Parkinson’s Disease Vocals and Machine Learning

CS506 - Rough Draft

Daniella DeWeerd

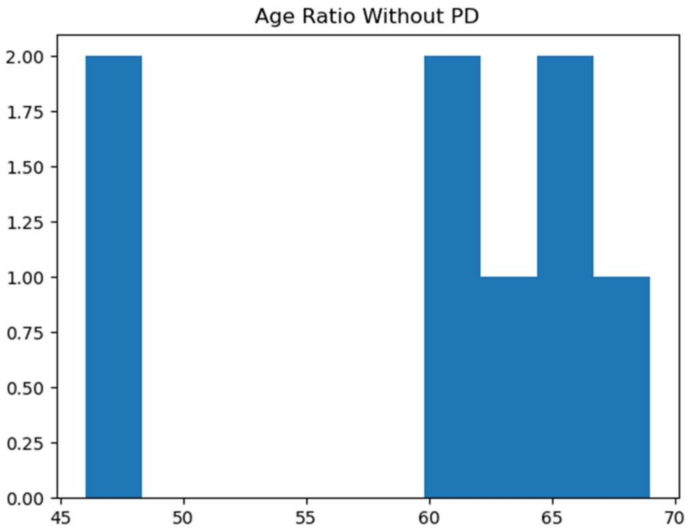
Background and Motivation

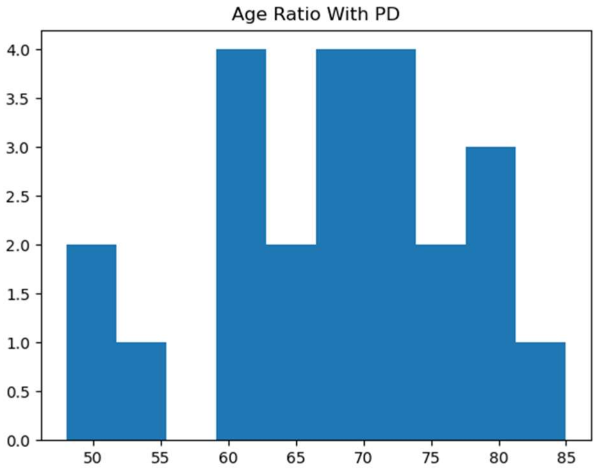
Parkinson’s Disease (PD) is a neurodegenerative disorder well known by the tremors it causes. It is also known to cause slowed movements, rigid muscles, impaired balance and posture, writing changes, loss of automatic movements, and speech changes [1]. While this is a well-known disease it is not clear exactly how it develops. Due to this, there isn’t any proven ways to prevent it. As such, it is super important to diagnose it at an early stage so treatment can begin as early as possible. Currently, diagnosis methods are as follows: looking at your medical history, reviewing your symptoms, imaging tests to rule out other disorders, utilizing current Parkinson’s medications to determine if they help [2]. Putting all these together as well as other similar tests, a doctor will give you a certain percentage of certainty that you have or don’t have Parkinson’s. This uncertainty can lead to either a correct diagnosis or a misdiagnosis. A misdiagnosis can lead to the actual disorder going untreated to a point where the progression is unable to be slowed or stopped which is why it is important for a neurologist to have as many tools available to be able to have a correct diagnosis.

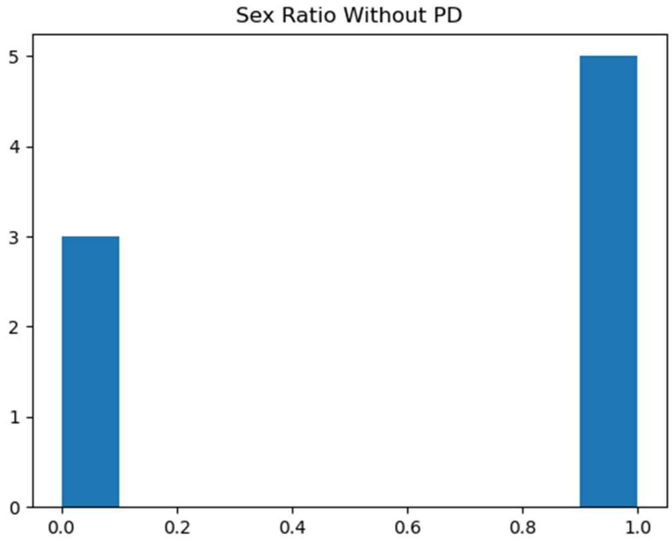
The motivation of this project lies in the last sign of PD, speech changes. As PD progresses, the muscle of the vocal cord becomes thinner and less taught and changes the person’s voice as well as their intelligibility which is a change that could hopefully be noticed in the early stages of PD to help with diagnosis. This occurs in approximately 89% of people with PD and therefore it would be helpful for this difference in speech to be identifiable [3]. As such, the idea of measuring people with PD and without PD's vocals came about. Max Little of the University of Oxford released a public dataset in 2008 containing data from 31 people, 23 of which with PD [4]. To best help doctors with diagnosing PD, I thought a computational outlook may help and so machine learning is the focus of this project. The major questions are as follows. Is it possible to predict PD from vocals with machine learning? What algorithm works best to predict Parkinson's Disease (PD) vs the healthy controls? How accurate can the results be?

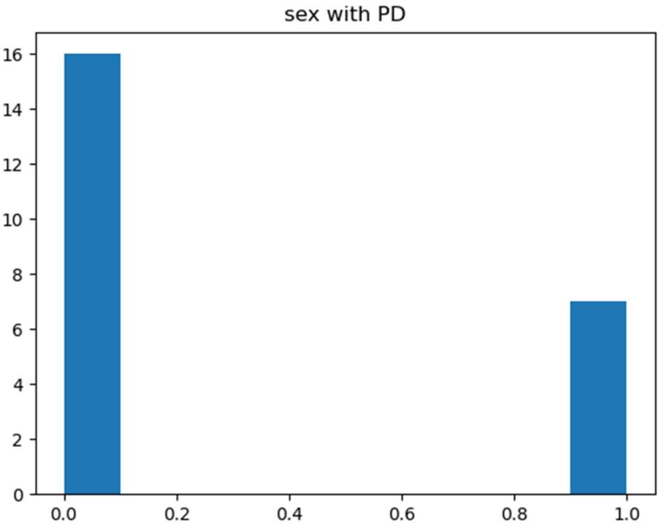
Exploration

The first step in utilizing this data to help with a diagnosis is to explore it. The data is from those patients with 6 recordings from each patient. The following are the features that are shown in the data: Average vocal fundamental frequency, Maximum vocal fundamental frequency, Minimum vocal fundamental frequency, measures of variation in fundamental frequency (MDVP:Jitter(%), MDVP:Jitter(Abs), MDVP:RAP, MDVP:PPQ, Jitter:DDP), measures of variation in amplitude (MDVP:Shimmer, MDVP:Shimmer(dB), Shimmer:APQ3, Shimmer:APQ5, MDVP:APQ, Shimmer:DDA), two measures of ration of noise to tonal components in the voice, two nonlinear dynamical complexity measures, a signal fractal scaling exponent, nonlinear measures of fundamental frequency variation (spread1,spread2,PPE), and whether a patient has or does not have Parkinson's [4]. To further explore the data, I brought it into Python and created some charts. First, I compared the age of the patients who have PD vs the age without PD as well as the same versus but looking at the sex of the patients.

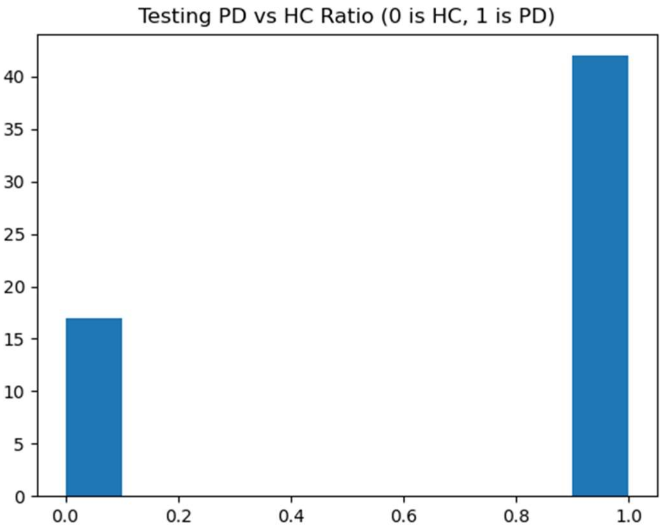

Age Ratio Without PD

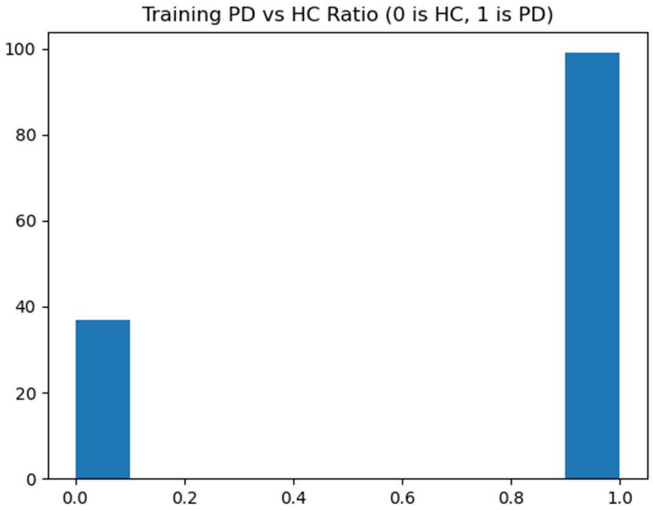

Age Ratio With PD





For the above figures, 0 is male and 1 is female. After that I split the data into training and testing, which is a common format for machine learning, and checked that it split the PD and non-PD people equally which is seen below.





Analysis

To find the most accurate diagnosis of PD using Machine learning, multiple algorithms where tested. Random Forest (RF), Logistic regression, SVM, Naïve Bayes Classifier, Neural Network Classifier, K-Nearest neighbor (KNN), PCA with Random Forest, and AdaBoost were all viable algorithms to test. After running a script that tested the base of each algorithm, it was found that Random Forest and KNN preformed the best with RF pulling just above a 90% accuracy on average and KNN pulling around 93%.

To further refine these algorithms, I used Grid Search to find the best parameters to get the best accuracy. The ending results of this was RF improving to around a 91% and KNN improving to 95%. With these results, the questions posed at the beginning can be answered. A 95% accuracy is most definitely good enough help a neurologist's confidence in their diagnosis. It can also be seen that KNN is best for predicting with this data and it can get up to around 95% accuracy.

There are of course some pitfalls to this including that the pool of people used is small and leans towards PD. There is also the fact that the recordings were done in a specific environment and it wouldn't be easy to recreate that environment every time a doctor wants to diagnose a patient. That was fixed in a later study done by Max Little where there are more people involved and the audio recordings were done with an app on the person's phone. That study used a total of 726 unique participants with 262 of them having PD. This study was able to produce a 75.3% accuracy using a gradient boosted decision tree model called XGBoost [5]. This is interesting considering our second-best results were seen using a decision tree model as well.

In another study done by Max Little, their results for classifying the same dataset we used can be found. They classified using a SVM and received around a 90% accuracy [6] while our SVM achieved an 85% accuracy. Overall, our tuned KNN had a 5% better accuracy than their ending results, so it would be interesting to run their newest data through a similar pipeline to see if better results can be found.

Conclusion

Parkinson's Disease is a neurodegenerative disorder that affects many people. When those people go to get diagnosed, they want to know that the doctor is most confident as they can be. To help with that, this study was run to try and find a tool to improve the doctor's confidence as well as the patients. The results of this study show that it is possible to create such a tool with a very good accuracy rate compared to past studies that have been done. It was also found that newer data has been collected that could make a tool like we found more accessible to the general population. Overall, a tool like what was created over the course of this project could help improve the lives of patients by helping ensure they receive a correct diagnosis.

Specifics From Deliverables

Deliverable 1

After an analysis of the data on the worries I voiced in the previous paragraph, I found that the people with PD range more from 60s to 80s in age while people without range more in the 50s to 70s range. While this most definitely could affect the pitch and such of the voice, it is not included directly in the data we are using to predict, so it may be okay for now. As for age, this is another variable that isn't directly included in the data, so it may be okay, but there is a larger male presence in those with PD and a larger female presence in the HCs.

In the quick code I wrote up, I used Logistic regression and random forest to try and answer my first question of whether it is possible to predict PD. Based on the results with RF pulling just above a 90% accuracy on average and LR pulling a middle to high 80%, I think it is possible. One thing I am noting for further exploration is the train test split and whether or not it is a fair split with its PD vs HC ratio. I also think a limit is going to appear with how small the data set is, so I would like to do research on if any other data was added to this set at a later date.

Deliverable 2

First, a note in regards to a previous question of if any additional data was added to the dataset at a later date. There wasn't anything added to this particular data set that I can work with in this project, but the creator of the data created another data set in 2021 that is very similar. (A further description can be found in the following link to a paper: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8564663/). This data is not publicly available based on what I could find, so even if the variables matched up, I couldn't add it to what I have now.

Running all of the algorithms that I wanted to try in the beginning, I found that Random forest and K nearest neighbors worked the best with RF hovering around a 90% accuracy and KNN above 90%. I also think that with the proper changes to PCA, it may also be able to reach a better percentage than 87%.

The question I was able to answer partially with this deliverable is what algorithm(s) work best. The next steps are to fine tune them with a focus on KNN to see if I can increase the accuracy by a decent amount. I also want to include some cross validation if I can and write a whole new script for that. I also can start working on the presentation of the data as I have reached some conclusions on the predictive ability of it when looking at the algorithms accuracy as a whole.

Deliverables 3, 4, and 5

Deliverable 3 included the first rough draft as well as the creating of the figures for the paper. It also included the creation of a script the allows the user to put in data and receive the classifications of that data out. Deliverable 4 is the second version of the rough draft for this paper. No further changes to the code were made. Deliverable 5 is this creation of this paper and the update to the readme.

References

1 https://www.mayoclinic.org/diseases-conditions/parkinsons-disease/symptoms-causes/syc-20376055#:~:text=Parkinson's%20disease%20is%20a%20progressive,stiffness%20or%20slowing%20of%20movement.

2 https://www.mayoclinic.org/diseases-conditions/parkinsons-disease/diagnosis-treatment/drc-20376062#:~:text=No%20specific%20test%20exists%20to,a%20neurological%20and%20physical%20examination.

3 https://www.parkinson.org/pd-library/fact-sheets/Speech-Therapy

4 https://archive.ics.uci.edu/ml/datasets/parkinsons

5 https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8564663/

6 https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3051371/