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# A Voice Recognition System to detect Respiratory Problems using Machine Learning

**Gola Faiz Ali[1], Shaikh Gulnaaz[2], Patel Amaan[3]**
*[1,2,3]Information Technology, M H Saboo Siddik College of Engineering, University of Mumbai, India.*

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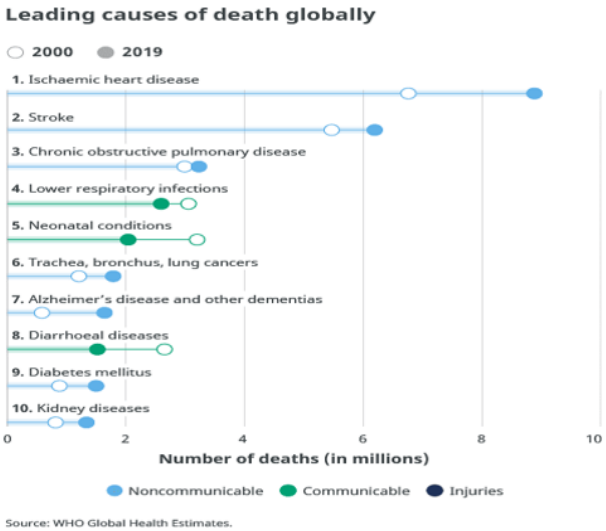
***Abstract**: The paper provides an overview of the development and intelligent voice data analysis from a machine learning perspective; a historical, state-of-the-art view and a view on some future trends in the field of artificial intelligence. The paper describes some areas within voice recognition domain which seem to be important for applying machine learning in medical diagnosis. This describes a recently developed method of detecting respiratory problems quickly by recognizing the changes in voice over time. Machine learning algorithms are applied here. Machine Learning is the core subarea of artificial intelligence. The different techniques available for Machine Learning are Linear Regression, Logistic Regression, Decision Tree, SVM, Naive Bayes, k-NN, K-Means, Random Forest, Dimensionality Reduction Algorithms and Gradient Boosting algorithms. The main idea of the paper is to apply Logistic Regression, K-nearest neighbors, Support Vector Machine (SVM), Naïve Bayes and Random Forest Algorithms in recognition and detection of respiratory problems based on voice. The findings of this paper contribute to the healthcare system.*

***Key Word**: Machine learning, voice recognition, data analysis*

## I. INTRODUCTION

With the fast lifestyle and hectic schedule into place, health diseases are on the rise everywhere. While heart diseases at the top of chart, after heart diseases, all types of cancer related problems come second and post that, respiratory problems lead the chart. Early detection of the same can prevent worsening of the same or problems going ahead. Moreover, respiratory problems can be symptoms of something more and if not cured in time can lead to adverse situations like pneumonia, etc. All these lead to the thinking that there can after all be something that can prevent respiratory problems and avoid further complexities.




Our project aims to resolve most of the problems of people who are suffering from respiratory problem. Early detection of respiratory diseases can prevent worsening of the situation. We hope to ease this process by using machine-learning methods to develop a model to predict whether patient have respiratory problems or not. The most promising element during a respiratory problem is that the patient's voice varies rapidly within a short duration.

The objectives are as follows:

1. To apply machine learning techniques for detecting respiratory problems using voice recognition.
2. To study various patterns and trends in detecting respiratory problems.
3. To design a user-friendly system for detecting respiratory problems.
4. To achieve maximum accuracy possible in detection of respiratory problems.

## II.EXISTING SYSTEM METHODOLOGY

To study the existing techniques and try to overcome the limitations during implementation. Respiratory problems are a rising cause for concern not just because of the fact that it's one of the top three killing problems, but due to the simple fact that it's really frustrating to not be able to speak, breathe or perform associated actions with ease. Our voice recognition system to detect respiratory problems can be used by all the people around the globe to check whether they are suffering from respiratory problems or not. A system is created, which is able to detect symptoms. Then using past history, a particular disease or a set of diseases can be predicted when symptoms are known. Using more training data, it can be extended (within future scope) to a point where future diseases can be predicted even before immediate symptoms are known.

The kinship between man and machines has become a new trend of revolutionary technology such that machines now have to respond by considering the human emotional levels. In the recent years, human-computer interaction has become more interesting. Respiratory problems are rising and are amongst the top three killing problems in the world. Artificial Intelligence, Machine Learning and Deep Learning have become the most advanced technologies in today's world. Machine learning provides algorithms to build many analytical models, helping computers to learn from data. We are using a set of machine learning algorithms to train a model for detection of respiratory problems in the early stages. The perspective is to apply Machine learning in the Health Sector, mainly in detection of problems.

In literature review, A low complexity diagnostic tools for screening respiratory infections is presented [1] Results show the pattern with regards to the changes in voice that occur along with the respiratory problems. [2] The said technology can be installed on smartphones and other ubiquitous devices and provides a point-of-care diagnosis without the need of a clinical examination or supplemental investigations, however, It only tests the diagnostic accuracy through cough sounds and identifies respiratory disorders in children below the age of 12 years old. [3] Mood predictions like Neutral, Anger, Surprise, Fear, Happiness, and Sadness can be made based this model. the system only considers voice to detect the mood of a person, 70% accuracy is achieved. Perhaps, having considered video and audio both the accuracy can be increased to 90%. [4]

Furthermore, the models and hyper parameter values are chosen manually, which can cause error to some extent in the results, accuracy should be increased. [5] Requirement of a microphone and MLT1132 Piezo Respiratory Belt Transducer to be placed on the subject. [6] This methodology used Wigner Distribution function and wavelet packet decomposition, which comparatively are difficult in implementation. [7] The process is slow; speech recognition is difficult in noisy environments as the pronunciation varies depending on user [8] Requirement of a large database. Additional requirement of cough and voice recordings required [9] Allows visually impaired people to engage in technology like browsing, sending, receiving emails, printing and converting articles from text-to-Braille, etc., Also can be used in teaching-learning module for the visually impaired. Although, not all visually impaired people can afford the system as it is costly. [10]

## III.PROPOSED SYSTEM

After going through all the literature surveys and our data set, we came to a final decision of using machine learning algorithms such as Logistic Regression, K-Nearest Neighbors, Support Vector Machine, Random Forest etc. Our detection system will make sure that such problems are detected an early level so that the patient can start their treatment as early as possible.

### 1. EXISTING SYSTEM ARCHITECTURE

A model for detecting respiratory problems using voice recognition is found, although, it cannot predict which specific respiratory problem the patient is suffering from. Our aim to implement a model is similar to this, but the methods and techniques used differ. The existing model working is as follows: Utilizing Intel's Deep Learning Kit, all the basic operations are done on Ubuntu 16.04 (Linux OS). Intel Deep Learning Deployment toolkit is the main focus here. Intel OpenVINO™ toolkit will be there for support. The various pre-trained models used here are:

**Training:** Dataset creation: The dataset is created manually. In that during training, various factors are identified for voice recognition like thickening of voice, inability to speak clearly, difficulty in speaking fluently, etc. All these factors account for significant changes during respiratory problems. Intel's Deep Learning Kit will be of all help here.

**Testing:** On random users: Once the features are identified for both voices with and without problems, we start testing it on random people. The device is brought near the user at a sufficient distance so that it can capture the voice clearly. Then, Intel's Deep Learning Deployment kit will be in use during testing. Finally, results will be given.

Topology: The topology used is CaffeNet as it's used for Classification Model. Framework: The frameworks used here are TensorFlow and Caffe Models. Deep Learning is the main technology used.

Maximize Performance: Intel's Deep Learning Deployment Toolkit is also used to maximize performance. Report generation and analysis: During learning, feedback and overall training processes, Model Optimizer produces a detailed report with various accuracy metrics, depends on the network architecture.

Classification Networks: x Classification Accuracy (in terms of top-N), is based on the accuracy layers defined in the network train/Val topology file. Intel's OpenVino Toolkit is utilized as delivers a comprehensive toolkit for developing vision-oriented solution. It's capable of delivering computing and graphics performance for vertical AI. With it and the other tools, voice can be processed, which is the need here. The development setup and environment is Ubuntu* 16.04 LTS 64-bit and Python* 2.7.

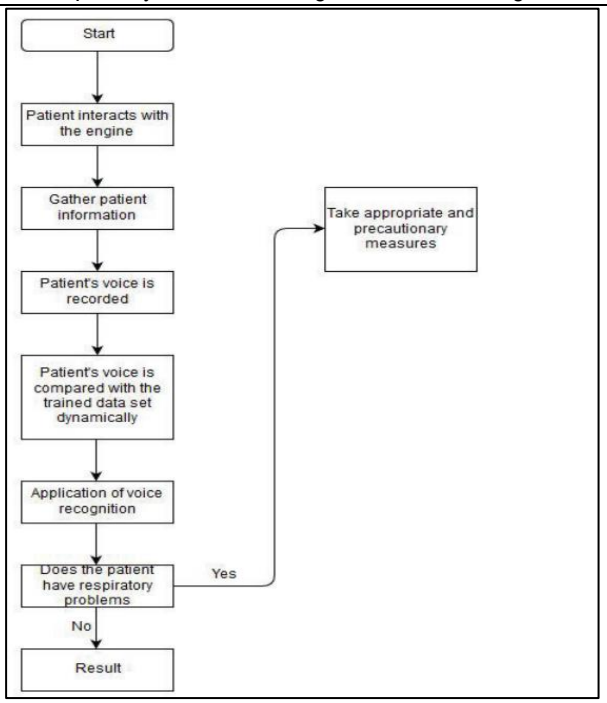
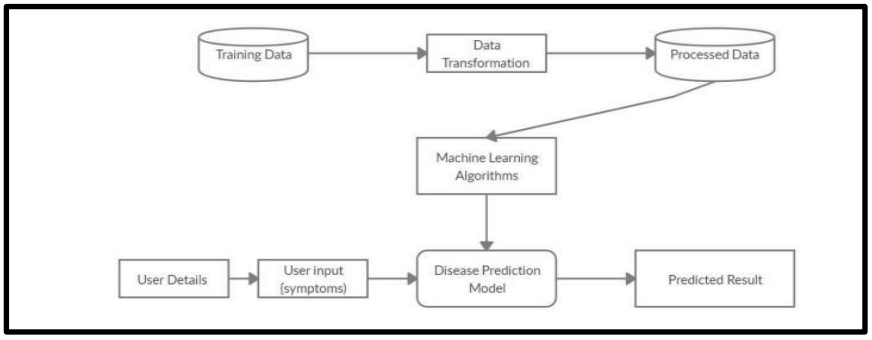



Fig 1.2: Existing system flow

## 2. PROPOSED SYSTEM ARCHITECTURE




A system using various machine learning algorithms is used for predicting values. The main aim is to make the system user friendly so that any user can fill the required data without any difficulty, to achieve this our primary goal is to design a web application with user friendly so anyone can use our system easily. We have utilized a dataset which was available online. The dataset used for the system was pre-processed and analyzed. The dataset which we used consisted of values such as age, sex, cp, contraction capacity of lungs etc. By applying various machine learning algorithms on the dataset such as Logistic Regression, K-Nearest Neighbors, Support Vector Machine, Random Forest for classification of data, we found out that Random Forest algorithm gave us the best result as compared to other algorithms. After analysis of the data with the help of this algorithm to find various insights thus, we have a model using random forest algorithm and applied that on our web application. Firstly, the user's voice sample is taken, and the extraction of necessary aspects such as the pitch, tone, clarity, thickness, wheezes etc. in the form of data is done by using an existing software (voice analyst & voice tools etc.). The website is designed in such a way that the user has to register themselves and after that they have to fill in their details, and provide the results from the voice analysis. This will provide us with the required values that will be used in our model and submitting them to us a predictive analysis will be conducted on their values by our machine learning model and the result will be displayed on the website.

### i. Logistic Regression

Logistic regression is the appropriate regression analysis to conduct when the dependent variable is dichotomous (binary). Like all regression analyses, logistic regression is a predictive analysis. Logistic regression is used to describe data and to explain the relationship between one dependent binary variable and one or more nominal, ordinal, interval or ratio-level independent variables.

### ii. K-Nearest Neighbor

K-NN is one of the most straightforward algorithms adopted in machine learning for classification and regression problems. Based on closest measures, KNN takes information and classifies recent information points. The information is then allotted to the class with the foremost closest neighbor. KNN is often used to classify future information due to its ease of execution and adequacy.

### iii. Support Vector Machine

SVM is a supervised machine learning algorithm which can be used for classification or regression problems. It uses a technique called the kernel trick to transform your data and then based on these transformations it finds an optimal boundary between the possible outputs. Simply put, it does some extremely complex data transformations, then figures out how to separate your data based on the labels or outputs you've defined.

### iv. Random Forest

Random forest is a supervised learning algorithm which is used for both classification as well as regression. But it is mainly used for classification problems, A random forest algorithm creates decision trees on data samples and then gets the prediction from each of them and finally selects the best solution by means of voting. It is an ensemble method which is better than a single decision tree because it reduces the over-fitting by averaging the result.

### v. Naïve Bayes

It is a classification technique based on Bayes' Theorem with an assumption of independence among predictors. In simple terms, a Naive Bayes classifier assumes that the presence of a particular feature in a class is unrelated to the presence of any other feature.

## 3. WORKING

The pre-processing, visualization and the various machine learning models including the random forest model which gave us the highest accuracy is done in python's Jupyter notebook. This model is linked to a web page.The user needs to first login. After logging in, the user needs to fill the form available on the web page. After submitting the form, the user will get the result if they have any respiratory related problem and if they should consult a doctor.

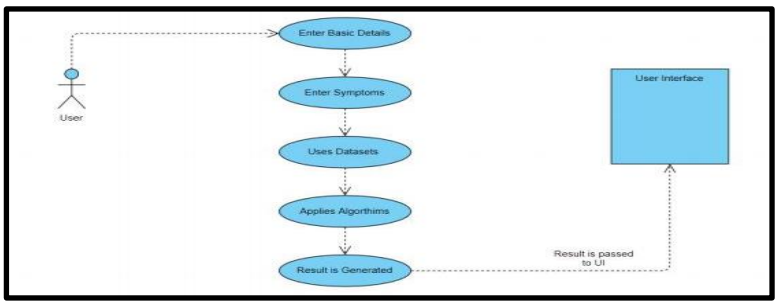



Fig 3.3: Use Case Diagram

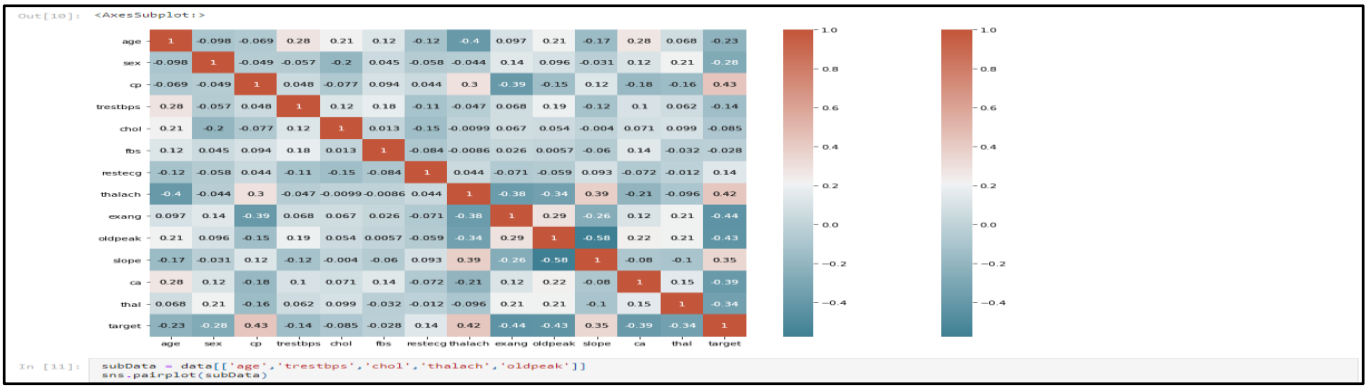
## IMPLEMENTATION SCREENS

```
In [1]: import numpy as np
        import pandas as pd
        import matplotlib as plt
        import seaborn as sns
        import matplotlib.pyplot as plt

In [4]: filePath = '/Users/USER/Desktop/notebook/dataset.csv'

        data = pd.read_csv(filePath)

        data.head(5)
```

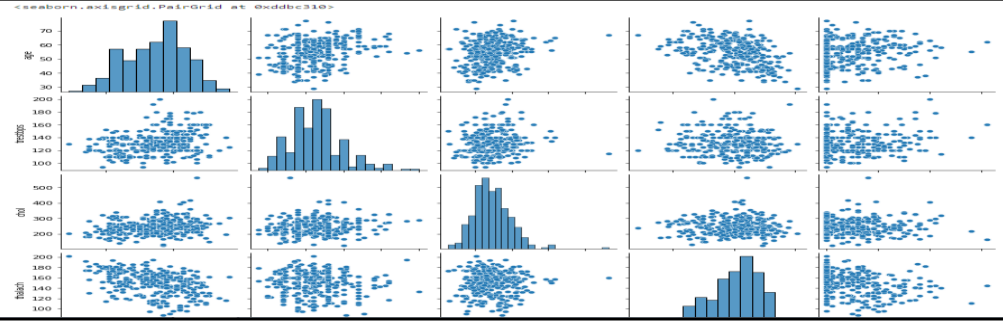
Out[4]:

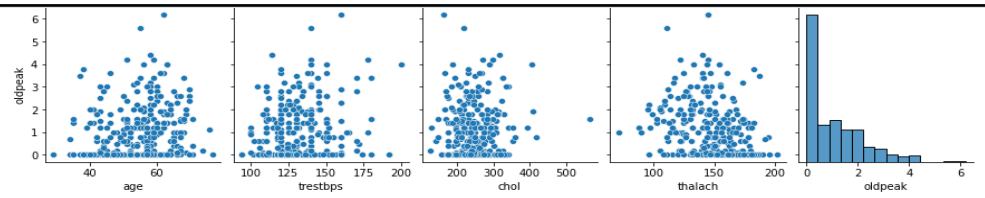
| | age | sex | cp | trestbps | chol | fbs | restecg | thalach | exang | oldpeak | slope | ca | thal | target |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 63 | 1 | 3 | 145 | 233 | 1 | 0 | 150 | 0 | 2.3 | 0 | 0 | 1 | 1 |
| 1 | 37 | 1 | 2 | 130 | 250 | 0 | 1 | 187 | 0 | 3.5 | 0 | 0 | 2 | 1 |
| 2 | 41 | 0 | 1 | 130 | 204 | 0 | 0 | 172 | 0 | 1.4 | 2 | 0 | 2 | 1 |
| 3 | 56 | 1 | 1 | 120 | 236 | 0 | 1 | 178 | 0 | 0.8 | 2 | 0 | 2 | 1 |
| 4 | 57 | 0 | 0 | 120 | 354 | 0 | 1 | 163 | 1 | 0.6 | 2 | 0 | 2 | 1 |

```
In [5]: print("(Rows, columns): " + str(data.shape))
        data.columns

(Rows, columns): (303, 14)
Out[5]: Index(['age', 'sex', 'cp', 'trestbps', 'chol', 'fbs', 'restecg', 'thalach',
               'exang', 'oldpeak', 'slope', 'ca', 'thal', 'target'],
              dtype='object')
```



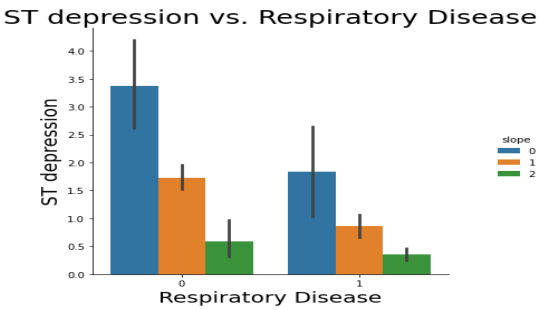
Out[11]: <seaborn.axisgrid.PairGrid at 0xddbc310>



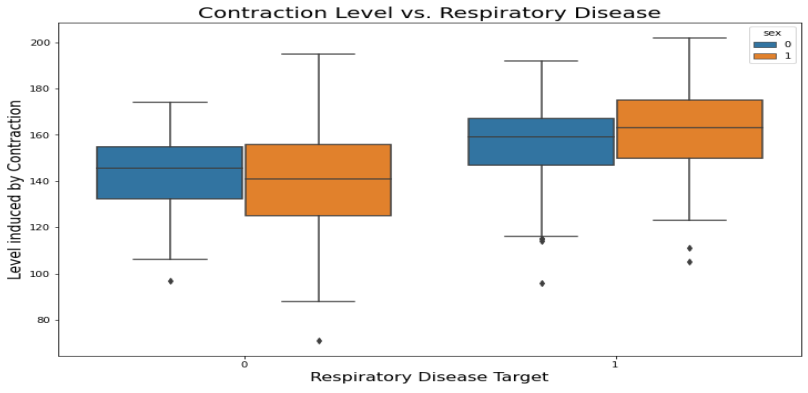

In [14]:
```
sns.catplot(x="target", y="oldpeak", hue="slope", kind="bar", data=data);

plt.title('ST depression vs. Respiratory Disease',size=25)
plt.xlabel('Respiratory Disease',size=20)
plt.ylabel('ST depression',size=20)
```

Out[14]: Text(10.778541666666662, 0.5, 'ST depression')




In [17]:
```
plt.figure(figsize=(12,8))
sns.boxplot(x= 'target', y= 'thalach',hue="sex", data=data )
plt.title("Contraction Level vs. Respiratory Disease", fontsize=20)
plt.xlabel("Respiratory Disease Target",fontsize=16)
plt.ylabel("Level induced by Contraction", fontsize=16)
```

Out[17]: Text(0, 0.5, 'Level induced by Contraction')




In [18]:
```
pos_data = data[data['target']==1]
pos_data.describe()
```

In [ ]:
```
model1 = LogisticRegression(random_state=1)
model1.fit(x_train, y_train)

y_pred1 = model1.predict(x_test)
print(classification_report(y_test, y_pred1))
```

```
              precision    recall  f1-score   support

           0       0.77      0.67      0.71        30
           1       0.71      0.81      0.76        31

    accuracy                           0.74        61
   macro avg       0.74      0.74      0.74        61
weighted avg       0.74      0.74      0.74        61
```

In [27]:
```
from sklearn.metrics import classification_report
from sklearn.neighbors import KNeighborsClassifier
```

```
                  precision    recall  f1-score   support

               0       0.79      0.73      0.76        30
               1       0.76      0.81      0.78        31

        accuracy                           0.77        61
       macro avg       0.77      0.77      0.77        61
    weighted avg       0.77      0.77      0.77        61
```

In [30]:
```
from sklearn.metrics import classification_report
from sklearn.tree import DecisionTreeClassifier

model5 = DecisionTreeClassifier(random_state=1)
model5.fit(x_train, y_train)

y_pred5 = model5.predict(x_test)
print(classification_report(y_test, y_pred5))
```

```
                  precision    recall  f1-score   support

               0       0.68      0.70      0.69        30
               1       0.70      0.68      0.69        31

        accuracy                           0.69        61
       macro avg       0.69      0.69      0.69        61
    weighted avg       0.69      0.69      0.69        61
```

In [31]:
```
from sklearn.metrics import classification_report
from sklearn.ensemble import RandomForestClassifier

model6 = RandomForestClassifier(random_state=1)
model6.fit(x_train, y_train)

y_pred6 = model6.predict(x_test)
print(classification_report(y_test, y_pred6))
```

```
                  precision    recall  f1-score   support

               0       0.88      0.70      0.78        30
               1       0.76      0.90      0.82        31

        accuracy                           0.80        61
       macro avg       0.82      0.80      0.80        61
    weighted avg       0.81      0.80      0.80        61
```

In [32]:
```
from sklearn.metrics import confusion_matrix, accuracy_score
cm = confusion_matrix(y_test, y_pred6)
print(cm)
accuracy_score(y_test, y_pred6)
```

```
[[21  9]
 [ 3 28]]
```

Out[32]:
```
0.8032786885245902
```

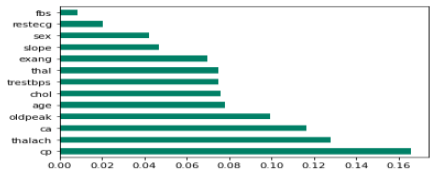
In [33]:
```
importance = model6.feature_importances_

for i,v in enumerate(importance):
    print('Feature: %0d, Score: %.5f' % (i,v))
```

```
Feature: 0, Score: 0.07814
Feature: 1, Score: 0.04206
Feature: 2, Score: 0.16580
Feature: 3, Score: 0.07477
Feature: 4, Score: 0.07587
Feature: 5, Score: 0.00828
Feature: 6, Score: 0.02014
Feature: 7, Score: 0.12772
Feature: 8, Score: 0.06950
Feature: 9, Score: 0.09957
Feature: 10, Score: 0.04677
Feature: 11, Score: 0.11667
Feature: 12, Score: 0.07473
```

In [34]:
```
index= data.columns[:-1]
importance = pd.Series(model6.feature_importances_, index=index)
importance.nlargest(13).plot(kind='barh', colormap='summer')
```

```
importance.nlargest(13).plot(kind='barh', colormap='summer')
```

Out[34]:
```
<AxesSubplot:>
```




In [35]:
```
print(model6.predict(sc.transform([[20,1,2,110,230,1,1,140,1,2.2,2,0,2]])))
```

```
[1]
```

In [36]:
```
y_pred = model6.predict(x_test)
print(np.concatenate((y_pred.reshape(len(y_pred),1), y_test.reshape(len(y_test),1)),1))
```

```
[[0 0]
 [1 1]
 [0 0]
 [0 0]
 [0 0]
 [0 0]
 [0 0]
 [1 1]
 [0 0]
 [1 1]
 [1 1]
 [0 0]
 [1 0]
 [0 0]
 [0 0]
 [1 0]
 [1 1]
```

## IV.RESULT

In this paper presented, the study of different machine learning techniques is presented. The different techniques such as Logistic Regression, K-Nearest Neighbour, Support Vector machine, Random Forest and Naïve Bayes are implemented. These techniques are studied in detail to achieve better accuracy. The dataset used for training and testing are 'Respiratory Sound' and 'heart disease'. The application of machine learning is identified and presented. The results include whether or not user has respiratory problems based on recognition of voice. Here, after performing the said application of machine learning we found that Random Forest algorithm provides most accurate results among the others, that is 80%. The model proves to be accurate when the both the values are 00 or 11, whereas when values are 01 or 10 at that instance the readings are inaccurate. The results show the pattern with regards to the changes in voice that occur along with the respiratory problems. Separate plots for changes in voice thickness, clarity v/s the happening respiratory problems is studied. The five elements of voice are tone, syntax, diction, detail and syntax. But the selection of attributes here is different as the problem is easily understood. Attributes taken into consideration are contraction capacity of the lungs, coughs or wheezes during breathing and oxygen capacity after or during any activity. Furthermore, the said system can improve its accuracy with other implementation techniques as well, which are yet to be explored.

## V.CONCLUSION

To conclude, the report represents ideas and techniques for implementing the said "Voice recognition system for detecting respiratory problems". After applying various machine learning techniques and algorithms like logistic regression, K-Nearest neighbour, Naïve bayes, Random Forest and Support Vector Machine, we came to conclusion that Random Forest Machine Learning Algorithm works best for this system as its accuracy is higher than the others mentioned. A general trend has been found out and it is presented. The changes in respiratory problems not due to the five variables, rather associated with those five variables have been studied. These are the core which is indicative towards major change. The contraction capacity of the lungs, coughs and wheezes during breathing and oxygen capacity are some of the attributes taken into consideration in the implementation and detection of respiratory problems. The greatest inspiration driving this thought was that respiratory problems are third most, when it comes to human deaths. So, if in some way their dependence could be figured out, the problem could be detected at the earliest and that would save many lives. This has very much been the driving force behind this paper. Thus, the above model can be extended for other diseases as well. As diseases like Alzheimer and types of dementia are increasing, this model can be used to understand patterns there and as a result applied there.

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