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Sentiment Analysis of Public Acceptance of Covid-19 Vaccines Types in Indonesia using Naïve Bayes, Support Vector Machine, and Long Short-Term Memory (LSTM)

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Abstract

The Covid-19 vaccination is a government program during the pandemic to create herd immunity so that people become more productive in their activities. In Indonesia, the Covid-19 vaccination campaign employs a range of vaccines and has sparked a range of responses from the public on social media, particularly Twitter. Users can tweet and communicate with one another on the social networking site Twitter. This study uses a Sentiment Analysis technique using the Nave Bayes (NB), Support Vector Machine (SVM), and Long Short-Term Memory (LSTM) algorithms to conduct a sentiment analysis of public acceptance of the type of Covid-19 vaccine used in Indonesia using Twitter data. Various types of vaccines in Indonesia include Sinovac, Vaksin Covid-19 Bio Farma, AstraZeneca, Pfizer, Moderna, Sinopharm, Novavax, Sputnik-V, Janssen, Convidencia, Zifivax, often confuse the public in determining the objectivity of this opinion. In addition, theoretically, this study also seeks to contrast the NB, SVM, and LSTM algorithms with experimental techniques to obtain the best algorithm model. The stages of the research involved gathering information based on Twitter user opinions about the type of Covid-19 vaccine on Twitter from January 2021 to January 2022. The researcher used Indonesian language tweet data with the keywords #vaksincorona, #vaksincovid19, #vaksinasi, #ayovaksin, #lawancovid19, and #vaksinindonesia. Before modelling, the pre-processing stage consists of case folding, tokenizing, filtering, stemming, and word weighting using TF-IDF. After that, model testing was carried out using Cross Validation with the Python programming language, and evaluation and validation of the test results using the Confusion Matrix. The results showed that the accuracy score of the SVM method for the best model was 84.89%, while for the Naïve Bayes and LSTM algorithms, they were 84.65% and 82.97%, respectively.

Keywords: sentiment analysis; public acceptance; covid-19 vaccine; naïve bayes; support vector machine; lstm.

1. Introduction

The SARS-CoV-2 virus has wreaked havoc on people all across the world since it first emerged in 2019. The virus causes a disease called Covid-19. The global population of this virus is quick. On March 11, 2020, the WHO declared the Covid-19 outbreak a global pandemic [1]. Then on January 22, 2022, the world's Covid-19 data recorded 347.172.997 cases of Covid-19, 5.603.940 deaths, and a recovery rate of 276.781.488 [2]. The government has undertaken some attempts to combat the Covid-19 epidemic. To slow the spread of Covid, the government enacts the Imposing Restrictions on Community Activities (PPKM) policy [3]. In addition, the government also launched the Covid-19 vaccination program to overcome the spread of the virus, build immunity so that it can deal with virus attacks (herd immunity), and reduce the death rate due to virus infection [4]. The Covid-19 vaccination campaign in Indonesia started on January 13, 2021, and the President of the Republic of Indonesia was the first to receive the vaccine [5]. The Covid-19 vaccination program in Indonesia has received both positive and negative feedback from the public, one of which is on social media, although people are increasingly aware of voluntarily participating in the Covid-19 vaccination program. Various types of vaccines in Indonesia, such as Sinovac, Vaksin Covid-19 Bio Farma, AstraZeneca, Pfizer, Moderna, Sinopharm, Novavax, Sputnik-V, Janssen, Convidencia, Zifivax, often make the public confused about determining the objectivity of this opinion. objectivity of this opinion. The existence of social media is a new phenomenon in the world of ICT because it can attract internet users to interact with each other. Indonesia has 160 million people actively using social media [6]. Social media such as Twitter has changed its function to become a very adequate means

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for the public to express their opinions on various matters. The topic of conversation for cyberspace citizens often becomes a trending topic on Twitter when many people expressed their opinions on this topic, one such these is the debate in Indonesia over the benefits and drawbacks of the Covid-19 vaccination. Based on the viewpoints expressed on Twitter, the appropriate technique is needed to conduct a poll on public acceptance of the Covid-19 vaccine type used in Indonesia.

Sentiment analysis is a method for extracting information about positive neutral, or negative attitudes from text data [7]. The sentiment is the personal opinion of internet users to provide an assessment of something. The number of opinions expressed would certainly be difficult to determine the sentiment on the topics discussed. Sentiment analysis has the role of classifying text polarity based on sentiment. Sentiment analysis also shows expressions of sadness, joy, or anger [8]. For sentiment analysis, a variety of categorization methods have been utilized such as the Naïve Bayes algorithm which can classify sentiment data on Covid-19 vaccination based on Twitter data in Indonesia based on probabilistic reasoning which produces a model with better and more stable performance with an average F1-score of 0.63 and a deviation standard 0.02 [9]. Several similar studies also used the SVM algorithm as a sentiment analysis classifier from Indonesian-language Twitter data related to regional head elections with an accuracy value of 75.50% [10], while English-language Twitter data employed the Support Vector Machine, which received an accuracy of 90.47% [11] and 84.78% [12]. Support Vector Machine is used to make good predictions in the case of sentiment analysis classification [13]. In addition to the machine learning approach, deep learning works by studying data features to generate sophisticated predictions and has been popularly used in sentiment analysis in recent years [14]. Utilization of deep learning using the LSTM algorithm for sentiment analysis regarding PPKM policies during the Covid-19 pandemic in Indonesia obtained very good accuracy reaching 92.59% [15].

In this study, the authors are interested in conducting an acceptance survey regarding public sentiment toward the use of this type of Covid-19 vaccine. Out of the 16 platforms used in 2021, Twitter was the author's choice because it is one of the most popular social networking platforms [16]. Contributions from this research include 1) the writers conducted a public acceptance sentiment analysis using a sentiment analysis approach to the type of Covid-19 vaccine used in Indonesia, 2) In this study, the author uses the latest and most relevant Indonesian-language tweets regarding public opinion about the use of the Covid-19 vaccine in Indonesia, 3) the writers compared the three algorithms including Naïve Bayes, SVM, and LSTM to analyze and classify the next tweet data.

2. Research Methods

An experimental research method was used for this research. The research began by collecting a dataset of public opinion on Twitter. Then pre-processing was carried out to clean the data. After the pre-processing activities are completed, the data is divided into training and test data. The modeling uses three algorithms to compare: Naive Bayes, SVM, and LSTM algorithms.

2.1 Research Design

This research is designed to mine public opinion from Twitter by applying and comparing several algorithms including Naïve Bayes, SVM, and LSTM. The algorithm is applied and compared to obtain information related to a sentiment analysis of public acceptance of variety of vaccines for Covid-19 in Indonesia. There are many positive and negative opinions expressed by the public so that it can be seen which type of vaccine is more accepted by the public.

2.2 Research Stages

Figure 1 shows the steps taken during this study's execution.

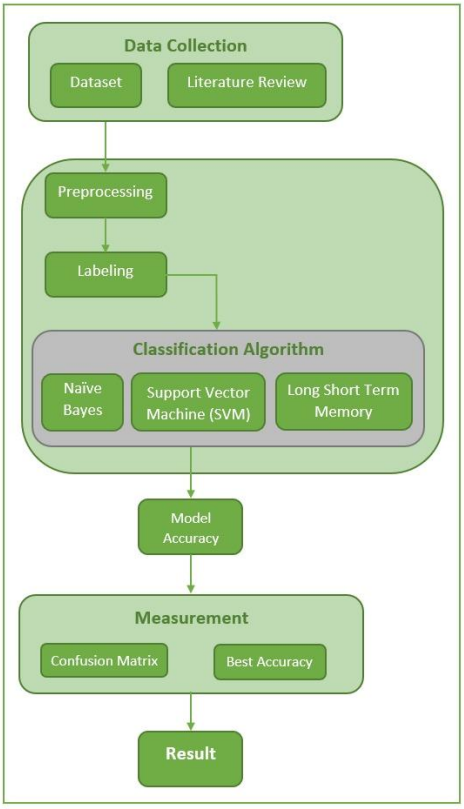

Figure 1. Research Stages

This research is motivated by the various types of Covid-19 vaccines used in Indonesia, where people give pros and cons responses on social media. Community environmental targets that are considered relevant in this study include Twitter users, vaccine recipients, vaccine administration or distribution

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managers, medical personnel, and the government, in this case, the Indonesian Ministry of Health. Based on Figure 1, it can be described that the following steps of the research were completed:

Collection Data: Data was collected using the Scrapping technique in the Python programming language using the Selenium and Twint libraries. The dataset used comes from Twitter user tweets on the site https://www.twitter.com regarding the public acceptance of the Covid-19 vaccine type in Indonesia. Data were collected from January 2021 to January 2022. The data used were tweets in Indonesian with the keywords #vaksincorona, #vaksincovid19, #vaksinasi, #ayovaksin, #lawancovid19, and #vaksinindonesia. This study used 2,000 public opinion data about the types of vaccines in Indonesia, where the data was taken from tweets on Twitter. As a support, researchers also conduct literature studies by reading and studying books, journals, and information related to the research topic.

Pre-processing: Datasets taken from Twitter cannot be used immediately. The dataset is internal communication data in which there are writing errors, slang words, or unnecessary things such as URLs, stopwords, or emojis. Preliminary data processing needs to be done before entering the classification process to obtain good data. The Python programming language, especially using the Pandas library, is used as a data cleaning process. After preprocessing, the data that can be further processed is 1910. The data is divided into 70% training data and 30% testing data, with the division of 1337 training data and 573 testing data. The pre-processing techniques used in this study include: Case Folding (The case folding procedure converts all of the text's letters to lowercase [17] so that the sentence becomes more structured.); Stemming (Process stemming is done to reduce vocabulary so that it focuses more on the meaning of words from data. The stemming process is done by removing the prefix or suffix of a word to produce a basic word [18].); Tokenizing (Tokenizing is the process of splitting a sentence into words, terms, symbols, or elements that have different meanings called tokens [19].); Stopword Removal (Stopword removal functions remove unnecessary words and choose words that can represent documents [20].); Word Weighting with TF-IDF (The Term Frequency-Inverse Document Frequency (TF-IDF) method is the next pre-processing step by using word weighting. The relationship of each word in a document is given a weight using the TF-IDF Method, as well as to calculate the weight of the word. Two concepts that make up the TF-IDF approach include the frequency of occurrence of a word in a document and its reverse and the frequency of documents containing the word in question [21].

Labelling: This research uses a supervised learning algorithm where each data must have a label as a target or class for classification. The information used in this investigation is unlabeled information. So that the data may be further processed using the present method, it needs to be labelled. After good data is obtained and ready to be processed, the data is labelled positive and negative using automatic labeling techniques. The process of labeling data into positive and negative labels uses a library in Python, namely the Valence Aware Dictionary And Sentiment Reasoner (VADER) [22].

Modelling with Classification Technique: After labelling the data, the next step is to perform data modelling with classification techniques. The classification algorithms used are Naïve Bayes, SVM, and LSTM. This algorithm has been widely and popularly used in the field of sentiment analysis and is proven to have good accuracy.

The Naïve Bayes Algorithm is one of the popular algorithms in sentiment analysis classification. The Naïve Bayes algorithm works on a probabilistic basis. The supervised learning algorithm includes the Naïve Bayes method with the naive assumption that each pair of class variables is independent. Naïve Bayer implements the Bayers theorem [7]. The Naïve Bayes method is the simplest classic text classification method [23]. With its simple algorithm, Naïve Bayes only requires small training data and is reliable for irrelevant attributes [24], as shown in equation 1.

$$P\ (A|B) = P(B|A)P(A)/P(B) \quad (1)$$

The probability that A will occur given the evidence that B has occurred (superior probability) is shown by $P\ (A|B)$. $P\ (B|A)$ is the probability that B will occur, given the evidence that A has occurred. $P(A)$ is the probability that A occurs. $P(B)$ is the probability that B occurs.

SVM is part of the supervised learning method. SVM can be used in case classification, regression, and to detect outliers [25]. SVM is a kernel technique that is very useful in solving complex problems [26]. SVM has been widely used in sentiment analysis cases and is proven to provide high-accuracy results [11][27][28].

A modification of the Recurrent Neural Network (RNN) algorithm is the Long-Short Term Memory (LSTM) algorithm which generally consists of a cell input gate, output gate, and forget gate [19]. In LSTM, there may be an unknown scarcity of duration between important events in a time series, so LSTM is the right choice for classifying, processing, and making predictions based on time series data [29].

The gate structure in the LSTM can be explained as follows [30]:

Forgetting some information that is not appropriate and is no longer needed by a system is a function of the

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Forget Gate. Input Gate serves to enter important information that will be used to support data accuracy, and through the Forget Gate, the previously selected information will be added. Output Gate serves to produce complete and actual data information.

Evaluation and Validation of Results for Measurements: Evaluation serves to measure, assess, and evaluate the success of the model. The evaluation carried out in this study used the Confusion Matrix to evaluate the value of accuracy, precision, recall, and F-1. Validation is done to validate the model based on existing data. The validation carried out in this study uses Cross-Validation.

3. Results and Discussions

The outcome and discussion of this study are packaged into several sub-sections, including:

3.1. Data Collection

Based on the Scrapping technique on Twitter using the Python programming language, a dataset relating to public opinion about the types of vaccines in Indonesia from Twitter was successfully obtained as many as 2,000 tweet data obtained from January 2021 to January 2022. Before the classification modelling process is carried out, pre-processing of the data is to be used. The pre-processing stages carried out include case folding, tokenizing, stopword removal, stemming, and the word weighting stage using TF-IDF.

3.2. Pre-processing

In the data cleaning process, several jobs were carried out, including case folding, stemming, tokenizing, stopword removal, and the word weighting stage using TF-IDF. The results of each pre-processing stage are as follows:

Case Folding: Tweet data before the case folding process is carried out, as shown in Figure 2. Based on the picture, it can be seen that in writing tweets still use a mixture of lowercase and uppercase letters. The case folding process will change all letters in the text to all lowercase so that sentences become more structured. The case folding process is done using the case fold () class from the Natural Language Toolkit (NLTK) library in Python. The results of the case folding process can be seen in Figure 3.

```
In [2]: tweet = 'PALING SULIT berdebat itu dengan anggota
        print(tweet)

PALING SULIT berdebat itu dengan anggota keluarg
a sendiri. ANTI vaksinasi VS Vaksinasi. Alhamdul
illah orangtua hanya bingung &amp;amp; mengikuti atu
ran tempat kerja ajah~
```

Figure 2. Tweet Data Before Case Folding Process

```
In [3]: tweet = tweet.lower()
        print(tweet)

paling sulit berdebat itu dengan anggota keluarg
a sendiri. anti vaksinasi vs vaksinasi. alhamdul
illah orangtua hanya bingung &amp;amp; mengikuti atu
ran tempat kerja ajah~
```

Figure 3. Tweet Data After Case Folding Process

Stemming: The Python Sastrawi library's stemmer function is used to perform the stemming operation. The Literary Python Library is a library that is used to produce basic words from affixes in Indonesian. The results of the case folding process can be seen in Figure 4 through Figure 6.

```
In [3]: # stemming process
        kataDasar = 'terutama'

In [4]: output   = stemmer.stem(kataDasar)

In [5]: print(output)

        utama
```

Figure 4. General Syntax of Stemming Process

```
In [3]: print(tweet)

paling sulit berdebat itu dengan anggota keluarg
a sendiri. anti vaksinasi vs vaksinasi. alhamdul
illah orangtua hanya bingung &amp;amp; mengikuti atu
ran tempat kerja ajah~
```

Figure 5. Tweet Data Before Stemming Process

```
In [6]: tweet = stemmer.stem(tweet)
        print(tweet)

paling sulit debat itu dengan anggota keluarga s
endiri anti vaksinasi vs vaksinasi alhamdulillah
orangtua hanya bingung amp ikut atur tempat kerj
a ajah
```

Figure 6. Tweet Data After Stemming Process

Tokenization: The results of the tokenization process in this study used the NLTK Python library tokenize function. Figure 7 is an example of using tokenizing.

```
In [6]: print(tweet)

paling sulit debat itu dengan anggota keluarga s
endiri anti vaksinasi vs vaksinasi alhamdulillah
orangtua hanya bingung amp ikut atur tempat kerj
a ajah

In [10]: tweet = nltk.tokenize.word_tokenize(tweet)
         print(tweet)

['paling', 'sulit', 'debat', 'itu', 'dengan', 'a
nggota', 'keluarga', 'sendiri', 'anti', 'vaksina
si', 'vs', 'vaksinasi', 'alhamdulillah', 'orangt
ua', 'hanya', 'bingung', 'amp', 'ikut', 'atur',
'tempat', 'kerja', 'ajah']
```

Figure 7. Tweet Data in the Process Before and After Tokenization

Stopword Removal: The results of the stopword function was used in this study's stopword elimination technique. Figure 8 is an example of using stopword removal.

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```
In [10]: print(tweet)

['paling', 'sulit', 'debat', 'itu', 'dengan', 'a
nggota', 'keluarga', 'sendiri', 'anti', 'vaksina
si', 'vs', 'vaksinasi', 'alhamdulillah', 'orangt
ua', 'hanya', 'bingung', 'amp', 'ikut', 'atur',
'tempat', 'kerja', 'ajah']

In [11]: list_stopwords = set(stopwords.words('indonesian'
         tweet_without_stopword = [word for word in tweet

         print(tweet_without_stopword)

['sulit', 'debat', 'anggota', 'keluarga', 'ant
i', 'vaksinasi', 'vs', 'vaksinasi', 'alhamdulill
ah', 'orangtua', 'bingung', 'amp', 'atur', 'kerj
a', 'ajah']
```

Figure 8. Tweet Data in the Stopword Removal Process

Word weighting using Term Frequency –Inverse Document Frequency (TF-IDF): The resulting TF-IDF calculation results can be seen in Figure 9.

term	TF	TF-IDF
masyarakat	0.07692307692307693	0.22766717105679143
indonesia	0.07692307692307693	0.1950660751509175
disuntik	0.07692307692307693	0.22766717105679143
vaksin	0.15384615384615385	0.1187309290868281
covid	0.07692307692307693	0.0823785760402249
dosis	0.07692307692307693	0.226606146277381
ketiga	0.07692307692307693	0.36549482253587257
meningkat	0.07692307692307693	0.45000346012572723
total	0.07692307692307693	0.3876242127244711
orang	0.07692307692307693	0.2343603539021476
menerima	0.07692307692307693	0.27682716792522755
booster	0.07692307692307693	0.24429971786214805

Figure 9. TF-IDF Calculation Results

1389 data can be processed further after pre-processing. The data are split into 972 training data and 417 testing data, or 70.00% training data and 30.00% testing data.

3.3. Labeling

VADER is a sentiment analysis tool in Python that functions to automatically label text data [31], but VADER cannot be directly applied to the data used in this study. The VADER sentiment library can only be used in English sentences, so the data must first be translated into English before being processed with VADER. The results can be seen in Figure 10 and 11.

```
In [17]: Tweet = "paling sulit debat itu dengan anggota",
                 "keluarga sendiri anti vaksinasi vs ",
                 "vaksinasi alhamdulillah orangtua hanya",
                 "bingung amp ikut atur tempat kerja ajah"
         Translate = ts.google(Tweet)
         print(Translate)

         The most difficult debate with the family member
         s themselves anti -vaccination vs. vaccination A
         lhamdulillah parents are just confused AMP joini
         ng the workplace Ajah
```

Figure 10. Tweet Data Translation Process

	Tweet	terjemahan	label
0	Berbagai informasi mengenai COVID-19 tersedia ...	Various information about Covid is available a...	neutral
1	Kasus Covid-19 Diprediksi Melonjak Pengamat: V...	Covid cases are predicted to surge in the key ...	negative
2	Gencarkan terus vaksinasi booster #LawanCovid1...	continue to keep the booster vaccination	positive

Figure 11. Tweet Data Labeling Process

In this study, two classes were used including the positive class and the negative class. Based on the labeling results, 216 data were obtained with negative labels, and 1173 data with positive labels as shown in Figure 12.

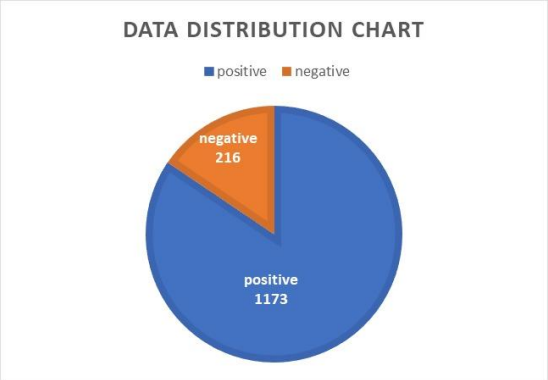

Figure 12. Chart of Data Distribution

3.4. Modelling with Classification Techniques

In this study, every data processing process, including preprocessing, data sharing, modeling with classification techniques to testing and measuring accuracy, was carried out using the Python programming language. After the data is ready to be processed, preparation for modeling is carried out, such as determining the data column and target column, dividing the data into training data and testing data, and preparing data vectors for classification process. The results can be seen in Figure13, 14 and 15.

```
[6] #menentukan kolom data dan target
    x = data['stopwords']
    y = data['label1']
```

Figure 13. Determination of Data Column and Target Column

```
[7] #split data
    X_train, X_test, y_train, y_test = train_test_split(x, y, test_size=0.3)
```

Figure 14. Data Training and Testing Spliting

```
[8] #vektorisasi
    vectoriser = TfidfVectorizer(ngram_range=(1,2), max_features=500000)
    vectoriser.fit(X_train)
    print('No. of feature_words: ', len(vectoriser.get_feature_names_out()))

    No. of feature_words:  9084
```

Figure 15. Data Vectorization

Naïve Bayes Algorithm: Data modelling by applying the Naïve Bayes method to the Python language uses the Multinomial Naïve Bayes method found in the Naïve Bayes algorithm from the sklearn library as shown in Figure 16.

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```
[11] from sklearn.naive_bayes import MultinomialNB
     mnb = MultinomialNB().fit(X_train, y_train)
     y_pred = mnb.predict(X_test)
     print('Multinomial NB Accuracy: ',format(accuracy_score(y_test, y_pred)))
     print('')
     model_Evaluate(mnb)
     y_pred = mnb.predict(X_test)
```

Figure 16. Modeling with the Naïve Bayes Algorithm

SVM Algorithm: For modelling with the SVM technique, the method used is Linear SVC. The Linear SVC method is contained within the SVM algorithm in the sklearn library. The result of modeling with the support vector machine algorithm can be seen in Figure 17.

```
[12] #New Model SVM
     SVCmodel = LinearSVC()
     SVCmodel.fit(X_train, y_train)
     print ('Akurasi Model Klasifikasi SVM : ',format(SVCmodel.score(X_test,y_test)))
     print('')
     model_Evaluate(SVCmodel)
     y_pred2 = SVCmodel.predict(X_test)
```

Figure 17. Modeling with the Support Vector Machine Algorithm

LSTM Algorithm: While modelling with the Long-Short Term Memory (LSTM) technique, is made using a sequential model. The sequential method is one of the methods found in the Keras module from the TensorFlow library as shown in Figure 18.

```
[13] del=Sequential()
     del.add(Embedding(50000,output_dim=embedding_vector_features,input_length=sent_length))
     odel.add(LSTM(128, dropout=0.2, recurrent_dropout=0.2))
     del.add(LSTM(128,activation='relu',return_sequences=True))
     del.add(Dropout(0.2))
     del.add(LSTM(100,activation='relu'))
     del.add(Dropout(0.2))
     del.add(Dense(32,activation='relu'))
     del.add(Dropout(0.2))
     del.add(Dense(4,activation='softmax'))
     del.compile(loss='sparse_categorical_crossentropy',optimizer='adam',metrics=['accuracy'])

     int(model.summary())
```

Figure 18. Modeling with the Long-Short-Term Memory (LSTM) Algorithm

3.4. Testing and Measurement Accuracy

Classification results are validated using Cross Validation. In the final stage of research, the accuracy of Naïve Bayes, SVM and LSTM using the Confusion Matrix will be measured. A total of 2000 data were collected in this study. After going through the data cleaning process through Case Folding, Stemming, Tokenizing, and Stopword Removal, the remaining 1389 data can be tested with the Naïve Bayes, SVM, and LSTM algorithms.

Data processing in this study, from pre-processing, and modeling, to measuring accuracy, was carried out using the Python language. The results of using the three selected algorithms can be seen in the following explanation.

The use of the Naïve Bayes algorithm in this study provides results that can be seen in Figure 19. Figure 19 shows that the application of the Naïve Bayes algorithm to public sentiment data about the Covid-19 vaccine produces an accuracy of 84.65%.

```
Multinomial NB Accuracy:  0.8465227817745803

              precision    recall  f1-score   support

    negative       1.00      0.02      0.03        65
    positive       0.85      1.00      0.92       352

   micro avg       0.85      0.85      0.85       417
   macro avg       0.92      0.51      0.47       417
weighted avg       0.87      0.85      0.78       417
```

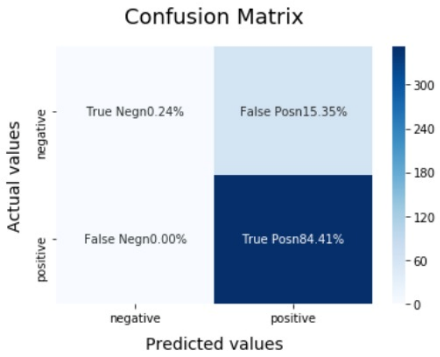

Figure 19. Confusion Matrix of Naïve Bayes Algorithm

Support Vector Machine Algorithm: The results of implementing the SVM algorithm in this study can be seen in Figure 20.

```
Akurasi Model Klasifikasi SVM :  0.8489208633093526

              precision    recall  f1-score   support

    negative       0.58      0.11      0.18        65
    positive       0.86      0.99      0.92       352

   micro avg       0.85      0.85      0.85       417
   macro avg       0.72      0.55      0.55       417
weighted avg       0.81      0.85      0.80       417
```

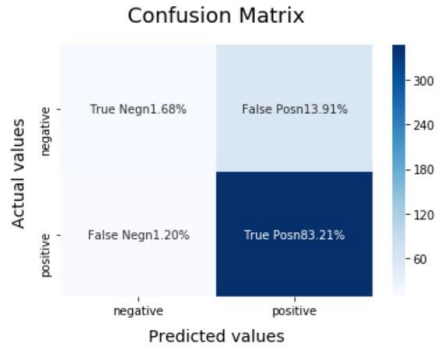

Figure 20. Confusion Matrix of Support Vector Machine (SVM) Algorithm

In Figure 20, it is apparent that the application of the SVM algorithm to public sentiment data about the Covid-19 vaccine produces an accuracy of 84.89%.

LSTM Algorithm: The results of applying the Long Short-Term Memory (LSTM) algorithm shown in Figure 21.

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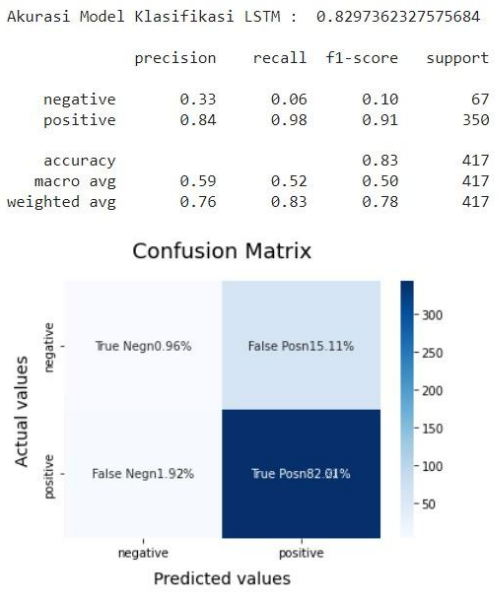

Figure 21. Confusion Matrix of Long Short-Term Memory (LSTM)Algorithm

In Figure 21 an accuracy of 82.97% was obtained when the Long Short-Term Memory (LSTM) algorithm was used to data on public opinion of the Covid-19 vaccination.

3.5. Testing and Measurement Accuracy

The results of the three methods were evaluated based on accuracy, precision, recall, and F-1. Based on the results of research using the Naïve Bayes, Support Vector Machine (SVM) and Long Short-Term Memory (LSTM) algorithms, the most accurate algorithm is the Support Vector Machine (SVM), with an accuracy of 84.89%, 85.00% precision, 100.00% recall, and 92.00% F-1. The Naïve Bayes algorithm is in second place with an accuracy of 84.65%, 86.00% precision, 99.00% recall, and 92.00% F-1, and Long Short-Term Memory (LSTM) is in third place with an accuracy of 82.97%, precision of 84.00%, recall of 89.00%, and F-1 of 91.00%. The results of the comparison between the Naïve Bayes, Support Vector Machine (SVM), and Long Short-Term Memory (LSTM) methods are in Table 1 and visualize the graphs in Figure 22 through Figure 25.

Table 1. Comparison of Classification Results

Algo-rithm	Accuracy (%)	Precision (%)	Recalls (%)	F-1 (%)
SVM	84.89	85.00	100.00	92.00
Algo-rithm	Accuracy (%)	Precision (%)	Recalls (%)	F-1 (%)
NB	84.65	86.00	99.00	92.00
LSTM	82.97	84.00	89.00	91.00

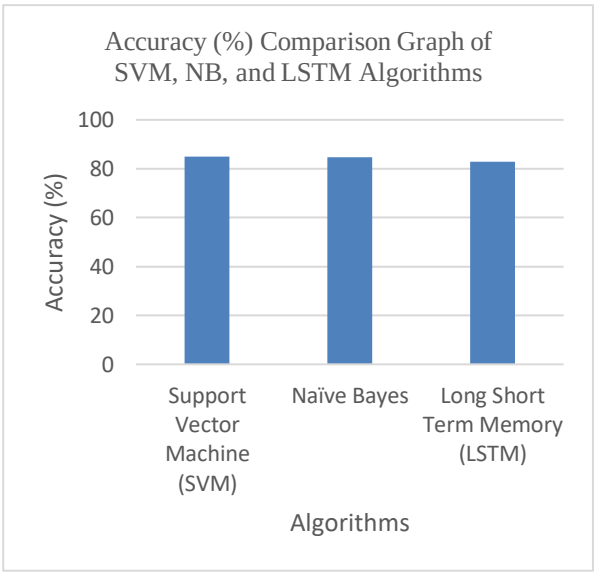

Figure 22. Accuracy (%) Comparison Graph of SVM, NB, and LSTM Algorithms

Figure 22 can be seen that the accuracy results of the three algorithms show a good accuracy value. Even though the Support Vector Machine (SVM) algorithm produces the highest accuracy, the difference in accuracy value with the other two algorithms is not too far. This shows that the three algorithms perform well in classifying text.

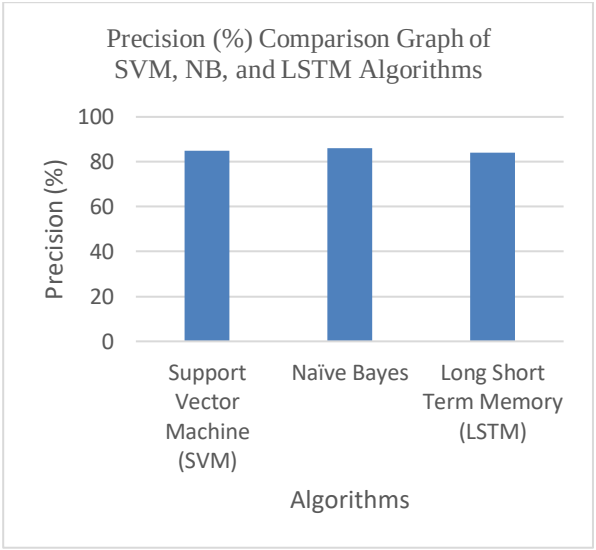

Figure 23. Precision (%) Comparison Graph of SVM, NB, and LSTM Algorithms

Figure 23 shows the Naïve Bayes algorithm has a high precision of 86.00%. This means that the Naïve Bayes algorithm succeeded in correctly predicting 86.00% of the data that was predicted to be positive. This result is more than the accuracy generated by the Long Short-Term Memory (LSTM) method, which is 84.00%, and the Support Vector Machine (SVM) which is 85.00%.

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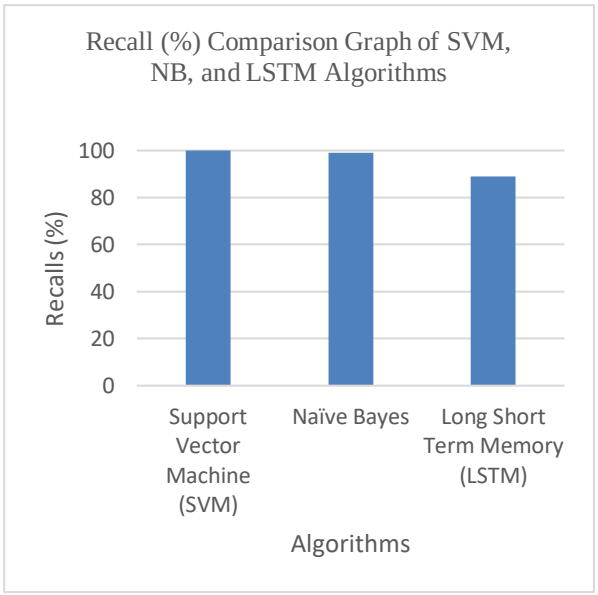

Figure 24. Recall (%) Comparison Graph of SVM, NB, and LSTM Algorithms

Figure 24 displays the recall outcomes for the three algorithms utilized in this study, with the Support Vector Machine (SVM) algorithm having the greatest recall value (100.00%), followed by the Naïve Bayes algorithm at 99.00%, and the Long Short-Term Memory algorithm at 89.00%. Recall shows how much the algorithm succeeds in predicting data that is labeled positive.

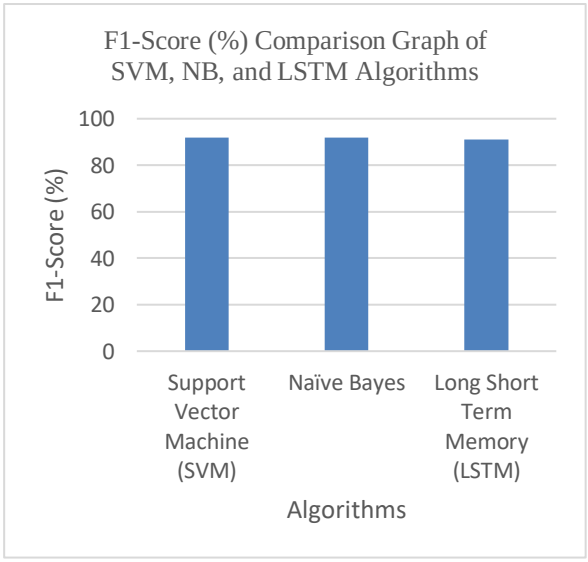

Figure 25. F1-Score (%) Comparison Graph of SVM, NB, and LSTM Algorithms

Figure 25, both Naïve Bayes, SVM and LSTM show F1-Score values that are not much different. Naïve Bayes and Support Vector Machine both have an F1-Score of 92.00%, while the F1-Score of Long Short-Term Memory is 91.00%.

The Decision Tree, Gradient Boost, SVM, LSTM-word embedding, BiLSTM-word embedding, 1D-CNN-word embedding, and TCN-word embedding algorithms in [32] used datasets sourced from Bangladesh netizen tweets about Covid-19, resulting in an accuracy of 52.00%, 60.47%, 63.72%, 86.05%, 87.44%, 85.12%, and 86.51%. Another study using the Naïve Bayes method and RNN using a tweet dataset about Covid-19 in Indonesian obtained accuracy of 97.77% and 80.00% [17]. Then, in research [33], sentiment analysis was also carried out on the Covid-19 dataset using Arabic tweet data using the Logistic Regression algorithm, Random Forest, Support Vector Classifier, Gaussian Naïve Bayes, Extra Tree Classifier, Long Short-Term Memory (LSTM), Convolutional Neural Network (CNN), Multilayer Perceptron (MLP), successively produce accuracy of 82.00%, 76.00%, 82.00%, 57.00%, 76.00%, 82.00%, 81.00%, and 82.00%. Similar research has also been conducted in [34], using the English language Covid-19 tweet dataset using the CNN, LSTM, and CNN-LSTM algorithms. All three produce accuracy values of 81.00%, 82.00%, and 83.00%. A comparison of accuracy between methods is shown in Table 2.

Table 2. Comparison of Accuracy Between Methods

Algorithm	The Language Used in the Covid-19 Dataset	Accuracy (%)
Decision Tree [32]	English	52.00%
Gradien Boost [32]	English	60.47%
SVM [32]	English	63.72%
LSTM-WE [32]	English	86.05%
BiLSTM-WE [32]	English	87.44%
1D-CNN-WE [32]	English	85.12%
TCN-WE [32]	English	86.15%
Naïve Bayes [17]	Indonesian	97.77%
RNN [17]	Indonesian	80.00%
Logistic Regression [33]	Arabic	82.00%
Random Forest [33]	Arabic	76.00%
SVC [33]	Arabic	82.00%
Gaussian Naïve Bayes [33]	Arabic	57.00%
Extra Tree Classifier [33]	Arabic	76.00%
LSTM [33]	Arabic	82.00%
CNN [33]	Arabic	81.00%
Multilayer Perceptron (MLP) [33]	Arabic	82.00%
CNN [34]	English	81.00%
LSTM [34]	English	82.00%
CNN-LSTM [34]	English	83.00%
SVM	Indonesian	84.89%
NB	Indonesian	84.65%
LSTM	Indonesian	82.97%

Based on the accuracy obtained from similar studies, namely both conducting sentiment analysis of public acceptance of this type of Covid-19 vaccine, the classification method used in this study shows relatively close accuracy results. From the simulation results, the implementation of the SVM, Naïve Bayes, and LSTM methods using the TF-IDF technique for sentiment analysis of the COVID-19 vaccine was able to make improvements as indicated by higher accuracy values. The accuracy value of the SVM algorithm is 84.89%;

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this is better than research [32], which only obtained an accuracy value of 63.72% using English. Furthermore, the accuracy value of the Naïve Bayes algorithm received an accuracy value of 84.65%, still superior to previous research using datasets with the same language, namely Indonesian, reaching 97.77%. Based on the results of the studies and analyses that have been carried out, the dataset in the previous research was more numerous, getting 5000 tweets, whereas, in this study, only 2000 tweets were used. Likewise, for the LSTM algorithm in this study, the accuracy value reached 82.97%, still superior to research [32], which obtained an accuracy of up to 86.05% using English datasets. However, it is still better than research [33]-[34], with an accuracy value of both being 82.00% using Arabic and English datasets.

3.6. Word cloud that Shows Public Acceptability of the Type of Vaccine Used in Indonesia

Word cloud is used to visualize discourse analysis using images from text data. In this study, public acceptance of the types of vaccines used in Indonesia, both positively and negatively, is displayed in the word cloud. The word cloud display regarding the positive public acceptance of the type of vaccine used is shown in Figure 26.

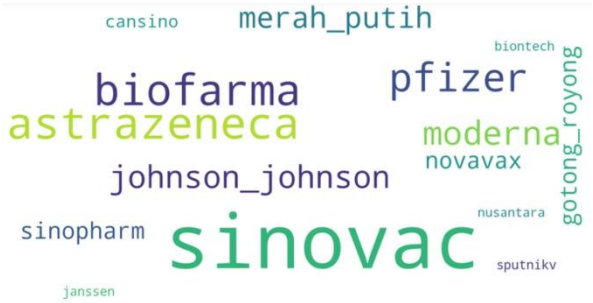

Figure 26. Wordcloud Related to Positive Public Acceptance of the Types of Vaccines Used in Indonesia

Based on Figure 26, the types of vaccines that have received many positive public responses are Sinovac, AstraZeneca, Biofarma, and Pfizer. Sinovac is the most common type of vaccine that has received a positive response from the public in Indonesia. Some analysis researchers obtained from public opinion data on Twitter stated that Sinovac received a positive response because most people had used it, and it had mild effects. State officials, including the president, widely used it. The results of this analysis are shown in the analysis graph of the public's positive response to the type of Sinovac vaccine based on the wordcloud in Figure 27.

Furthermore, the researchers also analyzed the types of vaccines that received a negative response from the public. The results of this analysis are displayed in word cloud in Figure 28.

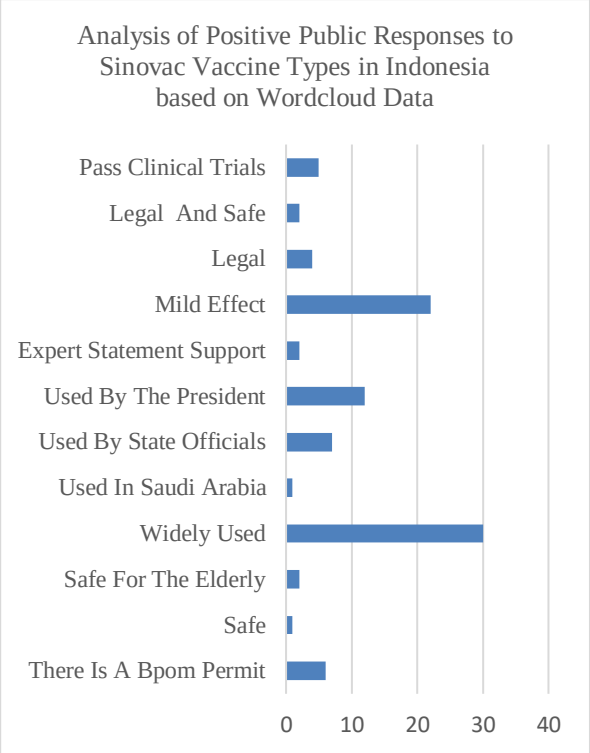

Figure 27. Graph of Analysis of Public's Positive Response to The Type of Sinovac Vaccine in Indonesia based on Word cloud Data

Figure 28. Wordcloud Related to Negative Public Acceptance of the Types of Vaccines Used in Indonesia

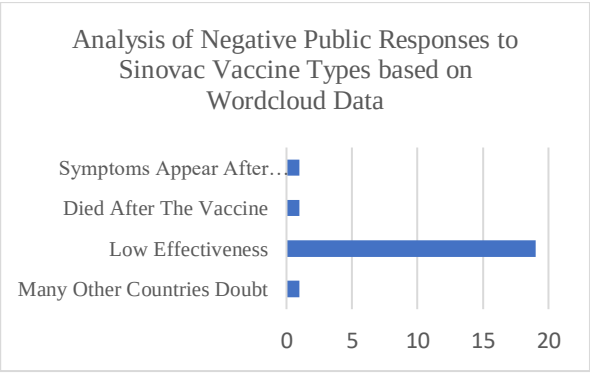

Figure 29. Graph of Analysis of Public's Negative Response to The Type of Sinovac Vaccine in Indonesia based on Wordcloud Data

Based on Figure 28, the types of vaccines that have received many negative public responses are Sinovac, AstraZeneca, and Pfizer. Something is interesting from the analysis obtained. The Sinovac vaccine type is the type of vaccine that gets the most responses for both positive and negative responses.

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Based on the data that we analyzed, several things stated that the Sinovac vaccine type received a negative response from the opinion of the Indonesian public on Twitter due to several opinions such as low effectiveness, many other countries doubted it, some people died after using it, and the appearance of symptoms after the vaccine. The results of this analysis the researchers display on the graph in Figure 29.

4. Conclusion

The application of the SVM, Naïve Bayes, and LSTM algorithms to the sentiment analysis of public acceptance of Covid-19 Vaccines types in Indonesia shows that the SVM algorithm produces a value with the highest 84.89% accuracy, 85.00% precision, 100.00% recall, and 92.00% F-1, compared to Naïve Bayes and LSTM with accuracy values of 84.65% and 82.97%. Based on wordcloud data, the type of Sinovac vaccine has received the most positive and negative responses from the Indonesian people based on a survey conducted from Twitter data. Some of the analyzes researchers obtained stated that Sinovac received a positive response because many people used it, and the effect was mild. In addition, state officials, including the president, use it a lot. The Sinovac vaccine also received the most negative responses from Indonesian public opinion on Twitter because of several views such as low effectiveness, many other countries doubted it, several people died after using it, and symptoms appeared after the vaccine. In future research, optimization can be carried out at the pre-processing stage or analysis related to parameter settings, as well as the type of algorithm used (for example, the Bernoulli, Gaussian, or Multinomial type in the Naïve Bayes algorithm or the kernel type in the SVM algorithm) so that they can produce accuracy, precision values, recall, and F-1 is better than this study. The use of multiple languages will also be engaging in the case of sentiment analysis because the use of different languages will undoubtedly affect the handling related to the pre-processing used and, of course, affect the resulting modeling results.

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