PARKINSON'S DISEASE DETECTION USING CNN & MACHINE LEARNING TECHNIQUES

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INTRODUCTION

- The Parkinson's Disease (PD) is a progressive **neurodegenerative disorder**. It develops when cells in a particular part of the brain - called the substantia nigra - stop working properly and are lost over time.
- Symptoms start to appear when the brain can't make enough dopamine to control movement properly. There are 3 main symptoms - **tremor** (shaking), **slowness of movement** and **rigidity** (muscle stiffness) [4].
- According to WHO, in 2019, PD resulted in 5.8 million disability- adjusted life years, an increase of 81% since 2000, and caused 329,000 deaths, an increase of over 100% since 2000 [3].

OBJECTIVE

- For patients suffering (**Early detection**) from Parkinson's Disease (PD), it has been observed that impairment in the handwriting is directly proportional to the severity of the disease.
- The **deflections in the voice, reduced voice** and generally a low-volume noise with a monotone quality can be used for detecting Parkinson's Disease.
- In this project, **CNN based model** can be used for analyzing the drawing patterns of spiral sketches and **Machine Learning models** for speech samples to predict weather the person is healthy or not.

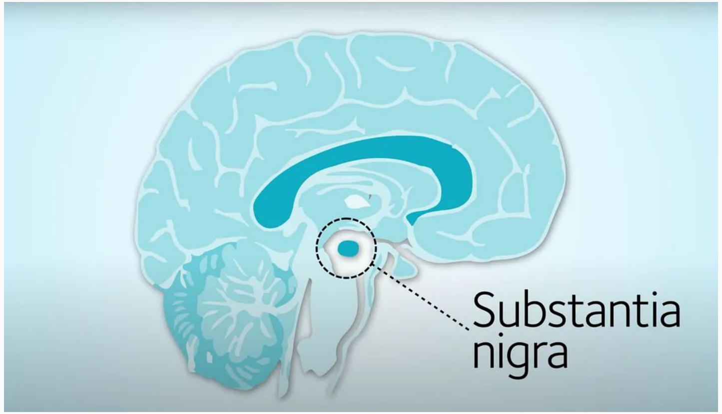
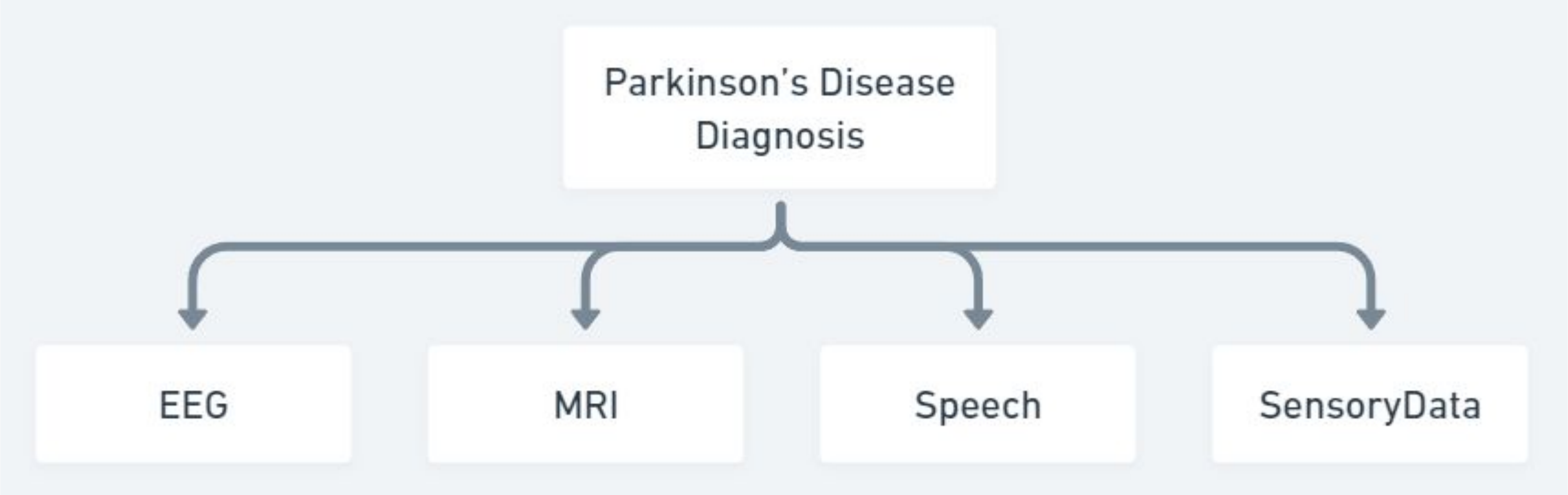


Fig. Pic of brain where the Substantia Nigra is located [4]

Early Diagnosis of PD



LITERATURE REVIEW

- Approximately 90% of cases detected with Parkinson’s syndrome practice variations in their sound or their energy to make communication sounds [1].
- Parkinson’s is the sickness that creates a biased or entire loss in engine reflexes, communication, ethics, reasoning processing, and other essential duties [2].
- Researchers proposed a study that used two criteria such as **speed, and pen-pressure** while performing the sketches to distinguish PD subjects at different stages [5].

LITERATURE REVIEW

- In paper [6], researchers presented an investigation based on the **trajectory of the tip of the pen** on the surface of the pad while drawing simple horizontal lines by the healthy subjects and PD subjects.
- In [7], researchers evaluated 10 features including static and dynamic information using the **Naive Bayes algorithm** for classification.
- Also in [8], used a CNN inspired in the **AlexNet** composed of two main parts (Convolutional layers for feature extraction and full connected layers for classification)

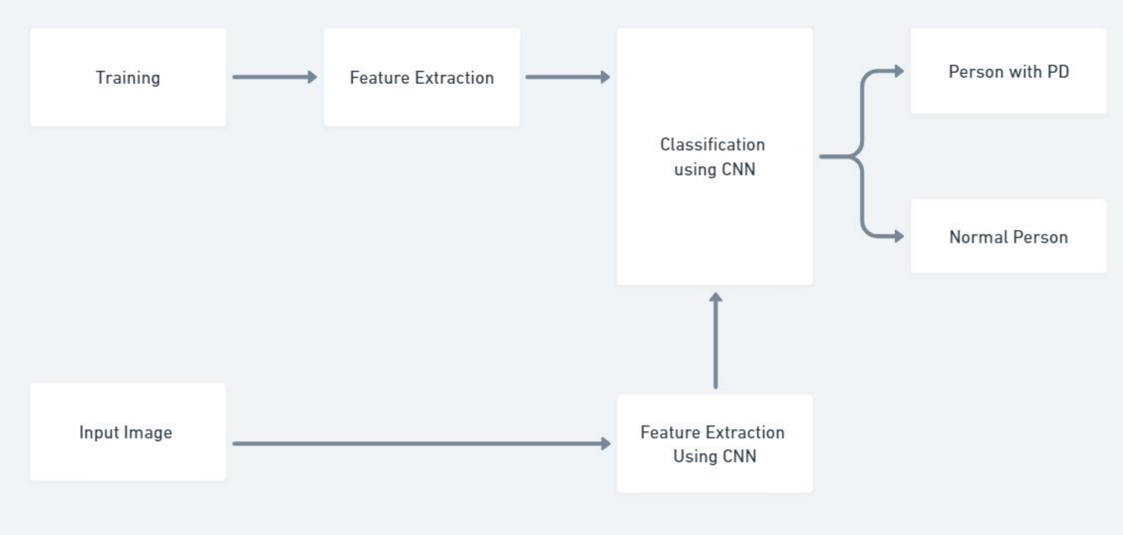
PROBLEM STATEMENT

- The problem statement of this project is **“Parkinson’s Disease Detection Using CNN & Machine Learning Techniques”**.
- This project aims at presenting a solution for PD detection using two different approaches.
- One of the approach is using Convolutional Neural Network **(CNN)**. The main idea behind the implementation is to classify a person as healthy or having PD by looking at the spiral drawing made by the person.
- Second approach is using statistical data and machine learning models such as Logistic Regression, XGBoost, Decision Tree Classifier, SVC, Random Forest Classifier, and KNN. The main idea is to classify a person having PD or not using **speech samples of that person**.

METHODOLOGY: SPIRAL SKETCHES

- The spiral drawn by a person with Parkinson's Disease will highly deviate from a perfect spiral shape and look distorted due to slow motor movements and decreased coordination between hand and brain.
- The whole process can be described as follows:
    - Data Preprocessing (Images are resized to a standard size (128, 128, 3))
    - Data Augmentation (Since the dataset have fewer images per category)
    - Training the CNN model
    - Testing the model on Images and Classify healthy or PD person

Block Diagram: Using Spiral Drawing

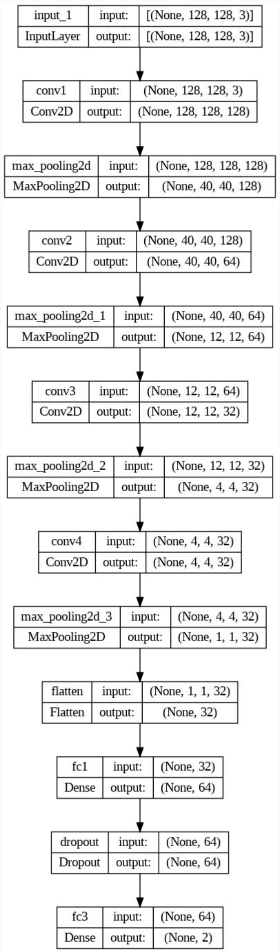


CNN MODEL

The model architecture has the following features:

1. Four convolutional layers with 128, 64, 32, and 32 filters each are present in the model.
2. There are filters with different filter sizes in the convolutional layers.
3. Each convolutional layer is followed by a MaxPool2D layer.
4. The convolutional block is followed by one fully linked layer.
5. The last layer includes 2 channels for 2 classification with softmax function

Using Adam optimiser, the model is trained at a learning rate of 3.15e-5. Epochs have been set to 50.



DATASET: SPIRAL SKETCHES

Spiral Drawing by a Healthy Person

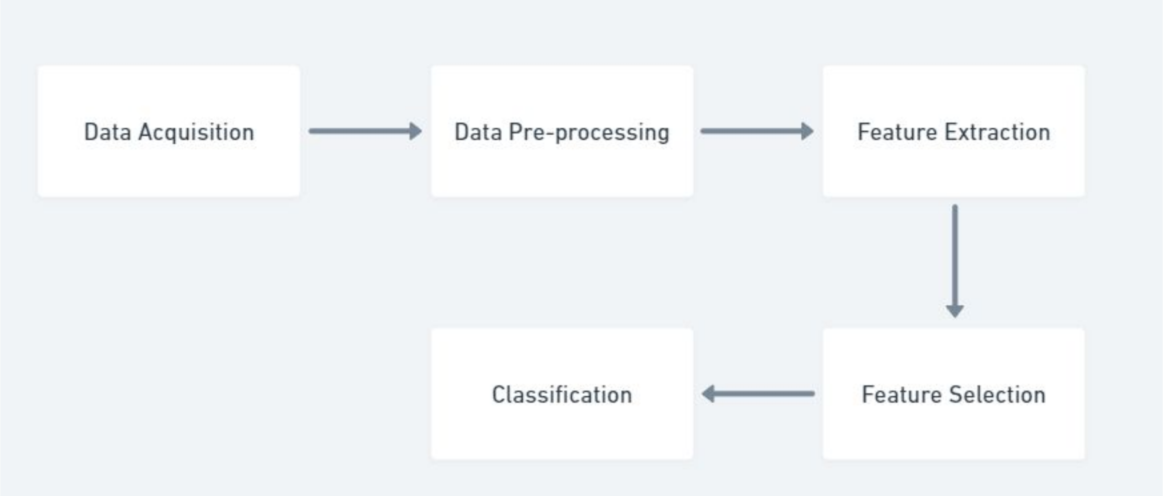
Spiral Drawing by a Person having Parkinson's Disease

METHODOLOGY: SPEECH SAMPLES

The whole process can be described as follows:

- Data Preparation & Exploratory Data Analysis
- Feature Selection & Feature Extraction: Vocal feature dataset suffers from curse of dimensionality problem. It is important for reducing dimensionality by selecting the relevant features
- Modelling can be done using various classification algorithms: Logistic Regression, Decision-Tree Classifier, XGBoost, SVC, Random Forest Classifier, and KNN.
- Model Evaluation

Block Diagram: Speech Samples



DATASET: SPEECH SAMPLES

- Dataset is provided by the UCI Donald Bren School of Information & Computer Sciences.
- The dataset comprises 195 items and 24 columns.
- Status is dependent variable, whereas the variables MDVP: Fo(Hz) to PPE are independent.
- The information is in CSV ASCII format
- Each patients has six recordings, and the first column lists the patient’s name.

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 195 entries, 0 to 194
Data columns (total 23 columns):
 #   Column            Non-Null Count  Dtype
---  ------            --------------  -----
 0   MDVP:Fo(Hz)       195 non-null    float64
 1   MDVP:Fhi(Hz)      195 non-null    float64
 2   MDVP:Flo(Hz)      195 non-null    float64
 3   MDVP:Jitter(%)    195 non-null    float64
 4   MDVP:Jitter(Abs)  195 non-null    float64
 5   MDVP:RAP          195 non-null    float64
 6   MDVP:PPQ          195 non-null    float64
 7   Jitter:DDP        195 non-null    float64
 8   MDVP:Shimmer      195 non-null    float64
 9   MDVP:Shimmer(dB)  195 non-null    float64
 10  Shimmer:APQ3      195 non-null    float64
 11  Shimmer:APQ5      195 non-null    float64
 12  MDVP:APQ          195 non-null    float64
 13  Shimmer:DDA       195 non-null    float64
 14  NHR               195 non-null    float64
 15  HNR               195 non-null    float64
 16  status            195 non-null    int64
 17  RPDE              195 non-null    float64
 18  DFA               195 non-null    float64
 19  spread1           195 non-null    float64
 20  spread2           195 non-null    float64
 21  D2                195 non-null    float64
 22  PPE               195 non-null    float64
dtypes: float64(22), int64(1)
memory usage: 35.2 KB
```

Fig. Summary of Speech Dataset

RESULTS

USING SPIRAL DRAWING

- Results after evaluating the model on validation data: Loss: 0.07 and Accuracy: 0.97

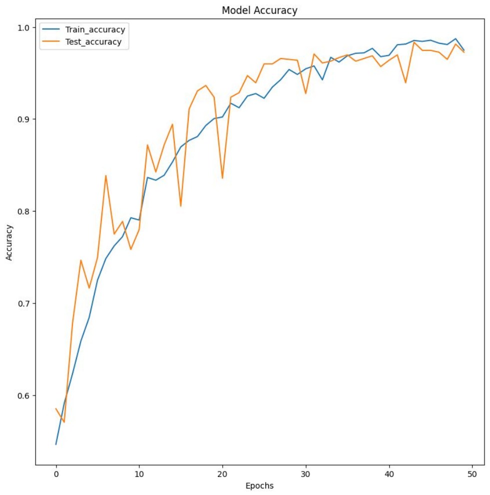


Fig. Plot of Train and Test Accuracy of CNN Model

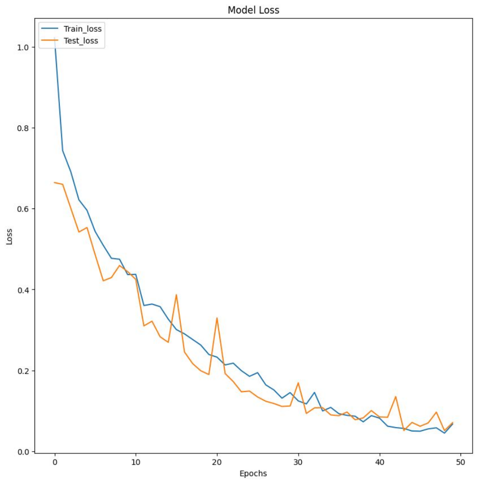


Fig. Plot of Train and Test Loss of CNN Model

Comparing the CNN with Other Medical Dataset

Brain Tumor Dataset

- Validation Loss: 0.27 and Validation Accuracy: 0.93.

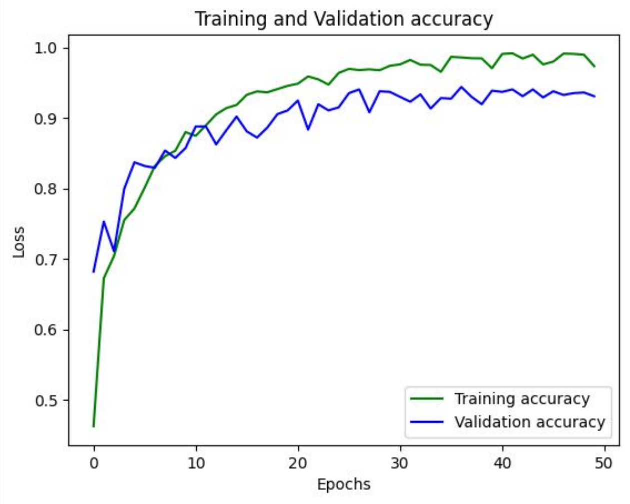


Fig. Plot of Train and Test Accuracy of Brain Tumor Dataset

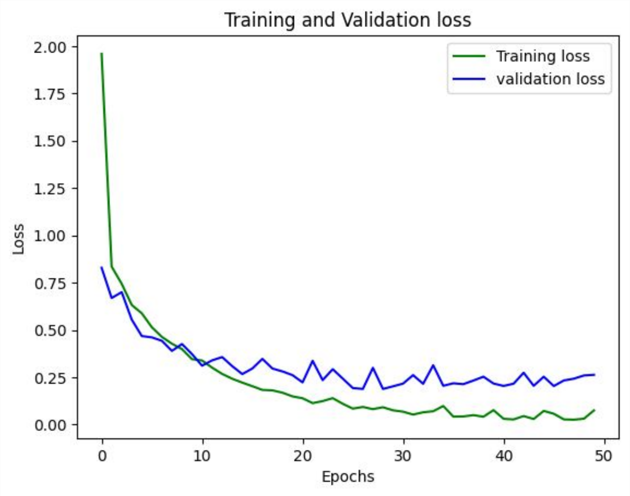


Fig. Plot of Train and Test Loss of Brain Tumor Dataset

Lung Cancer Dataset

- Validation Loss: 0.14 and Validation Accuracy: 0.95.

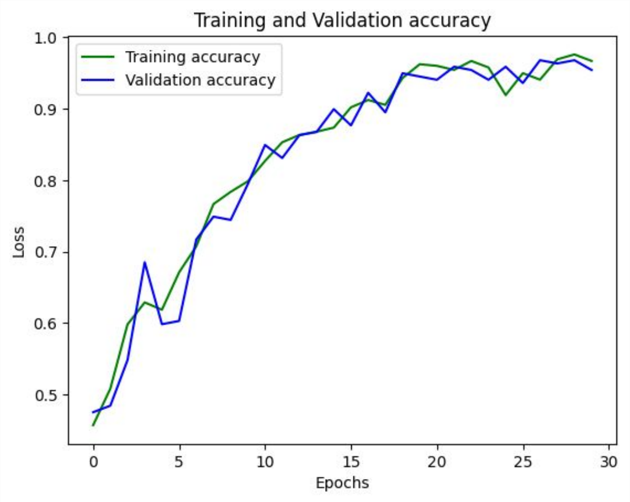


Fig. Plot of Train and Test Accuracy of Lung Cancer Dataset

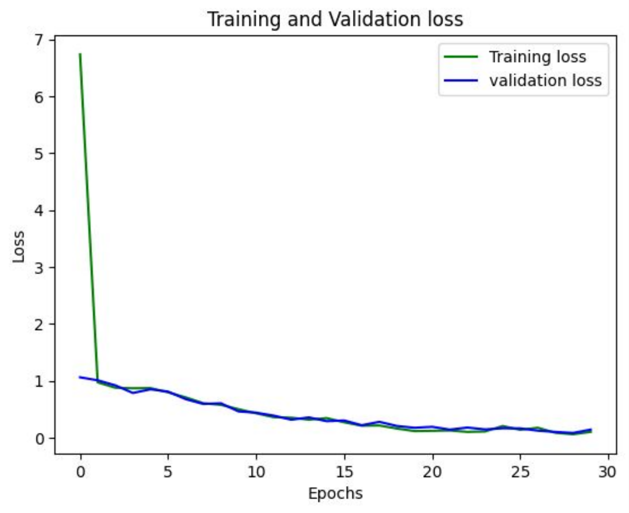


Fig. Plot of Train and Test Loss of Lung Cancer Dataset

USING SPEECH SAMPLES

Machine Learning Models	Accuracy of Training Set	Accuracy of Test Set
Logistic Regression	0.88	0.79
XGBoost	1.00	0.82
Decision-Tree Classifier	1.00	0.90
SVC	0.89	0.92

Classification Report

SVC:

	precision	recall	f1-score	support
0	0.69	0.75	0.72	12
1	0.88	0.85	0.87	27
accuracy			0.82	39
macro avg	0.79	0.80	0.79	39
weighted avg	0.83	0.82	0.82	39

Random Forest Classifier:

	precision	recall	f1-score	support
0	0.91	0.83	0.87	12
1	0.93	0.96	0.95	27
accuracy			0.92	39
macro avg	0.92	0.90	0.91	39
weighted avg	0.92	0.92	0.92	39

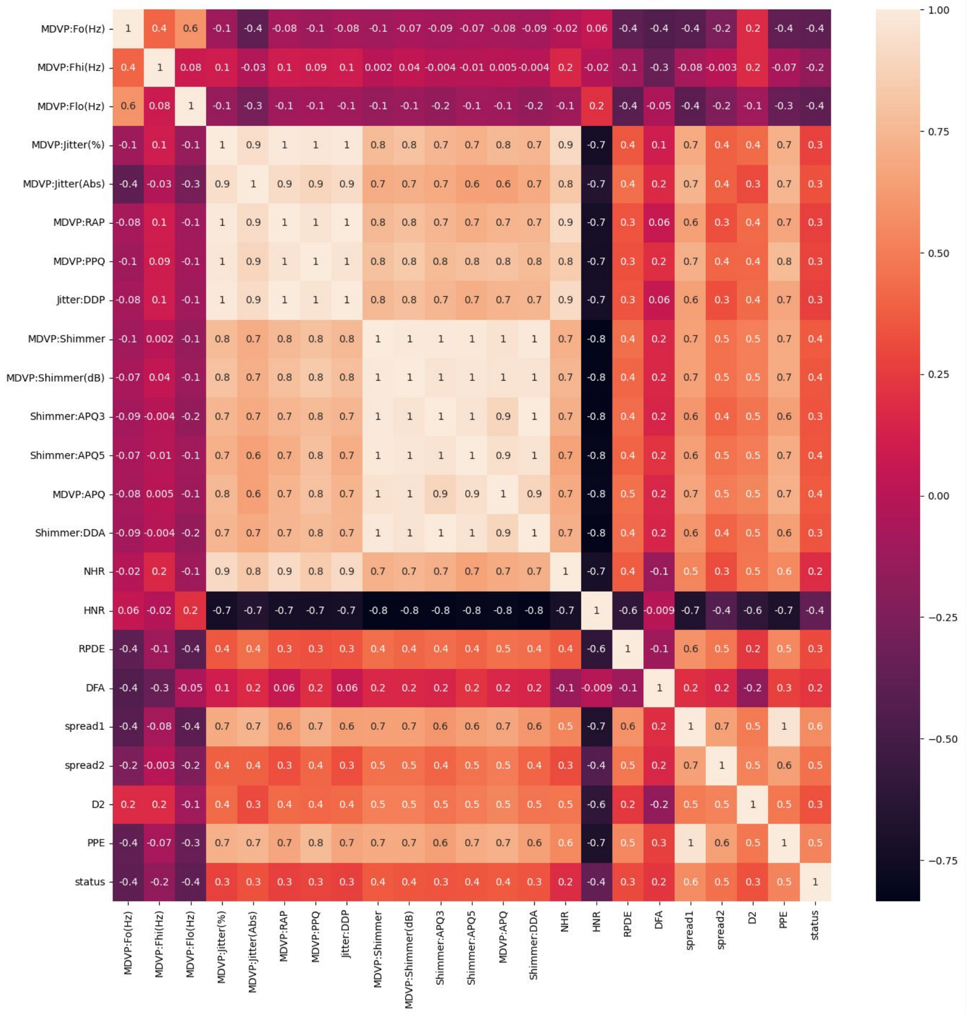
Decision-Tree Classifier:

	precision	recall	f1-score	support
0	0.67	0.83	0.74	12
1	0.92	0.81	0.86	27
accuracy			0.82	39
macro avg	0.79	0.82	0.80	39
weighted avg	0.84	0.82	0.83	39

KNN:

	precision	recall	f1-score	support
0	0.88	0.58	0.70	12
1	0.84	0.96	0.90	27
accuracy			0.85	39
macro avg	0.86	0.77	0.80	39
weighted avg	0.85	0.85	0.84	39

Correlation Matrix



CONCLUSION

- The use of ML techniques and CNN model for PD detection holds great promise for improving the accuracy and early diagnosis of this debilitating disease.
- By analyzing various patient data such as spiral sketches and speech sample data, these techniques can detect early signs of Parkinson's disease with high accuracy rates.
- The use of CNN model to analyze spiral drawings made by patients with PD is one of the most promising approaches.
- The project aims at optimizing the model to limit the number of parameters under 250k for easy deployment on edge devices.

FUTURE WORK

- Future research should focus on developing larger and more diverse datasets, conducting longitudinal studies, exploring multi-modal analysis, and working towards clinical translation.
- However, there is still much work to be done to validate the effectiveness of these techniques and to ensure that they can be translated into clinical practice.
- With continued research and development, the use of CNNs and machine learning techniques for Parkinson's disease detection could become an essential tool for healthcare professionals in the diagnosis and treatment of Parkinson's disease, ultimately improving patient outcomes and quality of life.

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THANK YOU