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Performance Comparison of SVM, Naive Bayes, and Random Forest Models in Fake News Classification

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ABSTRACT: The proliferation of fake news (hoaxes) in the digital era represents a significant challenge to public trust and social stability. The objective of this study is to evaluate the performance of three prominent machine learning algorithms, specifically Support Vector Machine (SVM), Naive Bayes, and Random Forest, in the classification of fake news. The dataset employed comprises validated examples of both authentic and fabricated news items. The research methods included text pre-processing, feature extraction using TF-IDF, model training, and performance evaluation using accuracy, precision, recall, and F1-score metrics. The experimental results demonstrated that SVM achieved perfect accuracy (100%), outperforming Naive Bayes (94%) and Random Forest (99%). Additionally, SVM exhibited the optimal performance in precision, recall, and F1-score metrics. This research provides empirical evidence that SVM is the most effective model for detecting fake news. The implication of this research is the potential application of SVM in automated systems to help reduce the spread of fake news on online platforms.

KEYWORDS: Fake News Detection, Machine Learning, SVM, Naive Bayes, Random Forest

I. INTRODUCTION

The advent of information and communication technology has facilitated the accelerated dissemination of misinformation, or "fake news," across a multitude of social media platforms. This phenomenon presents a significant challenge to the maintenance of accuracy in the information received by the public. The proliferation of misinformation can result in the dissemination of false narratives, the manipulation of public sentiment, and the potential for social unrest (Matemilola & Aliyu, 2024). Consequently, the field of fake news detection is becoming an increasingly important area of research.

A variety of machine learning techniques have been put forth for the detection of fake news, including Support Vector Machine (SVM), Naive Bayes, and Random Forest. SVM is renowned for its capacity to classify non-linear data with maximum margin (Ruise et al., 2023). In their comparative study of methods for classifying fake news on Twitter, Ruise et al. (2023) demonstrated the potential of SVM and compared it with other methods, including Logistic Regression and Random Forest (Ruise et al., 2023). Furthermore, the SVM approach has been investigated in conjunction with other algorithms, including K-Nearest Neighbors (KNN) and social capital variables (Dedeepya et al., 2024), as well as in a hard voting approach with Naive Bayes and Decision Tree (Ahmed, 2023). Moreover, the efficacy of SVM in detecting fake news on social media has been evaluated and contrasted with that of the Naive Bayes algorithm (Vadlamudi et al., 2023).

The Naive Bayes model, which assumes independence between features, offers a simple yet effective approach to text classification (Natheem et al., 2023). The use of Naive Bayes in the detection of fake news has been the subject of several studies. One such study, conducted by Sun and Ning (2023), employed a combination of BERT and Naive Bayes models to profile individuals responsible for disseminating fake news on the social media platform Twitter (Sun & Ning, 2023). In a comparative study, Yadav and Rao (2023) employed the Naive Bayes Classifier (Yadav & Rao, 2023). Other studies have evaluated and compared the performance of Naive Bayes with other algorithms, including Support Vector Machines (Neelapala & Malaiyalathan, 2023) and Gradient Boosting (Reddy & Pramila, 2023). Furthermore, Shabani et al. (2023) employed a combination of Naive Bayes and Passive Aggressive Classifier in a system designed to detect fake news (Shabani et al., 2023).

In contrast, Random Forest, as an ensemble method, is capable of capturing data complexity by combining multiple decision trees, thereby enhancing accuracy and reducing overfitting. Prior research has yielded inconclusive results regarding the efficacy of Random Forest in detecting fake news. In a recent study, Ali et al. (2024) employed the Random Forest algorithm for the classification of fake news. The results demonstrated that this model exhibited high accuracy in the detection of fake news (Ali et al., 2024). Furthermore, Felicilda et al. (2024) underscored the enhanced efficacy of the Random Forest algorithm in discerning fake news, reinforcing the pivotal role of this approach in this domain (Felicilda et al., 2024). Saranya and Juliet (2023) conducted a comparative analysis between Random Forest and K-Nearest Neighbors (KNN) algorithms and concluded that Random Forest exhibited superior accuracy in detecting fake news (Saranya & Juliet, 2023). Furthermore, Random Forest has been evaluated for its ability to detect misinformation related to the Coronavirus Disease 2019 (Covid-19) pandemic (Singh et al., 2023)(Birunda et al., 2024). The versatility of Random Forest was also demonstrated in the study conducted by Saadi and Al-Jawher (2023), who employed this method for the prediction of image-based fake news (Saadi & Al-Jawher, 2023). Additionally, Ayankemi et al. (2024) conducted a comparative analysis between Random Forest, Logistic Regression, and Decision Tree in a fake news detection system (Ayankemi et al., 2024).

The objective of this research is to conduct a comparative analysis of the performance of SVM, Naive Bayes, and Random Forest in the classification of fake news. The performance of these models will be evaluated based on accuracy, precision, recall, and F1-score metrics in order to determine which model is most effective in detecting fake news. Additionally, the factors that affect the performance of each model will be analysed, including dataset size, feature type, and model parameters. By understanding the strengths and weaknesses of each model, it is hoped that this research can provide valuable insights for the development of a more accurate and reliable fake news detection system.

II. METHOD

The objective of this study is to evaluate the efficacy of Support Vector Machine (SVM), Naive Bayes, and Random Forest models in the classification of fake news. To this end, a series of experiments were conducted, comprising several main stages: data collection, text pre-processing, data sharing, vectorization, model training, model evaluation, and result visualization. The following is a detailed description of each stage:

A. Data Collection

The data employed in this study is comprised of two principal datasets: those pertaining to the dissemination of misinformation, colloquially referred to as "fake news," and those representing the dissemination of factual information, colloquially referred to as "true news." The data has been sourced from a number of reliable news outlets and collated into a single, comprehensive dataset. The data set comprising fake news is labelled as such, while the data set comprising true news is labelled as such, thus facilitating the classification process. The combination of these two datasets forms a single dataset that is employed for the training and testing of the classification model. This dataset is sourced from the Kaggle platform, specifically from the following link: https://www.kaggle.com/datasets/anitakataria/fake-news-dataset. This dataset comprises a diverse range of news items spanning various topics and time periods, rendering it an optimal data source for this research.

B. Text Pre-processing

Text pre-processing is a crucial initial step in text analysis and fake news classification. It involves cleaning the data and improving the quality of the extracted features. The pre-processing stage comprises a series of principal steps. First, all text is converted to lowercase (lowercasing) to ensure consistency and reduce discrepancies caused by capitalization. Subsequently, punctuation marks and numbers were removed in order to reduce the amount of extraneous data, which could otherwise interfere with the subsequent analysis. Subsequently, the text is tokenized, that is, broken into individual words, using the `word_tokenize` function from the NLTK library. Subsequently, common words that do not contribute significant information, such as "the," "is," and "in," are removed using the stop words list provided by the NLTK library, leaving only more meaningful words. Ultimately, the text is subjected to lemmatization, a process whereby words are converted into their base form. This is achieved through the use of the WordNetLemmatizer, which serves to streamline the text. Following the completion of these stages, the processed text is stored in the 'text' column of the data frame, thus preparing it for utilization in the subsequent stage of analysis and classification.

C. Data Split

The dataset utilized in this study is divided into two primary subsets: a training set and a test set. The data was divided into two subsets: training set and test set. The ratio of the training data to the test data was 80% to 20%, respectively. This was done to train the model and test its performance. The splitting process was randomized using the `train_test_split` function from the sklearn library. To ensure reproducibility of results, random_state was set to 42. This allows the study to be repeated with consistent results.

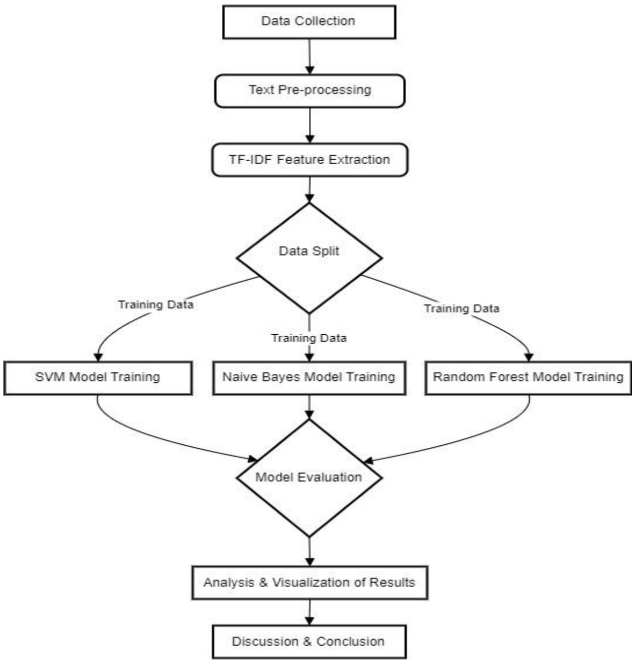

Figure 1. Model Comparison Method

D. Vectorization

The text must be transformed into a numerical format to facilitate processing by machine learning models. To this end, the TF-IDF (Term Frequency-Inverse Document Frequency) method is employed as a text vectorization technique. TF-IDF assigns a weight to each word based on its frequency of occurrence in the document and across the corpus, thereby highlighting important words and reducing the influence of common words. This process is conducted using the `TfidfVectorizer` of the sklearn library, which generates a vector representation of the text for use in machine learning models.

E. Model Training

In this study, three distinct machine learning models are employed for the purpose of classifying fake and real news. The initial model is Naive Bayes (MultinomialNB), which is a probabilistic model. The model operates under the assumption of a multinomial distribution, and has proven to be an effective tool for text data classification based on extracted features. The second model is the Support Vector Machine (LinearSVC), which employs a linear kernel to identify the optimal hyperplane that separates the classes of data with the greatest margin. To ensure computational efficiency, especially when the number of features exceeds the number of samples, we enable the `dual='auto'` option. The third model is Random Forest, an ensemble model comprising numerous decision trees. Each tree is trained on a distinct subset of data, and the final prediction is generated through majority voting of all trees. We assess the performance and accuracy of these three models in news classification by testing them with test data after training them with training data.

F. Model Evaluation

The efficacy of a given model is gauged through the utilisation of a multitude of evaluation metrics, which are employed to ascertain the accuracy and efficacy of the classification process. The accuracy of a model is determined by calculating the proportion of correct predictions to the total number of predictions made. This metric provides insight into the model's ability to accurately categorize inputs. Precision is a metric that gauges the proportion of accurate positive class predictions relative to the total number of positive class predictions, offering insight into the precision of positive predictions. The recall metric gauges the proportion of accurate predictions for positive classes relative to the total number of instances within that class. This measure indicates the model's capacity to identify all instances of positive classes. The F1-Score, as the harmonic mean of precision and recall, provides insight into the balance between the two, which is particularly useful when there is a trade-off between precision and recall. These metrics collectively offer a comprehensive understanding of the model's performance in fake and real news classification.

G. Visualization of Results

The results of the model evaluation were represented in the form of bar charts, which facilitated a comparison of the accuracy, precision, recall, and F1-score of the three models tested. This representation provides a clear and intuitive picture of the relative performance of each model, allowing for the rapid identification of the strengths and weaknesses of each approach. The use of bar charts in this context enables a comprehensive analysis of model performance, allowing for more informative conclusions to be drawn.

H. Results and Discussion

Following the completion of the experiments and evaluations, the results of each model are subjected to a thorough interpretation and comparison. This is done in order to ascertain the most effective model for the detection of fake news. The conclusions reached are based on the aforementioned evaluation metrics, including accuracy, precision, recall, and F1-score. In this process, the advantages and disadvantages of each model are subjected to careful analysis. This is done in order to ensure that the most suitable model is selected, one that is capable of providing optimal performance in the classification of news with high accuracy and efficiency.

III. RESULT AND DISCUSSION

In this experiment, three machine learning models were implemented to detect fake news: Naive Bayes, SVM, and Random Forest. The evaluation results demonstrate the performance differences among these models. The following is a summary of the results obtained for each model:

Table 1. Naïve Bayes Evaluation Results

	Precision	Recall	F1-Score	Support
fake	0.95	0.94	0.94	4733
true	0.93	0.94	0.94	4247
accuracy			0.94	8980
macro avg	0.94	0.94	0.94	8980
weighted avg	0.94	0.94	0.94	8980

The Naive Bayes model demonstrated robust performance, with an accuracy of 94% and consistent precision, recall, and F1-score values of 0.94. This demonstrates that the model is highly effective in classifying fake and real news, exhibiting a balanced capacity to detect both categories. In more detail, the model demonstrated a precision of 0.95 for the fake news class and 0.93 for the true news class. Similarly, the recall reached 0.94 for both classes, resulting in a balanced F1-score of 0.94. This evaluation is based on a total of 8,980 test data samples. The results of the Naive Bayes evaluation are shown in Table 1.

Table 2. SVM Evaluation Results

	Precision	Recall	F1-Score	Support
fake	1	1	1	4733
true	1	1	1	4247
accuracy			1	8980
macro avg	1	1	1	8980
weighted avg	1	1	1	8980

The Support Vector Machine (SVM) model demonstrated an exceptional degree of accuracy, achieving a perfect score of 100%. All evaluation metrics, including precision, recall, and F1-score, also reached a value of 1.00, indicating that the model was highly effective in classifying fake and real news. The SVM model demonstrated perfect precision and recall in both the "fake news" and "true news" categories, successfully identifying all cases with no errors in the test data. The evaluation was based on a total of 8,980 samples, with a consistent average metric value of 1.00 for both classes, both macro and weighted average. Table 2 shows the results of the SVM evaluation.

Table 3. Random Forest Evaluation Results

	Precision	Recall	F1-Score	Support
fake	0.99	0.99	0.99	4733
true	0.99	0.99	0.99	4247
accuracy			0.99	8980
macro avg	0.99	0.99	0.99	8980
weighted avg	0.99	0.99	0.99	8980

The Random Forest model demonstrated exceptional performance, achieving a 99% accuracy rate. Other evaluation metrics, including precision, recall, and F1-score, also demonstrated a value of 0.99, indicating that the model exhibits an exceptional capacity to discern between fake and true news. The precision and recall values remained consistently at 0.99 for both the fake and true news categories, indicating that the model exhibited a markedly low error rate in classifying news. The evaluation was conducted on a total of 8,980 samples, with the average metric value stabilizing at 0.99 for both the macro and weighted averages. The results of the random forest evaluation can be seen in Table 3.

The experimental results demonstrate that all three models—SVM, Random Forest, and Naive Bayes—are highly effective in detecting fake news. Nevertheless, the discrepancies in accuracy rates and other metrics offer invaluable insights into the relative strengths and weaknesses of each model. The following section presents an in-depth analysis of the performance of each model.

The performance of the SVM is as follows: The Support Vector Machine (SVM) model demonstrated the highest level of accuracy among the three models, with a perfect score of 100%. SVM employs a linear kernel to differentiate the data in the feature space with the greatest possible margin. The primary advantage of the SVM is its capacity to identify the optimal hyperplane for class separation, which enables this model to effectively handle data with numerous and intricate text features. In our dataset, the SVM's ability to distinguish between fake and real news exemplifies its proficiency in addressing challenging classification problems. This performance reflects the high accuracy of the SVM in processing and classifying the data, with no errors in the test data. The results of the model accuracy comparison can be seen in Figure 2.

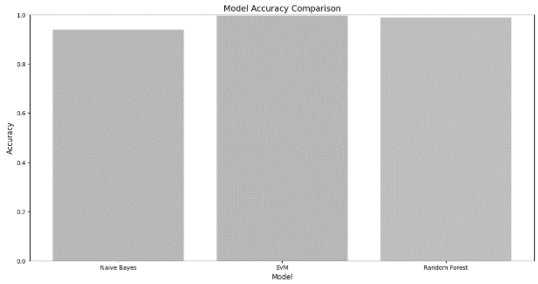

Figure 1. Model Accuracy Comparison

The performance of the Random Forest model is presented below. Furthermore, the Random Forest model demonstrated an impressive degree of accuracy, with a success rate of 99%. This model is an ensemble method that combines the results of numerous decision trees, thereby demonstrating an ability to handle data variability effectively. One advantage of the Random Forest model is its capacity to mitigate the risk of overfitting. This is achieved through the aggregation of results from multiple decision trees, each trained on a distinct subset of the data. This renders the Random Forest particularly resilient to fluctuations and noise within the data set, especially in the case of large and complex data sets. Although the accuracy of the Random Forest model is slightly inferior to that of the SVM, its capacity to process diverse and stable data sets makes it an optimal choice for the classification of fake news.

The performance of the Naive Bayes model is as follows: The Naive Bayes model demonstrated an accuracy of 94%, which, although commendable, is not as precise as that of SVM and Random Forest. One of the primary reasons for this is the independence assumption inherent to the Naive Bayes model, which posits that the features within the text data are mutually independent. In the context of complex and often interrelated text data, this assumption may not be entirely valid, which can affect classification accuracy. However, Naive Bayes has advantages in terms of computational speed and simplicity of the model. The model is highly efficient in terms of training and prediction time, and is straightforward to implement and interpret. This makes it an optimal choice for applications where speed and ease of implementation are of greater importance than absolute accuracy. The results of the model evaluation comparison can be seen in Figure 2.

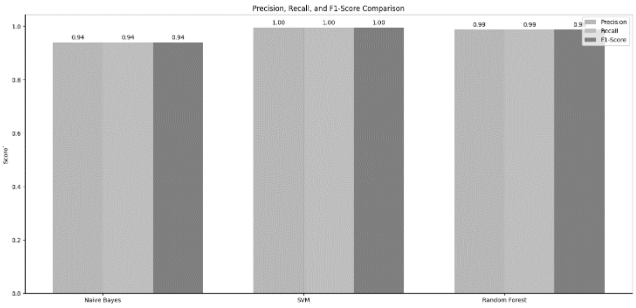

Figure 2. Comparison of Model Evaluation Results

The experimental results demonstrated that the SVM model exhibited the greatest efficacy in detecting fake news within this dataset, with the Random Forest and Naive Bayes models also demonstrating notable performance. However, the selection of the optimal model should consider factors beyond mere accuracy. Other considerations, such as computational speed, model interpretability, and the availability of computing resources, must also be taken into account. SVM, with its near-perfect accuracy, offers the best performance, but Random Forest and Naive Bayes also provide viable options with their own advantages. Therefore, the final model selection should be based on the specific needs of the application and the trade-offs that are accepted.

CONCLUSIONS

In this study, we evaluated the performance of three machine learning models—Naive Bayes, SVM, and Random Forest—in a fake news classification task. The experimental process entailed data preprocessing, feature extraction through the use of TF-IDF, model training, and performance evaluation through the application of metrics such as accuracy, precision, recall, and F1-score.

The experimental results demonstrated that the SVM model exhibited the highest level of performance, achieving a 100% accuracy rate. This was followed by the Random Forest model, which demonstrated a 99% accuracy rate, and the Naive Bayes model, which exhibited a 94% accuracy rate. The SVM demonstrated an exemplary capacity for identifying fake news, exhibiting no errors on the test data set. The Random Forest model also exhibited a near-perfect performance. The Naive Bayes model, although exhibiting a slight decline in performance compared to the other two models, still demonstrated a commendable level of efficacy and may be a suitable option for applications that require a straightforward and expedient model.

In conclusion, SVM is the optimal choice for the classification of fake news based on the results of this experiment, due to its optimal class separation capabilities. Additionally, Random Forest represents a robust alternative, particularly in instances where an ensemble model is sought to enhance accuracy and mitigate overfitting. Naive Bayes, despite exhibiting lower accuracy than the other two models, remains applicable in specific scenarios where speed and simplicity are paramount.

These findings offer valuable insights for researchers and practitioners in the selection of machine learning models for fake news detection, taking into account specific requirements and resource constraints. Further research can delve into the potential of larger and more diverse datasets, as well as the integration of other techniques, with the aim of enhancing model performance.

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