Title: Detection of Parkinsonism (symptom of Parkinson's disease and other forms of dementia) with geometric drawing test using Machine Learning

Domain background

Parkinson's is a neurological disease which specifically affects movement. One of the most distinguishing symptoms of the disease is tremor and rigidity faced by patients. The patient's condition keeps worsening over time and being a neuro-degenerative disease, it's incurable in nature.

In medical terms, nerve cell damage in the brain causes the dopamine levels to drop, causing tremor in hands, legs and other parts of the body. The tremor in hand causes the patient to produce messy, non-clear greatly impacting the visual appearance of diagrams and figures drawn by Parkinson's patients. Parkinson's disease is a disease in itself and other than that it can also act as a symptom in other forms of dementia, for eg: people suffering from Fronto-Temporal Dementia have a tendency to display signs of tremor although the disease is not Parkinson's. It's known as Parkinsonism. With that said, it's not possible to detect Parkinson's disease just by few tests or symptoms but Parkinsonism in itself can be detected by asking the patient to draw certain shapes.

Various stages of Parkinson's disease are:

1. Mild form
2. Moderate form
3. Middle stage
4. Stage in which physical assistance is necessary
5. Advanced/severe stage

Motivation

I've been seeing Dementia since a long time now. My father is a victim to this deadly neurological disease and that has fueled my passion to do something in this domain. Over the last few years, I've spoken to a lot of neurologists, speech linguists and neuropsychologists who have been dealing with this disease. My father shows symptoms of Parkinsonism which led me to know that Parkinsonism can be a symptom of some other dementia and not be a disease in itself. This raised my curiosity as to how to go about this illness and how we can detect and take appropriate steps. Further, I'm also a part of a long-term project with neurology so this projects like these are very much my lifeline.

I want to develop something so that other people wouldn't suffer as much as I did and wouldn't have to go through what I went through.

Historical Information & Previous attempts

There have been attempts [2], [3], [4], [5], [6] to address this problem and detect Parkinson's disease. Using Random Forest [12], the accuracy achieved was 83.4%. I'm trying to improvise over that using Deep Learning. There have been other attempts to detect this disease [1], [7], [8], [9], [10], [11] but their base varies when compared with me.

Uniqueness

I can say that Parkinson's disease comprises of a lot of other health conditions. The symptoms of tremor and rigidity can be at times a part of other dementia in the form of symptoms. Generally, spiral wave test is used to detect tremors displayed on the hand while drawing. But in my case, I'm using a bunch of geometric drawings to detect Parkinsonism. Mine is different in that manner as it's not related to just spiral wave test. I know of some of the other shapes & figures neurologists use to detect Parkinsonism as I've experienced the same.

Problem Statement

Research has shown conclusive evidence that the drawing speed and pen pressure is affected the most among Parkinson's patients. From stage 2, this is generally the case. The current procedure of identifying Parkinsonism includes offline based test taken by neurologists. There is no digitized form of detecting Parkinsonism from drawn shapes & geometric drawings with Deep Learning in high accuracy. Such a project would advance the research further and prove to be useful in understanding drawing semantics in detail. Summarizing, it can be used to distinguish between healthy people and people with Parkinsonism symptoms.

Datasets

The dataset would contain the images of geometric drawings (spiral, triangle, circle, square and other shapes) of healthy people and people with Parkinsonism.

Inputs- The inputs would contain hand drawn images of people who are to be detected for this particular symptom of Parkinsonism.

Samples-
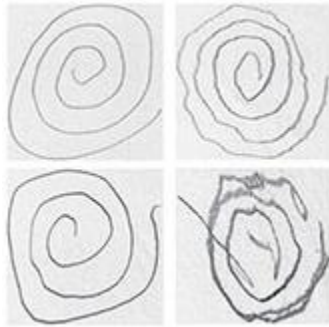
Solution Statement

The proposed solution consists of data uploading, feature extraction, classification, model training and calculating accuracy.

The model used is Convolutional Neural Network.

Benchmark Model

The benchmark model is the use of HOG (for Computer Vision) and Random Forest Classifier with an accuracy of 83.4%.

HOG: Histogram of Oriented Gradients is a feature descriptor specifically used for object detection in Computer Vision and Image processing. In projects such as these, HOG is used to quantify the input images. It performs really well when coupled with Random Forest even in limited amount of training data. It comes with *scikit-image* python package. Programmatically, HOG is a method used to define with a spiral or other diagram image. HOG is a *structural descriptor* which captures and quantifies changes in local gradient within the input image. HOG is naturally able to quantify the directions of a both spirals as well as waves gradient.

Additionally, HOG is able to capture if these patient's drawings have more of a *tremor* to them, as we might generally expect from a Parkinson's patient.

Random Forest Classifier: The training is done using Random Forest classifier on top of extracted features. Random Forest fits several decision tree classifiers on various sub-samples of the dataset and leverages averaging to improve the predictive accuracy and particularly control over-fitting.

Evaluation Metrics

The evaluation metrics include accuracy and a confusion matrix.

Target set distribution:

Project Design

A dataset of geometric drawings of healthy people and Parkinson patients will be loaded first. It would be done using fastai.
cnn would be used to train the model.
Compare training loss with validation loss.
Find out the accuracy and plot the results.

References

[1] https://github.com/imadtoubal/Parkinson-s-Disease-Classification-from-Speech-Data

[2] https://github.com/venessalobo/Parkinsons-Disease-Classification

[3] https://github.com/shubhamjha97/parkinson-detection

[4] https://github.com/topics/parkinsons-disease

[5] https://github.com/anttisaukko/parkinsons_cnn

[6] https://github.com/motlabs/parkinsons

[7] https://github.com/mittrayash/Parkinson-s-Disease-Detection-using-Gait-Analysis

[8] https://github.com/shusinthebox/Classification-Analysis-Of-Parkinson-Speech-Dataset

[9] https://github.com/AlhasanAlkhatib/Parkinson-s-Disease-Detection

[10] https://github.com/govardhan26/Parkinsons-Disease-Prediction

[11] https://github.com/varmichelle/Diagnosing-Parkinsons

[12] https://www.pyimagesearch.com/2019/04/29/detecting-parkinsons-disease-with-opencv-computer-vision-and-the-spiral-wave-test/