PROJECT BASED LEARNING - II REPORT

ON

DETECTING THE EXTENT OF HYPERTENSION OF THROUGH VOICE

REPORT SUBMITTED TOWARDS PARTIAL FULFILLMENT OF THE REQUIREMENT FOR THE AWARD OF THE DEGREE OF

BACHELOR OF TECHNOLOGY IN
COMPUTER SCIENCE & ENGINEERING

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CERTIFICATE

The project titled "**Detecting the extent of Hypertension through Voice"** submitted to the Symbiosis Institute of Technology, Pune for the third-year project in **Computer Science & Engineering** is based on our original work carried out under the guidance of **Prof. Preeti Mulay**. The report has not been submitted elsewhere for the award of any degree or for any other research related activity.

The material borrowed from other sources and incorporated in the report has been duly acknowledged and/or referenced.

We understand that we could be held responsible and accountable for plagiarism, if any, detected later.

Date: 07.05.2022 **Signature of the candidate**

Research Guide **Head of the Department**

Dr. Preeti Mulay (Dr. Deepali Vora)

ACKNOWLEDGEMENT

It gives us great pleasure in presenting the preliminary project report on "**Detecting the extent of Hypertension through Voice**".

I would like to take this opportunity to thank my internal guide, **Prof. Preeti Mulay**, for giving us all the help and guidance we needed. I am grateful to them for their kind support. Their valuable suggestions were very helpful.

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ABSTRACT

The aim of this project is to extract features from an audio clip and through those features, determine if the person is having hypertension or not. The features extracted from the audio will represent the relationship between the voice and anxiety levels. For this purpose, we have created a database consisting of small audio clips of different characters from Netflix and Youtube. Voices of 5 characters are used to make the database, 60% of which are dealing with the problem of hypertension.

Contribution of this project includes:

- Database creation from various sources like Netflix, Youtube.
- Feature Extraction like Jitter, Shimmer, etc.
- Using those features to detect hypertension
- Quantifying the extent of hypertension

To what has been already done in regard to this topic, our approach would be slightly brief and unique. Instead of elongating the data wrangling process and using mathematical jargon in the modeling process, we will be using the "surfboard" & "librosa" library available in python language to directly extract the audio features (feature extraction) required for classification.

This paper is divided into two parts, Part 1 of this paper shows the process of feature extraction while part 2 deals with the overall detection. Feature extraction is done through the Surfboard library in Python and further those features are used for training and testing of different machine learning models like CNN model, logistic regression.

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CHAPTER 1
INTRODUCTION

1.1 Overview

Blood pressure is basically the measure of the pressure at which the blood flows in the blood vessels. A normal BP range is between 90-120mm of Hg/ 60-84mm of Hg. Maintaining blood pressure levels is very important. Any change in the levels can be witnessed by symptoms including weakness, nausea, headache, etc. Changes in blood pressure levels, high blood pressure[1], or low blood pressure, can cause much damage to one's health, the organs are directly affected and cause further damage. Major health problems including heart attack and heart failure can be caused. It can be an onset of diseases such as Parkinson's disease, shocks that can cause less oxygen going to the brain, depression, etc. These health issues due to LBP and HBP are growing all over the world. BP which is higher than normal levels is known as hypertension and lower than the range is hypotension. So there should be a regular check of these levels and if there is any imbalance, you can detect it and cure it.

1.2 Project Idea

The project is based on speech analysis technology[2], machine learning, and deep learning algorithms and its applications. The project code has tested and trained the data according to the ranges of the features to detect the extent of hypertension. So, if we input an audio clip, using the project model we can detect if the person is hyper tensed or not. This project specifically deals with males in the range of age 25 to 40yrs. The dataset has been collected from platforms including Netflix and YouTube. Voice has certain features like jitter, shimmer, pitch, etc. we can study these values and then with the help of which we can determine the results. We will then extract the features of the voice using the code. After analyzing these features, we can predict if the person is hyper tensed or not[8].

We will be using the surfboard and librosa library in python to directly extract the audio features which are required for classification. We will be using different algorithms like SVM, logistic regression. So we will have the range of values to judge from and then further test the input audios.

1.3 Motivation

Hypertension is one of the most pressing medical problems in existence because it cannot be truly cured. There are more than 700 million hypertension cases in existence. It can only be controlled by medication. Thus, the quick and early detection of Hypertension is of utmost significance. The motivation behind our project is to get useful information from the voice samples we collect from a variety of sources and make use of different Python libraries and machine learning techniques[9] to analyze the collected data and detect(with some accuracy) if a particular individual might have Hypertension.

CHAPTER 2 LITERATURE SURVEY

Saloni, & Sharma, Rajinder & Gupta, Anil. et.al [1] have defined a methodology which uses voice parameters for the detection of Hypertension. Since voice has a lot of different characteristics, they use different feature extraction techniques to extract those characteristics and then apply different ML algorithms such as K-means clustering, ANN, etc. to predict which samples have hypertension. They also visually demonstrate the difference between the parameters of a normal person and a hypertension patient, with the help of graphs and probability density distribution.

Despotovic V, Ismael M, Cornil M, Call RM, Fagherazzi G, et.al [2] analyze not only the voice parameters but the cough and breathing patterns as well, so naturally there are more variables in play and that helps in a thorough analysis and prediction of Hypertension as well.

Jiang, Nan & Liu, Ting. et.al [3] provides a way for improved speech segmentation and clustering using K means which really helps our project as we also make use of the same algorithm.

Lenain, Raphael & Weston, Jack & Shivkumar, Abhishek & Fristed, Emil. et.al [4] gives us knowledge about the python library “Surfboard” which has in-built voice parameter analysis and is perfectly suited for our project.

ankışhan, Haydar. et.al [5] in their study describe that speech recordings and blood pressure are closely related values. The feature vector indicates that high blood pressure symptoms can be tracked by the vowels of an individual. They make use of algorithms such as Multiple Linear Regression which helps us immensely in our project.

CHAPTER 3
PROBLEM DEFINITION AND OBJECTIVES

3.1 Problem Definition

In the world with deadly contagious viruses such as COVID-19, it is difficult to measure Blood Pressure physically. Also, In the modern world where hypertension is very common, not many people get to know about it and then they suffer from its repercussions because of the lack of treatment.

3.2 Scope and Objectives

3.2.1 Scope

- This project primarily focuses on predicting and scaling the extent of hypertension in a person through his voice so that he can take preventive measures.
- Gender: Male, since men are more prone to hypertension than women.
- Age: 25-40 years of age
- Through this project, we aim to help those with high blood pressure to avoid serious conditions such as heart failures.

3.2.2 Objectives

- Training and testing the model from a set of voice samples of the user itself, which in our project are the voices taken from characters from Netflix and Youtube series.
- Extracting the features[6][7] which helps in spotting hypertension like jitter, shimmer, HNR etc. from the voices.
- Detecting if the user has hypertension or not.
- Quantifying the level of hypertension from which the user is suffering.

3.3 Software Requirements

1) Platform: Python
2) Technology : Python 3
3) IDE: Jupyter Notebook
4) Python libraries: Surfboard, Librosa, sklearn etc.

CHAPTER 4

SYSTEM DESIGN

4.1 SYSTEM DESIGN

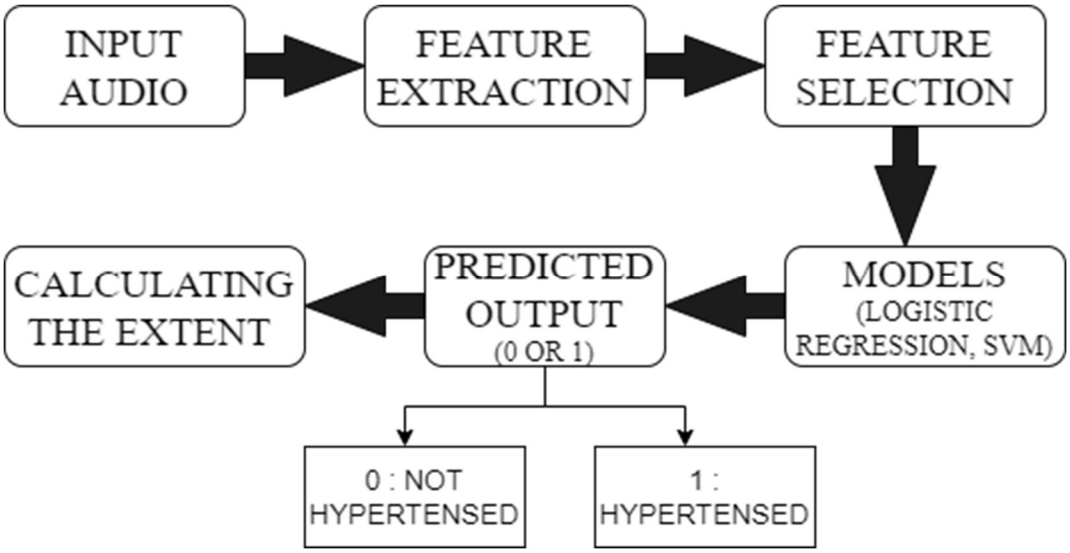

Figure 1 System Design

4.2 UML DIAGRAMS

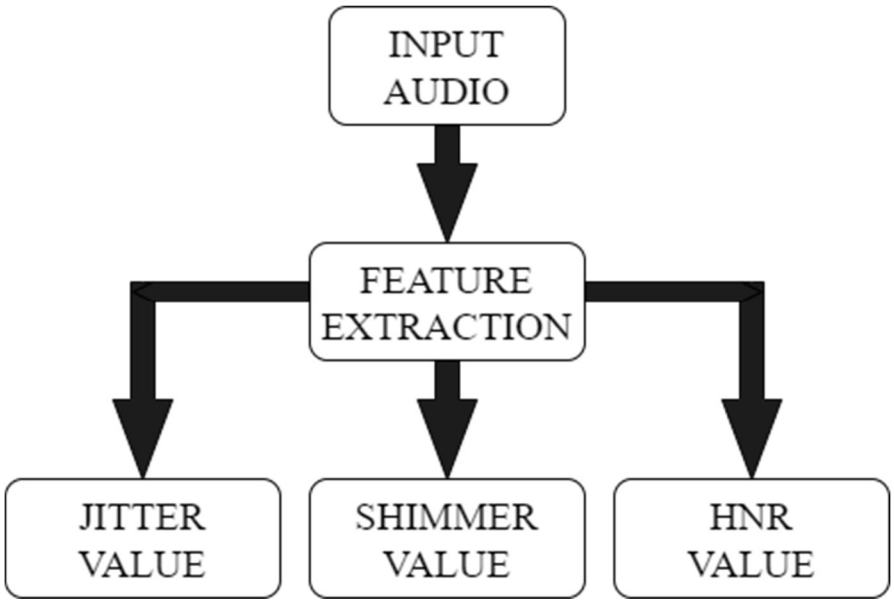

Figure 2 Feature Extraction

4.3 MODEL DIAGRAMS

4.3.1 SUPPORT VECTOR MACHINE or SVM

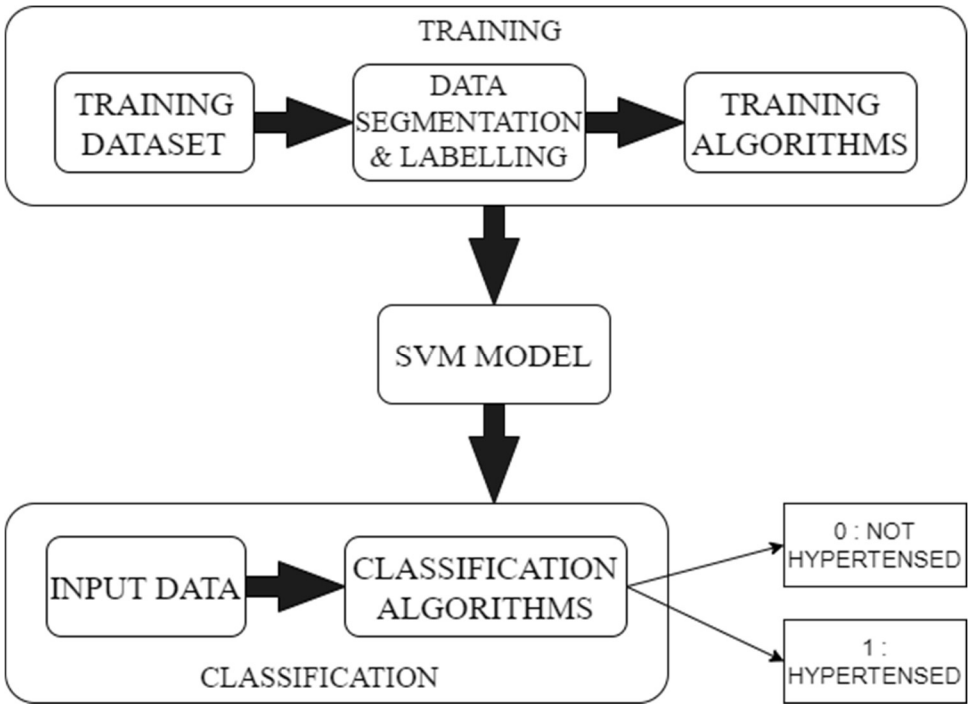

Figure 3 SVM Classifier block diagram

4.3.2 LOGISTIC REGRESSION

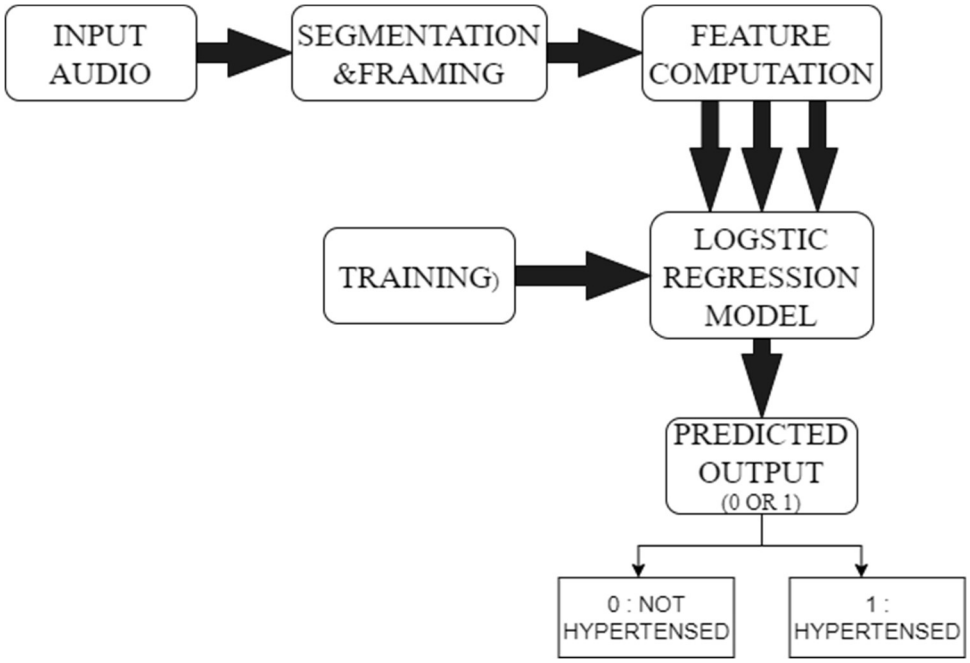

Figure 4 Logistic Regression block diagram

CHAPTER 5

IMPLEMENTATION

5.1 IMPLEMENTATION METHODS:

Algorithms:

Algorithm 1: Feature Extraction for finding the specific features from the voice which will then be used to predict if the user is suffering from hypertension or not.

// Input: Sound sample S

// Output: Features of the sound

Step 1: Start

Step 2: Get path of a voice sample.

Step 3: Import the surfboard and librosa library

Step 4: Get the frequency-time diagram and mel spectrogram of the sound using librosa library

Step 5: Get jitter, shimmer and harmonics-to-noise ratio using surfboard library.[8]

Step 6: Stop

The algorithm 2 clearly indicates the details of this step as follows.

Algorithm 2: Hypertension Detection and Scaling the extent of hypertension

Step 0: **Start**

Step 1: **Load** the dataset

Step 2: Retrieve the paths from the dataset

Step 3: Get the Waveform of all the sounds using Surfboard Library

Step 4: Calculate the Jitter, Shimmer and HNR and load it on to the dataframe

Step 5: Get the values of the columns Jitter, Shimmer, HNR in dataframe X and shuffle X

Step 6: Get the values of the column Target in a dataframe Y and shuffle Y

Step 7: Split the testing and training data of X and Y in ratio 3:7

Step 8: Train a SVM model and a logistics regression model using the data

Step 9: Test the models

Step 10: Load a random voice sample and use the model on it

Step 11: Using the std dev of the J,S,H , we scale the extent of hypertension of the person

Step 12: **END**

CHAPTER 6 RESULTS AND DISCUSSION

The proposed system is built on Python on Jupyter Notebook.

In [1]:

```
pip install surfboard
```

```
Requirement already satisfied: surfboard in /Users/somaaymaheshwari/op
t/anaconda3/lib/python3.8/site-packages (0.2.0)
Requirement already satisfied: pysptk>=0.1.18 in /Users/somaaymaheshwa
ri/opt/anaconda3/lib/python3.8/site-packages (from surfboard) (0.1.20)
Requirement already satisfied: pandas>=1.0.1 in /Users/somaaymaheshwar
i/opt/anaconda3/lib/python3.8/site-packages (from surfboard) (1.2.4)
Requirement already satisfied: tqdm>=4.42.1 in /Users/somaaymaheshwar
i/opt/anaconda3/lib/python3.8/site-packages (from surfboard) (4.59.0)
Requirement already satisfied: numba==0.48.0 in /Users/somaaymaheshwar
i/opt/anaconda3/lib/python3.8/site-packages (from surfboard) (0.48.0)
Requirement already satisfied: Cython>=0.29.15 in /Users/somaaymaheshw
ari/opt/anaconda3/lib/python3.8/site-packages (from surfboard) (0.29.2
3)
Requirement already satisfied: SoundFile>=0.10.3.post1 in /Users/somaa
ymaheshwari/opt/anaconda3/lib/python3.8/site-packages (from surfboard)
(0.10.3.post1)
Requirement already satisfied: pytest>=5.4.1 in /Users/somaaymaheshwar
i/opt/anaconda3/lib/python3.8/site-packages (from surfboard) (6.2.3)
Requirement already satisfied: librosa>=0.7.2 in /Users/somaaymaheshwa
ri/opt/anaconda3/lib/python3.8/site-packages (from surfboard) (0.9.1)
Requirement already satisfied: pyloudnorm==0.1.0 in /Users/somaaymahes
hwari/opt/anaconda3/lib/python3.8/site-packages (from surfboard) (0.1.
0)
Requirement already satisfied: PeakUtils>=1.3.3 in /Users/somaaymahesh
wari/opt/anaconda3/lib/python3.8/site-packages (from surfboard) (1.3.
3)
Requirement already satisfied: pyyaml>=5.3 in /Users/somaaymaheshwari/
opt/anaconda3/lib/python3.8/site-packages (from surfboard) (5.4.1)
Requirement already satisfied: llvmlite<0.32.0,>=0.31.0dev0 in /Users/
somaaymaheshwari/opt/anaconda3/lib/python3.8/site-packages (from numba
==0.48.0->surfboard) (0.31.0)
Requirement already satisfied: setuptools in /Users/somaaymaheshwari/o
pt/anaconda3/lib/python3.8/site-packages (from numba==0.48.0->surfboar
d) (52.0.0.post20210125)
Requirement already satisfied: numpy>=1.15 in /Users/somaaymaheshwari/
opt/anaconda3/lib/python3.8/site-packages (from numba==0.48.0->surfboa
rd) (1.20.1)
Requirement already satisfied: scipy>=1.0.1 in /Users/somaaymaheshwar
i/opt/anaconda3/lib/python3.8/site-packages (from pyloudnorm==0.1.0->s
urfboard) (1.6.2)
Requirement already satisfied: future>=0.16.0 in /Users/somaaymaheshwa
ri/opt/anaconda3/lib/python3.8/site-packages (from pyloudnorm==0.1.0->
surfboard) (0.18.2)
Requirement already satisfied: audioread>=2.1.5 in /Users/somaaymahesh
wari/opt/anaconda3/lib/python3.8/site-packages (from librosa>=0.7.2->s
urfboard) (2.1.9)
```

```
10.3.post1->surfboard) (2.20)
Note: you may need to restart the kernel to use updated packages.
```

In [2]:

```
import pandas as pd
import seaborn as sns
import matplotlib.pyplot as plt
from surfboard.sound import Waveform
```

In [3]:

```
data=pd.read_csv("~/Desktop/PBL-2/PBLAudio.csv")
```

In [4]:

```
data.head()
```

Out[4]:

	name	emotions	type	size (KB)	target	path
0	bojack	bojack_afraid	WAV File	2441	1	/Users/somaaymaheshwari/Downloads/dataset/boja...
1	bojack	bojack_angry	WAV File	1849	1	/Users/somaaymaheshwari/Downloads/dataset/boja...
2	bojack	bojack_calm (2)	WAV File	2992	1	/Users/somaaymaheshwari/Downloads/dataset/boja...
3	bojack	bojack_calm	WAV File	1099	1	/Users/somaaymaheshwari/Downloads/dataset/boja...
4	bojack	bojack_confused	WAV File	1563	1	/Users/somaaymaheshwari/Downloads/dataset/boja...

In [5]:

```
paths=data.path
paths
```

Out[5]:

```
0     /Users/somaaymaheshwari/Downloads/dataset/boja...
1     /Users/somaaymaheshwari/Downloads/dataset/boja...
2     /Users/somaaymaheshwari/Downloads/dataset/boja...
3     /Users/somaaymaheshwari/Downloads/dataset/boja...
4     /Users/somaaymaheshwari/Downloads/dataset/boja...
5     /Users/somaaymaheshwari/Downloads/dataset/boja...
6     /Users/somaaymaheshwari/Downloads/dataset/boja...
7     /Users/somaaymaheshwari/Downloads/dataset/boja...
8     /Users/somaaymaheshwari/Downloads/dataset/boja...
9     /Users/somaaymaheshwari/Downloads/dataset/boja...
10    /Users/somaaymaheshwari/Downloads/dataset/rick...
11    /Users/somaaymaheshwari/Downloads/dataset/rick...
12    /Users/somaaymaheshwari/Downloads/dataset/rick...
13    /Users/somaaymaheshwari/Downloads/dataset/rick...
14    /Users/somaaymaheshwari/Downloads/dataset/rick...
15    /Users/somaaymaheshwari/Downloads/dataset/rick...
16    /Users/somaaymaheshwari/Downloads/dataset/rick...
17    /Users/somaaymaheshwari/Downloads/dataset/rick...
18    /Users/somaaymaheshwari/Downloads/dataset/rick...
19    /Users/somaaymaheshwari/Downloads/dataset/rick...
20    /Users/somaaymaheshwari/Downloads/dataset/otis...
21    /Users/somaaymaheshwari/Downloads/dataset/otis...
22    /Users/somaaymaheshwari/Downloads/dataset/otis...
23    /Users/somaaymaheshwari/Downloads/dataset/otis...
24    /Users/somaaymaheshwari/Downloads/dataset/otis...
25    /Users/somaaymaheshwari/Downloads/dataset/otis...
26    /Users/somaaymaheshwari/Downloads/dataset/otis...
27    /Users/somaaymaheshwari/Downloads/dataset/otis...
28    /Users/somaaymaheshwari/Downloads/dataset/otis...
29    /Users/somaaymaheshwari/Downloads/dataset/otis...
30    /Users/somaaymaheshwari/Downloads/dataset/howa...
31    /Users/somaaymaheshwari/Downloads/dataset/howa...
32    /Users/somaaymaheshwari/Downloads/dataset/howa...
33    /Users/somaaymaheshwari/Downloads/dataset/howa...
34    /Users/somaaymaheshwari/Downloads/dataset/howa...
35    /Users/somaaymaheshwari/Downloads/dataset/howa...
36    /Users/somaaymaheshwari/Downloads/dataset/howa...
37    /Users/somaaymaheshwari/Downloads/dataset/howa...
38    /Users/somaaymaheshwari/Downloads/dataset/howa...
39    /Users/somaaymaheshwari/Downloads/dataset/howa...
40    /Users/somaaymaheshwari/Downloads/dataset/varu...
41    /Users/somaaymaheshwari/Downloads/dataset/varu...
42    /Users/somaaymaheshwari/Downloads/dataset/varu...
43    /Users/somaaymaheshwari/Downloads/dataset/varu...
44    /Users/somaaymaheshwari/Downloads/dataset/varu...
45    /Users/somaaymaheshwari/Downloads/dataset/varu...
46    /Users/somaaymaheshwari/Downloads/dataset/varu...
47    /Users/somaaymaheshwari/Downloads/dataset/varu...
48    /Users/somaaymaheshwari/Downloads/dataset/varu...
49    /Users/somaaymaheshwari/Downloads/dataset/varu...
Name: path, dtype: object
```

In [6]:

```
j=[]
s=[]
hnr=[]
for path in paths:
    sound=Waveform(path,sample_rate=44100)
    j.append(sound.jitters()['localJitter'])
    s.append(sound.shimmers()['localShimmer'])
    hnr.append(sound.hnr())
```

```
/Users/somaaymaheshwari/opt/anaconda3/lib/python3.8/site-packages/surf
board/hnr.py:81: RuntimeWarning: divide by zero encountered in true_di
vide
  r_x = ffts_outputs[0] / ffts_outputs[1]
/Users/somaaymaheshwari/opt/anaconda3/lib/python3.8/site-packages/surf
board/hnr.py:81: RuntimeWarning: invalid value encountered in true_div
ide
  r_x = ffts_outputs[0] / ffts_outputs[1]
```

In [7]:

```
data['Jitter']=j
data['Shimmer']=s
data['Harmonics-Noise Ratio']=hnr
```

In [8]:

```
data.head()
```

Out[8]:

	name	emotions	type	size (KB)	target	path
0	bojack	bojack_afraid	WAV File	2441	1	/Users/somaaymaheshwari/Downloads/dataset/boja...
1	bojack	bojack_angry	WAV File	1849	1	/Users/somaaymaheshwari/Downloads/dataset/boja...
2	bojack	bojack_calm (2)	WAV File	2992	1	/Users/somaaymaheshwari/Downloads/dataset/boja...
3	bojack	bojack_calm	WAV File	1099	1	/Users/somaaymaheshwari/Downloads/dataset/boja...
4	bojack	bojack_confused	WAV File	1563	1	/Users/somaaymaheshwari/Downloads/dataset/boja...

In [9]:

```
X=data.drop(['name','emotions','type','size (KB)','target','path'],axis='columns')
X.head()
```

Out[9]:

	Jitter	Shimmer	Harmonics-Noise Ratio
0	0.021646	0.118881	6.149633
1	0.026623	0.081227	6.648721
2	0.007718	0.075143	6.357798
3	0.025226	0.068337	8.803255
4	0.019048	0.109710	4.468049

In [10]:

```
Y=data.target
Y.head()
```

Out[10]:

```
0    1
1    1
2    1
3    1
4    1
Name: target, dtype: int64
```

In [11]:

```
from sklearn.utils import shuffle
X,Y = shuffle(X,Y, random_state=20)
```

In [12]:

```
from sklearn.model_selection import train_test_split
```

In [25]:

```
X_train, X_test, Y_train, Y_test= train_test_split(X,Y,test_size=0.2)
```

In [26]:

```
from sklearn.svm import SVC

model= SVC(kernel='linear')
```

In [27]:

```
model.fit(X_train,Y_train)
```

Out[27]:

```
SVC(kernel='linear')
```

In [28]:

```
model.score(X_test,Y_test)
```

Out[28]:

```
0.7
```

In [29]:

```
from sklearn.linear_model import LogisticRegression
model1 = LogisticRegression(random_state=0).fit(X_train,Y_train)
```

In [30]:

```
model1.score(X_test,Y_test)
```

Out[30]:

```
0.7
```

In [33]:

```
path2="/Users/somaaymaheshwari/Desktop/PBL-2/bojack.wav"
sound2= Waveform(path2,sample_rate=44100)
name= "bojack"
j= sound2.jitters()["localJitter"]
s= sound2.shimmers()["localShimmer"]
hnr= sound2.hnr()
d=[[name,j,s,hnr]]
N=pd.DataFrame(d,columns= ["Name","Jitter","Shimmer","HNR"])
Nin= N.drop(['Name'],axis="columns")
```

In [34]:

```
model.predict(Nin)
```

Out[34]:

```
array([1])
```

In [35]:

```
model1.predict(Nin)
```

Out[35]:

```
array([1])
```

In [36]:

```
jc=[]
sc=[]
hnrc=[]
```

In [37]:

```
for ind in data.index:
    if(data["name"][ind]==name):
        jc.append(data["Jitter"][ind])
        sc.append(data["Shimmer"][ind])
        hnrc.append(data["Harmonics-Noise Ratio"][ind])
```

In [38]:

```
jc
```

Out[38]:

```
[0.02164605788526312,
 0.026623089873592395,
 0.00771813850191868,
 0.02522625655897197,
 0.01904804363832035,
 0.01896874954514465,
 0.015292816254804342,
 0.014527366495085133,
 0.014350974028008648,
 0.010232100023762803]
```

In [39]:

```
import numpy as np
a=np.array(jc)
b=np.array(sc)
c=np.array(hnrc)
stdj= np.std(a)
stds= np.std(b)
stdhnr= np.std(c)
meana=np.mean(a)
meanb=np.mean(b)
meanc=np.mean(c)
```

In [40]:

```
stdj
```

Out[40]:

```
0.005801847307185703
```

In [41]:

```
stds
```

Out[41]:

```
0.018826330921132093
```

In [42]:

```
stdhnr
```

Out[42]:

```
1.2898570567473469
```

In [43]:

```
pa=(stdj/meana)*100
pb=(stds/meanb)*100
pc=(stdhnr/meanc)*100
```

In [44]:

```
pt=(pa+pb+pc)/3
pt
```

Out[44]:

```
25.28154932926275
```

In [45]:

```
print("The extent of hypertension: " + str(pt//10))
```

```
The extent of hypertension: 2.0
```

CHAPTER 7 CONCLUSION AND FUTURE SCOPE

In this system the extent of Hypertension is detected by extracting features from audio clips, which are voices/dialogs of a few characters, taken from different online sources. Major components of the proposed system are: extracting features from voice, detecting whether the person is suffering from hypertension or not, and further quantifying the extent of it on the scale of 1-10. This project is based on various python libraries and machine learning algorithms. This project successfully demonstrates how voice features like jitter, shimmer, HNR, etc can be used to predict whether a person is hypertensed or not with the accuracy of around 70%.

Using the results and learning of this project we can say that voice plays an important role in determining any disease in a person based on its features. These observations can be used in future and the efficiency of this project can be increased.

As a future study, we will develop a mobile app or web application in which users can provide their medical details and their voice data will be fed. The functionalities will be such that it will record the voice of the user and determine if their BP is shooting high and will inform the user through notifications and other family or friends in extreme cases. This will help them prevent any kind of emergencies as the phrase says, ‘Prevention is better than cure’.

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