Sentiment Analysis of speech using Python in Raspberry pi

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Abstract - **Sentimental analysis can be defined as the process of determining computationally whether a piece of text or a sentence or a document is positive negative or neutral. Due to the rapid development in e-commerce and internet marketing, analyzing customer feedbacks is an unavoidable task in making business decisions. It is also applicable to social media analysis, political analysis and financial analysis to take effective and efficient decisions based on the user's feedback. As the classification is most widely used in gathering the opinion of the customers in product reviews it's also known as opinion mining. The work related to the analysis of speech is found to be rare so we aim to get the input as speech using speech recognition and then categorize the sentences based on the polarity of sentiment and hence can be used in speech-based applications. By using a generalized python based approach to natural language processing, we try to construct a real-time speaking user interface in Raspberry Pi.**

Keywords — Sentiment analysis, Opinion mining, Speech recognition, Python, Natural language processing, Raspberry Pi

I.   INTRODUCTION

Sentiment analysis technique means the automatic classification of public opinions. Due to the rapid development of e-commerce websites and social networking sites a lot of data is getting accumulated in the World Wide Web [1]. Proper analysis of the data helps in understanding what other people think and to take many useful business decisions and improvement actions. Sentiment analysis is an emerging field and somewhat established in the analysis of text data. Social websites are full of opinionated data about different products, services, personalized interests, and needs. We get more valuable information in the section of reviews and comments [2]. The work related to this topic has been accumulated in the text-based approach and to take this field of opinion mining to a new dimension, real-time sensing of speech has been included and also to interact with the user with human understandable language. The term sentiment analysis was first introduced by Nasukawa and Yi in 2003. The raw data available on the websites cannot be analyzed directly as it should be processed before performing the analysis. The processing involves extraction, filtering, tokenization of data [3]. There are basically two approaches of sentiment analysis, one is machine learning based and the advantage of using this is that gives more

accuracy and targeted for a specific application. It consists of two phases, the training phase, and the classification phase [4]. The second approach is a lexicon-based approach and is also known as dictionary based method. The lexicon-based approach is used in this project where a dictionary called Vader-lexicon is used and it consists of a list of positive and negative words and their polarity score. By comparing the words in the data to be analyzed and the lexicon data we can categorize the sentence based on the negativity or positivity score.
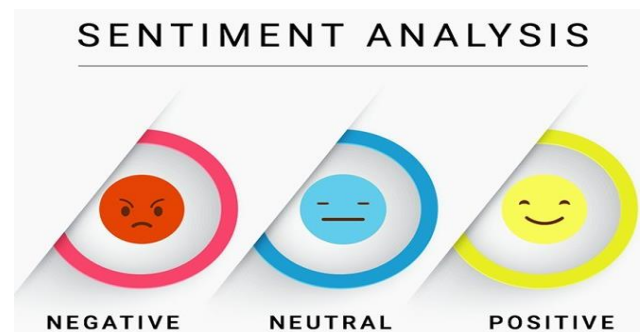

Fig.1. Categories of sentiment

A.   Natural Language Processing

Natural language process may be a branch of the sphere in AI that deals with the human language. it's a field of computing that involves creating the computers perceive and derive which means from the human language and input as the way of interacting with the live world. The

sentimental analysis comes underneath the sphere of the linguistic communication process and has been handled at several levels of granularity ranging from a document level classification task to a phrase level. Human language technology techniques are typically supported machine learning and particularly applied mathematics learning that uses a general learning algorithmic program combined with an oversized sample, a corpus of knowledge to be told the principles and process the text.

B. *Need for sentiment analysis*

The need for analysis in Information technology is

- Drives proactive business solutions

- Measure ROI (Return on Investment) of marketing campaigns

- Improve product quality and customer satisfaction

II. TOOLS FOR SENTIMENT ANALYSIS

A. *NLTK Sentiment Analyzer*

Sentiment Analysis is a tool that facilitates sentiment analysis tasks using NLTK features and classifiers. The nltk.sentiment.util module has different lexicons related to different domains. Some of them are demo_liu_hu_lexicon, demo_movie_reviews, demo_vader_instance. The util module also supports classes for training data sequences related to the specific application [5]. Another module present in NLTK for sentiment analysis is nltk.sentiment.vader which has a class called SentimentIntensityAnalyzer which uses a lexicon and Vader based approach to determine the intensity of sentiment in a given text. It has a method called polarity_scores() which returns float value based on the strength of sentiment in the input text..

B. *TextBlob*

TextBlob is a python library which is a part of NLTK. It supports all basic tasks for natural language processing and has advanced features such as spelling correction, sentiment extraction, translation and detection of language. It uses a machine learning based model for sentiment extraction. It has two sentiment analyzers named pattern analyzer and Naive Bayes analyzer where pattern analyzer is the default. We can override the default parameter. Sentence tokenization of a paragraph and word tokenization of a sentence can also be done using TextBlob.

C. *SentiwordNet*

SentiwordNet is a freely distributed lexical resource and also independent of domain. It uses Word Sense Disambiguation (WSD) method for classification of sentiment. It is a class of NLTK and based on python. By assigning positive, negative and objective scores to the synsets of WordNet, sentiwordNet is formed. The sentiment score assigned is a real value from 0 to 1 inclusive of 1. It defines how positive, negative or neutral a term is. SentiwordNet has sentiment scores at provides sentiment score at the syntactic level.

D. *Stanford CoreNLP*

Stanford CoreNLP is a suite is a software toolkit developed at Stanford University by NLP research group. It provides Java-based modules for providing a solution to a range of NLP tasks. It is a deep learning based model and gives importance in considering individual words in a longer phrase. A recursive neural network that builds on grammatical structures called sentiment Treebank was developed. It can be used from command line or through java programming API or via a web service. It works on popular platforms such as Windows, Linux, and MacOS.

E. *RapidMiner*

RapidMiner is a tool for data mining and analysis of text which allows users to extract information from externally available data sources that let them understand what is being said about their company or products or their services. It is a software platform developed by a company named Rapid Miner [6]. It is a top layer application which is based on drag and drop can also be used by non-programmers for data analytics. It has over 1500 operators and has almost all functions for natural language processing such as tokenization, stop-word filtering, case transformation, stemming etc. The extract sentiment feature from wordnet extension can be used to get a graphical representation of the histogram of sentiment values.

F. *General Architecture for Text Engineering (GATE)*

General Architecture for Text Engineering (GATE) was developed at the University of Sheffield. It is an open source java based software tool for all types of basic computations involving human language. It contains several sentiment analysis systems. One of them uses supervised machine learning methods, trained in human-annotated data, co-occurrence statistics, and lexicons of positive and negative words to analyze problems with products or services reported on blogs. Others use lightly-supervised and unsupervised approaches. It is an information extraction system and also used for many text analysis processes such as stemming, Parts of Speech (POS) tagging, visualizing and manipulating text, annotations etc.

G. *R Package: RSentiment*

R is a programming language for statistical analysis, graphical representation and reporting. The RSentiment package lets users analyze the sentiment of an English sentence and assign a score to it. A special function calculate_sentiment classifies the sentiment of sentences into six categories: positive, negative, very positive, very negative, sarcasm and neutral. It also takes into account the

negations and adjectives while calculating the score. The calculate_custom_score function returns a positive value for positive sentiment, a negative value for negative sentiment, zero for neutral, and 99 for sarcasm.

H. R Package: Sentiment Analysis

It is a dictionary-based sentiment analysis package which uses the existing dictionaries and also allows creating personalized dictionaries suitable for a particular domain or application. The package provides methods and functions to measure the sentiment of written materials. The class SentimentDictionary helps user for creating domain specific dictionaries based on input.

III. RELATED WORK-TWITTER SENTIMENTANALYSIS

Millions of individuals are exploiting social network sites to precise their emotions, opinion and disclose concerning their daily lives. Twitter is a popular real-time microblogging service that allows users to share short information known as tweets which are limited to 140 characters [7]. Users write tweets to precise their opinion concerning numerous topics about their daily lives. Twitter is one of the important platforms for the extraction of general public opinion on type-specific issues. A collection of tweets is employed because of the primary corpus for sentiment analysis that refers to the utilization of opinion mining or linguistic communication process. Twitter, with five hundred million users and million messages per day, has quickly become a valuable asset for organizations to invigilate their reputation and brands by extracting and analyzing the sentiment of the tweets by the public about their products, services market and even about competitors [8]. From the social media generated opinions with the mammoth growth of the planet-wide net, super volumes of opinion texts within the sort of tweets, reviews, blogs or any discussion groups and forums are available for analysis, thus making the world wide web the fastest, most comprising an easily accessible medium for sentiment analysis. The sentiment will be found within the comments or tweet to produce helpful indicators for several totally different functions. It is stated that a sentiment can be categorized into two groups, which is negative and positive words. Sentiment analysis is a natural language processing technique to quantify an expressed opinion or sentiment within a selection of tweets. There have two main approaches for extracting sentiment automatically which are the lexicon-based approach and machine-learning-based approach.
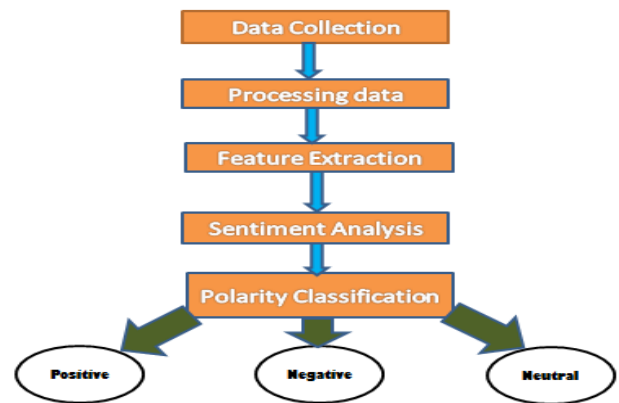

Fig 2.Flow diagram for twitter sentiment analysis

The figure.2 shows the methodology for sentimental analysis of tweets in which the first step is collecting the data from Twitter API. 'Tweepy' library in python is used here and also the libraries of python help to communicate with Twitter API to collect tweets using access tokens and secret keys.

The next step is pre-processing of tweets which mean extracting the keywords from the raw data to give us meaningful information. It involves removing special symbols, spaces, emojis, stop words, etc.

The third step is feature extraction which means collecting the positive and negative words related to a specific subject and finally, we perform sentimental analysis of the words classifies the polarity of the opinion.

IV. PROPOSED WORK

The objective is to analyze the intensity of sentiment in a sentence given as input in form of voice using speech recognition and natural language processing using python in Raspberry Pi 3. Sentimental analysis of speech is a research area which is not yet explored fully as compared to social media analysis [9]. The work aims on the applications of sentiment analysis using speech as a feedback analyzer. It not only classifies the sentiment but also analyze the intensity of the same by listening to our speech.

A. Hardware Requirements

The hardware components used for constructing the system are:

i.   Raspberrry pi 3 model b+ board
ii. Sound card
iii. Microphone with 3.5mm audio jack
iv. 5v speaker
v.   Ethernet cable
vi. USB Power cable
vii. Memory card with raspbian image
viii. Bread board, connecting wires and LED's

B. Software Requirements

The software packages and python libraries which are needed to be installed in the rasbian os are:

i. Python 3 IDE
ii. Omxplayer
iii. Alsamixer
iv. Python libraries :
    a. nltk,
    b. gtts,
    c. SpeechRecognition

C. Raspberry Pi 3 Model B+

The latest Raspberry Pi 3 Model B+ acts as a minicomputer and has a faster 64-bit 1.4GHz quad-core processor, 1GB of RAM, faster dual-band 2.4GHz and 5GHz wireless LAN, Bluetooth 4.2, and significantly faster 300Mbit/s Ethernet. These features make this board suitable for many applications and hence we choose the pi board for our project. Fig 3 shows the model b+ board used in this project.

Fig 3.Raspberry pi 3 model b+ board

The features of Raspberry pi model b+ are

- 1.4GHz 64-bit quad-core ARM Cortex-A53 CPU (BCM2837)
- 1GB RAM (LPDDR2 SDRAM)
- On-board wireless LAN - dual-band 802.11 b/g/n/ac (CYW43455)
- On-board Bluetooth 4.2 HS low-energy (BLE) (CYW43455)
- 4 x USB 2.0 ports
- 300Mbit/s Ethernet
- 40 GPIO pins
- Full size HDMI 1.3a port
- Combined 3.5mm analog audio and composite video jack
- Camera interface (CSI)
- Display interface (DSI)
- micro SD slot
- Video Core IV multimedia/3D graphics core @ 400MHz/300MHz
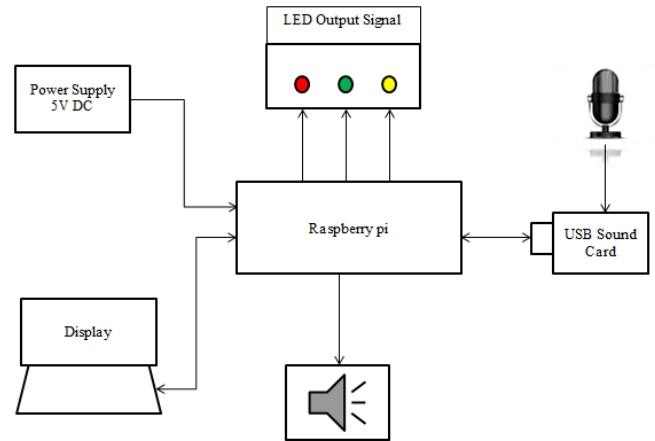
D. Experimental Setup

Fig 4.Block diagram of experimental setup

The experimental setup consists a raspberry pi minicomputer which is powered with a 5v DC power supply and connected to the display of laptop or desktop with a Ethernet cable. As the raspberry pi does not support input via audio jack and it is only for providing output signal, we need to provide an external sound card compatible with the pi to convert the analog signal provided by the microphone to a digital signal with the help of analog to digital convertor present in the USB sound card. A USB web camera compatible with raspberry pi with an inbuilt microphone can also be used replacing the sound card and microphone. Also a 5v speaker is interfaced with the setup to give us real time instructions and error handling by giving human understandable speech audio and also to verify the speech input given by the user. The speech signal is then converted to text and the converted text is analyzed by the program to find the polarity of the sentiment and the output based on the sentiment whether the input opinion is positive, negative or neutral different color LED's will provide the output by blinking effect. The polarity score will also be displayed in the output console screen

1) Setting up Raspberry Pi

- Download the Raspbianos for raspberry pi and flash the image in a memory card minimum of 16 GB using etcher or any other flashing software.
- Insert the SD card in the slot of raspberry pi and power it with a 5v dc supply.
- Set the username and password
- Set a static IP address for both Ethernet (wired) and WLAN (wireless) for effortless connection with laptop.
- As the laptop keyboard, mouse and display is used as the input and output console for raspberry pi every time we power it on the DHCP of

raspberry pi assigns a new IP address and we have to use a network finder application to find the assigned address hence setting up static IP makes it easy for us to interface with the laptop or any desktop.

- Install the necessary libraries needed using PIP package manager in python 3

2) Checking Microphone for Voice Recognition

- We need to first check whether our microphone records properly.
- Check if the webcam or microphone is listed using the command "lsusb".
- Enter the command "alsamixer" in the terminal.
- On the graphical interface that shows up, select the webcam or mic from the list and then rise the recording volume to a appropriate level.

E. Python Libraries Used

Python is one of the dynamic and high level programming languages that focuses on code readability. It is a robust and provides an easy usage of the code lines, maintenance can be handled in a great way, and debugging can also be done easily. Python has a strong source of external libraries and diversified application framework which makes it easy for programming and research purposes.

1) NLTK

NLTK library can be called as the heart of the project because it provides us the feature for natural language processing and sentiment analysis. NLTK is an acronym for Natural Language Toolkit and is one of the popular building platforms for building programs in python to work with human language. It provides easy to use interfaces to more than 50 corpora and lexical databases. It also provides us with the rich text processing libraries for stemming, tagging, parsing, tokenization and semantic reasoning makes it suitable for Engineers, researchers, students and linguistics. NLTK is available for most popular platforms like Windows, Mac OS X and Linux distributions. One of the advantages of NLTK is that it is a free, open source and community driven project making it an amazing library to play with natural language. NLTK comes with an inbuilt sentiment analyzer module – *nltk.sentiment.vader* that can analyses a piece of text and classify the sentences under positive, negative and neutral polarity of sentiments. Vader is valence aware dictionary and acts here as a lexical resource to work with the sentiments. NLTK can be installed with PIP package manager in Python.

2) GTTS

gTTs helps in converting the Text to Speech for providing the instructions to user via speech. gTTs is an acronym for Google Text To Speech. It is a python library and CLI tool to interface with Google Translate's text to speech API. It converts the text input to speech and writes the spoken mp3 data to a file or converts to a byte string for further manipulation or plays it with a stdout. The features of gtts include customizable speech specific sentence tokenizer that allows to read unlimited length of text and also keeping proper abbreviations, intonations, decimals etc. It supports multiple languages and also platform independent.

3) SpeechRecognition

The first and foremost component of speech recognition is speech input. Speech must be converted from a physical sound media to an electrical signal with a transducer called microphone which is the converted to digital data with the help of a analog to digital convertor. The digitized signal can be transcribed to text using a python library called Speech Recognition known popularly for its ease of use. The library acts as a wrapper for much popular speech API's such as Google Web speech API and also it is flexible for usage in applications. It supports a default API key that is hard coded into the library class means that we can use it for free without getting a license or signing up for a service. The effect of ambient noise can also be adjusted based on our working environment. The flexibility and easy to use feature makes it suitable for the project. As it works with Google speech API, an active internet connection is needed for the service [10].
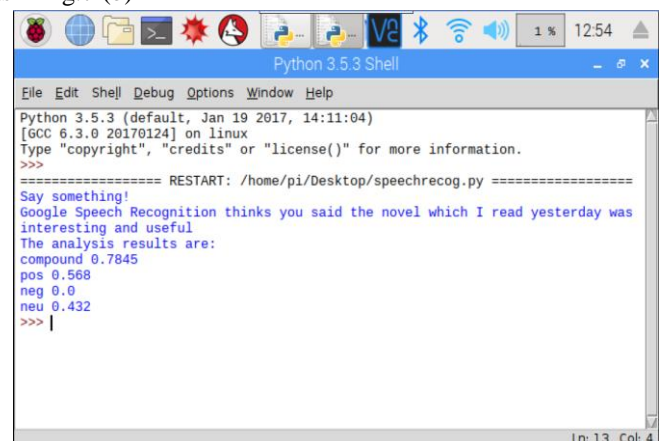
V. OUTPUT AND RESULT

The analysis for different sentences and their sentiment score and polarity is shown in the fig.5 (a), fig.6 (a), fig.7 (a) and also the overall sentiment of a sentence is also indicated with different color LED's by configuring the GPIO pins of raspberry pi according to the compound score such as:

If compound > 0 => Positive (Green LED starts blinking) as in fig.5 (b)

If compound < 0 => Negative (Red LED starts blinking) as in fig.6 (b)

If compound = 0 => Neutral (Yellow LED starts blinking) as in fig.7 (b)

Fig.5 (a) Score obtained for a positive sentence

In this sentence we used the words like interesting and useful which are positive words and so positivity score is more. Negative words are not used so negativity score is null hence overall compound score is positive which makes the green LED to start blinking.
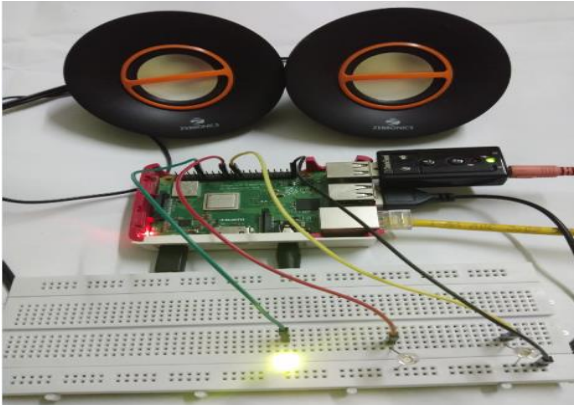

Fig.5 (b) Output for a positive sentence

Fig.6 (a) Score obtained for a negative sentence

In the above example sentence we used the words like tragic, flop which are negative words and so negativity score is more. Supporting positive words are not used so Positivity score is null hence overall compound score is negative which makes the red LED to start blinking.
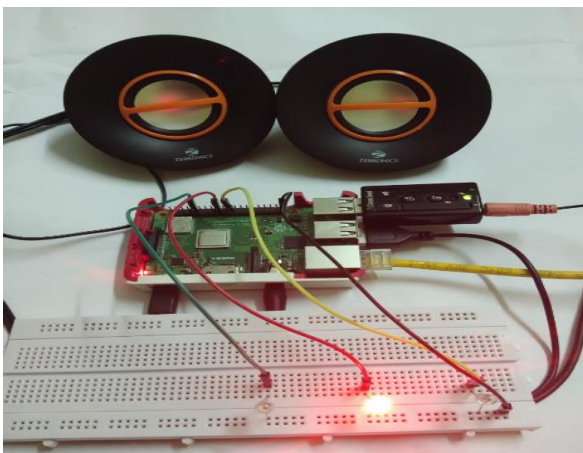

Fig.6 (b) Output for a negative sentence

Fig.7 (a) Score obtained for a neutral sentence

In this experimentation neither positive words nor negative words are used and so positive as well as negative score is null which makes the compound analysis score '0.0' hence yellow LED starts blinking.
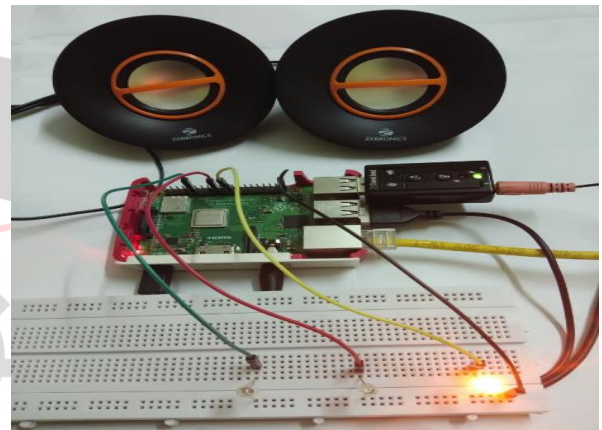

Fig.7 (b) Output for a neutral sentence

VI. APPLICATION OF SENTIMENT ANALYSIS

A. Social media monitoring

Social media, the voice of the entire community can make or break any brand. By monitoring social media, we can get insight into the quality of conversation that's happening around a brand. By analyzing the tweets or facebook post for a period of time we get to see the sentiment of a particular audience. The top benefits of using sentiment analysis in social media are to prioritize actions according to sentiments of customers. It helps to easily filter out unread mentions showing which action needs to be taken immediately and which can be delayed a bit. Also, it helps us to monitor our competitor's social media such as a negative response to a feature of their product and we can respond it by overcoming the defect and take a leading edge in a suitable situation.

B. Sentiment analysis in customer feedback

Customer feedback or review is an invaluable resource for a marketing campaign. There is an evident saying that customer retention is always better and more economical than finding a new customer. Leading companies have now

understood that how they deliver is much more important as what they deliver. We should be careful that within just one negative interaction there is a chance of 25 per cent of customers will switch to the competitor service in no time. By automating systems to run sentiment analysis on all customer support queries we can rapidly take some needful action to save and retain those customers.

C. *Sentiment analysis in the political area*

Finding people opinions via surveys and polls have been a time consuming and expensive task. It is difficult for humans to read and analyze all relevant information in terms of expressed sentiment. It creates a need for automated analysis of subjective data. Politics and marketing campaigns can leverage the use of social media. For example in a political campaign for the role of U.S President, there is a debate T.V program between John McCain and Barack Obama where they asked the audience to post the comments on twitter. Thus twitter has become a communication channel for the political arena. Therefore it creates an expectation that sentiment analysis will be going to be a part of every political campaign in future. It is a key enabling technology that allows automatic analysis of opinion that people give about pending policy or government regulation proposals making it a promising technology for e-rulemaking [11].

VII. FUTURE SCOPE

Sentiment analysis is on the edge of breaking into new areas of application. Businesses are looking at alternative ways that sentiment analysis can be done outside of their marketing campaigns. As a result of better understanding of feelings, emotions and sentiments of customers, they receive personalized products, messages and services directly related to their wants and needs. A true social democracy will be created where we harness the wisdom of crowd rather than selecting a special few and each and every opinion counts in decision making. As social media is becoming more expressive and emotive deeper insights from sentiment analysis helps social media platforms to update themselves and add more useful features. Thus sentiment analysis is going to play a vital role in understanding the consumers behind the screens. As technology evolves we can even make machines to understand sarcasms and hyperboles thus making the analysis more accurate and better.

VIII. . CONCLUSION

In this work real time implementation of speech recognition and converting the speech to text has been done with the help of Google speech API and sentimental analysis on the data has been done using Python natural language processing technique called lexicon method which is found to have more generalized approach than machine learning method. Also different sentiment analysis tools are studied. The computational power and low power consumption of Raspberry Pi makes our system complete and standalone without depending on any co-processors. Hence the work acts as a feedback analyzer to detect the opinion of the user and based on the results obtained we can infer some decisions commercially or personally. In future sentiment analysis has much scope in the business prediction, product analysis and customer opinion mining and also effective when integrated with big data analytics.

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