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Machine Learning Approach on Cyberstalking Detection in Social Media Using Naive Bayes and Decision Tree

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Abstract: Social media has increased the chance to communicate through many things such as video calls and can be connected globally. But there is also a growth in the vulnerability of the system. With this advancement, some threat is bound to happen. Cyberbullying is one of the social issues that users deliberately and tenaciously misuse social media. It became an issue because most cases affect the victim's mental health. Before, detecting these crimes only has traditionally used linguistic features, but cyberbullying on social media has more than that. Therefore, technologies today may play an important role in detecting cyberstalking on social media by using Machine Learning (ML). In this paper, cyberbullying detection will use the ML algorithm, which is Naïve Bayes and Decision Tree, and compare which algorithm is better to detect. ML has a wide range of methods that allow systems to quickly access the data and learn from it to make decisions for complicated problems. Cyberstalking has been concerning as it psychologically affects the victims. An experimental result indicates that Naïve Bayes algorithms achieve the best accuracy, which is 0.958.

Keywords: Cyberbullying, detection, machine learning, naive bayes, decision tree

1. Introduction

Cyberbullying is an activity that exploits information and communication technologies to assist intentional, ongoing, and aggressive action by an individual or a group of individuals [1]. This activity is meant to injure someone physically or emotionally. Cyberbullying is not limited to adolescents; it is also recognized as the same thing when the adult does the deed. Cyberbullying is a common psychological crime that happens on the Internet and usually occurs on social media. Social media is an online platform where people have a real-life connection online to interact [2]. Cyberbullying quickly happens because most social media is where people share and gain information and access to almost everyone. Cyberbullying can happen to anyone, and since there are many users using social media and not all people use social media to communicate. Some people use it to promote their business or want to post some personal feelings. When there are various kinds of tweets, it is pretty hard to detect cyberbullying when that happens to someone. But, Machine Learning (ML) makes up for a wide range of methods that allows systems to access and enable systems to access and learn from data and solve problems in a fast-paced [3]. Machine Learning approaches can be used to detect the stalking keywords within the corpus [4].

Nowadays, the Internet has been used openly by many peoples as their platform to share any information from it. This is because most people have access to the Internet and can utilize it for their own profits. Besides getting information, the Internet has also been widely used for communication in society. Social media has been well developed for users to interact with each other online [2]. As technology advances, there also will be many people using the technology, especially smartphones. Each smartphone usually has social media application in it which means the user of social media has also increased. The crimes also become more difficult to discover and have taken another

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platform to do the acts [1], [3]. There are many types of crimes on the Internet, but the crime that commonly happens on social media is cyberbullying.

The crime of cyberbullying has increased as the years go by. As stated by Malaysian Institute for Youth Development Research, cyberbullying has increased by 55.6 percent in 2013 compared to 2012. Three hundred eighty-nine cyberbullying cases were reported, with 62.3 percent of the teenagers being victims while the other 37.7% had never been victims of cyberbullying [5]. Correlative to this source, about 7 out of 10 teenagers have experienced cyberbullying.

Anyone with access to the Internet can become a victim. The effect of these crimes will impact psychologically and can cause emotional damage, particularly to young victims, especially if they are still in their formative years. Most parents do nothing to protect their children from this crime because they do not understand how serious the crimes are [6]. The impact is psychological. It may have a long-term effect on children if this crime is not being restrained early. There are also adults among the victims, and sometimes when facing things like this, they wait for it to worsen before reporting. This makes the perpetrators will become more daring and may create another victim. Nowadays, mobile technology has become more available to anyone, even to teens and children. Cyberstalking and cyberbullying can happen to anyone with mobile technology [7]. That is one of the reasons why crimes are increasing year by year. With more users on social media, pinpointing the crime perpetrator is quite hard. The are many data from the users, and they cannot differentiate which data is from doers and victims. Machine Learning approaches for detection are proposed for this project because the result we need will be more significant as more data is collected. Thus, this project aims to study cyberbullying detection on Twitter using Naïve Bayes classifier and Decision Tree classifier, perform experiments using Naïve Bayes and Decision Tree cyberbullying detection problem, and finally evaluate the performance of the classifiers in terms of accuracy.

2. Literature Review

2.1 Cyberbullying

Bullying and cyberbullying are somewhat similar to each other. Cyberbullying occurs by using electronic mediums such as cell phones, tablets, and computers [8]. It usually happens on the Internet, especially on platforms where people usually interact with each other, like social media such as Facebook, Twitter, Instagram, and more. Cyberbullying is a cover for various types of online bullying, some of it more severe than others. The perpetrators of online bullies get through to their targeted victims in many ways [6]. The disparity between traditional bullying and cyberbullying is that the perpetrators of cyberbullying plan to offend the victims' feelings [9].

2.2 Social and Psychological Effects

Cyberbullying is a crime. Such acts like this can mentally and physically affect the victim. There may be a dangerous outcome to such harassment, especially for victims. As being described by the World Health Organization (WHO), health is a condition of perfect physical, mental and social well-being and not solely without disease or frailty [10]. Cyberbullying can affect health in many ways, and the consequences of this agony are likely multi-layered with possible major effects.

The repeated pursuit by the offender will cause fear for the victims. The accumulated fear may develop anxiety due to the fear response and cannot find something to relieve this fear. Most victims felt conscience-stricken and belief that this happened because of their fault [11]. Anxiety commonly will occur together with depression. We learned that most patients reported that they have depression and also have anxiety within them. Depression has many symptoms that may interrupt our daily lives, such as feelings of helplessness and hopelessness [12]. Studies found that majority of the victims had symptoms of anxiety and depression and had experienced panic attacks [11]. There are also victims with depression who showed symptoms of self-harming behavior [13]. Another study also mentioned that alcohol consumption by victims rose, and they also suffered sleep disturbances [11].

In conclusion, the victims of cyberbullying and all harassment on the Internet experience many harmful effects, especially on mental health. All negative emotions and physical symptoms were not gender-related. Both male and female victims experienced all of these effects. That is why detection is needed for early prevention.

2.3 Machine Learning

Machine Learning is a field of study that looks at applying computational algorithms to change empirical data into a functional model [14]. Machine Learning is making computers learn and act like what humans do. It enhances their learning steadily at their own pace. All input data and information in the shape of surveying and real-life interactivity [15]. Mainly, the idea of machine learning is teaching the computer to predict or detect patterns or outcomes by learning from data[16]. It involves the automated computing procedures developed to learn to resolve a problem based on existing examples [17]. Machine Learning, there are four types of it. But, the most commonly used types are supervised machine learning and unsupervised machine learning.

In supervised machine learning, a data set with all inputs and outputs will go through this algorithm to form a mathematical model [18]. Supervised Machine Learning performs two functions that are Classification and Regression. Unsupervised Machine Learning is contrary to Supervised Machine Learning, where classification and regression methods do not work with this type of Machine Learning. This is because there is no explicit labeled data correlated with Unsupervised Machine Learning. Clustering and Association are split from this type, but the most common one is Clustering [16]. In this research, the machine learning algorithm is more focused on Naïve Bayes and Decision Tree.

i. Naïve Bayes: Naïve Bayes classifier is a simple probabilistic classifier [19]. In the Naïve Bayes classifier, every attribute of a data set is assumed to come up with the same amount of probability. It is also one of the most uncomplicated algorithms for supervised classification because its algorithms do not consider the relationship between attributes. Even a large data set is suitable for using Naïve Bayes algorithms and can surpass the most sophisticated classification methods [16].

ii. Decision Tree: The data structures form a tree with decision nodes where a decision needs to be made. Leaf nodes are nodes that show the final classification result based on the decision. The algorithm will determine all the data that is going through the decision tree and decide on the new label by concluding the decision nodes [16].

Table 1 shows the descriptions of papers that use Machine learning for the detection and the research result. Each journal has a different purpose for the study.

Table 1 - Comparison between previous research papers

Title of the research	Authors	Method used	Description	Result
Cyberbullying Detection Using Machine Learning	[20]	Random Forest Naïve Bayes Support Vector Machine Logistic Regression Ensemble	This study-specific aimed to explore cyberbullying detection using machine learning. Cyberbullying has a vast term and has different aspects. This study includes sarcasm as one of the aspects of bullying.	The result of the research records that Ensemble and Support Vector machines are better than others, with 79% average accuracy. The second one is 78% from Logistic Regression. Then, Random Forest with 76.7% and Naïve Bayes executed with 76% accuracy.
Non-Linguistic Features for Cyberbullying Detection on a Social Media Platform using Machine Learning	[21]	Naïve Bayes Decision Tree Tree Ensemble Random Forest Logistic Regression Support Vector Machine	In this study, the research is about improving cyberbullying detection on social networks using machine learning and expanding the feature set of cyberbullying acts. The feature set that is multi-dimensional being proposed in this study is expanded from the traditional linguistic content feature set. It takes into consideration non-linguistic features of cyberbullying behavior on a social network.	Naïve Bayes has the highest Recall score, but the Precision value produces its final performance inferior compared to the other Machine Learning classifiers. Both Random Forest and Tree Ensemble have the same performance since they belong to the ensemble classification algorithm. These two algorithms exceeded the Decision Tree for the detection. SVM has a better performance compared to Random Forest, and the Decision Tress algorithm with results of AUC are 87.36%, 85.87%, and 84.99%, respectively. Logistic Regression provided the best results in Precision, F1-Measure, Accuracy, and AUC.
Cyberbullying Detection: Arabic Content Detection using Machine Learning	[22]	Naïve Bayes Support Vector Machine	In this study, the research is focused on the detection and mitigation of cyberbullying. Since previous research proposed solutions for detecting cyberbullying in the English language, this study covered the Arabic language. A few techniques help in cyberbullying	Support Vector Machine is higher in precision result compared to Naïve Bayes. Precision result for SVM is 93.4% while Naïve Bayes is 90.1%. For Recall, Naïve Bayes obtained 90.9%, and SVM is 94.1%. F-Measure for SVM is 92.7% and Naïve Bayes is 90.5%.

Title of the research	Authors	Method used	Description	Result
			detection, mostly Natural Language Processing (NLP) and Machine Learning	
Social media bullying detection using machine learning on Bangla text	[23]	Decision Tree Naïve Bayes Support Vector Machine K-Nearest Neighbours	This study is specific to detecting cyberbullying in the Bangla language. For cyberbullying detection in Bangla text, this article proposes the use of machine learning techniques as well as the integration of user information. For this objective, a collection of Bangla text was gathered from various social media platforms and labeled as either bullied or not bullied in order to train several machine learning-based classification models.	Support Vector Machine has the highest accuracy result compared to others which are 97.27%. Followed by K-Nearest Neighbors with 97.73%. Decision Tree and Naïve Bayes got 97.23% and 50.73%. Decision Tree and Support Vector Machine got the same result for F1-Score, which is 0.99. Naïve Bayes and K-Nearest Neighbors obtained 0.66 and 0.98. For precision, the Decision Tree and Support Vector Machine has the highest result, which is 0.99. Naïve Bayes and K-Nearest Neighbors have the same result, which is 0.98.

The proposed study for this paper is also similar to the previous research paper, as both are related to the detection of cyberbullying in social media. The methods used for this research are Naïve Bayes and Decision Tree.

3. Methodology/Framework

Cyberstalking has been concerning as it psychologically affects the victims. The framework for this research study explains the process of detection and classification of cyberstalking in social media. There are a few phrases that need to be completed in order to get the best result. Fig.1 shows the steps to conduct the study. This framework simplifies the process flow of this research study into an understandable form.

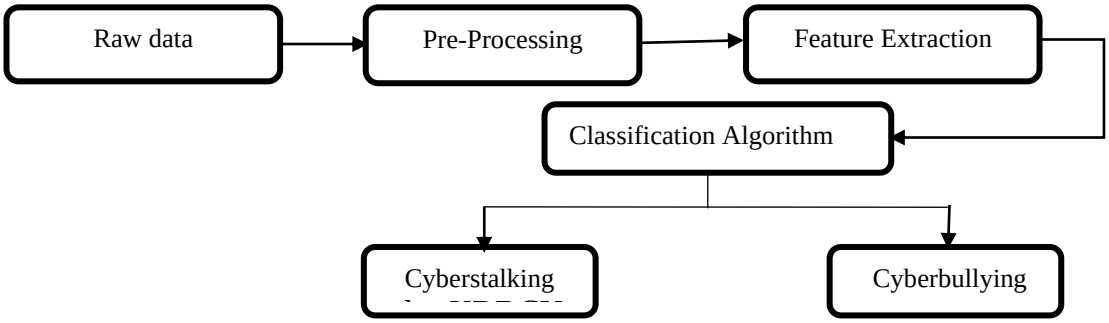

Fig. 1 - Framework to detect the cyberstalking attack

3.1 Raw Data

Raw data is recognized as data that does not undergo filtering and normalization processes. Basically, it is unprocessed data. Data that is saved in the database is usually called raw data. It can be entered by the user or the computer-generated by itself. It may be a collection of characters and numbers that are kept on the computer's hard disk or in a file. For this experiment, the dataset that will be used in this research was acquired from [24]. The dataset contains hate speech about racism and sexism. Then, the data are loaded and saved in a CSV file. The total number of samples in the dataset is 31962. The data file is processed by removing the redundant data and dividing it into 70:30 ratios for the training and testing process.

3.2 Pre-Processing

Normally, the value in the raw data is inconsistent and lacking in a particular behavior and also has many errors. Pre-processing is needed before it is used to publish into the learning machine. The tweets in the dataset were transmuted to lower case to steer clear of any sparsity problem, standardized URLs, lessen repeated letters, and

@usermention to remove noise in tweets. Then, tokenization was applied by using the Lambda function, which can take any number of arguments but can only have one expression. Tokenization is the procedure of fragmentation of a text corpus into the most frequent phrases, words, or other significant elements. The stop words and stemming process were conducted before doing feature extraction. Stop words are described as the unimportant words that show in the document which are not distinct or biased to the contrary classes. Stemming is the process of lessening words to their stems. For example, singular, plural, and contradictory strained are merging into a single word. For stemming in this research, PorterStemmer was applied.

3.3 Feature Extraction

The Feature Extraction function is to decrease the number of features in a data set by making new features from existing ones into more manageable groups. This technique is useful for a large data set as the features are reduced, but any related or important information does not lose. The new feature set that is being reduced managed to summarize the information that has in the original set of features. Combining the existing dataset can produce an outlined version of the original features. All tweets were represented with bag-of-words, one of the most effective and time-saving methods. In this method, the text is designated by a set of words, and each word is treated as an independent feature. Part-of-speech (POS) tagging with Twitter specific-tagger build on CMU TweetNLP library for word sense clarification. Part-of speech assigned by POS tagger to tag each word of the designated text in the form of tuples.

3.4 Classification Algorithm

In this classification algorithm phase, this study included two machine learning approaches: the Decision Tree algorithm and Naïve Bayes. These two methods are executed in software named WEKA. Then, the dataset is classified based on its performance and accuracy in detecting cyberstalking features from the dataset. Thus, the training dataset and testing dataset are loaded into classifiers to acquire the output.

i. Naïve Bayes: Naïve Bayes is sentiment classification in machine learning. Naïve Bayes is a supervised type of algorithm in ML [25]. It is a simple probabilistic classifier that is based on Bayesian probability. Based on the assumption of the Naïve Bayes classifier, the feature probabilities are unrestrained of one another [26]. This type of classification technique supposed that any trait in the document is independent and not influenced by other features. Because Naïve Bayes classification can be applied skillfully without any complex iterative parameters, it is beneficial for very large datasets [27]. Bayesian classification gives practical learning algorithms, and previous knowledge and observed data can be collected. Bayes theorem comes up with a method to calculate the posterior probability.

$$Posterior\ Probability = \frac{Prior\ x\ Likelihood}{Evidence}$$

$$P(c|x) = \frac{P(c|x)P(c)}{P(x)} \tag{1}$$

$$P(c|x) = P(c)Y\ i\ P(xi|c)$$

From the naïve Bayes equation, the chance probability (Q i P(xi |c)) could be used as a score of class C. This score can be used as a threshold to distinguish an attack from normal traffic. A valuable perspective for understanding and examining various learning algorithms can get from Bayesian Classification.

ii. Decision Tree

A Decision Tree is an algorithm that categorizes instances conditioned on attribute values[28]. In Machine Learning, the Decision Tree is like a tree graph structure [29]. The Decision Tree is like a hierarchical organization with the accumulation of nodes and links. It has one incoming link, which every node except the root node[30]. Each branch in the tree graph structure represents the result of the experiment, and the leaf nodes stand for the class label obtained after all options made through the branch [29]. From root to leaf, the paths represent classification rules. This plan aims to point out the data while decreasing the complexity of the model[29]. When a data set is obtained, a prediction about the condition of the predictor variable can be produced by the next track of the tree from the root to a leaf, utilizing tree structure[30]. The splits are contained in internal nodes, which experiment with the value of an expression of attributes. Tracks are starting from the Internal node to its children's peak into a clear test result [31].

3.5 Training and Testing

The data is divided into training and testing sets that are crucial for evaluation. Most of the data were used for training, and the data that was selected for the testing was only a small part of it. The model will be tested to make predictions after it is processed using the training system. The dataset that is being used in the testing set carries the values, which are traits that need to predict. After it is trained and tested, the performance of the model needs to be evaluated. Three things need to be evaluated: precision, recall, and accuracy. Equations 2 and 5 are the formula for the evaluation.

$$\text{Precision} = \frac{TP}{(TP + FP)} \tag{2}$$

$$Recall = \frac{TP}{(TP + FN)} \tag{3}$$

$$\text{Accuracy} = \frac{(TP + FN)}{(Total\ Samples} \tag{4}$$

$$\text{F} - \text{Measure} = \frac{(2 * Precision * Recall)}{(Precision + Recall)} \tag{5}$$

where TP- True Positive, FP- False Positive, TN- True Negative, FN- False Negative

True Positive Rate or Recall as the part of the application where it is accurately classified to a certain class and how much part of the class was captured. False Positive Rate is part of the sample where it is classified into a particular class but belongs to the disparate class. Next is the Precision, where it is part of the sample that accurately belongs to a class out of those where it is classified into a specific class. F-Measure is the composite calculation of Recall and Precision. This can be explained as the weighted average.

4. Result and Analysis

In this experiment phase, the classifier performance evaluation is conducted based on the proposed algorithm, which is Naïve Bayes and Decision Tree. In this experiment, the Accuracy, Precision, Recall, and Time Complexion of the classifiers in analyzing the dataset are tabulated. The same dataset that was used to test and train using the proposed algorithm is split with the ratio of 70:30 randomly in the experiments. The training dataset contains 70% of the data, and the testing dataset contains 30% of the data. The classifier is trained well with more data in the training phase for it to function normally.

4.1 Results

The performance metrics used in both experiments to study the dataset with the classifiers are Accuracy, Precision, Recall, and F1 Score. Through the result obtained as shown in Table 2, Naïve Bayes is able to identify the dataset with the accuracy of 0.957953, while Decision Tree is able to classify the dataset accurately by 0.943812. For the Precision, Naïve Bayes has 0.819484 as its results, and Decision Tree has 0.597518. The result of recall for Naïve Bayes and Decision Tree are 0.511628 and 0.602862. F1 Score result of Naïve Bayes is 0.629956 while Decision Tree has 0.600178.

Table 2 - Results

Algorithm	Accuracy Test	Precision Test	Recall Test	F1 Score Test
Naïve Bayes	0.957953	0.819484	0.511628	0.629956
Decision Tree	0.943812	0.597518	0.602862	0.600178

Fig. 2 displayed the summary of the classification results of the experiment. From the graph, Naïve Bayes has the best results for accuracy, F1 Score, and Precision. The result for accuracy of Naïve Bayes is 95.8%, the result for F1 Score is 63.0%, and the result for precision is 81.9%. The best result for the recall is 60.3% which is the result of the decision tree.

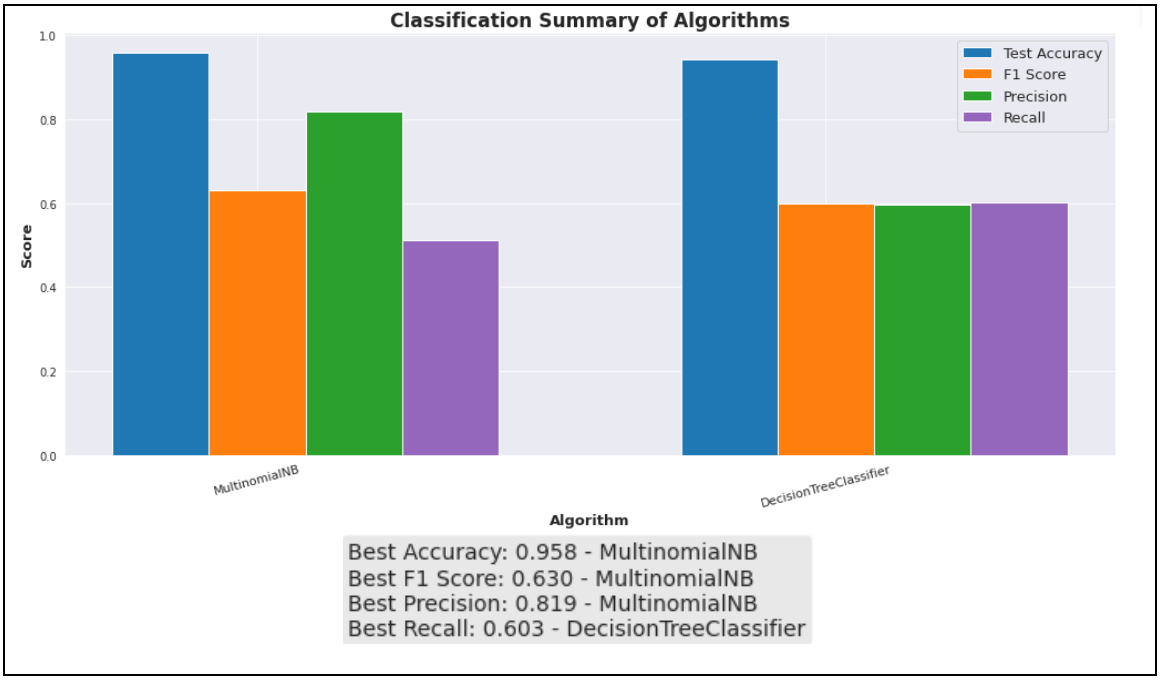

Fig. 2 - Classification results summary of the algorithm

Fig. 3 displayed the time complexity graph. Naïve Bayes has the best result for prediction time. Naïve Bayes executed for 0.015 seconds, and Decision Tree had the worst prediction time for 5.111 seconds.

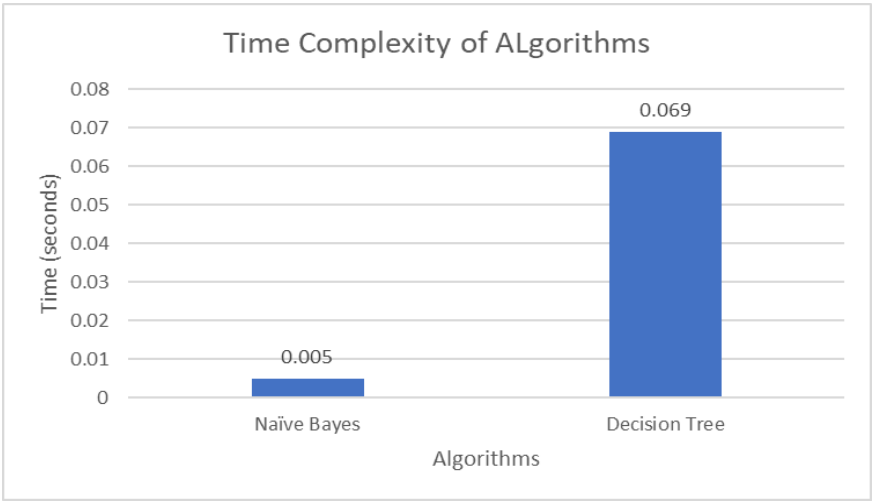

Fig. 3 - Time complexity

5. Conclusion

In conclusion, swift technological growth helps users broaden their human network mainly via social media. Contradictorily, when users misuse social media to commit cyberbullying, they can label as barbaric fellow human beings. It is important to have early detection of something that will bring harm to social media, such as cyberbullying, to prevent it from increasing. Therefore, in this paper, Machine Learning approaches are used for cyberbullying detection. Society needs to be more aware of the existence of such harmful things so that they can counter them and not fall prey to the bully. Generally, there are two machine learning algorithms used in this paper to detect cyberstalking on social media. A few processes need to be completed before the result can be analyzed. An experimental result indicates

that Naïve Bayes algorithms achieve the best accuracy, which is 0.958. Meanwhile, the Decision Tree is not the worst as a result, for its accuracy is 0.944. This research shows that Naïve Bayes is better than Decision Tree.

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