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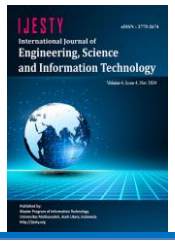

Sentiment Analysis of User Reviews on BSI Mobile and Action Mobile Applications on the Google Play Store Using Multinomial Naive Bayes Algorithm

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Abstract

Mobile banking services are designed to facilitate customer transactions. Bank Syariah Indonesia (BSI) and Bank Aceh also provide these online services through their respective applications, BSI Mobile and Action Mobile. The mobile banking apps aim to simplify customer transactions, which can be conducted remotely via several features, from transfers, payments, and purchases to zakat payments, by simply connecting to the internet. Therefore, this research aims to classify the sentiment of user reviews for BSI Mobile and Action Mobile applications on Google Play Store to understand the users' experiences. The Multinomial Naïve Bayes algorithm is used in this study, where the algorithm analyzes and classifies the user reviews into positive and negative sentiment categories. The study involves several stages, such as text preprocessing, sentiment visualization, splitting the data into an 80:20 ratio for training and testing datasets, and training the model using the Multinomial Naïve Bayes algorithm. The results of this study show that the Multinomial Naïve Bayes algorithm performs well in analyzing user sentiment for BSI Mobile and Action Mobile, achieving an accuracy of 78.7%, precision of 76.5%, recall of 86.2%, and an F1-score of 80.6% for BSI Mobile, and an accuracy of 85.6%, precision of 75%, recall of 75%, and an F1-score of 75% for Action Mobile. Additionally, the sentiment classification results reveal that 52.8% of BSI Mobile user reviews are positive and 47.2% are negative, while for Action Mobile, 35.1% are positive and 64.9% are negative. For BSI Mobile, 21,497 reviews express a positive sentiment with dominant keywords such as "updated," "good," "balance," "transaction," and "thank." Meanwhile, for Action Mobile, 274 reviews express a negative sentiment with dominant keywords such as "transaction," "application," "network," "register," "please," and "update."

Keywords: *Analysis, Sentiment, BSI Mobile, Action Mobile, Multinomial Naive Bayes.*

1. Introduction

The rapid development of digital technology has significantly reshaped the landscape of the banking industry. The adoption of digital technology in the banking sector has spurred various innovations, including digital banking services. Digital transformation in the banking sector has enabled customers to conduct financial transactions more flexibly and efficiently through multiple devices, especially smartphones. One manifestation of this digital transformation is the increasing popularity of mobile banking services [1].

Bank Syariah Indonesia (BSI) and Bank Aceh, two prominent banking institutions in Indonesia, have responded to this trend by launching their respective mobile banking applications, BSI Mobile and Action Mobile. The growth in the user base of these two applications indicates the high public interest in more practical and accessible digital banking services. However, with the increasing number of users, both banks need to evaluate the quality of their services periodically. To improve service quality, banks must optimize the use of technology, one of which is through the development of mobile banking applications [2].

To understand the level of user satisfaction with the mobile banking services provided by BSI and Bank Aceh, an effective method is needed to analyze the text data generated by users. As a branch of text mining, sentiment analysis offers an appropriate solution to

measure user reviews' positive and negative sentiments. Sentiment analysis aims to classify text documents that express opinions or views, allowing one to discern the attitudes or feelings of individuals toward a given topic [3]. Thus, sentiment analysis can be used to identify areas of improvement in mobile banking services and to assess the success of marketing strategies implemented by the bank.

One popular algorithm used in sentiment analysis is the Multinomial Naive Bayes algorithm. This algorithm effectively classifies text based on word frequency within a document [4]. The Multinomial Naive Bayes algorithm is an appropriate choice for sentiment analysis as it can find the highest probability of a sentiment class in the text [5]. Previous studies, such as those conducted by Eka Purwiantono & Aditya in 2020 and Aulia Rahman et al. in 2023, have demonstrated the effectiveness of this algorithm in classifying sentiment in various domains, including social media and customer services [6][5].

In the context of this study, the Multinomial Naive Bayes algorithm will be used to analyze user sentiment toward the BSI Mobile and Action Mobile applications based on reviews from the Google Play Store. By analyzing thousands of user reviews, this study aims to provide a comprehensive overview of the strengths and weaknesses of both applications. The results of the sentiment analysis are expected to provide valuable input for both banks in their efforts to improve the quality of their mobile banking services, thereby better meeting the expectations and needs of their customers.

The urgency of this research arises from the growing need for reliable and high-quality digital banking services. Mobile banking services are crucial to customer satisfaction and loyalty in this fast-paced digital era. As competition intensifies in the banking sector, banks must provide solutions that are not only innovative but also responsive to the needs and complaints of users. Reviews on platforms such as the Google Play Store often reflect the real experiences of customers using the service. If issues or complaints are not adequately addressed, it could negatively impact the bank's image and potentially reduce customer trust. Therefore, analyzing the sentiment of these reviews is essential to understand user perceptions and offer strategic recommendations for banks to improve the quality and competitiveness of their mobile banking services.

Through this research, a deeper understanding of user perceptions of mobile banking services is expected to be obtained while also providing concrete recommendations for both banks to enhance the quality of their services. The findings of this study are also likely to serve as a reference for similar research in the field of sentiment analysis.

2. Literature Review

2.1. Previous Research

The research conducted by Fibriyanti, N. A., Sulistiyowati, N., and Padilah, T. N. in 2023, titled "Implementation of the Multinomial Naïve Bayes Algorithm for Sentiment Analysis on BRIMO User Reviews," used BRIMO, BRI's mobile banking service, as the object of study. This service requires user feedback to develop a system that meets public needs. The study analyzed 1,011 review datasets from the Google Play review feature to measure user satisfaction through sentiment analysis. The application of the Multinomial Naïve Bayes Algorithm in this research achieved an accuracy of 98.02%, with 670 reviews classified as negative sentiment and 341 as positive sentiment. With such a high accuracy level, the Multinomial Naïve Bayes Algorithm has proven effective in sentiment classification [1].

The research conducted by Putra, R. R., Johan, M. E., and Kaburuan, E. R. in 2019, titled "A Naïve Bayes Sentiment Analysis for Fintech Mobile Application User Review in Indonesia," aimed to analyze the sentiment of fintech mobile application users in Indonesia. The fintech industry in Indonesia is rapidly growing. It ranks as the 5th largest in terms of internet users globally, making it crucial for fintech companies to understand user opinions in real time to address increasing competition. This study analyzed user reviews that mixed English and Indonesian and reviews solely in Indonesian. The Naïve Bayes method was applied for sentiment classification, yielding an accuracy of 78% for mixed-language reviews and 75% for reviews in Indonesian only [7].

The research conducted by Andrian, B., Simanungkalit, T., Budi, I., and Wicaksono, A. F. in 2022, titled "Sentiment Analysis on Customer Satisfaction of Digital Banking in Indonesia," focused on sentiment analysis of customer satisfaction for three digital banks in Indonesia: Bank Jago, Bank Jenius, and Bank Blu. This study utilized user review data from social media platform Twitter, comprising 22,572 tweets, and compared several classification methods, including Naïve Bayes, Logistic Regression, K-Nearest Neighbours, Support Vector Machine (SVM), Random Forest, Decision Tree, Adaptive Boosting, eXtreme Gradient Boosting, and Light Gradient Boosting Machine, to determine the best accuracy. The findings revealed that the SVM method achieved the highest accuracy at 74.29%. Sentiment analysis results showed that Bank Jago had the highest positive sentiment at 82.62%, Bank Jenius had the highest negative sentiment at 43.50%, and Bank Blu had the highest neutral sentiment at 44.46% [8].

The research conducted by Farisi, A. A., Sibaroni, Y., and Faraby, S. Al. in 2019, titled "Sentiment Analysis on Hotel Reviews Using Multinomial Naïve Bayes Classifier," aimed to assist tourists in understanding the sentiments of other visitors regarding hotels through online reviews. These reviews are not only beneficial for tourists but also serve as a guideline for hotels to enhance their services in the future. This study employed the Multinomial Naïve Bayes Classifier method and achieved satisfactory results, with an average F1-Score exceeding 91% in sentiment analysis on hotel reviews [9].

The research conducted by Eka Purwiantono, F., and Aditya, A. in 2020, titled "Classification of Sentiments on SARA, Hoaxes, and Radicalism in Social Media Posts Using Multinomial Naïve Bayes Algorithm," utilized Twitter as the object of analysis, focusing on issues related to SARA, hoaxes, and radicalism. This study aims to assist government officials in formulating policies that prevent violations of the ITE Law, radicalism, and dissemination of false information, as well as SARA issues in Indonesia. The Multinomial Naïve Bayes method was chosen for its ability to classify documents while considering the frequency of appearing words. The study's results demonstrated a high accuracy rate of 99.62% in processing sentiment data [6].

The research conducted by Wardani, N. S., Prahutama, A., and Kartikasari, P. in 2020, titled "Sentiment Analysis of the Capital Relocation Using Naïve Bayes Classification for Bernoulli and Multinomial Models," discusses the planning of the capital relocation, a hot topic among the Indonesian public, both through direct conversations and social media. This study utilized comments on YouTube, specifically from videos uploaded by the Kompas TV channel on August 26, 2019, as the object of analysis. One thousand five hundred comments collected from August 26 to October 12, 2019, were analyzed to determine positive and negative sentiments. The results revealed 849 comments with negative sentiment and 651 with positive sentiment. The study also demonstrated that the Bernoulli Naïve Bayes method achieved an accuracy of 93.45%, while the Multinomial Naïve Bayes method reached an accuracy of 90.19%. It can be concluded that both methods provided promising results in the sentiment classification process [10].

The study conducted by Rina Refianti and Novia Anggraeni (2023), titled "Sentiment Analysis Using Convolutional Neural Network Method to Classify Reviews on Zoom Cloud Meetings Application Based on Reviews on Google Playstore," aims to analyze the sentiment of user reviews for the Zoom Cloud Meetings application. This application, used for video conferencing, had over 500 million downloads and a rating of 3.8 on the Google Play Store as of March 2021. Despite having many advantages, such as good video and audio quality and minimal interruptions, the application still requires service improvements. Therefore, this research developed a web-based application using the Convolutional Neural Network (CNN) method to classify user reviews and calculate the accuracy. The application was built using the Flask framework and Python programming language, with model training conducted through the TensorFlow library. Testing results demonstrated that the system functioned well, and the classification accuracy reached 91.5% [11].
The research conducted by M. Oriza Syahputra, Bustami, and Lidya Rosnita in 2024, titled "Analysis of Public Sentiment Toward Celebrity Endorsement on Social Media Using Support Vector Machine," aimed to analyze public sentiment towards celebrity endorsements on social media. This study combined the VADER labeling method with the Support Vector Machine (SVM) method to classify text sentiment into positive, negative, or neutral. Data was collected from social media platforms such as Twitter, Instagram, and Facebook, then preprocessed and labeled using VADER. The labeled data was used to train the SVM model, which was validated to measure its accuracy and performance. The results showed that the SVM method with an 80:20 ratio achieved a precision of 77%, recall of 100%, f1-score of 87%, and accuracy of 76.92%. Sentiment analysis of Twitter users revealed that 77% provided positive sentiment, while 23% provided negative sentiment from 517 data points. The researchers suggested that future studies could include more data and explore other classification methods, such as Naive Bayes or Deep Learning, to improve accuracy [12].
The research conducted by Muhammad Faisal, Nurdin, Fajriana, and Zahratul Fitri in 2022, titled "Information and Communication Technology Competencies Clustering for Vocational High School Students Using K-Means Clustering Algorithm," aimed to cluster the Information and Communication Technology (ICT) competencies of students at SMK Negeri 3 Lhokseumawe using the K-Means Clustering algorithm. This study utilized ICT competency test scores of students from the 2021/2022 academic year, which were processed using the K-Means Clustering method and the RapidMiner application. The data clustering results generated three clusters: extraordinarily competent, competent, and less competent. The analysis revealed that 80 students fell into the "Very Competent" cluster, 64 students into the "Competent" cluster, and ten students into the "Less Competent" cluster. This research is expected to assist teachers and school management formulate ICT-related policies at SMK Negeri 3 Lhokseumawe [13].
The research conducted by Suhaili Shibul Muna, Nurdin, and Taufiq in 2022, titled "Tokopedia and Shopee Marketplace Performance Analysis Using Metrix Google Lighthouse," aimed to analyze the performance of the Tokopedia and Shopee marketplaces using Google Lighthouse metrics. This study evaluated aspects of performance, accessibility, best practices, and SEO, with a score ranging from 0 to 100. The results showed that Tokopedia achieved a performance score of 85 (yellow), which can be optimized by improving the speed index, time to interact, and total blocking time. Meanwhile, Shopee experienced a performance drop with a red score of 13, particularly in first contentful paint, speed index, time to interact, and total blocking time. Based on these results, it can be concluded that Tokopedia outperformed Shopee in various aspects of the tested metrics [14].

2.2. Data Mining

Data mining is a method that can be used to discover new knowledge or information hidden within large amounts of data, commonly referred to as big data [15]. The data processing can involve one or more analytical techniques to produce accurate and optimal results [16]. Through various approaches, data mining aims to extract patterns or trends within the previously unseen data, thereby providing valuable insights for decision-making.
In its application, several data mining methods can be employed in analytical or learning systems. These methods include (1) Prediction, which generates information related to events that may occur in the future; (2) Classification, which focuses on grouping topics based on specific categories using a target variable; (3) Clustering, which functions to group records with similarities and distinguish them from dissimilar records, without using a target variable as in classification; and (4) Association, which determines relationships between attributes over a specific time frame, allowing for the identification of new attribute patterns [17].

2.3. Sentiment Analysis

Sentiment analysis is a study in machine learning that focuses on opinions expressed in text form. This analysis aims to determine sentiment by grouping texts based on their polarity to categorize them as positive or negative sentiment [18]. Sentiment analysis, also known as opinion mining, aims to identify the tendency of someone's opinion or view on a particular issue or object. This process automatically understands, extracts, and processes textual data to obtain the sentiment information contained within an opinion sentence [19].

2.4. BSI Mobile

BSI Mobile is a Sharia banking service application that enables customers to conduct financial transactions more easily without physical contact. It can be accessed anytime and anywhere through a mobile phone. This service also helps reduce costs and resolves issues more quickly, efficiently, accurately, and effectively. The presence of BSI Mobile reflects the banking sector's adaptation to utilizing the internet and technological advancements as a medium for electronic services. As one of the banks in Indonesia, BSI Mobile continuously strives to enhance the capabilities of its available features to strengthen its competitive edge and differentiate its products from those of other banks [20].

2.5. Action Mobile

Action Mobile (Aceh Online Transactions) is a mobile banking service owned by PT. Bank Aceh Syariah, which can be downloaded from the Google Play Store and accessed by customers through their mobile phones to conduct online transactions using the internet. The presence of Action Mobile facilitates customers in performing transactions quickly through various service features, such as account information, fund transfers, online payments via QRIS, and several other transaction features [21].

2.6. Multinomial Naive Bayes

Multinomial Naïve Bayes is one of the methods commonly used for text classification. This method performs calculations based on the frequency of each term in a document [1]. In the classification process, Multinomial Naïve Bayes not only categorizes documents based on the words that appear within them but also considers the frequency of those words [10]. In other words, this method assumes independence among the occurrences of words in a document without considering the order of the words or the contextual information present [6]. The calculation steps for the Multinomial Naïve Bayes algorithm can use the following formula.
The Multinomial Naïve Bayes calculation is done by finding the probability value of each class with the equation:

(1)

$$P(c) = \frac{Number\ of\ documents\ in\ class\ c}{Total\ number\ of\ documents}$$

Description:
P(c) : Probability of a document belonging to class c

After that, the conditional probability of the word is calculated to find out the number of words that appear in the review. The conditional probability formula of the word can be seen in the following equation:

$$P(\omega|c) = \frac{Number\ of\ occurrences\ of\ word\ \omega\ in\ class\ c + \alpha}{\sum_{\omega'}(Number\ of\ occurrences\ of\ word\ \omega'\ in\ class\ c) + \alpha \times |V|}$$

(2)

Description:
α : Smoothing parameter (value 1 for Laplacs smoothing)
|V| : Number of unique words in the dataset

Next, the data will be calculated for the likelihood of the document to determine the value that will prove how likely a review is to be included in the positive or negative class. The likelihood calculation can use the following equation:

(3)

$$P(d|c) = P(w_1, w_2, \ldots w_n|c) = P(w_1|c) \times (w_2|c) \ldots \times (w_n|c)$$

3. Research Methods

3.1. Research Workflow

In conducting this research, some steps must be followed to ensure the research process runs smoothly. The research workflow can be described as follows.

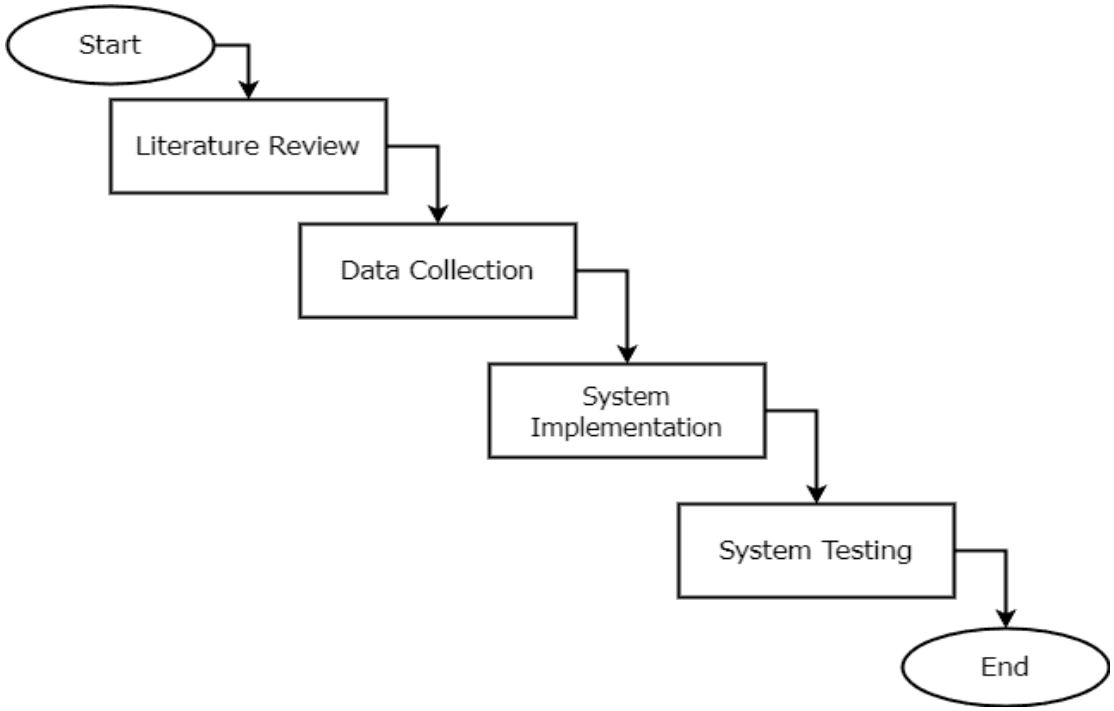

Fig 1 Research Workflow

3.2. Literature Review

Before conducting the research, an important initial step is to perform a literature review to understand the fundamentals of the research topic. This literature review focuses on the collection, reading, and comprehension of references related to user reviews of the BSI Mobile and Action Mobile applications sourced from the Google Play Store. The algorithm used in this research is the Multinomial Naive Bayes Algorithm. The research literature encompasses theories obtained from various sources, such as articles, books, journals, and other references from previous studies that correlate with the application of the Multinomial Naive Bayes Algorithm for sentiment analysis.

3.3. Data Collection

In this study, it is necessary to collect user review data for the BSI Mobile and Action Mobile applications. User reviews are obtained using web scraping techniques, which involve extracting data from a web page. In this research, the author collected user review data from the Google Play Store for the BSI Mobile and Action Mobile applications using the Google extension called Web Scraper.

3.4. System Implementation

System implementation is the stage of applying the designed system to prepare the system for operation [22]. In this phase, the previously created system design will be implemented using Python programming language and the Multinomial Naive Bayes algorithm to classify user sentiment in BSI Mobile and Action Mobile application reviews.

3.5. System Testing

A system testing phase is necessary after the system has been successfully implemented. This stage aims to ensure that the implemented system meets the previous objectives. The system testing results will determine whether the algorithm used can classify sentiment effectively and accurately.

3.6. System Diagram

Here is the system schematic for sentiment analysis of user reviews of the BSI Mobile and Action Mobile applications using the Multinomial Naive Bayes algorithm

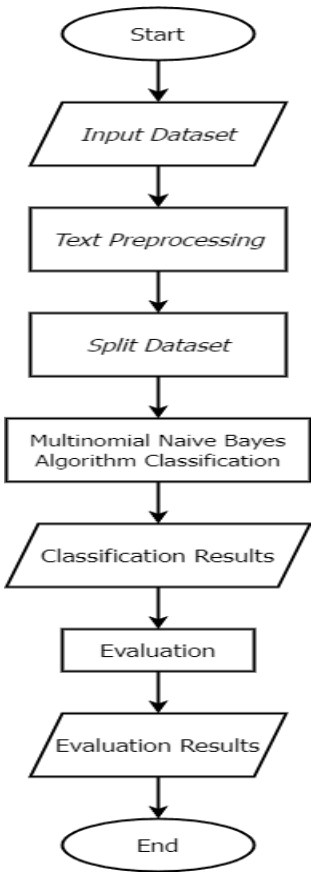

Fig 2 System Diagram

The system to be implemented starts from the "start" phase to the "finish" phase, where each stage will be described in detail. First, in the "Input Dataset" phase, this process aims to input user review data from the BSI Mobile and Action Mobile applications into the system for further processing. Next, the "Text Preprocessing" phase is a crucial step that transforms raw data into cleaner data. The steps involved in this preprocessing include case folding, tokenization, stopword removal, and stemming. After that, in the "Split Dataset" phase, the dataset will be divided into two parts with a ratio of 80:20, where 80% will be used for training data and 20% for testing data. The training data will be used to train the model to recognize patterns, while the testing data will be used to evaluate the model's performance.

The next phase is "Classification using the Multinomial Naive Bayes Algorithm," where the system will classify the sentiment of user reviews to determine whether the sentiment is positive or negative. The output of this process, known as the "Classification Results," will provide sentiment categories for the reviews. Once classification is complete, the following step is "Evaluation," which aims to assess the classification model's performance using the Multinomial Naive Bayes algorithm. This evaluation will be conducted using the Confusion Matrix method to provide an accurate picture of the model's effectiveness. The end of this process is marked by the "Finish" stage, indicating that the system has functioned as expected.

4. Research and Discussion

4.1. Research Results

This study tested the Multinomial Naive Bayes algorithm to analyze sentiment in reviews submitted by BSI Mobile and Action Mobile application users. The reviews from both applications were classified into positive or negative sentiments. The sentiment analysis process used the Python programming language to build the sentiment analysis system. The sentiment analysis results consist of reviews from the BSI Mobile and Action Mobile applications, each labeled with either negative or positive sentiment. Based on the sentiment analysis using the Multinomial Naive Bayes algorithm, the BSI Mobile application achieved an accuracy of 78%, precision of 79%, recall of 77%, and an f1-score of 77%. The same classification was applied to the Action Mobile user reviews using the Multinomial Naive Bayes algorithm, which resulted in an accuracy of 85.6%, precision of 75%, recall of 75%, and an f1-score of 75%. These accuracy values also found that 52.8% of BSI Mobile users expressed positive sentiment, while 47.2% expressed negative sentiment. Meanwhile, 35.1% of Action Mobile users expressed positive sentiment, while 64.9% expressed negative sentiment in their reviews.

4.2. System Analysis

The result of this research will be a system capable of analyzing user reviews of the BSI Mobile and Action Mobile applications available on the Google Play Store platform using the Multinomial Naïve Bayes Algorithm. Although online banking services aim to facilitate transactions for customers, they often face various challenges encountered by users as banking applications provided by Bank Syariah Indonesia and Bank Aceh, BSI Mobile, and Action Mobile have also received diverse feedback regarding the performance and features offered. Therefore, this research focuses on implementing the Multinomial Naive Bayes Algorithm to analyze user reviews' positive and negative sentiments for both applications.

4.3. Scraping Data

In this research, the user reviews of the BSI Mobile and Action Mobile m-banking applications will undergo a scraping process to collect data for testing purposes. The reviews will be scraped using the google_play_scraper library, which is available in the Python programming language. The scraped data includes reviews within the time range from January 1, 2023, to June 30, 2024. Below is **Table 1.**, which contains the results of scraping user reviews of BSI Mobile from the Google Play Store.

Table 1. Scraping data BSI Mobile

No	Reviews
1	*I want to activate mobile banking again, but the face verification is complicated.*
2	*This makes it harder to log in; even face verification alone is complicated. Good lighting and sound wifi: What is BSI's face verification standard? Instead of making things easier, this app makes it harder for customers.*
3	*Very helpful in making transactions easier when the ATM is far from the location.*

The following is **Table 2.** which contains the results of scraping Action Mobile user reviews on the Google Play Store.

Table 2. Scraping data Action Mobile

No	Reviews
1	*I can't make a transaction to transfer to another account. Even though I have sufficient funds, when I try to make the transaction, it says my balance is insufficient.*
2	*Many bugs and transactions fail often due to bugs.*
3	*Very useful and good.*

4.4 Labelling Data

At this stage, the scraping review data, through sentiment labeling, is divided into positive and negative classifications. Labeling is done on each data by considering each word's polarity value based on the lexicon dictionary. Data with neutral values or categories will not be used in this labeling because the study will only group reviews based on positive and negative sentiments. Here is **Table 3.** BSI Mobile review data is labeled with positive and negative categories.

Table 3. Labeling data BSI Mobile

No	Reviews	Sentiment
1	*I want to activate mobile banking again, but the face verification is complicated.*	Negative
2	*This makes it harder to log in; even face verification alone is complicated. Good lighting and good wifi, so what exactly is the standard for BSI's face verification? Instead of making things easier, this app makes it harder for customers.*	Negative
3	*Very helpful in making transactions easier when the ATM is far from the location.*	Positive

Table 4 contains Action Mobile user reviews with positive and negative sentiment categories.

Table 4. Labeling data Action Mobile

No	Reviews	Sentiment
1	*I can't make a transaction to transfer to another account. Even though I have sufficient funds, when I try to make the transaction, it says my balance is insufficient.*	Negative
2	*Many bugs and transactions fail often due to bugs.*	Negative
3	*Very useful and good.*	Positive

4.5. Preprocessing Text

This stage involves the data-cleaning process. The cleaning process includes converting all words in a sentence to lowercase (case folding), removing unnecessary words (stopword removal), splitting the text into individual words (tokenization), removing punctuation from the text, and applying stemming.

1. Cleaning Text
   At this stage, all numbers and symbols, such as commas (,), periods (.), and even emoticons present in the reviews will be removed. Additionally, all letters in the review sentences will be converted to lowercase.
2. Deleting neutral sentiment reviews
   This stage is done by deleting neutral sentiment because the study will only test reviews into two categories of sentiment: positive and negative. In addition, this is done so that the resulting sentiment is more specific. Word Normalization
   This stage is performed on the data to ensure that the words conform to the guidelines of the Indonesian dictionary (KBBI). During this stage, if the data contains the word "yg," it will be changed to "yang" by proper grammar.
3. Word Normalization
   This stage is performed on the data to ensure that the words conform to the guidelines of the Indonesian dictionary (KBBI). During this stage, if the data contains the word "yg," it will be changed to "yang" by proper grammar.
4. Stopwords
   At this stage, words that have no meaning will be removed or not used to increase the efficiency level in word processing. An example of a word that has no meaning is "nya".
5. Tokenizing dan Stemming
   At this tokenization stage, each review sentence is cut into several constituent words (tokens), and stemming is performed on the sentence to simplify the text by removing affixes to words or changing them to bare words.

The results of the text preprocessing stage in the BSI Mobile application user reviews are listed in **Table 5.**

Table 5. Result of preprocessing text BSI Mobile

No	Reviews	Sentiment
1	*want to activate mobile banking again, face check is tough*	Negative
2	*its getting harder to log in just verifying your face is really hard good lighting good wifi is the standard for facial verification this BSI doesnt make things easier it just makes it difficult for customers this application*	Negative
3	*very helpful in facilitating transactions when the atm is far from the location*	Positive

The results of the preprocessing stage of Action Mobile user review text are shown in **Table 6**.

Table 6. Result of preprocessing text Action Mobile

No	Reviews	Sentiment
1	*unable to perform account transfer transactions even though there is a balance when making the transaction the balance is insufficient*	Negative
2	*many bugs transactions fail frequently often bugs*	Negative
3	*very useful good*	Positive

Table 7. Result of preprocessing text Action Mobile (Continued)

4.6 Visualization of Sentiment Count

After classifying sentiments on the Mobile Banking applications from Bank Syariah Indonesia, namely BSI Mobile and Bank Aceh, namely Action Mobile, using the Multinomial Naïve Bayes algorithm, a comparison of the number of positive sentiments and negative sentiments of BSI Mobile can be described in Fig. 3 and Action Mobile in Fig. 4.

In **Fig 3**, there is a comparison of 52.8% positive sentiments and 47.2% negative sentiments from the review data range from January 2023 to June 2024, totaling 55,059 reviews that have been scraped and classified using the Multinomial Naïve Bayes algorithm.

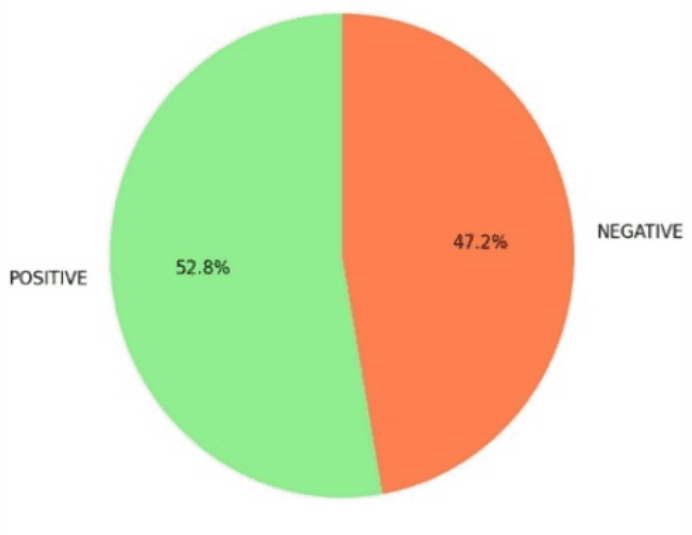

Fig 3 Sentiment classification of BSI Mobile

In **Fig. 4**, the results of comparing positive sentiment 71.8% and negative sentiment 28.2% were obtained. In this case, the range of review data used was also from January 2023 to June 2024, with 615 Action Mobile user reviews that had also gone through data processing stages from text preprocessing to sentiment classification using the Multinomial Naïve Bayes algorithm.

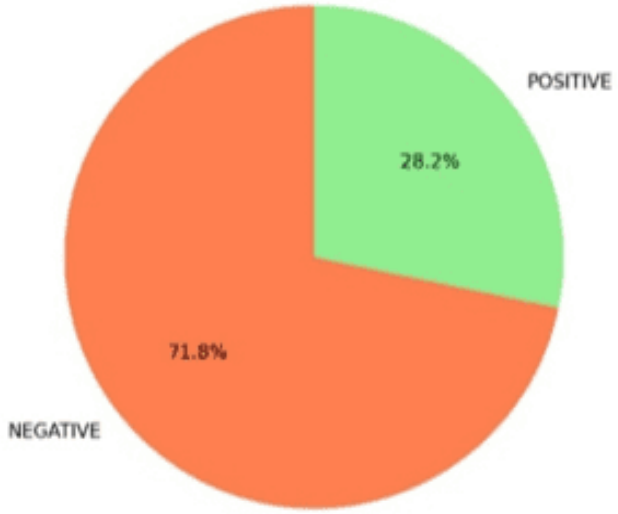

Fig 4 Sentiment classification of Action Mobile

4.7 Positive Sentiment Visualization Using WordCloud

By doing this visualization, we can describe words with positive labels that are often written by users of the BSI Mobile and Action Mobile Mobile Banking applications. In this visualization, the larger the size of a word, the greater the value of the word's appearance in user reviews. In **Fig 5**, it can be seen that the words most often uttered by users are "updated", "good", "balance", "transaction" and "thank".

Fig 5 Sentiment positive of BSI Mobile

In **Fig 6**, it can be seen that the words most frequently uttered by users regarding the Action Mobile application are "thank," "hopefully," "transaction," "helpful," "feature," and "good."

Fig 6 Sentiment positive of Action Mobile

4.8 Negative Sentiment Visualization Using WordCloud

This visualization allows us to describe words with negative labels that users often write for the BSI Mobile and Action Mobile Banking applications. In this visualization, the larger the size of a word, the greater the value of the word's appearance in user reviews. In **Fig 7**, it can be seen that the words most often uttered by users are "application," "difficult," "overlapping," "transaction," and "problem."

Fig 7 Sentiment negative of BSI Mobile

In **Fig 8**, it can be seen that the words most frequently uttered by users are "transaction", "aplication", "network", "register", "please" and "update".

Fig 8. Sentiment negative of Action Mobile

4.9 Classification Evaluation

The evaluation stage applies the Confusion Matrix method, which aims to evaluate the performance of an algorithm and classification model built by showing the value of model accuracy, precision, and error rate in the algorithm model. The results of the Multinomial Naïve Bayes algorithm evaluation for BSI Mobile user reviews are shown in **Fig. 9** with an accuracy value of 78.7%, precision of 76.5%, recall of 86.2%, and f1-score of 80.6%

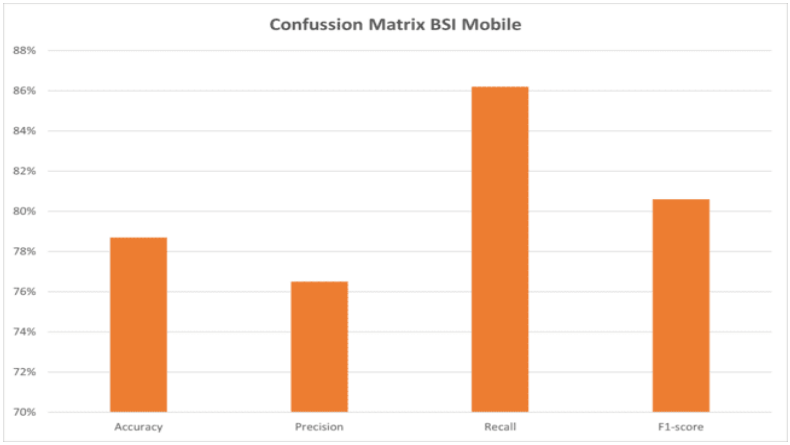

Fig 9. Evaluation of BSI Mobile

The evaluation results of the Multinomial Naïve Bayes algorithm for Action Mobile user reviews are shown in **Fig. 10** with an accuracy value of 85.8%, precision of 75%, recall of 75%, and f1-score of 75%.

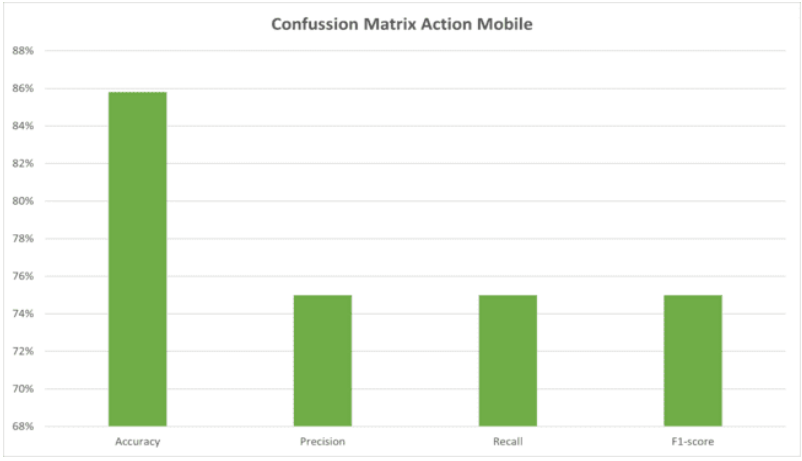

Fig 10. Evaluation of Action Mobile

5. Conclusion

Based on the results of sentiment analysis research on user reviews of Bank Syariah Indonesia's mobile banking service (BSI Mobile) and Bank Aceh's service (Action Mobile) using the Multinomial Naïve Bayes algorithm, it can be concluded that this algorithm is effective for classification and sentiment analysis, with accuracy, precision, recall, and f1-score values exceeding 70%. For the BSI Mobile application, with a dataset of 55,059 reviews, the Multinomial Naïve Bayes algorithm produced an accuracy of 78.7%, precision of 76.5%, recall of 86.2%, and f1-score of 80.6%. Meanwhile, with a dataset of 615 reviews for the Action Mobile application, this algorithm resulted in an accuracy of 85.6%, precision of 75%, recall of 75%, and f1-score of 75%.
User reviews also provide a clear picture of the strengths and weaknesses of both applications. Of the 55,059 reviews for BSI Mobile, 21,497 were positive, with dominant keywords such as "easy to use," "easy transactions," and "complete features." However, 19,315 reviews were negative, with keywords like "difficult to log in," "issues," and "error," indicating the need for improvements in stability and handling technical issues. For Action Mobile, out of 615 reviews analyzed, 274 were negative, with significant complaints related to "difficult to log in," "error," and "deducted balance." In comparison, 148 positive reviews highlighted appreciation for features and services. Although Action Mobile has received praise for some features, significant application stability and transaction security improvements are still necessary.

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