The Implementation of Probabilistic Neural Networks to Sentiment Analysis of National Principle and Religion Issues in Indonesia

Mustakim, Rice Novita

Department of Information System, Universitas Islam Negeri Sultan Syarif Kasim Riau, Indonesia

mustakim@uin-suska.ac.id

Abstract. Indonesia's diverse population presents critical issues, including political, social, religious freedom, National Principle, and conflict issues. With the widespread use of internet and social media, machine learning technology has become a tool to analyze public opinions about anti-Pancasila, intolerance, khilafah, and radicalism. This study examines the frequency of discussions on these topics on social media and utilizes probabilistic neural networks (PNN) to classify text data. The study conducted several trials with different parameters and employed hold-out and K-fold cross-validation schemes. The results show that the radicalism keyword had the best accuracy of 64.9% on the hold-out with a spread of 0.1 and 20% of testing data, while the keyword khilafah had the best accuracy of 87.9% with a spread of 0.001 and K=6 in the K-fold cross-validation. The study also finds that cross-validation has better accuracy than hold-out to analyze the distribution of data. In 2019, the sentiment analysis revealed that almost 50% of Indonesians show neutral attitudes toward these four critical issues. This study demonstrates the potential of machine learning technology to analyze public opinions on complex sociopolitical issues in Indonesia.

Keywords: Hold-Out, K-Fold Cross Validation, Classification, Probabilistic Neural Network, Anti-Pancasila

1. Introduction

Indonesia is a unitary state consisting of several aspects of ethnicity, languages, ethnicity, and religions. The diversity of Indonesia is presented in its national symbol and basis, namely the Garuda Pancasila. Diversity, which includes the concept of unity and oneness, has become the main idea of the Guidelines on the Appreciation and Practices of Pancalisa (P4) and has long been the main guideline for Indonesians' life. The first principle of the Pancasila states that Indonesia is a country that believes in God. This principle functions as a life guideline and points of view as well as provides freedom of religion to ensure Indonesians' respective beliefs (UUD, 1945).

Freedom of religion has become a trending topic lately. This topic reveals people's understanding of freedom of religion that agrees with Pancasila and the 1945 Constitution. Unfortunately, this understanding becomes a polemic in society resulting in the emergence of several SARA issues. Dividing and compartmentalizing religions have discredited certain sections to create friction in society (Bustamam-ahmad & Zulfidar, 2021). Such a condition has lasted quite a long time and involved several elements of society, both the lower and upper classes. Religious issues are frequently associated with the rise of issues of anti-Pancasila, terrorism, radicalism, and *khilafah* (caliphate) in Indonesia (Syah, 2017).

In computer science, sentiment is more focused on analyzing people's thoughts; this topic is discussed in a cyberspace article and is known as sentiment analysis (Shaik, 2023). Sentiment analysis is a field of study that analyzes an individual's opinions, sentiments, evaluations, judgments, attitudes, and emotions toward an organization, individual, problem, event, or particular topic (Drus & Khalid, 2019). Several studies have conducted a sentiment analysis. For example, Satriya et al. (2023) state that the sentiment analysis of social media is very interactive and real-time to track the behavior of an individual or group of Indonesians (Satrya, 2023). Another study by Patel et al. (2023) deploys that sentiment analysis has drastically shifted from initially analyzing online product reviews to analyzing online product reviews and social media texts from Twitter and Facebook (Patel et al., 2023). Finally, Chan (2022) conducts a sentiment analysis on social media (Chen et al., 2022).

Computer science is the media to conduct data analytics, of which the process starts by collecting raw data, processing the collected data to produce a conclusion, and concluding several research techniques. One of the techniques is the classification technique, which is a part of data mining science. A classification is a group of supervised learning sections, divides data into training and testing data (Gharavi et al., 2022; Utami & Mustakim, 2021), has a special class called a target (Gurning et al., 2022), and has a dynamic measure of accuracy (Abbas et al., 2023). Each algorithm in the classification techniques, such as the probabilistic neural network (PNN) algorithm, has several weaknesses and advantages. PNN is a reliable algorithm that applies to sentiment analysis cases (Behera et al., 2016) and has a very high accuracy value (Savchenko & Belova, 2022). PNN is a part of the development of an artificial neural network (ANN), and this algorithm offers more advantages than its predecessor algorithms, namely the neural network perceptron and neural network backpropagation (Jia & Wu, 2022). Some of these algorithms have been implemented in several cases and evaluated, and even compared to the Support Vector Machine (SVM); the advantage of the PNN is the accuracy (L. Xu et al., 2020). The previous studies only employed one type of data-sharing technique, namely hold-out. Meanwhile, data mining consists of three sharing data techniques: hold-out, cross-validation, and clustering.

To date, there are 63 million Twitter users in Indonesia (Kominfo, 2019). Millions of tweets posted by social media users are tabulated daily into a database. The tabulated data are then analyzed to reveal in-depth critical information. This information is employed for three purposes. The first is to understand and solve national public perceptions. The second is to respond to cases of radicalism, intolerance, *khilafah,* and anti-Pancasila in Indonesia. The third is to map several keywords frequently discussed by applying one of the data mining techniques, namely PNN. Further analysis can examine a relationship and answer the main issues that arise from religion or political keywords.

This current research is expected to provide the widest possible information on Indonesians' perceptions of the general public, government, and intellectuals. These perceptions are divided into three aspects of opinion: positive, negative, and neutral aspects. These aspects could address any issues, which could undermine the Unitary State of the Republic of Indonesia. In addition, the results of this research can countermeasure parties who undermine the authority of the Unitary State of the Republic of Indonesia.

This research's novelty is the application of the classification technique that infers public opinions by comparing several data-sharing techniques. The collected data were then validated by language experts. Finally, this research could conclude the best accuracy of the applied algorithm. The difference with previous researchers in this study is in determining the spread parameter, which uses a combination of decimal values, in data sharing using Cross Validation (Bau et al., 2022) minimum and maximum combinations based on the number of datasets used. In addition, the dataset used refers to four issues that are being discussed on a national scale, in this case the data filtering process is carried out by combining sub-items between keywords, resulting in a better dataset compared to other dataset filtering techniques.

2. Related Work

The existence of text mining technology has resulted in non-structural data as the main consideration to conduct data-based research. Text data analysis has become more interesting for data science researchers, especially for those who concern about the sentiment analysis of social media. Public opinion is frequently associated with positive, negative, and neutral issues, especially economic, social, political, and religious issues. Rusydiana (2018) analyzes public opinion about *waqf* in Indonesia and has proven that 66% of the public positively responds to the zakat while 445 of the respondents show negative and neutral responses. The study oncludes that the government should support the zakat revival to overcome the economy of Indonesia (Rusydiana, 2018).

Previous studies have widely applied sentiment analysis using several techniques of data mining, such as classification, clustering, and association. For example, Najyah and Haryanti (2021) investigate the sentiment of the Covid-19 cases in Indonesia. They have proven that the use of a probabilistic neural network (PNN) can obtain an accuracy of 89% (Najiyah & Haryanti, 2021). Meanwhile, Ghiassi (2022) examines clustering cases, spam filtering, and text data grouping with feature engineering using the K-Nearest Neighbor (K-NN), spectral algorithms, and DBSCAN algorithms (Ghiassi et al., 2022). The data were analyzed using sentiment analysis.

One of the data mining classification techniques with high accuracy to process training and testing data Is the PNN, an algorithm part of the artificial neural network (ANN). PNN offers higher accuracy than another algorithm does. Lin et al. (2022) explain that the variational mode decomposition parameters can be optimized with cuckoo search and PNN; thus, intelligent gearbox errors can be identified. The PNN algorithm can increase the effectiveness of algorithm optimization (Lin et al., 2022). Furthermore, Alam and Yao (2018) compare PNN, SVM, Naïve Bayes, and MaxE and have proven that PNN has the highest accuracy of 98 % (Alam & Yao, 2018). Therefore, text mining and structural data cases can be selected using algorithms with high accuracy.

Research of the text-based sentiment analysis cases of anti-Pancasila, radicalism, intolerance, and *khilafah* is a continuation of several previous studies by Mustakim et al. (2019), which comparatively investigates the same Islamic objects. Other previous studies classify texts of Tafsir Al-Qur'an Bil Ma'tsur and Bil Ra'yi by applying the K-NN algorithm (Nur et al., 2019), map topics in the Qur'an using classification and association techniques to distinguish and decipher relationships between words in the translation of the Al-Qur'an (Novita et al., 2021), and interpret verses in the Qur'an using a combination of the fuzzy K-NN, improved K-NN, and modified K-NN algorithms (Nur et al., 2021).

3. Research Methodology

This research collected data on the basic concepts and theories of data mining, radicalism, intolerance, anti-Pancasila, and khilafah. The collected data included constraints, advantages, and disadvantages that will affect the work system in the field. This research employed experimental and descriptive analysis methods. The method of this research is presented in Figure 1.

Data were collected by observing Twitter as the main data source. Data were collected from literature studies of journals on computing, data mining, text mining, intolerant cases, and radicalism. Furthermore, data were collected by interviewing big data analytic experts about modeling and analysis results as well as experts in the social, religious, and political fields to gain additional analysis materials. The data were then classified using the probabilistic neural network (PNN) algorithm with an experimental split value of 0.1, 0.001, and 0.0001. The best trial results were continued with analyzing and concluding research results.

To calculate the data accuracy in the PNN algorithm, this study employed the confusion matrix. This method calculated the accuracy of the results of each prediction in the training data. For A priori, accuracy was gained by calculating the precision value of each resulting association.

This research was carried out in general to provide an overview of the results of algorithm accuracy on cases that are trending topics in Indonesia today, which are related to radicalism, intolerance, anti-Pancasila, and Khilafah. In addition to this, the implication to be achieved is to provide a broad overview of the issues that have been used as benchmarks to bring down one group against another. The role of machine learning becomes an important part of resolving sentiment issues in Indonesia if this can be researched continuously.
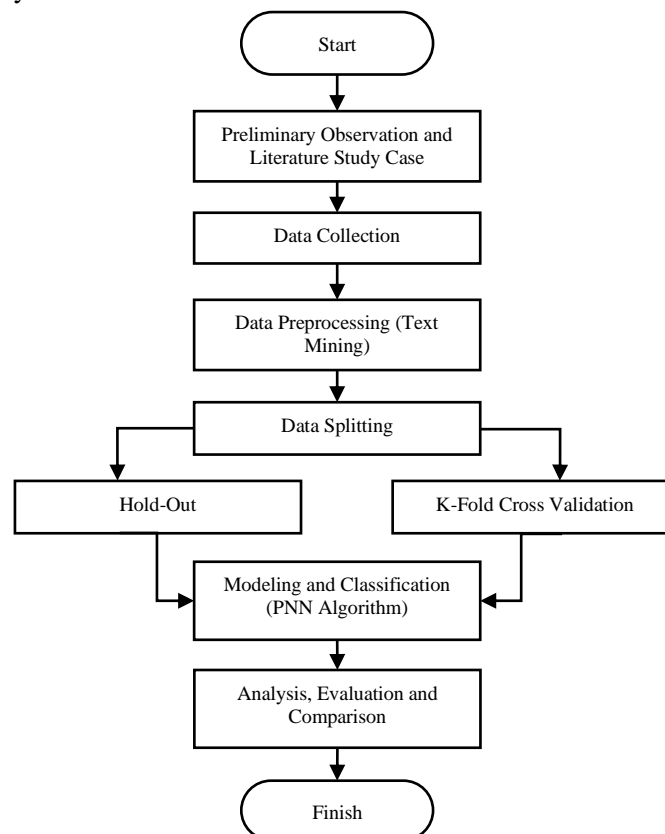

Fig. 1: Research Methodology

3.1. Text Preprocessing

Text pre-processing consists of tokenizing, filtering, stemming, tagging, and analyzing (Hickman et al., 2022). Text processing has a term known as the vector space model (VSM), which represents a

collection of documents as vectors in a vector space. VSM is a basic technique to obtain information to assess the relevance of documents by searching keywords (queries) on search engines, classifying documents, and grouping documents (Bau et al., 2022; Eminagaoglu, 2022; Ho et al., 2022). The pranking measure in VSM can rank documents according to their similarity or relevance to the query. The simulation of the similarity size is presented in Figure 2 (D. Xu & Miller, 2022).
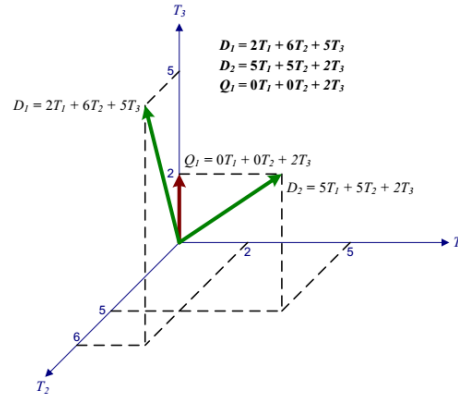

Fig. 2: VSM with Two Documents D 1, and D 2, and User Query Q 1

The equation for calculating the point distance on VSM is presented in equation 1.

$$\text{Similarity}\left(\overrightarrow{d_j}, \overrightarrow{q}\right) = \frac{\overrightarrow{d_j} \cdot \overrightarrow{q}}{\left|\overrightarrow{d_j}\right| \cdot \left|\overrightarrow{q}\right|} = \frac{\sum_{i=1}^{t}(W_{ij} \cdot W_{iq})}{\sqrt{\sum_{i=1}^{t} W_{ij}^2 \cdot \sum_{i=1}^{t} W_{iq}^2}} \tag{1}$$

3.2. Probabilistic Neural Network (PPN)

Probabilistic Neural Network (PNN) is an artificial neural network that has been widely developed and applied for policy-making, clustering, and human interests (Tan et al., 2022). PNN has a fairly high level of classification accuracy and only requires a relatively short training time. PNN offers the best classification accuracy because it has the smoothing parameter (spread) (Alweshah et al., 2022). PNN consists of four layers: input layers, pattern layers, summation layers, and output layers (Chaki et al., 2022).

4. Results and Discussion

This study collected the primary data, known as a dataset, using the Python programming language. This study collected data posted on Twitter from January 2014 to December 2020. The initial data from the data crawling process are summarized in Table 4.1. The data were divided into four keywords: anti-Pancasila, intolerance, khilafah, and radicalism. This study collected 2783 data on anti-Pancasila, 4939 data on intolerance, 53,396 data on khilafah, and 25,561 data on radicalism. In total, this study collected 86,679 data before conducting the preprocessing. The next process was preprocessing the data by cleaning the data that still contained layers, noise, and redundancies.

The data classification process employed the probabilistic neural network (PNN) algorithm with trial division. First, this study employed 86,679 data consisting of 2783 anti-Pancasila data, 4939 intolerant data, 53,396 khilafah data, and 25,561 radicalism data. Second, this experiment consisted of three hold-out schemes with training data distribution of 90%, 80%, and 70% as well as one cross-validation scheme with a total of K=10. Third, the spread on the PNN consisted of 0.001, 0.01, and 0.1.

The best modeling of this study was collected based on the best accuracy in each experiment from three spreads, three data divisions based on hold-outs, and 10K based on cross-validation of four keywords on Twitter datasets. Based on the previous experiments and data processing, the results of the algorithm processing are divided into three main parts: comparisons based on the distribution of hold-

out data, comparisons of cross-validation data, and comparisons of the best hold-outs with the best cross-validation.

4.1. Hold-Out

The experiment was conducted using the keywords anti-Pancasila, intolerance, khilafah, and radicalism with a spread of 0.001, 0.01, and 0.1, testing data of 10%, 20%, and 30%, and training data of 90%, 80%, and 70%. The details of the experimental results are shown in Table 1.

Table 1: Hold-out Trial Results

No	Spreads	Test Data	Anti-Pancasila		Intolerance		Khilafah		Radical	
			Acc	Misclass	Acc	Misclass	Acc	Misclass	Acc	Misclass
1	0.001	10%	0.435	0.565	0.437	0.563	0.444	0.556	0.470	0.531
2	0.001	20%	0.421	0.579	0.439	0.561	0.447	0.553	0.580	0.420
3	0.001	30%	0.393	0.607	0.453	0.547	0.454	0.546	0.492	0.508
4	0.01	10%	0.435	0.565	0.477	0.523	0.446	0.554	0.541	0.459
5	0.01	20%	0.424	0.576	0.477	0.523	0.449	0.551	0.607	0.393
6	0.01	30%	0.393	0.607	0.479	0.521	0.465	0.535	0.573	0.427
7	0.1	10%	0.454	0.546	0.520	0.480	0.477	0.529	0.626	0.374
8	0.1	20%	0.431	0.569	0.529	0.471	0.467	0.533	0.650	0.350
9	0.1	30%	0.395	0.606	0.519	0.481	0.454	0.546	0.639	0.362

The experimental process was conducted using a spread value of 0.001 and with 10% of testing data Based on the confusion matrix, the accuracy is 43.52% These results are summarized in Figure 3.
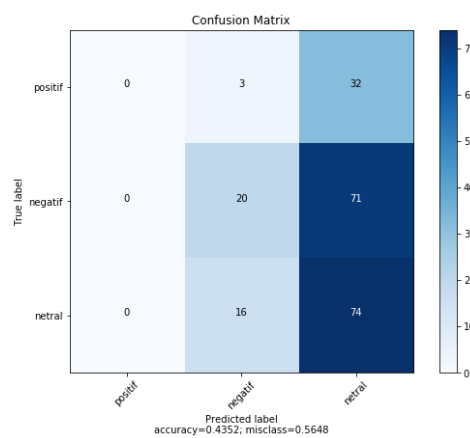

Fig. 3: Confusion matrix accuracy Spread 0.001; test data 10%; Anti-Pancasila

This experiment examined all the data distribution and the trial process on the spread to get the best accuracy results. The four experimental results conclude that the best spread of the PNN for dividing hold-out data is 0.1. Meanwhile, the best data testings are 10% and 20%. The details of these results are shown in Figure 4.
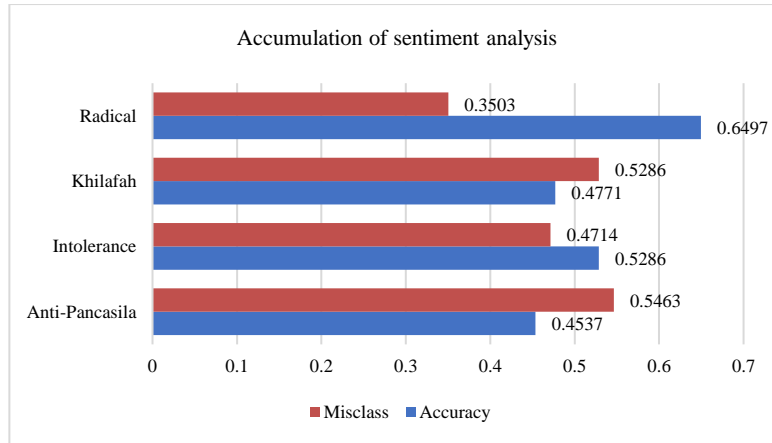
Fig. 4: Accumulation of each keyword sentiment analysis using PNN

4.2. Cross Validation

The cross-validation with a spread of 0.001 for the data on anti-Pancacila has discovered the value of 4.80 with 10K divisions for each keyword. Meanwhile, the highest accuracy is 83.3% at K=4.
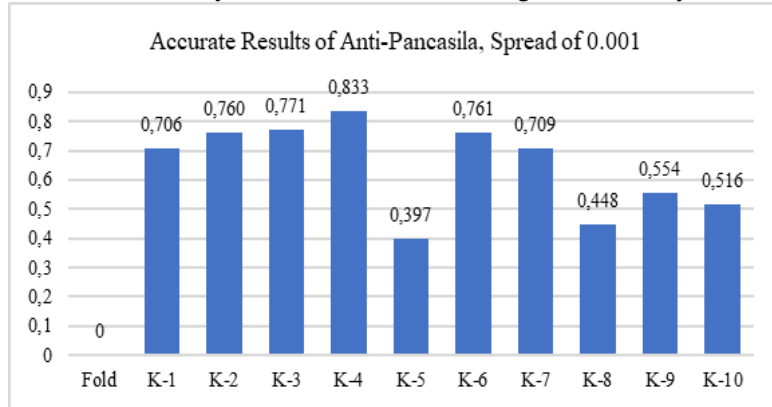

Fig. 5: Accurate Results of Anti-Pancasila Cross Validation with a Spread of 0.001

This process constitutes the modeling conducted in this study. Each model is visualized equally. Other keywords excluding intolerance, radicalism, and khilafah were analyzed using cross-validation.
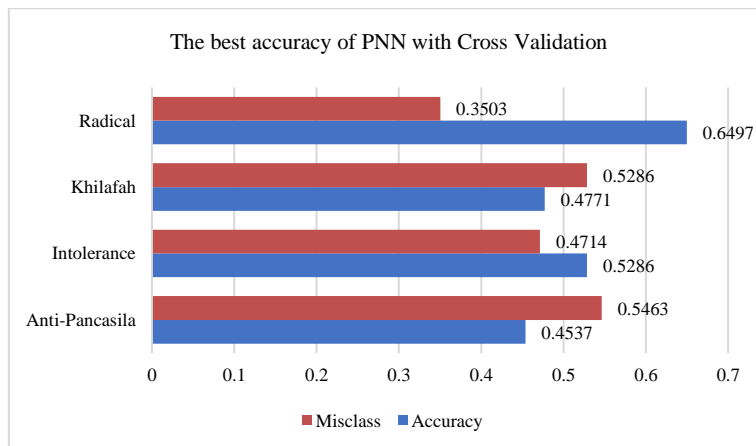

Fig. 6: Comparison results of the best accuracy of PNN with Cross Validation

The results of comparing the entire cross-validation are shown in Figure 6. Meanwhile, the conclusions of 12 previous processes are presented in Table 2.

Table 2: The Best Cross Validation Accuracy Details for each Keyword

No	Keyword	Spreads	K	Accuracy	Misclass
1	Anti-Pancasila	0.1	6	0.854	0.477
2	Intolerance	0.001	10	0.857	0.498
3	Khilafah	0.001	6	0.879	0.392
4	Radical	0.001	7	0.825	0.421

4.3. Best Modeling

This study employed two data-sharing models: hold-out and cross-Validation, with spreads of 0.001, 0.01, and 0.1 on PNN. The result shows that the best accuracy comparison is cumulative, as presented in Figure 7.
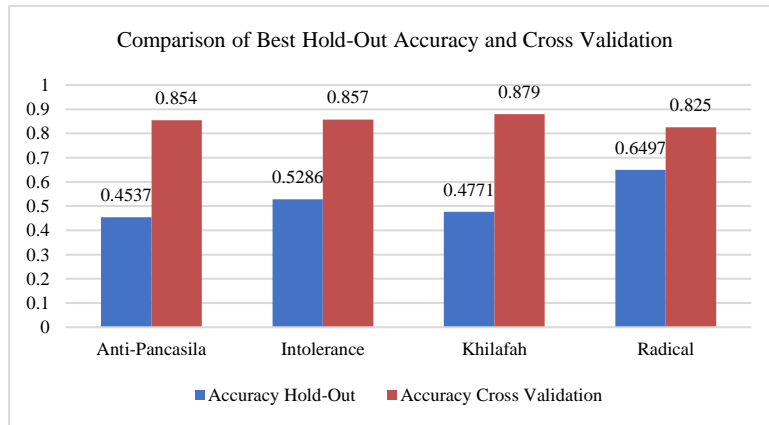

Fig. 7: Results of Final Comparison of the best accuracy of PNN Hold Out and Cross-Validation

4.4. Discussions

This study conducted a sentiment analysis on the keywords anti-Pancacila, intolerance, khilafah, and radicalism. The data were collected from Twitter users in Indonesia in 2019. The results of the sentiment analysis were shown in Figure 8.
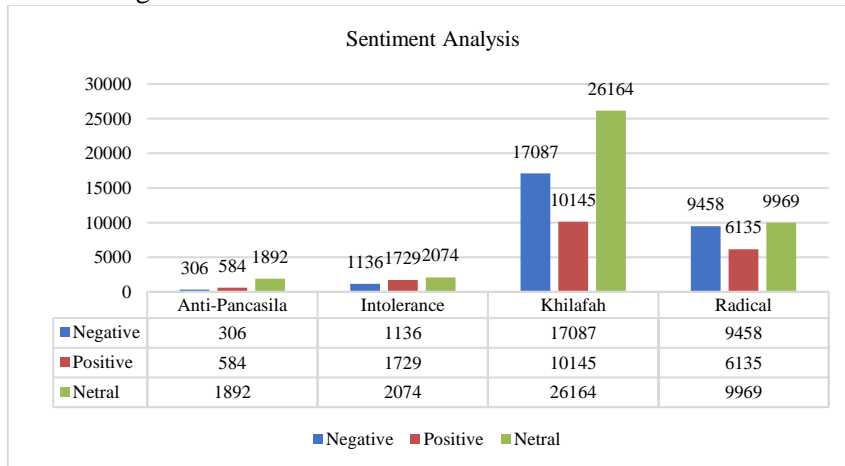

Fig. 8: Final of Sentiment Analysis

The explanation of Figure 8 shows the implications of this research and what develops in society related to the issue that has become a trending topic on social media Twitter tends to be mediocre. The existence of certain group conflicts is most likely caused by provocation from mainstream media, social media controlled by certain groups in the form of massive or buzzers, and some indications of divisive groups in the country. In addition, artificial neural networks are often known as knowledge-based

networks to solve classification cases in this case have high accuracy, it is an effort as a machine-based validator to answer questions about issues that have been developing in society.

This research has more contributions in terms of the utilization of artificial neural network-based algorithms, namely PNN. In the future, other researchers can optimize with other algorithms to obtain better results and performance in solving text-based cases and sentiment analysis. It should also be noted that PNN has many parameters that support hybrid with other algorithms including in determining spreads by utilizing algorithms to obtain high accuracy with a minimum error rate.

The limitation of research with social media data datasets like previous research is that it is difficult to distinguish between data that is written by people and data that is sourced from machines. This is a major obstacle for most text-based research. Therefore, in the future, some techniques are needed to overcome this problem. Some studies have implemented spam filtering that can be applied to this text-mining case. However, there are still some weaknesses that make these techniques often have low accuracy.

5. Conclusion

This study has discovered 2783 data on anti-Pancasila, 4939 data on intolerance, 53,396 data on khilafah, and 25,561 data on radicalism. These data were collected from social media. The probabilistic neural network (PNN) has several advantages to classify text data. This study processed several trials. First, parameter spreads are 0.001, 0.01, and 0.1. Second, hold-out data were distributed by dividing training data and discovered 90%, 80%, and 70%. Third, one cross-validation scheme has a total of K = 10. The experiments have obtained that keyword radicalism has the best accuracy of 64.9% on the hold-out with a spread of 0.1 and testing data of 20%. Meanwhile, the cross-validation has revealed that the keyword khilafah has the best accuracy of 87.9% with a spread of 0.001 and K=6. The experimental results show that the distribution of data by K-fold cross-validation in each model has better accuracy than hold-out does. Finally, the sentiment analysis collected in 2019 has revealed that 32% of Indonesians show a negative sentiment value, 21% of Indonesians show a positive sentiment value, and 46% of Indonesians show a neutral sentiment value.

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