# Predicting Parkinson's Disease using AI and Machine Learning


## By: Shreya Ramesh, Milton High School, GA


## About Parkinson's Disease

- Patients often diagnosed with idiopathic parkinsonism, showing that there is no distinguishable cause as to why the patient has been affected with Parkinson's Disease
- Results in neurological disturbances often manifesting in various ways such as cognitive, behavioral, mood, as well as through one's thoughts
- Negatively affects the human body and mind, such as tremors in the hand, lack of control of fine motor skills, degenerative speech conditions, as well as a serious case of dementia and requires frequent visits to the doctor
- Nearly a 20-25% inaccuracy rate, leading to many misdiagnoses and nearly 40% of people with Parkinson's disease may not be diagnosed with the disorder at all

## Telemonitoring Tests

- Non-invasive speech test to determine Parkinson's in a patient using the "unified Parkinson's disease rating scale" (UPDRS) to classify the stage of the disease
- Often requires frequent visits to the doctor's office and many physical examinations
- Shows possible impairment signs of vocal disorders through the measure of various linguistic units in the voice recording
- The data set used for modelling consists of sound recordings gathered from 20 people with PD, 20 healthy individuals with a total of 168 test results with 26 distinct features extracted from voice samples were used for modelling
- The data set was obtained from University of California, Irvine under the archive titled "**Parkinson Speech Dataset with Multiple Types of Sound Recordings**"

Fig. 1: Parkinson's patient's Voice Recording (5/100 of a second)

Fig. 2: Healthy patient's Voice Recording (5/100 of a second)

## Static/Dynamic Spiral Tests

- Used to monitor fine motor skills and tremors of patients
- Records absence in visual flow that impairs overall body movement and other adjustments
- Motor rating scales such as the Unified Parkinson's Disease Rating Scale motor subscale is widely used to detect Parkinson's
- Patients with and without PD were asked to draw a spiral on a tablet to assess condition
- The data set used for modelling consists of spiral test images 62 people with PD, 15 health individuals. There are 3 sample images for each individuals in the data set
- Data set was obtained from University of California, Irvine under the data archive named "**Parkinson Disease Spiral Drawings Using Digitized Graphics Tablet Data Set**"

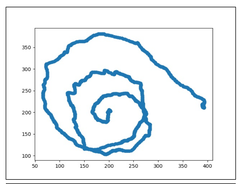


Fig. 3: Parkinson's patient's Spiral Test Image

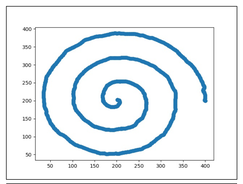


Fig. 4: Healthy patient's Spiral Test Image

All images and diagrams were made by Shreya Ramesh or obtained from a public data source.

## Introduction

- Diagnosing Parkinson's disease is a cumbersome process, requiring multiple tests and visits to the neurologist's office
- The recent development in motor skill tests such as the Spiral Test and the Vocal Pattern tests have been used to improve the overall accuracy rate
- In this research project, the data gathered from the UCI Database containing these 2 specific tests results were analyzed using machine-learning algorithms to predict a diagnosis based on patterns from the data
- The prediction model was developed using Neural Network, SVM, Logistic Regression, Random Forest, kNN, and Naive Bayes
- The Neural Network model was able to accurately predict diagnoses with a 94.2% accuracy rate for Spiral Tests and about a 70- 77% accuracy rate for the Vocal pattern tests, conducted using multiple machine learning algorithms

## Telemonitoring Initial Model

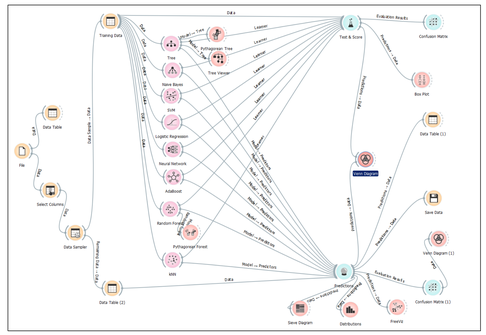


Fig. 5:Initial Telemonitoring model used to finalize best ML algorithm

## Telemonitoring Initial Results

| Model | AUC | CA | Precision | Recall |
|---|---|---|---|---|
| **Neural Network** | **0.779** | **0.702** | **0.716** | **0.750** |
| SVM | 0.730 | 0.684 | 0.654 | 0.886 |
| Logistic Regression | 0.689 | 0.650 | 0.660 | 0.734 |
| Random Forest | 0.778 | 0.717 | 0.720 | 0.785 |
| kNN | 0.717 | 0.675 | 0.690 | 0.729 |
| Naïve Bayes | 0.672 | 0.634 | 0.661 | 0.673 |
| AdaBoost | 0.656 | 0.662 | 0.677 | 0.721 |

Table 1:Initial Telemonitoring model results for various ML algorithms

## NN Telemonitoring Fine-tuning Parameters

| Alpha | Hidden Layer Sizes | Learning Rate | Max Iterations | Solver |
|---|---|---|---|---|
| 0.2 | 50 | 0.1 | 100 | lbfgs |
| 0.1 | 100 | 0.01 | 200 | sgd |
| 0.01 | 150 | 0.001 | 300 | adam |
| 0.001 | 200 | | | |
| 0.0001 | 300 | | | |
| **Total Combinations to Optimize: 675** | | | | |

Table 3: Combinations of NN parameters used to find highest accuracy

## Modelling Methodology

- For training and testing the various models, 70% of the data was split to train the model and 30% was used to test and predict the outcome of the model
- The prediction accuracy results from each of the models were compared to finalize the best model to be used for PD detection
- Multiple iterations of the various models were run to compare the best results for prediction
- Neural Network and Logistic Regression models predicted PD better than other models. Neural Network was picked as the model to be used for both Spiral Test and Telemonitoring due to its adaptability. It had overall higher accuracy and precision than the other machine learning models
- After conducting initial analysis of the data, Python scripts were developed to fine tune the optimal parameters for better accuracy

## Spiral Test Initial Model

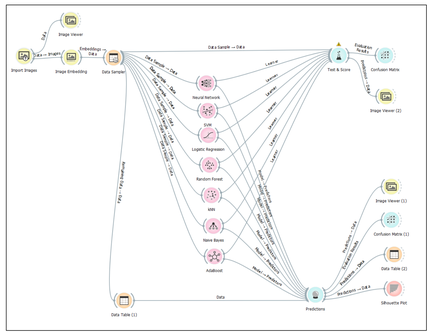


Fig. 6: Initial Spiral Test model used to finalize best ML algorithm

## Spiral Test Initial Results

| Model | AUC | CA | Precision | Recall |
|---|---|---|---|---|
| **Neural Network** | **0.920** | **0.907** | **0.934** | **0.961** |
| SVM | 0.926 | 0.890 | 0.888 | 1.000 |
| Logistic Regression | 0.925 | 0.907 | 0.918 | 0.981 |
| Random Forest | 0.887 | 0.864 | 0.885 | 0.971 |
| kNN | 0.842 | 0.873 | 0.915 | 0.942 |
| Naïve Bayes | 0.782 | 0.636 | 0.984 | 0.592 |
| AdaBoost | 0.685 | 0.907 | 0.926 | 0.971 |

Table 2: Initial Spiral Test model results for various ML algorithms

## NN Spiral Test Fine-tuning Parameters

| Parameter | Value |
|---|---|
| Bottleneck_tensor_size, input_height, input_width | 2048 |
| Training Set | 200 |
| Learning Rate | 0.1 |
| Step Interval | 10 |
| Train_batch_size | 200 |
| Validation_batch_size | 50 |
| **Final Test Accuracy** | **94.2%** |

Table 4: Combinations of TensorFlow parameters used to find highest accuracy

## Results

- **Telemonitoring**
  - The Telemonitoring data set was comprised of numerical data with 27 features that recorded various parameters such as maximum and minimum voice deviations, mean pitch, and number of voice breaks
  - This numerical data was then analyzed using the Orange3 application to predict whether or not a patient had PD. The initial accuracy of the model conducted using the various algorithms outlined earlier
  - The accuracy ranged from 70- 77% based on the various analyses and parameter combinations from the initial model and scripts
- **Spiral Test**
  - Since the Neural Network model had the highest accuracy, TensorFlow was used to further fine tune the modelling parameters
  - TensorFlow's Inception-v3 was used for the training and prediction of PD in patients in this analysis of Spiral Test Images. Using TensorFlow, the images were converted into multidimensional Tensor vectors
  - The resulting accuracy ranged between 90-94%. The accuracy of the training and predictions results are shown in Tensorboard below

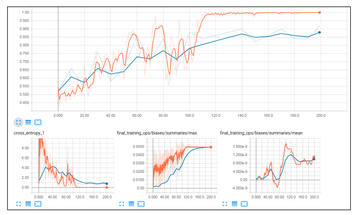
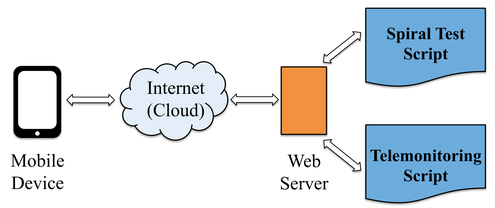


Fig. 7: Tensorboard is a TensorFlow-based program that provides a visual representation of the neural network learning accuracy rates.

## Real World Applications

- The above models were used to create a mobile application that combines the Spiral and Telemonitoring Tests to improve reliability and accessibility of PD diagnosis
- Helps physicians to gather and analyze results of a patient over a period of time




## Conclusion

- Neural Network predicts patients with PD with a 94.2% accuracy rate from the spiral test images
- Neural Network only has 70% accuracy rate for predicting PD using telemonitoring data
- Results from this experiment prove that this Machine Learning & AI algorithm can be used for future predictions and diagnoses.
- Increased accuracy rate for the prediction of PD allows for more cost saving and preventive measures to be taken
- With the expanding field of artificial intelligence and machine learning capabilities, the prospect of accurately predicting PD in a patient can now be a reality