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Sentiment Analysis of NU Online Applications Using Artificial Neural Network

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Abstract

The NU Online app on the Playstore serves the needs of Muslims, especially those in Islamic boarding schools, by providing information and services. Its success is gauged not just by the number of downloads or popularity but by the quality of user interactions and how well it meets user needs. Sentiment analysis of user reviews provides deeper insights into these aspects. This research focused on finding words influencing sentiment from NU online and producing the best performance of artificial neural networks. This study collected user reviews from the NU Online app between February 9, 2021, and May 31, 2024, totalling 12613 reviews. After preprocessing, 8546 reviews remained. Using the Indonesian Sentiment Lexicon (INSET), 66% of the reviews showed positive sentiment, 21% were neutral, and 13% were negative. The words "aplikasi" (application) and "nya" (its) appeared in the top three across all sentiment classes, while "fitur" (feature) was common in both positive and negative sentiments. For neutral sentiments, "nan" was frequently mentioned. The data were split into training and testing sets in an 80:20 ratio, preserving the proportions of each sentiment class. Sentiment analysis was performed using a neural network, with input neurons ranging from the top 10 words from each sentiment class to all words. Accuracy improved as more words were used, peaking at 0.95 for the top 1690 words, compared to 0.71 for the top 10 words. The findings highlight the importance of using a comprehensive set of words to train the ANN. Including more words significantly enhances the model's performance, indicating that a richer vocabulary captures sentiment nuances better.

Keywords: Neural Network, NU online, Sentiment

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A. Introduction

The teaching and learning process is supported nationwide by a wide range of educational institutions, contributing to Indonesia's well-known rich diversity in education. Islamic boarding schools are among the educational establishments that significantly impact the country's educational system (Thahir, 2014). As established Islamic educational establishments, Islamic boarding schools are crucial in molding the knowledge and character of santri (students enrolled in Islamic boarding schools). Islamic boarding schools use various technology technologies to enhance the quality of instruction and preaching, keeping up with technological advancements (Irmi et al., 2023; Zulkarnain & Tamwifi, 2023).

Islamic boarding schools have seen tremendous changes in technological use and instructional methodology in the last few decades. Islamic boarding schools have historically relied on traditional teaching techniques, but a growing number of them are increasingly enhancing instruction through information and communication technology (ICT) (Huda, 2020; Sutarman et al., 2020). Islamic boarding schools are now including the use of social media (Indrioko, 2023), the internet (Ihsan et al., 2020), and mobile applications (Bajari et al., 2021) in their efforts to keep up with the times. Islamic boarding schools can now reach a wider audience and provide more effective and widespread access to education thanks to the implementation of this technology (Muhith et al., 2023).

One of Indonesia's most prominent Islamic groups, Nahdlatul Ulama (NU), actively promotes Islamic boarding school education. NU has created several programs to improve da'wah and education by utilizing technology (Iqbal, 2020). The creation of the NU Online application, which is accessible on the Play Store, is one of NU's significant projects. This application aims to assist the requirements of Muslims, particularly those of Islamic boarding schools and their students, by offering information and services. Access to the most recent news, religious studies, details on NU events, and instructional materials tailored to the requirements of Islamic boarding schools are just a few of the things that NU Online provides (Betos et al., 2021). Success for NU Online is determined not just by the number of downloads or popularity of the app, but also by the caliber of user interactions and the degree to which the app fulfills the user's demands (Bothma, 2023). A deeper understanding of these aspects can be achieved by sentiment analysis of user evaluations.

In machine learning-based sentiment analysis, popular approaches and techniques include K-nearest neighbor classification (Isnain et al., 2021; Pamuji, 2021), Maximum Entropy (Cindo et al., 2020; Xie et al., 2019), Naïve Bayes (Abbas et al., 2019; Wongkar & Angdresey, 2019), Support Vector Machine (Ahmad, Aftab, Salman, & Hameed, 2018; Ahmad, Aftab, Salman, Hameed, et al., 2018; Cindo et al., 2020; Han et al., 2020), neural network (Amalia & Sibaroni, 2020; Gunawan et al., 2021). Although Naïve Bayes has a relatively straightforward representation, elaborate hypotheses are unsupported. Furthermore, it is very restrictive to assume that qualities are independent. Maximum Entropy works well with dependent features alone, but it estimates the probability distribution from data. While SVM might offer the appropriate kernel, it does not provide a standardized method for handling multi-class situations. (Borele & Borikar, 2016) Neural network are widely used to improve performance concerning correlation and relationships between variables (Wendemuth et al., 1999). So, this research used neural network methods to understand aspects that can be achieved by sentiment analysis of user evaluations.

Moreover, this study used feature selection to enhance sentiment-based categorization performance.

The purposes of the study are (1) to classify the sentiment of user reviews (positive, neutral, or negative) using the INSET lexicon, (2) to identify specific words that significantly influence user sentiment in reviews of the NU Online app, (3) to evaluate and enhance the performance of an artificial neural network (ANN) in sentiment analysis by experimenting with different sets of input words. There are three importance of the study. First, it provides valuable insights into user opinions and concerns, enabling more informed decisions in app development and customer support. Second, understanding the keywords influencing user sentiment can help developers and marketers enhance user satisfaction by addressing the most impactful features and issues. Last, by improving the accuracy of sentiment classification models, the study contributes to more reliable and effective sentiment analysis, which is crucial for automated review processing and analysis.

B. Literature Review

1. Sentiment Analysis

The process of obtaining and examining people's views, ideas, and perceptions about various subjects, products, and services is known as sentiment analysis (Wankhade et al., 2022). The basic concept in sentiment analysis is to classify text, sentences, or opinions in a document into positive, negative, or neutral opinion categories (Budianita & Cynthia, 2022). Labeling in sentiment analysis can be done manually and with a lexicon-based approach. Because automated procedures are prone to error, the manual approach is typically employed in conjunction with automated ways as a final check, as it is labor-intensive and time-consuming (Liu, 2022). The lexicon-based approach is a method that uses a word dictionary or corpus equipped with a weight (polarity score) for each word as a language or lexical source (Azhar, 2017). There are two types of lexicon-based approaches, namely dictionary-based and corpus-based. Dictionary-based uses keyword search techniques in a dictionary list, while corpus-based looks at the relationship of words to each other and has a set of linguistic rules (Wikarsa et al., 2022). The lexicon-based approach can be applied to the data labeling stage in sentiment analysis. Corpus-based data has higher accuracy than dictionary-based data (Abdulla et al., 2013), but it depends on the quality and amount of training data. According to Liu (2022), dictionary-based is more effective because it produces good performance across conversation topics and can be easily improved with various sources of knowledge.

This research is based on dictionaries, especially the Inset lexicon. Inset Lexicon is an Indonesian language sentiment dictionary compiled by Koto & Rahmaningtyas (2017), which was obtained via the site https://github.com/fajri91/InSet. InSet Lexicon consists of 3,609 positive words and 6,609 negative ones in Indonesian, with a polarity score for each word. The word weight ranges from -5 to +5; a minus value (-) indicates that the word has a negative sentiment, while a plus value (+) indicates that the word has a positive sentiment. An example of a list of words in the InSet Lexicon is presented in Table 1.

Table 1. Example of A List of Words in The Inset Lexicon

Word	Weight
Ganggu (Disturb)	-4
Tolong (Help)	-4
Bagus (Good)	2
Puas (Satisfied)	3
Nyaman (Comfortable)	4

Each word in the review will be matched with the word, and then the polarity score for each sentence will be calculated. The equation of the polarity score for each review is expressed in equation (1).

$$polarity\ score = \sum_{i=1}^{n} word\ frequency_i \times word\ weigth_i \quad (1)$$

The classification of review sentences into sentiment classes is determined based on the polarity score obtained as depicted in equation (2).

$$sentiment = \begin{cases} positive, & polarity\ score > 0 \\ neutral\ , & polarity\ score = 0 \\ negative, & polarity\ score < 0 \end{cases} \quad (2)$$

2. NU Online Application

NU Online is an application available on the Google Play Store designed to serve the needs of users seeking access to content and services related to Nahdlatul Ulama (NU), a prominent Islamic organization in Indonesia. The app provides various features and resources tailored to its users, including religious content, educational materials, news updates, and community services. NU online was released on 27 January 2021.

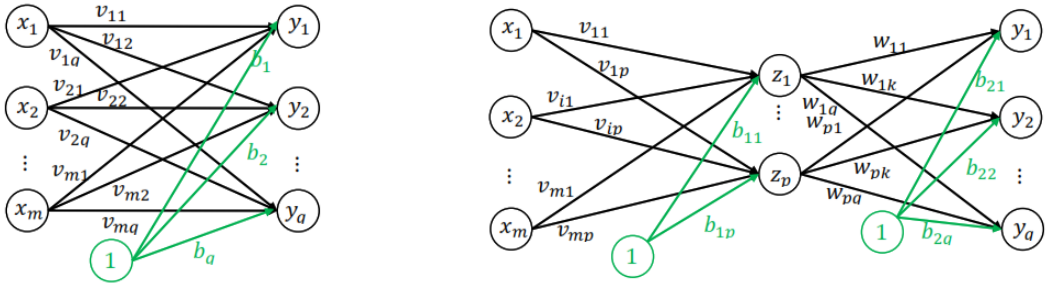
NU online features include *Al Quran* (Facilitates Al-Quran lovers to be able to read in per page or verse format, equipped with translation, Latin transliteration, and interpretation), *Doa & Wirid* (Providing hundreds of daily prayers, rejecting reinforcements, travel, health, etc.; also sholawat, ratib, hizib, istighotsah, and other wirids from authoritative sources), *Jadwal Sholat* (Reminds Muslim prayer times throughout the world, including imsak, dhuha, and sunrise times. There are various notification options: drum sounds, kentongan sounds, or the call to prayer), *Kalender Hijriah* (Not only the Gregorian and Hijri calendars, this calendar also features Javanese market days (Legi, Pahing, Pon, Wage, Kliwon), Islamic holidays, Sunnah fasting schedule, national holidays and essential NU moments.), *Kiblat* (The Qibla direction compass is equipped with angle degree information, as well as the option to find the Qibla direction via camera), *Tutorial Ibadah* (Provides complete guidance on worship, starting from purification, prayer, fasting, to pilgrimages, both in the form of articles and videos.), *Khutbah* (Contains a collection of material for Friday sermons, Eid al-Fitr sermons, and Eid al-Adha sermons. Everything is entirely prepared so as not to violate the pillars of the sermon), *Yasin & Tahlil* (Contains Yasin and Tahlil readings that are commonly read by Muslims in Indonesia, starting from Fatihah gifts, text composition to closing prayers.), *Tasbih Digital* (Digital counting machine equipped with vibration and sound mode options, as well as quantity setting and reset buttons), NUpedia (It is a digital NU encyclopedia which contains information about biographies of figures, history, institutions, communities,

traditions and Islamic boarding school treasures), *Maulid* (Contains at least six maulid books along with their translations: Maulid ad-Diba'i, Maulid al-Barzanji, Maulid al-Azab, Simthud Durar, Qasidah Burdah, and adl-Dliyaul Lami'.), *Kalkulator Zakat* (Makes it easier for users to calculate the mandatory zakat wealth components, starting from the trade, agriculture, gold-silver jewelry, livestock, ponds, companies and professions sectors.), Video (Channel integrated with the NU Online YouTube channel, which broadcasts a variety of content: worship tutorials, exclusive interviews, prayers, short films, yellow book studies, and others.), *Ziarah* (Facilitate Muslims in finding the location of essential graves to visit. This feature also includes address info, Google Map, images and character biographies.), *Kalam* (Displays a variety of graphic content divided into at least three categories: Infographics, Pearls of Words, and Prayers & Dhikr), *Artikel* (This feature is connected to the NU Online website which contains more than 100 thousand articles. Find various kinds of Islamic information from mu'tabar sources), *Kalkulator Waris* (Automatically calculate the portion of inheritance that is entitled to each heir. This feature was compiled based on the Islamic jurisprudence of the Syafi'i school of inheritance.), *Zakat & Sedekah* (Providing a channel for people who want to fulfill their zakat obligations or social action through donations.), and *Haji & Umrah* (Contains Hajj and Umrah guidance, including prayers, as well as a list of essential destinations in Mecca and Medina.). (NU Online Official, 2024)

3. Artificial Neural Network

Artificial neural networks (ANN) are an artificial representation of the human brain which always tries to copy the learning process in the human brain (Kusumadewi, 2004). ANN was first developed in 1943 by Mc Culloch and Pitts. The idea of ANN is the structure or architecture and how neurons work in the human brain. Artificial neural networks are determined by three things: the pattern of connections between neurons (called the network architecture), the method for determining the connecting weights (called the training method or learning method), and the activation function used.

Three network architectures are often used in artificial neural networks: single-layer networks, networks with more than one layer, and recurrent networks (Haykin, 1999; Siang, 2009). A single-layer network of x neurons is connected directly to all y neurons, and no x neurons or y neurons are interconnected (see Figure 1a). A single-layer network is then generalized into a network of more than one layer (multilayer network). Networks with more than one layer have almost the same characteristics as single-layer networks, namely that neurons in the same layer have no connection. In this network, apart from having input and output layers, there are also hidden layers (see Figure 1b).



(a) **(b)**

Figure 1. (a) Single Layer Networks, (b) Two Layer Network

Figure 1 describes the input layer having m neurons (symbol x), the hidden layer having p neurons (symbol z), and the output layer having q neurons (symbol y).

Determining the number of hidden layers and the number of neurons in the hidden layers has an important role. Masters (1993) states no theoretical reason exists for more than two hidden layers. Problems that require two hidden layers are rarely encountered in real life. The number of hidden layers affects the length of the learning process; this is due to two things. (Rodrigues et al., 2018). The first is that additional layers cause model errors to be backpropagated, which will cause unstable gradients. The second is that the number of false minima usually increases drastically. So, it will happen that the iteration will continue and will not be completed. (Ifeoma, 2022)Therefore, the number of hidden layers that are often used is one hidden layer.

One guideline for choosing the number of hidden neurons is the geometric pyramid rule, where the input layer has more neurons than the neurons in the hidden layer. Meanwhile, the number of output neurons is smaller than the number of hidden neurons. The formula used to calculate the number of hidden neurons in one hidden layer follows:

$$\sqrt{mn} \tag{3}$$

Where, n is the number of input neurons and m is the number of output neurons.

C. Method

1. Research Design

This study is quantitative research that uses crawling data of user evaluations in the NU online applications from February 9th, 2021, until May 31st, 2024. Data preprocessing is carried out on the results of crawling data, which includes cleaning (removing punctuation, emoticon, UR, numbers, multiple whitespaces into single whitespace, and nu online), case folding, tokenizing, normalization, removal and stemming using the Sastrawi dictionary. Sentiment is divided into three classes: positive, negative and neutral using INSET (Indonesian Sentiment Lexicon). INSET is a lexical dictionary developed specifically for sentiment analysis of Indonesian language texts. The words used as input neurons are words that are not used as calculation references in the INSET. Lines that do not have words as input neurons were then removed (Milosavljevic et al., 2018). The training and testing data were divided with a proportion of 80:20 randomly and proportionally in each sentiment class. The input neuron is determined using several words with the highest frequency in each sentiment class. This research started from the 10 words with the highest frequency in each sentiment class to using all the words, then calculated the number of hidden neurons using equation 1. Parameter estimation of artificial neural networks used a backpropagation algorithm. Finally, this research predicted the class of testing data, and calculated its accuracy.

2. Data and Data Sources

This study used user reviews in the NU online application as the objects of the study in the form of words, starting February 9th, 2021, until May 31st, 2024.

3. Instruments

The input neuron is determined using several words with the highest frequency in each sentiment class. In this research, starting from the 10 words with the highest frequency in each sentiment class to using all the words. The ouput neuron is

sentiment class, i.e. positif, negative, and netral. The research variables are shown in Table 2.

Table 2. The Research Variables

Variable	Definition
x_1 (1st input neuron)	frequency of occurrence of the first word
x_2 (2nd input neuron)	frequency of occurrence of the second word
⋮	
x_p (p^{th} input neuron)	frequency of occurrence of the p^{th} word
y_1 (1st output neuron)	1 if sentiment is positive and 0 otherwise
y_2 (2st output neuron)	1 if sentiment is negative and 0 otherwise
y_3 (3st output neuron)	1 if sentiment is neutral and 0 otherwise

4. Data Analysis Techniques

Pie chat was used to describe how much percentage of sentiment class. Wordcloud was used to describe the most frequent words. Artificial neural networks were used to classify sentiment on testing data. Then, it determined the best number of input neurons based on accuracy in testing data.

D. Findings

There are 12613 user evaluations (review) in the NU online application starting February 9th, 2021, until May 31st, 2024. Preprocessing was carried out until it removed lines that did not have words as input neurons, and 8546 reviews remained. By using INSET, sentiment classes can be described as follows

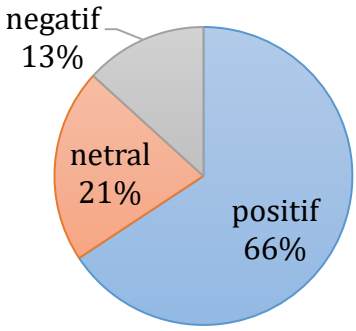


Figure 2. Pie Chart of Sentiment Class

Based on Figure 2, it can be seen that the majority of NU online received positive sentiment, namely 66%. Meanwhile, neutral and negative sentiments, respectively, were 21% and 13%.

The frequency of words in each sentiment class can be described as follows

(a) (b) (c)

Figure 3. WordCloud of Sentiment (a) Positive, (b) Negative, (c) Neutral

Based on Figure 3, The top 10 words in positive sentiment i.e. 'aplikasi', 'nya', 'fitur', 'al', 'ah', 'iya', 'qur', 'warga', 'notifikasi', and 'jadwal'. The top 10 words in neutral sentiment i.e. 'nan', 'aplikasi', 'nya', 'iya', 'update', 'barokah', 'ah', 'rekomen', 'download', and 'komplit'. The top 10 words in negative sentiment i.e. 'aplikasi', 'nya', 'fitur', 'iya', 'al', 'update', 'ah', 'qur', 'notifikasi', and 'tulis'. Based on the top 10 words with the highest frequency in each sentiment class, 17 unique words can be obtained. Equation 1 is used to calculate hidden neurons, if it is known that there are 17 input neurons and 3 output neurons, then there are 7 hidden neurons. Based on the artificial neural network architecture, it was used to predict sentiment classes on testing data and obtained an accuracy of 0.71. Same steps as before in increments of 10 until all words are used (5300). The accuracy of testing data can be described in Figure 4.

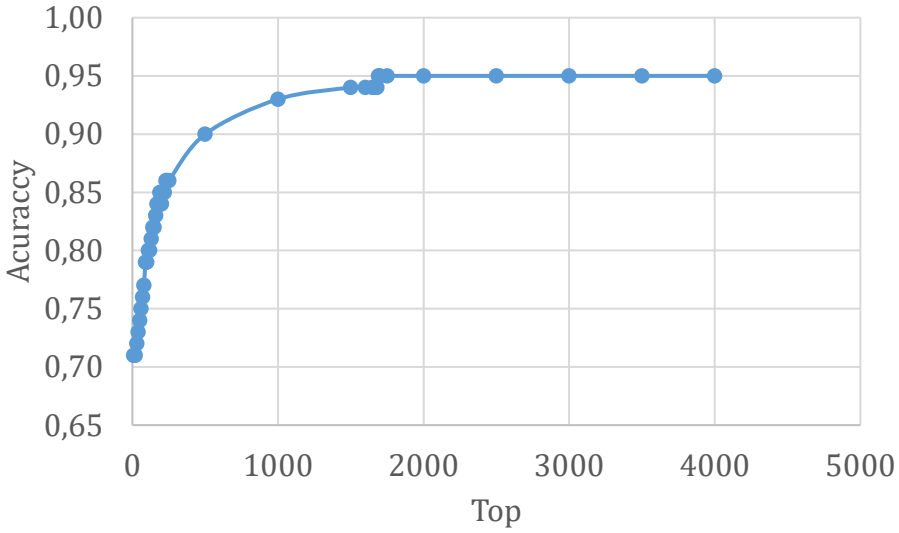


Figure 4. The Accuracy of Testing Data

Based on Figure 4, it can be seen that accuracy starts from 0.71 at the top 10 and goes up to 0.95 at the top 1690. The input neurons in the top 1690 are 3368 words, and the hidden neurons are 101 neurons.

E. Discussion

Based on the research results, in the top 10, there are words that have no meaning, such as "Al", "qur", "nan", and others. This is caused by the presence of symbols in the Arabic language. Meanwhile, in the pre-processing process, symbols will be removed. So that the word Al-Qur'an becomes the words Al, Qur, an. This can reduce classification accuracy. We were able to get more valuable results by using a certain pre-processing activity connected to a tweet data attribute (Hidayatullah & Ma'arif, 2017).

Based on the Indonesian Sentiment Lexicon (INSET), the results of this study show that 66% of the reviews showed positive sentiment, 21% were neutral, and 13% were negative. Based on the top 10, it can be seen that the unique words for positive sentiment are "*warga* (community)" and "*jadwal* (schedule)". This refers to the application, which is very helpful for the Nahdliyyin community and notifications of prayer schedules. Unique words for neutral sentiment include "nan", "*barakah* (blessing)", "*rekomen* (recommended)", "download", and "complete". Meanwhile, the unique word for negative sentiment is "tulis (write)". This refers to the writing of

verses, some of which are too small, some of which are written incorrectly, some of which have too small gaps in writing and the need for Roman writing. As many as 72 percent of Indonesian Muslims are illiterate in the Qur'an (CNN Indonesia, 2023), this supports the need to add Roman writing to the NU Online application.

The artificial neural network architecture with the best testing data accuracy has 3368 words as input neurons from 5300 words. This shows that 64% of the best information can be used as input neurons. The less information used, the smaller the accuracy of the testing data. Words that influence positive, negative or neutral sentiment cannot be done because artificial neural networks are machine learning. If the focus of the research is words that influence sentiment classes, then use statistical learning. However, it must meet the required assumptions. Artificial neural networks are used to classify new reviews as including positive, negative, or neutral sentiments with an accuracy of 95%. The high accuracy is in line with Razzaq et al. (2019) research.

Apart from using top frequencies, the words used as input neurons can use statistical approaches, as well as content and syntax model approaches such as Latent Dirichlet Allocation or maximum entropy modelling (Duric & Song, 2012).

F. Conclusion

Based on the top 10, positive sentiment is described by the NU community feeling helped by the schedule notifications and the Quran. Negative sentiment is illustrated by difficulties in downloading and updating applications. Neutral sentiment is depicted by the app's features, such as notifications. The best testing data accuracy was 95%, with 64% of the word information used as input neurons. The findings highlight the importance of using a comprehensive set of words for training the ANN. Including more words significantly enhances the model's performance, indicating that a richer vocabulary captures sentiment nuances better. The limitation of this study is in the pre-processing of data to handle symbols so that many words do not have meaning from the preprocessing results, so it is recommended that further research carry out normalization first and then carry out cleaning.

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