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Stress detection system for social media users

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Abstract

Stress detection is a growing topic in the field of natural language processing. The study of stress detection for mental health prediction has been proven to benefit the development of recommender systems and automated mental health assessments in previous studies. Additionally, the widespread usage of social media has served as a potential data source for developing such models. Our research tried to detect whether the users of social media were under stress or not. We used a dataset from Dreaddit consisting of posts from one of the popular social media platforms, Reddit. We propose a machine learning model consisting of Support Vector Machine (SVM), Naïve Bayes, Decision Tree, Random Forest, Bag of Words, and Term Frequency – inverse document frequency (TF-IDF) for stress detection. The final evaluation of the model achieved an 80.00% F-1 Score and 75.00% accuracy, and both were scored by SVM.

Keywords: Machine Learning; Stress Detection; Social Media; Natural Language Processing

1. Introduction

Stress is a feeling of emotional or physical tension. It can come from any event or thought that makes you feel frustrated, angry, or nervous. According to Vincent Cornelli, Stress is a mental health disorder in the body and mind caused by changes and life demands [1]. According to the World Health Organization (WHO), stress affects the brain and body. Little stress is good for performance and protection, but too much stress will be overwhelming to fight, flight, and freeze, depending on how individuals react to it [2]. A considerable amount of stress can lead to depression,

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which results in the individual itself suicide.

Globally, stress disorders can be experienced by all age groups. This results in a lot of people, no matter how old or young they are, will experience stress in parts of their life. In World in Data 2017 [3], there are approximately 284 million people has suffered from a kind of stress which is anxiety. The chart below will show ten countries that has the highest rates of stress based on data from Gallup 2022 [4].

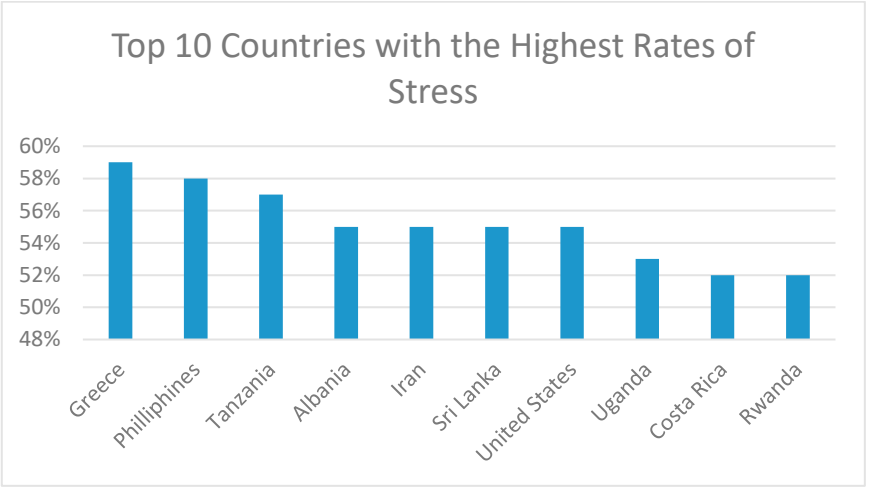

Fig. 1. Top Ten Countries with the Highest Rates of Stress around the Globe

World Health Organization described that at least 800,000 people commit suicide yearly because of stress and depression [3]. In other words, one person commits suicide every 40 seconds globally. Globally, the suicide rate due to stress are all above 1.500.000 [4]. One of the causes of this high suicide rate is social media which can interfere with someone's mental health.

WHO Global Health estimates the death rate of suicide in the world in 2019 was 3.4/100,000 population. Men (4.8/per 100,000 population) were higher than women (2.0/100,000 population). In general, the incidence is higher in the older age group, except for the age of 20-29 years (5.1/100,000 population) [5]. The Number of deaths from suicide by age group data is illustrated in Figure 2.

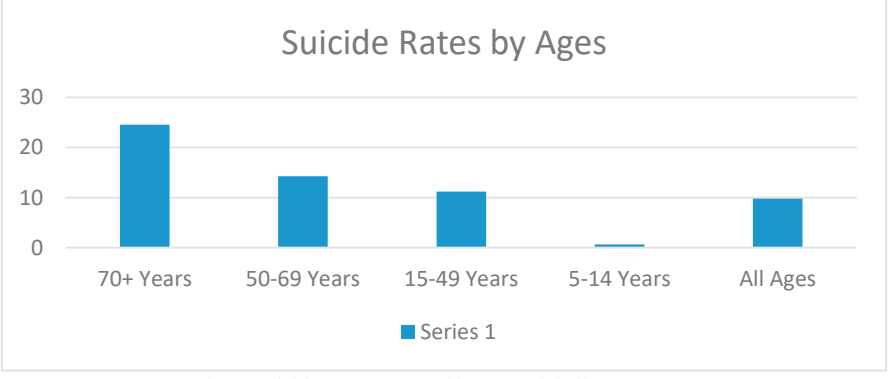

Fig. 2. Suicide Rates Grouped by Age Globally

Social media addiction is at an all-time high in the modern day; once someone joins, it is tough to stop using it. Positive feedback from comments and likes makes it more challenging to control. Some people contrast their lives with their friends' spotless existence [5]. This results on people uses social media as a way for them to vent their emotions, such as sadness, anger, or even stress itself. This is quite important as the technology are evolving, and more people are continuing to vent while people on social media are taking jokes and pranks way too far, thinking it

won't have any impact to the people that are in an actual stress, not for taking attention. Through social media, we can find out a person's mental condition based on the text they post on social media by using the Natural Language Processing (NLP) algorithm. NLP analyses linguistic data, most commonly in the form of textual data such as documents or publications, using computational methods [6]. This method helps to process a text in general because it is not structured and can only be read by humans due to the arrangement of text that is difficult to read by computer.

This study aims to create an early detection system for stress disorders in a person in hopes of reducing the suicide rate. In this study, we tried to detect stress from the words used by people in their posts that can indicate whether this person is experiencing anxiety or not. In this study, we used a dataset from Dreaddit [7]. We consist of 715 columns containing hundreds of texts posted by users on social media. We also use NLP for text processing and six machine learning algorithms for text classification: NB (Naïve Bayes), SVM (Support Vector Machine), DT (Decision Tree), TF-IDF (Term Frequency – inverse document frequency), RF (Random Forest), and BOW (Bag of Words).

2. Related Works

Several studies also try to detect stress through machine learning with different kinds of methods. A study from the Suratkhal National Institute of Technology in India using the WESAD dataset distinguishes between stressed people and those not based on existing data. The results of the study used KNN (K-Nearest Network), DT (Decision Tree), AB (AdaBoost), and SVM, which achieved an accuracy of 81.65% to 93.20% [8]. Another study that uses the WESAD dataset is from the National Institute of Technology in India, which aims to detect stress in a person. The methods used are KNN (K-Nearest Network), LDA (Linear Discriminant Analysis), RF (Random Forest), AB, and SVM, which produce an F1-Calculated score of 83.34% and 65.73%, respectively [9].

Another study was conducted at the Jaypee Institute of Information Technology in India, using a dataset involving 206 students as a test sample. Using LR (Logistic Regression), Naïve Bayes, Random Forest, and SVM and sharpened using a technique called 10-Fold Cross-Validation (a technique where the procedure of fittings is carried out ten times and uses 90% of the data from the dataset as training), this study managed to get a score of 85.71% using SVM [10].

To find the best method to detect stress, research at Tsinghua University in Beijing, China, showed an experiment conducted by ten people using datasets from Weibo and Twitter. The methods used in this research are LRC with a score of 83.00%, SVM with a score of 80.82%, RF with a score of 84.18%, and FGM (Flamelet Generated Manifolds) with the highest score of 93.40%. The highest accuracy in this report is the sharpened SVM 10-Fold, resulting in an accuracy of 85.71% [10].

BMC (BioMed Central) Medical Informatics and Decision Making have also attempted to detect stress using machine learning methods. Thus, they created a Neural Network to aid them in the task. They used two methods, which are Deep Convolutional Neural Network, which reached an accuracy of 99.8% and 99.5%, respectively on binary and 3-class, and Deep Multilayer Perceptron Neural network, which reached an accuracy of 99.6% and 98.38%, respectively [12].

Studies conducted by the Journal of Big Data to extend sentiment and emotion analysis for detecting stress on individual users around social media have attempted to do the same. This research used machine learning algorithms such as Decision Tree, Random Forest, LDA, and BERT reached 72.04%, 86.96%, and 78.99% accuracies. They also mentioned how accurate they are in testing emotions by using the BERT model, which resulted in 95.38% on Anger, which is the highest result in the model [13].

Symbiosis Centre for Applied Artificial Intelligence in India has tackled the same problem. By using specific techniques for creating a Multimodal AI-Based framework, they tried to detect stress automatically by checking stress patterns and their level over a period. The result they got was 96.09% accuracy in stress detection and classification. They also reduced their loss on the prediction model to 0.036 using the modalities [14].

Computer Science and Industrial Engineering and Management in Stockholm, Sweden, tried to apply machine learning theories on data points for a company named Linkura AB, a medical technology company based on Linkoping and handles, among other stress measuring for different company employees. Using Google Cloud Platform to create machine learning that can analyse and detect stress-related behaviour with data points from Linkura's HRV-Sensors, their K-Means Algorithm, and Hierarchical Agglomerative Dynamic clusters shows promising results with an increasing amount of automation in detecting stress of patients [15].

Hellenic Open University conducted a study to detect stress. The methods used in this study were AB, and deep

learning which showed the highest F1 scores of 97.37% and 92.63% [16]. Study from the Journal of Emerging Technologies and Innovative Research (JETIR) addressed the same problem with 150 students. The techniques used are SVM, Naïve Bayes, LR, and RF, which get the best accuracy is to use SVM which has an accuracy of 85.71% [17].

Table 1. Related Works

No	Model	Dataset	Metrics	Performance
1	KNN, Linear Discriminant Analysis, Random Forest, Decision Tree, AdaBoost, SVM	WESAD	Accuracy	93.20% (best accuracy)
2	LR, Naïve Bayes, Random Forest, SVM	206 Participant	Accuracy	85.71%
3	LRC, SVM, FGM, GDBT, RF.	Weibo	Accuracy	85.71% (best accuracy)
4	KNN, LDA, RF, DT, AB, SVM	WESAD	F-1 Score and Accuracy	78.71% (best F-1 Score) and 83.42% (best accuracy)
5	Deep Convolutional Neural Network and Deep Multilayer Perceptron Neural network	Schmidt et al.	Accuracy	99.6% (best accuracy)
6	Decision Tree, Random Forest, LDA and BERT	Twitter	Accuracy	95.38%
7	Multimodal AI-Based framework	ROCO	Accuracy	96.09%
8	K-Means Algorithm, and Hierarchical Agglomerative Dynamic	Linkura AB	Success	Success
9	AdaBoost	58 Participant	F-1 Score	97.37% (best F-1 score)
10	SVM, Linear Regression, Naïve Bayes, and Random Forest	JETIR	Accuracy	85.71%

3. Materials and Methods

We propose some machine learning models by training the dataset of posts in English. The dataset's preparation and the model's development are discussed thoroughly in the following subsections.

3.1. Data Preparation and data pre-processing

The proposed designs are various deep-learning prediction models for the English language. The dataset used is obtained from Dreaddit [9], collected from Reddit, consisting of 190K posts from five categories of the Reddit community. The reason of why we used the dataset is due to lack of Indonesia based dataset that is globally available to be used in Reddit, this is also mostly caused by how popular English is in social media such as Reddit. To reduce the unnecessary data, we used some strings of codes nicknamed 'cleaning' that work as such:

- Stop word removal.
- Remove Punctuations.
- URL Removal.
- Changing capital letters into lowercase letters.
- Reposting Omitting.
- Emoji Removal.

Table 2. Sample of English Reddit Posts Dataset

User ID	Posts	Label
0	Its like that, if you want or not. “ME: I have...	Not Stressed
2	We'd be saving so much money with this new hou...	Stressed

The user posts used in this study were selected based on a study of Reddit data on Reddit posts [7]. Then we separate the text and label column from other columns because we want to train the posts in the dataset and the labels

according to the posts.

Table 3. Example of Separated Text and Label Fields

User ID	Posts	Label
0	Its like that, if you want or not. “ME: I have...	Not Stressed
1	I man the front desk and my title is HR Custom...	Not Stressed
2	We'd be saving so much money with this new hou...	Stressed
3	My ex used to shoot back with "Do you want me ...	Stressed
4	I haven’t said anything to him yet because I’m...	Not Stressed
7	More specifically, for example, I live with ro...	Stressed

After the text data and label data, this study performed clean text in the data pre-processing to clean up the posts in the dataset to ensure the computer could read the texts without any problems or slow timing on decrypting symbols and capitals, making it more efficient and timesaving in the long run.

Table 4. Example of Clean Text

User ID	Posts	Label	Clean Text
0	Its like that if you want or not. “ME: I have...	Not Stressed	its like that if you want or not me i have no ...
1	I man the front desk and my title is HR Custom...	Not Stressed	i man the front desk and my title is hr custom...
2	We'd be saving so much money with this new hou...	Stressed	wed be saving so much money with this new hous...
3	My ex used to shoot back with "Do you want me ...	Stressed	my ex used to shoot back with do you want me t...
4	I haven’t said anything to him yet because I’m...	Not Stressed	i havent said anything to him yet because im...
7	More specifically, for example, I live with ro...	Stressed	more specifically for example i live with room...

After doing clean text, this paper converts posts that have been clean text into tokenizing to divide the text into a list of sentences and as a separator between texts. after tokenizing the next step, this paper does stop words in English with the aim of filtering words before or after data processing [18].

Table 5. Example of Tokenize and Stop Words Text

ID	Posts	Label	Clean Text	Tokenize	Stop Words
0	Its like that, if you want or not.“ ME: I have...	Not Stressed	its like that if you want or not me i have no ...	[its, like, that, if, you, want, or, not, me, ...	[like, want, problem, takes, longer, asked, fr...
1	I man the front desk and my title is HR Custom...	Not Stressed	i man the front desk and my title is hr custom...	[i, man, the, front, desk, and, my, title, is,...	[man, front, desk, title, hr, customer, servic...
2	We'd be saving so much money with this new hou...	Stressed	wed be saving so much money with this new hous...	[wed, be, saving, so, much, money, with, this,...	[wed, saving, much, money, new, housrits, expe...
3	My ex used to shoot back with "Do you want me ...	Stressed	my ex used to shoot back with do you want me t...	[my, ex, used, to, shoot, back, with, do, you,...	[ex, used, shoot, back, want, go, time, matter...
4	I haven’t said anything to him yet because I’m...	Not Stressed	i havent said anything to him yet because im...	[i, havent, said, anything, to, him, yet, beca...	[havent, said, anything, yet, im, sure, someon...

7	More specifically, for example, I live with ro...	Stressed	More specifically for example i live with room...	[more, specifically, for, example, i, live, wi...	[specifically, example, live, roommates, cant,...

The dataset used is ready for training/process when the steps above have been done. We process this dataset with clean text, stop words, and tokenizing methods so that we and the computer can process and train the provided dataset and replace the anticipation of errors when training data as in Table 5 because if it is not processed like this, it will be prone to errors and cannot be trained.

3.2. Proposed Model Architecture

To consider performance improvements in this machine learning model, the posts dropped earlier are incorporated into the machine learning model in the classification. Posts training dataset in English for the model, pre-trained models will be used, namely Support Vector Machine, Decision Tree, Naive Bayes, Random Forest, Bag of Words, and TF-IDF. All these methods will retain the ability to classify the text with all the models used in this study to find data on a person who experiences stress or is not stressed. Later we will get results from which posts are showing the experience of stress and which posts are not showing stress, and the results of all the models used will be put together into one and compile which method is the best for this study.

We decided to divide Group A and Group B into processing posts. The reason behind this is to make it easier for us to understand the models instead of placing all of them into 1 model altogether and make it more accessible to find the problem inside our coding in case we run into an error.

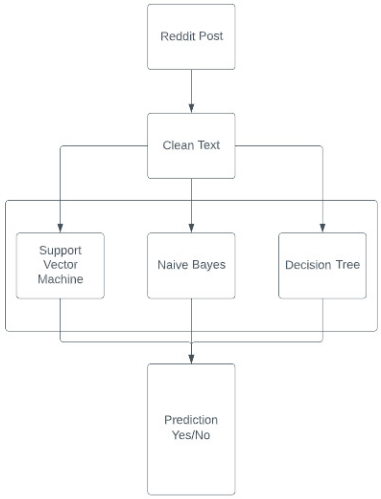

Fig. 3. Example proposed model Support Vector Machine, Naïve Bayes, Decision Tree

In this group, after we run clean text towards the Reddit Posts in the dataset, we randomly pick 80% of the dataset and put them each onto SVM, Naïve Bayes, and Decision Tree. A test run will be done to train the three models before testing them using the last 20% of the dataset for the yes/no prediction.

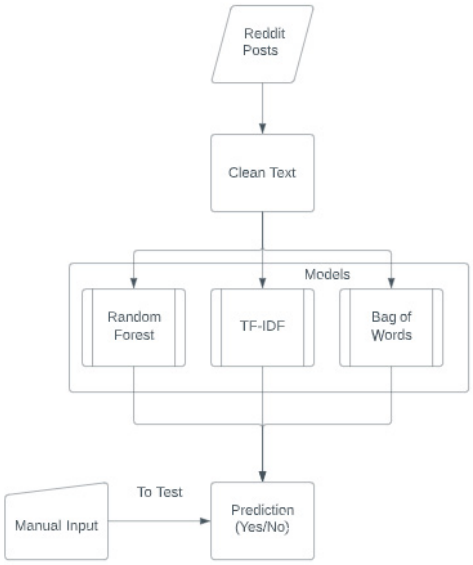

Fig. 4. Example proposed model Random Forest, TF-IDF, Bag of Words.

3.3. Model Training and Evaluation

All six models are trained separately with the same settings and ratio number of input (80% training and 20% testing). For group A, after the texts have gone through the clean text function, tokenizing and stopwords. It is randomly given to SVM, Naïve Bayes, and Decision Tree for them to train and test. For group B, after going through the same function, it is given to Random Forest, TF-IDF, and Bag of Words. It is also given some manual input to test if it is accurate or not.

After all the data processing is done above, we will create a new variable with the name new data to store the data that has been processed before. After being stored in the new variable, we calculate the new data. With the data that has been calculated, the value we conduct a splitting train test which is used to evaluate the performance of the machine learning model used.

SVM are given the training data with the labelled '1' and '0' numbers, resembling they're stressed or not stressed. Then within the test data, SVM will check on the hyperplane that is made from the training data and check on it, thus it will see which data are the closest match with the hyperplane data and will label it as stressed or not.

$$y_i(x_i \cdot w + b) \geq 1 - \xi i \tag{1}$$

$$min_w = \tau\,(w) = \frac{1}{2\left|\left|w\right|\right|^2} + C \sum_{i=1}^{I} \varepsilon_i \tag{2}$$

Naïve Bayes are given the same training data, processed and saved the data including with the labels. Then when it is given the test data, it will check the data from training data, and predict for the new data's labels, then it will label the new posts as '1' and '0'.

$$P\,(A|B) = \frac{P(B|A) \cdot P(A)}{P(B)} \tag{3}$$

Decision Tree are given the same training data, checks for the data labels and how do they separate the data between the '1' and '0' then save the states as branches created for the decision tree. When it is given the test data, it will

process it through the Decision Tree through the branches and given the result of '1' and '0'.

$$E(S) = \sum_{i=1}^{c} -P_i \log 2\ P_i \tag{4}$$

Random Forest are given the same training data and create branches accordingly to the result '1' or '0', which we set 10 Trees in total. This resulted with the test data tested processed fully then showed the result counted accordingly with which resulted more to one of the options, for example if 6/10 of the trees resulted as '1', then RF will show it as '1'.

$$f(x) = \frac{1}{j}\sum_{j=1}^{1} h_j\,(x) \tag{5}$$

Bag of Words are given the training data and process it thoroughly, checking the structures and words from each of the posts in the training dataset. It will label each word from the '1' labelled data as score '1'. This then helps it to check if the words do reappear in the other dataset. The model then will use the structures and words saved inside the model to check and classify the posts in the test dataset to give its results.

TF-IDF are given the training data and process is through TF using the TF formula. After TF weights the importance of words by the reoccurrence in posts of the training dataset, it will then process it through the IDF section with the IDF formula. It will then be multiplied with TF and finished processing from the training dataset. When it is given with test dataset, it will check by the value of the weights processed through the TF-IDF then it will result with '1' or '0'.

$$tf(t,d) = f_t, \frac{d}{\sum t' \in ft', d} \tag{6}$$

$$idf(t,D) = \log \frac{|D|}{|\{d \in D : t \in d\}|} \tag{7}$$

After all the models have been trained, and then we enter all the methods used by creating a pipeline model where the output in a method is directly used with other methods so that it can be directly processed. We enter the testing and training data with the method that has been entered earlier so that the data is processed with the method we use. After it is run, we validate the model from the training data to immediately look for the accuracy score obtained.

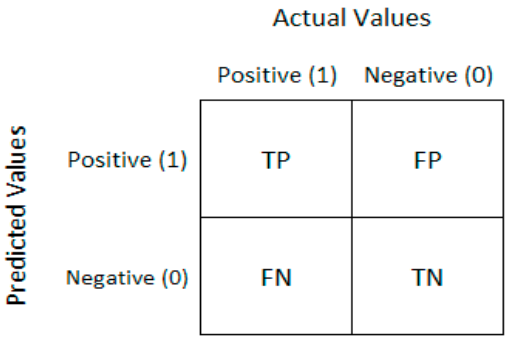

Fig 5. Confusion Matrix

For the evaluation, the F1 Score and Accuracy are calculated on each model. The correct prediction must be based on the labels in the confusion matrix in Figure 5. As seen in the equation, we can determine F-Score and Accuracy by getting equations 3 and 4. This equation is used for measuring all the methods, and the result will be placed on a table later to be checked and compared to one another.

$$Accuracy = \frac{TP + TN}{TP + FP + TN + FN} \tag{8}$$

$$Recall = \frac{TP}{TP + FN} \tag{9}$$

$$Precision = \frac{TP}{TP + FP} \tag{10}$$

$$F - Score = 2 \times \frac{Precision \times Recall}{Precision + Recall} \tag{11}$$

4. Result and Discussion

The experiment we did used Dreaddit [7], As explained in the previous section, we test the accuracy results of all the methods used. The results of this experiment will be discussed thoroughly in this section.

4.1. Performance Evaluation

This paper tests the performance of all the methods of the SVM, Naïve Bayes, and DT as sophisticated machine learning to classify posts in the dataset used. The results of the experiment using this method can be observed in table 4. We tested each of these methods and then executed them afterward. After testing the performance and checking the F1-Score, Accuracy, Recall, and Precision, we decided to try Group B by putting manual inputs based on the predictions so we can see the actual result of the model.

The result of the manual inputs revealed that on TF-IDF, there are three correct and three wrong answers on it, which answers why TF-IDF scored lower than SVM, Naïve Bayes, and Random Forest. The same inputs given to BOW (Bag of Words) instead give us a low accuracy on testing—two false answers out of three shows how BOW is the second lowest on this test.

Table 6. Performance of All Methods Used

Method	F1-SCORE	Accuracy	Recall	Precision
SVM	80.00%	75.00%	92.00%	71.00%
NB	77.00%	69.00%	95.00%	65.00%
RF	72.46%	60.97%	81.96%	69.10%
TF-IDF	64.66%	61.78%	70.49%	61.79%
BOW	63.07%	69.10%	67.21%	59.42%
DT	61.00%	56.00%	61.00%	60.00%

The results show that SVM is the highest on performance in general, with Accuracy of 75% and F-Score of 80%, this explains that SVM is quite competent at predicting stress. There are a lot of differences of result with the other experiments that had been done in the same dataset, especially the result of NB is quite lower. One of the reasons is how large the dataset been used in this experiment compared to the other datasets used in other experiments. For example, in WESAD dataset, there are 15 subjects in total, while in Dreaddit[7], there are 190k posts. Another one is the lack of fold used to minimize the work done by each method. As example, some of models with bigger dataset used fold technique to compress the dataset to make sure it can be run and given a good result.

5. Conclusion

Stress detection is an ever-evolving study. Therefore, our study proposes a machine learning model for predicting stress from social media. The methods used in our machine learning models are SVM, NB, DT, TF-IDF, Random Forest, and Bag of Words. The experiments in this paper show that SVM has a good performance with F1-SCORE 80.00%, Accuracy 75.00%, Recall 92.00%, and Precision 71.00% to predict a personality trait. Our experiments have achieved good scores, but they are far from perfect, so the development of these personality predictions must be constantly developed to improve their effectiveness. We do suggest using either a smaller dataset or doing ten-fold onto such models to get better results. Many newer machine learning models or deep learning models for text classification can be used to analyse personality prediction.

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