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Patient feedback System using Sentimental Analysis

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ABSTRACT: Hospital attempt to collect feedback from patients to study their sentiment towards facilities provided by the hospital to improve the hospital environment. In present scenario, grading technique is used for feedback. This grading technique does not reveal the true sentiment of patients, but the textual feedback provides a chance to the patients to highlight certain aspects. In this paper, a method has been proposed for sentimental analysis of patient's feedback using machine learning algorithms such as Decision Tree, Logistic Regression, K-Nearest Neighbors, Multinomial Naïve Bayes Classifier, and Random Forest. A comparative analysis is also conducted between these machine learning techniques. To improve accuracy Ensembling Learning method are used. The experimental results suggest that Ensemble Classifier is more accurate than other methods.

KEYWORDS: Sentiment analysis, Ensemble Method, Machine Learning

I. INTRODUCTION

Feedback is the statement sent to an entity about its past behaviour from which the entity can analyse the future and current behaviour to achieve the expected result. Feedback plays an important role in hospital by helping to adopt new facilities and prevent repetitive mistakes. Feedback is a process which helps the organization to monitor, evaluate, and regulate the overall working environment. Good feedback practice provides useful information to the organization in improving the behaviour and facilities.

Depending on the feedback given by patients it can be classified as textual or grading (Likert-scale based score) form. In Likert-scale based score questions are provided to the patients and are asked to answer those questions using a rating-based scale. This technique mainly focuses on a question that is related to same topic and it does not express the exact sentiment of the patients.

In order to know the exact sentiment of the patients textual feedback technique is used. In this textual form patients are given with set of questions and they need to answer it in sentences. It is helpful to both the hospital management and the staff to overcome the issues related to their organization. In this paper, the patients feedback is taken in Hindi, Marathi and English having varied opinion is collected through their voice and later it is converted into English text using google translator and transcripator. The aim is to extract expressions of opinion and classify it as negative, positive or neutral using machine learning techniques.

Sentimental analysis is a method for identifying the sentiment expressed in texts. The need of Sentiment Analysis of text has gained more importance in today's situations faced by the people of the world. Generally, there are three approaches in sentimental analysis. They are lexicon based, machine learning and hybrid approach. In machine learning technique, it uses unsupervised learning or supervised learning. Classification problem can be carried out using several algorithms like Decision Tree, Logistic Regression, K-Nearest Neighbors, Multinomial Naïve Bayes Classifier, and Random Forest. In lexicon-based method sentiment polarity of the textual content is detected using sentiment lexicon. A lexicon is a list of words with associated sentiment polarity. Hybrid approach is a combination of lexicon-based and



machine learning methods. The training data set is labelled using sentiment lexicon and this is used to for the machine learning model. Then testing data is evaluated using this model.

The remaining of this paper is organised as follows: In section „Literature Review“ we provide a brief description about some work related to sentiment analysis and machine learning techniques. The process of classifying the text into different classes using feedback obtained from students is presented in section „Methodology“. Comparative analysis of different machine learning algorithms based on accuracy and F-score are presented in section „Performance Analysis“. Section „Conclusion“ concludes the research work.

II. LITERATURE REVIEW

YUAN LIN et al. [1] proposed Comparison Enhanced Bi-LSTM with Multi-Head Attention for classification task in sentiment analysis. In this model, bidirectional LSTM is utilized for inceptive component extraction, and Multi-Head Attention is utilized for valuable data from various angles and representation of subspaces. The aim of correlation component is to acquire the element vectors by dissecting with the marked vectors. The results show that Comparison Enhanced Bi-LSTM with Multi-Head Attention has improved execution.

Nora Al-Twairesh and Hadeel Al-Negheimish [2] proposed a feature ensemble model of deep features and surface. The deep features are sentiment specific word embedding's and generic word embedding's and surface features are physically extracted features. The huge experiments was executed to test the advantages of the deep features ensemble and surface feature ensemble, cross-dataset models, embedding's size and pooling functions. The experimental outcome signify that the highest performing model is the ensemble of deep and surface features and the methodology accomplished best in class results on multiple standard datasets.

Azwa Abdul and Andrew Starkey [3] gave a Contextual Analysis (CA) strategy, a cycle that construct a connection among words and sources that is builded in a tree structure known as Hierarchical Knowledge Tree (HKT). To discover comparability and changes among train and real dataset they produce Tree Similarity Index (TSI) and Tree Differences Index (TDI) equation from tree structure. This technique can group the opinion words into positive and negative without having any semantic assets utilized and simultaneously changing of opinion words when another dataset is tried.

Tong Gu et al. [4] planned MBGCV model to lighten over-fitting, vanishing gradient, and to enhance the precision, MBGCV utilizes a multichannel model and combine Bidirectional Gated Recurrent Unit, Convolutional Neural Network and Variational Information Bottleneck. The model integrate the benefits of Variational Information Bottleneck and Maxout actuation capacity to reduce the limitation , for example, over-fitting, vanishing gradient in existent sentiment analysis models.

Cem Rifki Aydin and Tunga Gungor [5] proposed a novel neural network structure for viewpoint based sentiment analysis that integrate recursive and recurrent neural models. Initially the author partition every review into sub reviews that contains the sentiment data applicable to the respective viewpoint label by using electorate and reliance parsers. After training and generating, recursive neural trees constructed from the parses of the sub reviews, then their result is provided to the recurrent model. It was observed that integrating the recurrent and recursive neural networks give more extensive and a powerful model.

III. METHODOLOGY & RESULTS

This paper deals the patients feedback collected using their voice and then converted into English text is an input data. i.e. training data using which the system is trained. On receiving test samples, the trained system classifies the sentence as negative and positive classes using machine learning algorithms. This outcome is graphically represented. The proposed methodology consists of six steps: preparing training data, collecting patients feedback, feature extraction, model training, evaluation of test data, graphical representation of the result as shown in Figure 1. To carry out these steps data required is collected through student feedback.

1. Preparing training data:

Machine learning is classified into unsupervised and supervised learning. In supervised learning the sentences are given with label of classes, whereas labels are not provided in unsupervised learning. Training data is collected for each question which is used to train the system.

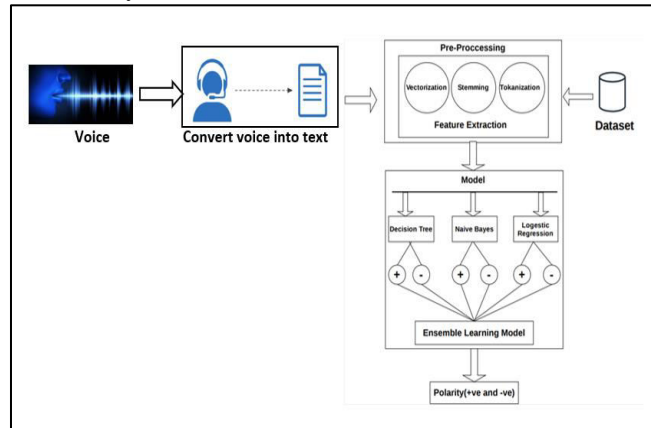


Figure 1: System Architecture

This training data is the responses in the form of sentence from the patients. Each sentence is converted to lower case and is given as input to the `Sentiment_Calculator()` Method which is available in package `Vader Sentiment.VADER` (Valence Aware Dictionary and Sentiment Reasoner) sentiment analysis returns a sentiment score in the range -1 to 1 from negative to positive.

Individual words have sentiment score between -4 and 4. The sentiment score (CompoundScore) of a sentence is calculated by summing up the sentiment scores of each VADER-dictionary-listed word in the sentence and normalized to map it to the value between 1 and -1 [10]. The normalization used by Hutto is given in equation 1.

$$\frac{x}{\sqrt{x^2 + \alpha}} \tag{1}$$

Where x is the sum of the sentiment scores of constituent words of a sentence and α is the normalization parameter set to 15.

If the compound score is ≥ 0.05 the sentence is classified as positive, if the compound score is greater than -0.05 and less than 0.05 the sentence is classified as neutral, if the compound score is ≤ -0.05 the sentence is classified as negative.

IV. COLLECTING PATIENTS FEEDBACK

The patient’s feedback is taken in Hindi, Marathi and English is collected through their voice and later it is converted into English text using google translator and transcript and the patient’s responses are collected and stored in Microsoft excel comma separated values file.

V. FEATURE EXTRACTION

This process involves feature extraction in a format required by machine learning algorithms from the datasets which consists of text. Both train and test data are subjected to feature extraction. The Scikit-learn library offers tools to perform both feature extraction and tokenization of textual data. Text documents can be tokenized and vocabulary of known words are built using `CountVectorizer`. It works as follows:

- a. Object of `CountVectorizer` class is created.
- b. To learn the vocabulary from one or more documents call the `fit()` function.
- c. One or more documents are encoded as vector using `transform()` function.

VI. MODEL TRAINING

There are many different algorithms for text classification with machine learning.

a) Random Forest (RF)

Random Forest is a supervised learning method. It can be used for both classification and regression task. Random Forest algorithm creates a forest with number of trees. As the number of trees in the forest increases accuracy also increases.

General steps in Random Forest:

Step 1: Creation of random vectors.

Step 2: sing random vectors to build multiple decision tree.

Step 3: Combining decision trees.

b) Logistic Regression

Logistic regression refers to a classifier that classifies an observation into one of two classes, and multinomial logistic regression is used when classifying into more than two classes, although informally and in this chapter we sometimes

use the shorthand logistic regression even when we are talking about multiple classes. To see what this means, recall that the job of a probabilistic classifier is to choose which output label y to assign an input x , choosing the y that maximizes $P(y|x)$. In the naive Bayes classifier, we used Bayes rule to estimate this best y indirectly from the likelihood $P(x|y)$ (and the prior $P(y)$).

$$Y^* = \operatorname{argmax} P(Y/X) = \operatorname{argmax} P(X/Y)P(Y)$$

c) Multinomial Naïve Bayes Classifier (MNBC)

The basic idea involved in naive bayes classification technique is to find the classes probabilities assigned to texts by using joint probabilities of classes and words. The features/predictors used by the classifier are the frequency of the words present in the document.

d) K-Nearest Neighbors (KNN)

K-Nearest-Neighbors (KNN) is a non parametric supervised classification algorithm. KNN algorithm classifies by analogy i.e. by comparing the unknown data point with the training data points to which it is similar. Similarity is measured by Euclidean distance. The attribute values are normalized to prevent attributes with larger ranges from outweighing attributes with smaller ranges. In KNN classification, the unknown pattern is assigned the most predominant class amongst the classes of its nearest neighbors. In case there is a tie between two classes for the pattern, the class that has minimum average distance to the unknown pattern is assigned. Through the combination of a number of local distance functions based on individual attributes, a global distance function dist can be calculated. As given in equation (1), the simplest way is to sum up the values:

$$\text{dist}(X^T, X) = \sum_{i=1}^n \text{dist}_{A_i}(X^T, A_i, X, A_i) \quad (1)$$

Where x^T is the test tuple, x is a nearest neighbor, and A_i ($i=1$ to n) represents the attributes of the data points. The weighted sum of local distances is known as global distance. The attributes A_i can be assigned specific weights w_i to depict their level of importance in deciding the appropriate classes for the samples. The weights usually range between 0-1. Irrelevant attributes are assigned a weight 0.

e) Decision Tree

A decision tree is a k-array tree in which each inside node indicates a test on a few characteristics from input feature set speaking to data. Every branch from a node relates to conceivable feature values determined at that node. The algorithm starts with tuples in the training set, selecting best characteristic yielding maximum information for classification. It creates a test node for this and after that a top down decision trees induction partitions current tuples set by test quality values. Classifier generation stops when all subset tuples f_i t_i in with the same class or on the off chance that it is not qualified to continue with extra partition to further subsets. Decision tree induction is the learning of decision tree classifiers building tree structure where each inward node (no leaf node) signifies property test. Every branch speaks to test outcome and every outside node (leaf node) indicates class prediction. At each node, the algorithm chooses best partition data credit to individual classes. The best credit to partitioning is chosen by trait selection with Information pick up.

f) Ensemble Classifier

Ensemble classifier aggregates multiple base classifiers in order to obtain a robust classifier [8]. Generally, ensemble classifiers have been used to enhance the performance and accuracy of base learning techniques. Base learners like Decision Tree, Logistic Regression, K-Nearest Neighbors, Multinomial Naïve Bayes Classifier, and Random Forest are used in ensemble classifier.

The system was trained using the training data. The Test feedback is a set of feedbacks that was used to test the system. Each base classifier in ensemble classifier determines the sentiment (Positive/Negative) of each feedback in Test feedback. In addition, the classification report of each base classifier was calculated on the testing data. The next step is to calculate the probability of each feedback being positive and negative. After assigning this probability, we assign the weight to each classifier in the ensemble technique based on the accuracy of each classifier. Finally, the algorithm calculates the positive and negative score of the feedback based on the prediction of each classifier. The inputs to this algorithm are the positive score and negative score of the feedback. If the positive score of the feedback is more than its negative score, then the sentiment of that feedback is taken as positive. And, If the negative score of the feedback is more than positive score then the sentiment of that feedback is taken as negative.

VII. EVALUATION OF THE TEST DATA

Evaluation is the process of collecting and analysing data, where the result can be used to determine whether an organization is effectively carrying out the planned activity. This corresponds to the final evaluation that the model goes through after the training phase has been completed. This step is critical to test the generalizability of the model by using test set we can get the working accuracy of the model.

VIII. GRAPHICAL REPRESENTATION

Data visualization is the presentation of data in graphical format. Python offers multiple graphical libraries that provide different features. Matplotlib is one among them. It is the library which offers lot of freedom at the cost of having to write more code.

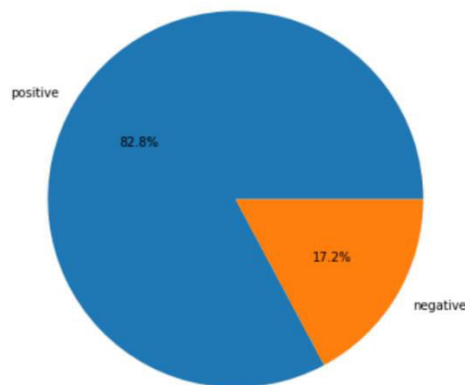


Figure 2: Graphical Representation of the result

IX. PERFORMANCE ANALYSIS

In this section, a comparative analysis is carried out using machine learning algorithms such as Decision Tree, Logistic Regression, K-Nearest Neighbors, Multinomial Naïve Bayes Classifier, and Random Forest based on accuracy and F-score.

Test dataset is used to examine the performance of learned model. The following metrics were considered: Accuracy, F Score.

Accuracy: Accuracy is defined as the ratio between number of correct predictions done by the model to the total number of rows in the dataset and it is given in equation.

$$\text{Accuracy} = \frac{\text{correct predictions}}{\text{rows in dataset}}$$

F-score: It is the weighted average of recall and precision and it is given in equation

$$F \text{ score} = \frac{2 \times \text{Precision} \times \text{Recall}}{\text{Precision} + \text{Recall}}$$

The following figures shows the Accuracy, Precision, Recall, f-score and Support of the Decision Tree, Logistic Regression, K Nearest Neighbors, Multinomial Naïve Bayes Classifier, and Random Forest

Algorithm	Accuracy
Decision Tree	72.1%
KNN	76.06%
Naïve Bayes	86.2%
Random Forest	84.9%
Logistic Regression	89%
Ensemble Classifier	89.2%

Table 1: Accuracy of Classifier

In Table 1 we can see that Ensemble Classifier gives the highest accuracy i.e. 89.2% than Decision Tree, Logistic Regression, K-Nearest Neighbors, Multinomial Naïve Bayes Classifier, and Random Forest.

X. CONCLUSION

Grading based feedback has disadvantage that it does not reveal exact sentiment of the patients. To overcome this disadvantage textual feedback is used. Sentimental analysis enables hospital to know the sentiments of the patients using their feedback. From this analysis they can improve the quality of their services and hospital environment.

In this paper to perform sentimental analysis, first the feedback was collected, given to the trained model and the sentiments are classified. An ensemble classification system has been proposed which is shown to improve the performance of feedback sentiment classification. The performance of the proposed ensemble classification system has been compared with various

traditional sentiment analysis methods and most popular majority voting ensemble classification system. The ensemble classification system is formed by different base learners like Decision Tree, Logistic Regression, K-Nearest Neighbors, Multinomial Naïve Bayes Classifier, and Random Forest. The results show that proposed ensemble classifier performs better than stand-alone classifiers and the popular majority voting ensemble classifier.

XI. FUTURE WORK

As future work, the main focus will be the study of the neutral feedback because some of the feedback have neither positive sentiment nor negative sentiment. The System is currently limited to only three languages i.e. the feedback is taken in Hindi, Marathi and English languages. In future we can take feedback in multiple languages and can find the sentiment.

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