed, but also grow and develop our own skills and expertise. Our objective to provide help to the parkinson's patients will need collaboration and cooperation between individuals to achieve this.