International Journal of Innovative Research in Advanced Engineering (IJIRAE) ISSN: 2349-2163
Issue 8, Volume 2 (August 2015) www.ijirae.com

A Neural Network Approach to Personality Prediction based on the Big-Five Model

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Abstract— The use of social networking websites has increased since last few decades. The social networking sites such as Twitter, Facebook, LinkedIn and YouTube are sources of human interaction, where the users are allowed to create and share their activities, thoughts and opinions pertaining to different subjects. These sites have not only connected large user populations but have also captured massive information associated with their daily interactions in the form of Big Data. This data provides unprecedented information about human behavior and social interactions. It makes it possible to understand who the users are, what their interests are and what they need. This information is vital for businesses to target potential consumers or seek customer opinions in the event of diversification as a business strategy. Thus, this work analyzes social media data to predict significant personality traits, i.e. qualities or characteristics specific to an individual, using the Big Five Model. The predictions can be applied to various domains like business intelligence, marketing, sociology and psychology. A parallelism between an individual's personality traits and his/her linguistic information is explored for analytics.

Keywords— Big Five model, Hadoop, Personality, Multi-label classification, Neural Networks, Social Media.

I. INTRODUCTION

Social media has become an essential component of everyday life. It has radically changed the ways in which people express their opinions and sentiments. Social networking sites like Facebook, LinkedIn and Twitter are based on the concept of human interactions and user generated data. Thus a huge amount of user data is been created and exchanged, entailing massive production of interactive data. Social media-oriented people tend to publish a lot about themselves through status updates, self-description, photos, videos and interests. The data available within social media platform is enormous in volume and reveals different aspects of human behavior and social interactions. An individual's personality is his/her characteristics and aspects that others perceive. The data available on social media platform enables us to understand who the users are and what their needs are. Thus, the analysis of social media data allows us to determine important personality traits i.e., characteristics which describes his/her personality.

A parallelism among individual's personality traits and his/her linguistic information is obtained from the Big Five model. Computational model for predicting personality can be defined using social processes and family words. Such applications depend upon lexical techniques to determine personality from Facebook and Twitter data [2], [3].

Developing a model that can predict personality accurately utilizing social media data has various applications. In marketing, it may be useful in identifying the sentiments hidden in a message e.g. Reviews and tweets for a product may reveal the likes or tastes of an individual. In the field of psychology, it may be applied to social media data to understand user behavior; to examine the dark triad (narcissism, machiavellianism and psychopathy) [3], [4], [5]; to identify criminal content; to model affection [6] etc.

Determining personality traits depending upon the Big Five model can be considered as "multi-label classification" problem. This is due to the fact that an individual can possess many traits and each of these personality traits corresponds to a classifier. A multi-label classification is a classification problem where multiple target labels must be assigned to each instance. In the Big Five Model, personality is partitioned into five categories (or dimensions) namely Openness, Conscientiousness, Extroversion, Agreeableness and Neuroticism (OCEAN).

Personality predictions traditionally depend upon user's profile information, status updates, messages posted by them, etc. This work introduces a personality prediction system that works with a group of tweets rather than a single line of text. This system comprises of three modules. The first module extracts meta-data from Tweets and creates a 'meta-base'. It does not consider user's profile information. The second module transforms multi-label problem into five binary classification problems. Finally, a multilayer neural network classification algorithm is applied to determine personality traits. Since the social media data is being generated at faster rate, this system utilizes a number of labelled data to classify the unlabelled data. To demonstrate the working of this system, set of Tweets particular to a user are obtained from Twitter API and applied to the system. The Multilayer Perceptron Neural Network machine learning algorithm is used as the classifier. The system produces positive results and accurately predicts the personality of 'Tweeters' without considering their profile information, which is a different approach from those reviewed in the literature.

The paper is organized as follows: Section II includes a discussion about the background of personality and Big Five model along with the neural network approach; Section III deals with the work that has been carried out in this field; Section IV gives the details about the proposed system; Section V discusses the experimental setup and results; Section VI includes a discussion on limitations and scope for future work; Finally section VII concludes the paper.

II. BACKGROUND

A. *Personality and the Big-Five Model*

The term "personality" is derived from Latin word "persona", which refers to the mask put on by the actors in theatre. The attributes which characterize a person such as emotions, behavior, mind and temperament define a personality. Due to the variety of attributes, gauging personality is crucial as there is no predefined structure for classifying and comparing people. The set of human emotions is vast, due to which a similar problem arises when we try to identify sentiments embedded in the message (also known as "sentiment analysis"), causing difficulty in choosing significant emotions for classification. Thus in order to automate task of sentiment analysis, a number of researchers accepted a simpler sentiments representation by means of their "polarity" (negative or positive) [7]. Similarly for personality prediction, several researchers have identified the important characteristics essential for building a personality model.

Personality can vary depending on the situation. Therefore the personality prediction model has to provide labels to all the groups of traits. In the analysis of a personality structure, definition of the "Big-Five Model" or "Five Factor Model" came into use.

The "Big-Five Model" of personality is a well-experimented and well-scrutinized standard of personality structure used by researchers in late years. This model describes a personality structure which is divided into five components known as "OCEAN": Openness, Conscientiousness, extroversion, Agreeableness, and Neuroticism , which were conceived by [8] as the key personality traits which came forth from the investigation of prior tests on personality [9]. Additional research proved that model's validity was not altered by different languages, tests and methods of analysis [9], [10]. Such broad research resulted in the acceptance of the Big-Five model by several psychologists as current definitive personality model. Table 1 shows the five dimensions of the Big Five Model.

TABLE I
THE DIMENSIONS OF THE BIG FIVE MODEL [15]

Openness		**Conscientiousness**		**Extroversion**		**Agreeableness**		**Neuroticism**	
Low	**High**	**Low**	**High**	**Low**	**High**	**Low**	**High**	**Low**	**High**
Commonplace	Wide interests	Careless	Organized	Quiet	Talkative	Fault-finding	Sympathetic	Stable	Tense
Simple	Imaginative	Disorderly	Tend to Plan	Reserved	Active	Cold	Kind	Calm	Anxious
Shallow	Intelligent	Frivolous	Efficient	Shy	Energetic	Unfriendly	Appreciative	Contented	Nervous
Unintelligent	Curious	Irresponsible	Responsible	Silent	Enthusiastic	Cruel	Generous	Unemotional	Worried

The Big Five traits can be described as follows:

- *Openness:* is ability of an individual to accept the new things. Individuals belonging to this category frequently use social media.
- *Conscientiousness:* indicates individuals who are organized, responsible and tend to plan things before hand. Such people make less use of social media as they find it as an undesirable distraction and waste of time.
- *Extroversion:* indicates enthusiastic, active, talkative and energetic people. Such people tend to make many friends beyond virtual world and invite them to web, in order to keep in touch, but do not replace personal relationships.
- *Agreeableness:* indicates how friendly people are towards each other. According to researchers the individuals with low degree of agreeableness are found to have many online contacts but it is difficult for them to begin and maintain friendship outside the virtual world.
- *Neuroticism:* relate to control over the emotions. Such people use the Internet because they find it as a means of reducing loneliness and creating a sense of belonging.

B. *Neural Network Approach*

A neural network is a "connectionist" computational system [20]. The computational systems are procedural. The program begins at first line of the code, completes executions, and then moves on to the next line. The instructions are executed in a sequence. A real neural network does not follow a sequence. Instead, information is processed in parallel throughout the network made up of nodes. Each element of the network, node, is referred to as the neuron. It reads an input, processes it and produces an output. Network of multiple neurons are more likely to have intelligent and rich behaviors.

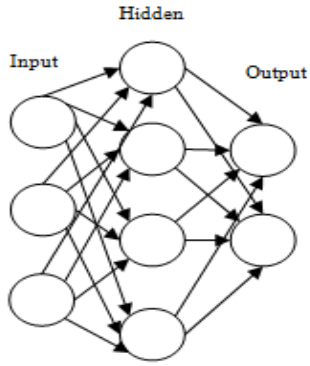

Fig. 1: A Simple Neural Network [19]

One of the major advantages of a neural network is that they have the ability to *learn*. It is a complex *adaptive* system i.e., it has the ability to modify its internal structure depending on the information that flows through it. This is accomplished by adjusting *weights*. Fig. 1 shows a simple neural network. Arrow indicates a connection between two neurons and also represents the flow of information. Each of the connection has a *weight associated with it*, i.e., a number that handles signals among two neurons. In case, if the network produces a "good" output, weights need not be adjusted. If the network produces "bad", erroneous output, then the system adapts itself by altering the weights so as to optimize later results.

Neural networks are distinguished based on the methods used for learning. There are several strategies for learning:

- *Supervised learning:* Here the network knows what the correct output is. The network determines the weights such that given an input, it produces the desired output. The idea behind supervised learning is that the network is repeatedly provided with facts pertaining to different cases, together with the desired outputs. In order to adjust the weights the network uses learning strategy so that it can produce the outputs closer to the desired outputs.
- *Unsupervised learning:* Here the network is provided only with the inputs and has no knowledge about the expected output. In this case the system learns to create patterns using the given inputs. These types of networks are occasionally referred to as Self Organizing Networks.

1) Multilayer Perceptron (MLP) neural network:

The multi layer perceptron is a most popularly used neural network [19]. Since it requires the knowledge of expected output, in order to learn, this type of network is known as supervised network. It is essentially used for creating a model which can accurately map the given input to the desired output making use of the historical data. Such model can be utilized to get the output when desired output is not known. MLP uses an algorithm called **back propagation** for learning. The idea behind back propagation is: the neural network is repeatedly provided with input data. Then an error is computed by comparing the output of neural network with expected output. Then this error is propagated back (fed back) into the network and employed to alter the weights such that the error reduces with each iteration and the network model comes nearer to achieving the expected output. This is called the training process.

In general, to create and train Multi Layer Perceptron neural network, the following steps are performed:

- Create Multi Layer perceptron network
- Create training set
- Train network
- Test trained network

III. RELATED WORK

Prediction refers to classification of unknown data or to forecast trends [17]. Prediction of categorical values is known as classification and modeling values or continuous functions is known as estimation [11]. Different machine leaning prediction techniques are used for mining social media data. Machine learning includes three strategies: supervised, semi-supervised and unsupervised.

In supervised learning, system is provided with set of labeled data also called as training set using which the classifiers (or predictors) are trained. Then the classifiers classify new data utilizing the labeled (pre-classified) data. In unsupervised learning the system is just provided with unlabelled data. The system learns by producing different patterns of what it is exposed to. Semi-supervised learning lies between supervised learning and unsupervised learning. It uses both labeled data and unlabeled data to train classifiers.

Personality prediction involves determining personality traits based on the big-five model [12].Various machine learning algorithms mentioned in previous section can be used in this task.

The study [12] was the first one that attempted to relate personality traits and social media profiles. First, the authors created a Twitter form comprising of Big-Five personality inventory consisting 45 questions. For each user their most recent 2000 tweets and their inventory were considered for evaluation. MRC Psycholinguistic Database and Linguistic Inquiry and Word Count (LIWC) were used to extract linguistic information from their messages. Then the extracted information and personality test results were given to the correlation table, and later Gaussian and ZeroR processes were used to identify personality.

The study [2] attempted to link personality scores to the Twitter users. They accomplished this by gathering data from a Facebook application named myPersonality. Around 40% of myPersonality users agreed to share their profile information and personality scores. Then the authors took into account only those users who had specified their Twitter account on their Facebook profile. Then they verified both these accounts and obtained 335 Twitter users who chose to do this. Then a Big-Five personality test was carried out on those individuals. They analyzed the connection among the Big-Five personality traits and five kinds of micro blog users: popular, highly read, listeners; and two influence factors i.e. time and Klout. Using these, the authors created a correlation table and then performed regression by the M5 Rules algorithm to predict personality of profiles.

In study [13], to identify personality, the authors extracted text based and demographic attributes from the Facebook profiles. They used 537 Facebook profiles. In order to predict personality on the basis of Big-Five personality index, each of the users was made to answer 45 questions. Then attributes such as gender, age, location, quotes, relationship status, photos, comments etc. where obtained so as to define each person. Then using this information, individuals were ranked in terms of the five personality traits, determining which individuals would appear below or above 5% or 10% of each personality trait. They employed numeric prediction models including decision tables, linear regression and REPTree. According to their results there is a potential to determine top 10% very open individuals with nearly 75% of accuracy and throughout all personality traits it can predict the top 10% with at the least 34.5% of accuracy. The authors also explicated that the results obtained can have privacy implications as it enables the advertisers to concentrate on particular subset of people depending on their personality. In that year, a similar study was performed using 2916 Twitter profiles [5].

The study [3] focused on using machine learning to predict “dark triad personality” (machiavellianism, psychopath and narcissism) in social media. The authors estimated the prediction ability of NB, SVM, C4.5 and Random Forests in 89 countries and 2927 Twitter profiles from them and recognized substantial correlations among the Twitter users and dark triads. Self-reported ratings were formulated from the “Short Dark Triad (SD3)” questionnaire supplying the measures of machiavellianism, psychopath and narcissism; and “Ten Item Personality Inventory (TIPI)”, supplying measures of OCEAN to extract personality for each user. 3200 tweets downloaded from Twitter API were analyzed with LIWC. The results contained 586 features like frequency of words, number of friends, number of tweets etc. for each user. They omitted the personal information and finally 337 features were utilized by the predictor. The study showed that Machiavellians and psychopaths used more of swears words and words indicating anger. The use of Mean Root Mean Square Error (RMSE) and Average Error (MAE) evaluation methods improved the accuracy of their results.

In [16] the authors proposed a new architecture to identify personality making use of the common sense knowledge along with associated affective labels and sentiment polarity. They used essays dataset which contains 2400 essays labeled manually along with the scores for five personality traits. They drew several attributes from the text using LIWC, MRC and combine them with the common sense knowledge based features extracted by sentic computing techniques (SenticNet, ConceptNet, EmoSenticNet and EmoSenticSpace). In particular, they combined common sense knowledge based features with frequency based features and psycho-linguistic features and then used these features in supervised classifiers. For each of the five personality traits an SMO based supervised classifier was designed. The common sense knowledge with sentiment information and affective labels increases the accuracy of the frameworks which only use frequency based analysis and psycho-linguistic features at lexical level.

The study [14] highlights drawbacks of supervised machine learning approach. It shows that the problem with supervised learning is the limited availability and greater price of finding labeled data i.e. training data. Thus this study proposes an approach which depends on ensemble learning. Here the classifiers were constructed utilizing the information extracted from different data sets which were obtained from several genres, several languages and different personality prediction systems. Five “meta-learning” experiments were carried out using data from Facebook. This data comprised of anonymous authors, their status updates and number of measures of social network. They made use of most frequent 2000 character trigrams as attributes. The ensemble classifier used 10-fold cross validation for each experiment.

In study [15] authors proposed a new architecture called PERSOMA. They first obtained 18,435 tweets from three datasets and then 41 groups were formed by means of clustering. In the preprocessing stage meta-attributes were extracted from tweets and a meta-base was created. The meta-base was then forwarded to the transformation module. The transformation module then transformed the “multi-label classification problem into five binary problems”. “The multi-label classification is performed by five classification algorithms, each one responsible for one single class, i.e., personality trait”. Three classification algorithms were used namely Multilayer Perceptron neural network, Support Vector machine and Naïve Bayes were utilized as classifiers. Semi-supervised learning is used for training the classifiers.

A k-fold cross-validation was used in the semi-supervised learning with k = 4; a single fold for training and three for testing. In order to form training set the (small number) tweets were previously classified using PRec.

Thus it can be inferred that most of the approaches typically require the users to fill a form containing several questions and then use this inventory to predict personality based on big five model. Some of them also consider the user's profile data for prediction. Social media-oriented people tend to publish a lot about themselves by status updates, self-description, interests and photos. But they do not share details they find sensitive. They keep it private either to themselves or make it available only to a certain group of people. Some users deliberately fake their personal information such as Birth date, location, and work , status and/or even create a fake identity just to become influential e.g. to increase number of follows; get more likes etc. They decide what must be shared and what not according to their convenience. As a result the social media data available may either be fake, missing or cannot be accessed due to privacy issues. Thus, results of personality prediction cannot be accurate. Most of the systems simply work with a single line of text. They extract grammatical information such as number of words, number of positive and negative words etc. These attributes are then used in further stages of prediction. They do not consider social behavior information like number of friends/followers, tweets, hash tags etc. These attributes may help in determining for e.g. how frequently the person makes use of social media for interactions.

IV. THE PERSONALITY PREDICTION SYSTEM

This work provides a personality prediction system for social network data analysis. The flow diagram of the system is given in Fig. 2. The system consists of four modules: Data collection, pre-processing, transformation and classification. These modules are explained below.

Fig. 2: Flow Diagram of Personality Prediction System

1) Data Collection:

For demonstrating the system, we need tweets posted by an individual(s). For this, tweets are obtained using Twitter API. Twitter API [18] provides an access to twitter data comprising of information about the users, tweets published by a user, search results on twitter etc. Tweet object is in .json format.

2) Pre-processing module:

The tweets are first obtained from the tweet object. Then the system extracts meta-attributes from the tweets. The information extracted can be divided into social behavior and grammatical information. The grammatical information includes: average length of text, average number of positive and negative words, average number of special characters like comma, question mark etc. The social behavior information includes: average number of links, average number of hash tags, average number of mentions etc. The average is calculated by dividing the total of a grammatical and social behavior category attribute by total length of the tweets. After extracting the meta-attributes, they are sent to the transformation module.

3) Transformation module:

This module transforms the multi-label problem into binary classification problems . This module receives the meta-attributes extracted from the previous module. Using this information, it constructs a feature vector. Each position in the vector corresponds to a meta-attribute. This vector is then forwarded to the classification module whose output will be either '1' (yes) or '0' (no). This transformation is necessary because multilayer perceptron neural network that is used as classifier can only identify numbers.

4) Classification module:

A Multilayer Perceptron (MLP) Neural Network is used for classification. There are five neural networks (classifiers), one for each personality trait. The classification module receives a training set already transformed plus test set. Each neural network compares the test feature vector with its training feature vectors. The output of each classifier is either '1' (yes) or '0' (no) depending on whether the vectors matches or not, further inferring that the individual has the personality trait or no.

The system architecture is shown in figure 3. The entire system runs on hadoop. Hadoop has two integral parts: Hadoop Distributed File System (HDFS) and Hadoop MapReduce as shown in fig. 3.

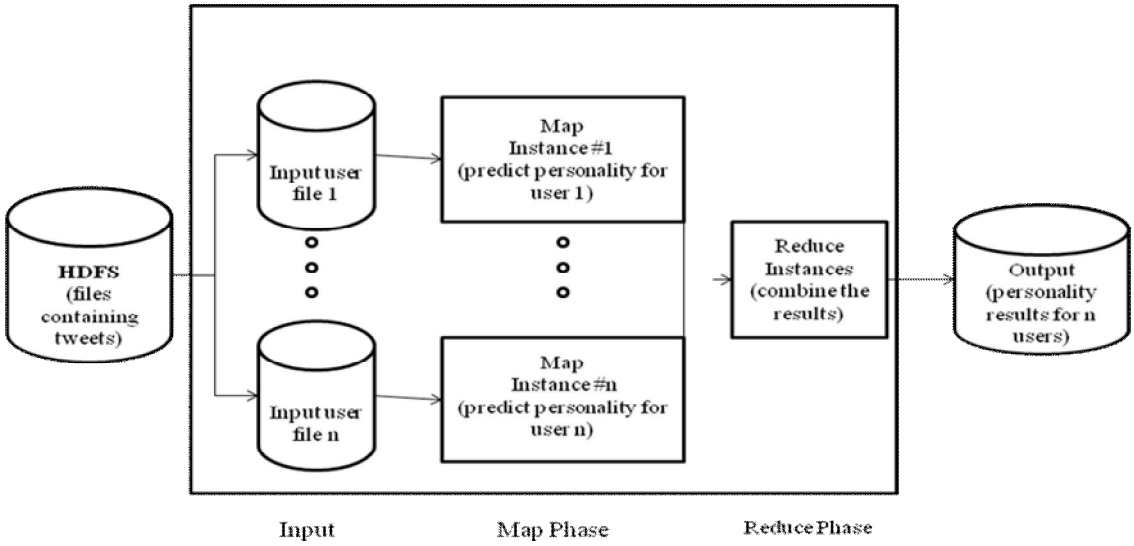

Fig. 3: System Architecture

In this system, the HDFS contains input folder, which contains an input file for the MapReduce job. The HDFS also contains jar files of the code.

- Mapper performs entire personality prediction task for each of the user file specified in the input file.
- Reducer aggregates the results obtained for each file.

V. EXPERIMENTAL SETUP AND RESULTS

The personality prediction system was implemented in java using the NetBeans IDE. It made use of the Apache single node Hadoop framework to predict personality of multiple users simultaneously using Hadoop MapReduce and HDFS. Hadoop was installed on a virtual machine with Ubuntu OS.

The HDFS included - the JAR files of the code; input folder containing a file which mentioned the location of files containing the tweets by individual users as shown in fig. 4; and the files containing tweets as shown in fig. 5. These files were given as the input to the hadoop system. The mapper function was designed so as to perform the personality prediction of multiple users, and the reduce function then aggregated these results and placed in one file.

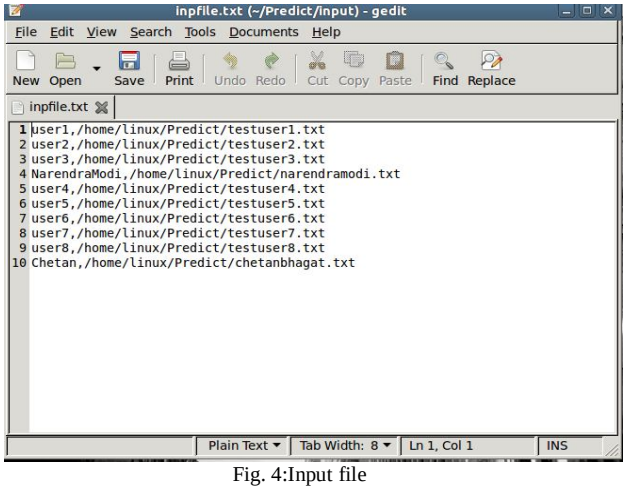

Fig. 4:Input file

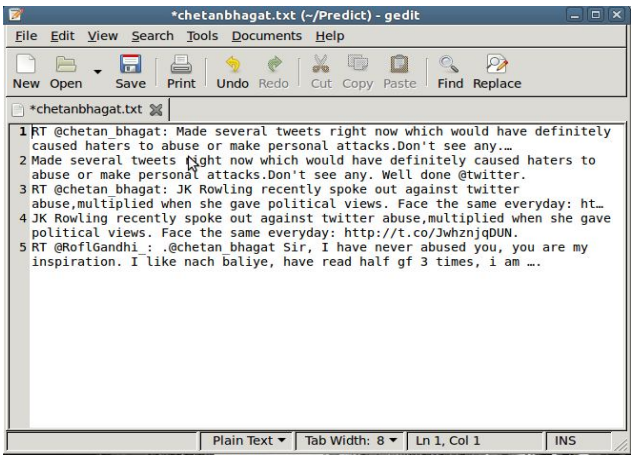

Fig. 5: File containing tweets of posted by a user

The system was tested on more than 100 users. The system could successfully predict personality (OCEAN) accurately as shown in figure 6. Here OCEAN stands for openness, conscientiousness, extroversion, agreeableness, neuroticism respectively. Y and N means Yes and No respectively. The output indicates that user1 is an extrovert and conscience person, user2 is an open and extrovert person and so on. In order to have a precise prediction, it is recommended to provide more than 20 tweets per user.

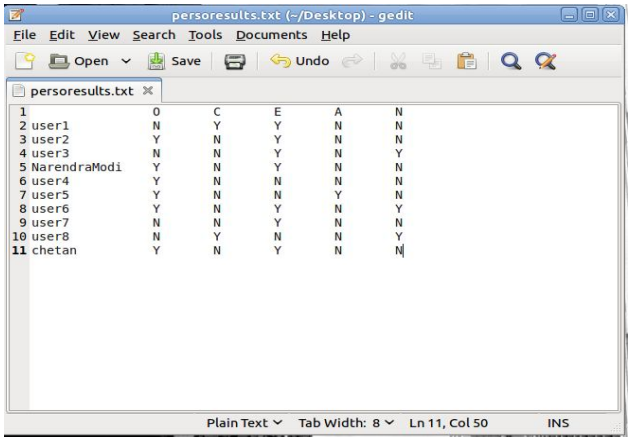

Fig. 6:Output

VI. DISCUSSION

This section includes general discussion on applications, limitations and scope for future work.

A. *Applications*

Some applications of this system, but not limited to, are listed below:

- In politics, it may be useful in identifying the personality traits of people following a politician; thus allowing that politician to take some steps to target his audience.
- In politics, it may also help the people to identify the personality of the candidates contesting for an election, thereby allowing them to vote for a deserving candidate.
- It can be useful in recommending books, music etc. to the user based on their personality.
- It can also help the job recruiters to select appropriate employees.

B. *Limitations and Future Work*

Twitter can be an excellent source for personality prediction. But there are limitations when considering only Twitter for analyzing user trends and behavior. Relevant information may not be available for analysis due to privacy issues. People may create fake accounts, or fake some information. This affects results of personality prediction. Moreover tweets may be written in slang language and contain special characters. Therefore, the automatic analysis of Twitter messages is a challenge. A successful personality prediction system should have a mechanism to compare two or more social media so that they can filter out fake accounts and/or obtain missing information. As a follow-up work, it is suggested to combine information from different sources such as Face book, LinkedIn, etc. This will enable us to accurately identify users' behavior across different social networking sites.

VII. CONCLUSION

Social media provides a platform where the users can share information as well as get feedback from colleagues and friends. The exposure of views by individuals encourages other users to comment and share their ideas as well as information about themselves. This facilitates an analysis of user behavior and trends. The Big Five model enables the identification of personality traits through linguistic information. This reveals the personality traits which can be applied to various domains like business intelligence, marketing and psychology. Thus this work provides a personality prediction system based on Big-Five model, which can predict the traits of an individual using the group of tweets posted by him. It is different from the approaches reviewed in the literature survey, in that it works with the group of tweets and does not take user's profile into account. Further, the system makes use of the Hadoop framework to predict personality traits of multiple individuals at the same time.

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