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Sentiment Analysis on IMDB Movie Reviews using BERT

[1]Rani Puspita, [2]Cindy Rahayu
[1,2] Computer Science Department, School of Computer Science, Bina Nusantara University, Jakarta, Indonesia 11480
Email: [1]rani.puspita@binus.ac.id, [2]cindy.rahayu@binus.ac.id

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ABSTRACT
Before technology existed, opinions could only be obtained from acquaintances, friends, or experts who were experts in certain fields. However, as technology develops, it turns out that opinions can be expressed through social media so that they can influence everyone who sees them. One of them is movie reviews. Human opinion about something is often not valid. So, this study aims to investigate the sentiment analysis related to IMDB Movie Reviews. The approach used is BERT. BERT is a deep learning approach. The data used in this study is the IMDB Movie Review of 50,000 data. The existing data is divided into three parts, namely training data, validation data, and testing data. The results obtained from the BERT model are 91.69% for training accuracy 0.187 for training loss, 91.85% for validation accuracy, 0.212 for validation loss, 91.78% for testing accuracy, and 0.207 for testing loss. It can be seen, that BERT is a very effective approach for sentiment analysis of IMDB Movie Review so that the research problem regarding the invalidity of one's opinion can be handled properly.

Corresponding Author:
Rani Puspita,
Computer Science Department, School of Computer Science, Bina Nusantara University,
Jakarta, Indonesia 11480.
Email: rani.puspita@binus.ac.id

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1. INTRODUCTION

Before the existence of the internet in the world, opinions were sought from acquaintances, friends, or experts. In the past, an important piece of information was the opinion of others. But as technology develops, it turns out that humans realize that sometimes someone's opinion is not valid [1]. Humans are subjective creatures. Their opinion is important to consider aspects of their satisfaction with a particular application or product. With the opinion of the user, it will make it easier for product makers to get information about the system that has been made. The result can be positive, it can be negative [2].

Besides that, database in this digital world is very developed. At this time, users can express their opinions on various social media such as Twitter, Facebook, Rotten Tomatoes, and Foursquare. Users can express their opinions in the form of reviews, thereby providing opportunities for exploration and finding likes and dislikes in cyberspace. One of them is movie reviews which can influence everyone from audiences, production companies to film critics [3].

Movies can be watched when relaxed and free. Currently there are so many movies that can be watched via the internet or cinemas. Usually, movies that are watched via the internet will be charged to the user who will watch them. Therefore, most users who will pay will read comments first from users who have watched the movie. The site that is often used to view comments about a movie is IMDB. From the website, From the website, users have difficulty reading positive or negative comments from users who have watched it. Users can also view comments based on the stars in the movie [4].

One of the appropriate processes for the above problem is sentiment analysis. Sentiment analysis is the process of using Natural Language Processing (NLP) to identify, categorize, and extract opinions that exist in a text format [5]. Currently, there are many studies that discuss sentiment analysis related to movie reviews. According to Bodapati and his colleagues, sentiment analysis is an analysis that functions to process

information in the form of text to analyze emotions in their writing. In simple terms, the existing words need to be analyzed whether the intent conveyed is positive or negative.

Sentiment analysis is very useful for understanding public opinion on a particular product or service so that it can be researched, improvised, and a final conclusion can be drawn [6]. Sentiment can be represented as a binary value. 0 as negative and 1 as positive [1]. This is in line with statement of Haque, et al, sentiment analysis helps us to understand the relationship between text and human emotion as a consideration. For example, nowadays, no one goes to see a movie unless they see good reviews about it on social media or from some movie reviewers on the internet. Currently, reviews are one of the marketing strategies in certain fields [7]. The focus on sentiment analysis is on movie reviews, comments, and someone's experiences with a product [8]. By doing this research, it will be easier for people to understand the entire review of a movie. This research also aims to improve the quality of films and shows that will be made in the future [9].

Bidirectional Encoder Representations from Transformers (BERT) is a method in deep learning. BERT is a pre-trained language that gives context to the words or sentences that have been learned. BERT is designed to take into account the context of words from both the left and right sides [10]. This is in line with Davlin et al, BERT is a new language model. BERT uses a two-way transformer to pre-trained [11]. BERT is suitable for research with sentiment analysis [12]. Sentiment analysis with BERT also has good accuracy [13]. According to research conducted by Dahir and Alkindy [14], sentiment analysis is a highly essential technique in the field of text analytics. Then, they compared three methods, namely Logistic Regression, SVM, and Random Forest for movie reviews using tokenization, lemmatization, Word of Bags, and TF-IDF. In this study, logistic regression had the highest accuracy of 89.20%, precision of 88.80%, recall of 89.80%, and an area under the operating characteristics curve (AUC) of 89%. In line with this, based on research conducted by Derbentsev, et al [15] who examined sentiment analysis using several deep learning methods including logistic regression, Convolutional Neural Network (CNN) models, Long-Short-Term Memory (LSTM), and Bi-Directional LSTM (BiLSTM) models with GloVe and Word2vec word embedding. In this study, researchers used the IMDB dataset and obtained the highest accuracy of 90.1% using the CNN model. Besides that, BERT is a popular method and has high accuracy on sentiment analysis. Based on research conducted by Mathew, et al [16], the accuracy results obtained from the comparison between the BiGRU and BERT models are 72.06% and 94.08%. Then for loss, for BiGRU is 0.5681 and for BERT is 0.2301. From this study, it was found that BERT has the highest accuracy. In line with the research conducted by Tao, BERT also gives high output. In this study, the researcher used several methods including BERT, ULMFIT, SentiBERT, BERT+MC-BiGRU-capsule, and MC-BiGRU-capsule. The accuracy for BERT is 90.14, ULMFIT is 91.21%, SentiBERT is 90.94%, BERT+MC-BiGRU-capsule is 91.89, and MC-BiGRU-capsule is 91.55%. From this, it can be seen that research using the BERT method has an accuracy of above 90% [17].

Based on the background that has been described, the focus of this research is the application of a deep learning approach to sentiment analysis using the BERT method which aims to be able to classify text on IMDB movie reviews. It can be interpreted that the research question in this research is how to apply sentiment analysis to IMDB film reviews using BERT so that researchers will get output with high accuracy and achieve research objectives.

2. LITERATURE REVIEW

In this session, the researcher will conduct a literature review on international journals related to predetermined research topics. This literature review aims to find references and at the same time learn something related to sentiment analysis related to IMDB movie reviews, and the BERT model. This section also serves to assist researchers in solving problems so they can find solutions to existing problems. The related works results from the sentiment analysis are shown in Table 1, and the related works results from the BERT model are shown in Table 2.

Table 1. Related Works to Sentiment Analysis

References	Methods	Processes	Results
Balaji [18]	Recurrent Neural Network (RNN)	Initialize dataset, training (VADER), pre-processing, feature extraction (TF_IDF), RNN for classification	Get accuracy of 98.45% for Amazon, 97.78% for TripAdvisor, 99.56% for E-bay, and 99.80% for IMDB
Çano [19]	Support Vector Machine (SVM), logistic regression, decision trees, and random forest	Preprocessing and vectorization with 4 methods, namely Support Vector Machine (SVM), Logistic Regression, Decision Trees, and Random Forest, and classification algorithms	The accuracy of the SVM is 0.925, logistic regression is 0.915, decision trees is 0.81, and random forest is 0.875

References	Methods	Processes	Results
Steinke [20]	Decision trees, random forests, and SVM	Movie reviews, pre-processing such as create corpora, tokenization, remove punctuation, numbers, symbols, and stopwords, stemming, feature extraction such as calculate term frequencies and TF-IDFs, select features, and classification	The random forest model and SVM get the highest accuracy, namely 85.27% and 86.18%
Tran [21]	Supervised machine learning techniques	User review, text data, processing text such as formatting, cleaning, sampling, and tokenizing, and experimental	Successfully categorizes film reviews into two categories, positive and negative
Rehman [22]	Long Short-Term Memory (LSTM) model and Convolutional Neural Network (CNN)	Pre-processing such as sentence segmention, tokenization, stemming/lemmatization, and stop work removal, word embedding word2vec, convolutional layers 20, global max-pooling layers, dropout, LSTM, and classification layers (0,1)	This research uses CNN-LSTM and gets an accuracy of 91%
Gandhi [23]	CNN, and LSTM	Preprocessing such as tokenization, word2vec, stop words, proposed work for CNN and LSTM model	The results of testing from this study were 87.74% for CNN and 88.02% for LSTM

Table 2. The Related Works to BERT

References	Method	Process	Result
Savini [24]	BERT	BERT pre-trained language model, intermediate-task transfer learning, and primary task fine-tuning	Experimental results show that BERT outperforms many previous models
Ogunleye [25]	SVM, CNN, and BERT	Pre-trained BERT, implementation CNN, SVM, and BERT, and comparison of SVM, CNN, and BERT	BERT gets the greatest accuracy of 90%.
Bowen [26]	BERT-CNN	Data pre-processing, logistic regression, implementation BERT-CNN, BERT and logistic regression	The accuracy results for logistic regression were 0.876, BERT was 0.930, and BERT-CNN was 0.929. Where BERT gets the highest accuracy results.
Singh [27]	BERT	Dataset preparation phase such as scraping data from twitter, cleaning the data, and selecting the relevant features, and sentiment analysis phase such as average likes over a period, intensity analysis, polarity and subjectivity, and wordcloud, and emotion classification using BERT	Validation accuracy for this research is 94%.
Chiorrini [28]	BERT	Word2vec, glove, emotion analysis, implementation BERT model	This experiment with the BERT model obtains an accuracy of 0.92.
Gao [29]	BERT	Collecting datasets, experiment settings, and classification with BERT model	BERT obtains stable accuracy and average classification accuracy is 80s.

3. THEORY AND METHODS

In this chapter, researchers will use the BERT model. Researchers will explain the theory and methods. Section 3.1 is an explanation to fully understand the BERT model that will be carried out for this research.

3.1. BERT

BERT's model architecture is multi-layer bidirectional Transformer encoder [11]. In order to describe the special architecture of BERT, it is necessary to compare the encoder and decoder of the Transformer first. The Transformer Encoder is basically a two-way Self-Attentive Model. Meanwhile,

Transformer Decoder is Unidirectional Self-Attentive Model, which only uses the token before the given token in order to attend to the token. Hence, Transformer Encoder gives BERT its Bidirectional Nature, as it uses tokens from both directions to attend to a given token.

The BERT architecture is built on top of the Transformer. Currently, there are two variants available namely [30]:

1. BERT Base with 12 layers (transformer blocks), 12 attention heads, and 110 million parameters, and
2. BERT Large with 24 layers (transformer blocks), 16 attention heads, and 340 million parameters

BERT Base is used to measure architecture performance comparable to other architectures and BERT Large yields good results reported in research paper. Besides that, the large model can serve to improve the training process and get better results. The BERT Base architecture has the same model size as OpenAI's GPT for comparison purposes. All of these Transformer layers are Encoder-only blocks. Figure 1 is a comparison between BERT Base and BERT Large, and Figure 2 is a flow of information of a word in BERT.

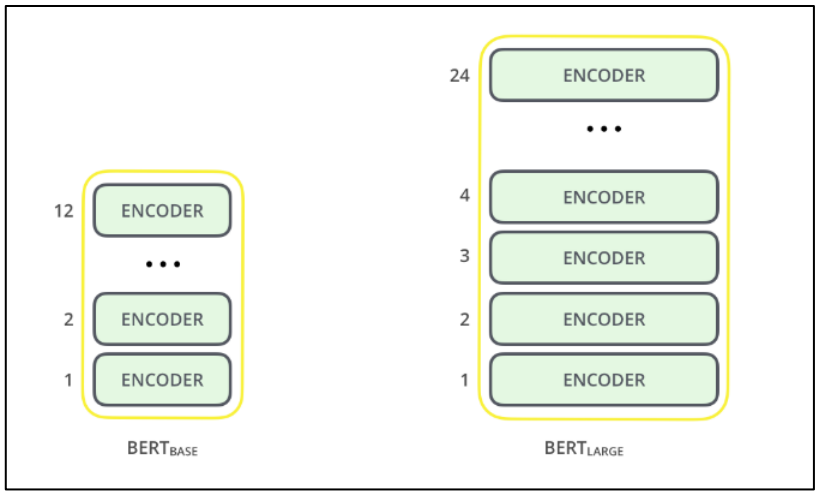

Figure 1. Comparison Between BERT Base and BERT Large

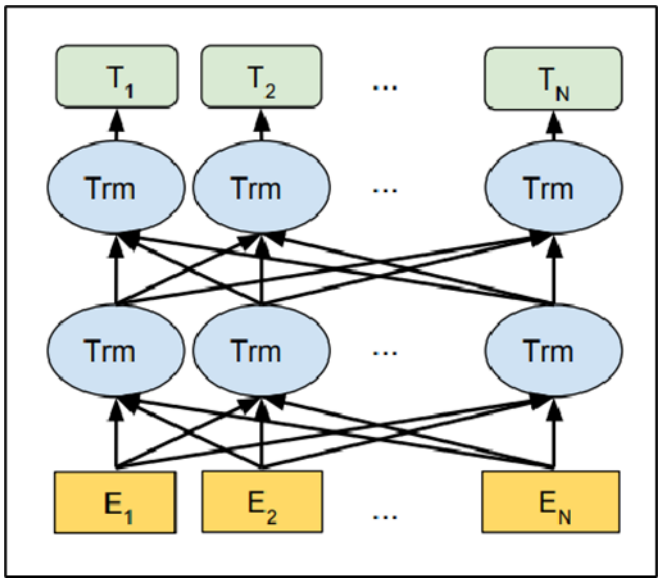

Figure 2. Flow of Information of A Word in BERT

BERT is one of the Transformer based language models. BERT is able to improve accuracy (or F1-Score) in many NLP tasks and Language Modeling tasks. Following are some of the input and output representations used in BERT:

1. [CLS]: This token is referred to as the 'classification' token which is used at the start of the sequence.
2. [SEP]: This token denotes the splitting of 2 sequences and acts as separator.

3. [MASK]: Used to show the masked token in MLM tasks.
4. Position Embeddings: BERT studies and uses positional embeddings to express the position of words in a sentence.
5. Segment Embeddings: Used to show the sequence that tokens have. If there are multiple sequences separated by [SEP] tokens in the input, then the position Embeddings (from Transformers) are added to the original Word Embeddings for the model to be able to identify the token sequences.
6. Token Embeddings: Tokens that use WordPiece embeddings.

4. RESEARCH MEHODOLOGY

This framework is made in the form of a flowchart to solve the research problems that have been written in the introduction. In addition, this flowchart is made so that research runs smoothly and is structured. An illustration of a research methodology can be seen in Figure 3.

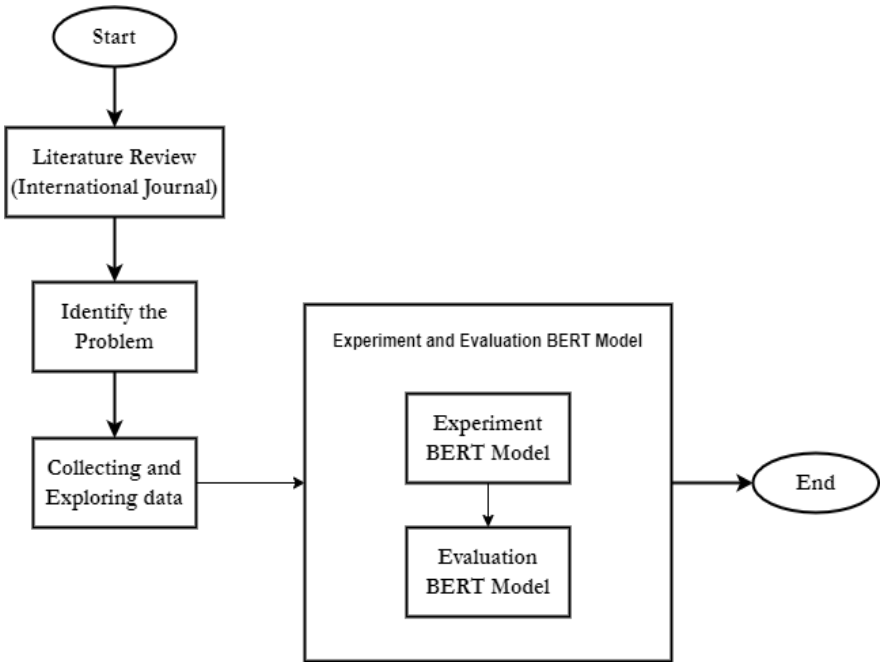

Figure 3. Research Methodology

The first step that will be carried out is a literature review by looking for international journal references with IMDB specifications, sentiment analysis, and deep learning approaches. In the literature that has been done, it can be seen that BERT is a method that is often used for sentiment analysis because it has a high level of accuracy for text classification. After that, the stage of identifying existing problems is carried out. Then enter the data collection stage and explore the data. After finishing with the data, the next step is the experimentation and evaluation of the BERT model. After that, the results show how good the accuracy is for text classification using the BERT model.

From a series of methods that have been carried out, when it reaches the final stage, namely looking at the accuracy results for text classification using BERT, the research problem has been successfully resolved. In addition, researchers have also achieved research objectives.

5. PROPOSED MEHODS

The purpose of the proposed methods is to explain in more detail what steps the researcher took for this research. An illustration for the proposed method can be seen in Figure 4. First of all, the researcher will collect the IMDB Movie Review data, after which exploration will be carried out on the collected data. After that the researcher will split the data that has been collected and explored into three parts, namely training data, validation data, and testing data. Then the researcher will build the model by means of training and validation, after that the researcher will receive accuracy training, loss training, accuracy validation, and loss validation. Kedian, go to evaluation. At this stage, the researcher will evaluate or test the BERT model that has been trained and validated. And finally, researchers will get testing accuracy from the BERT model. From the research, we can be seen that researchers know that BERT is a good method for sentiment analysis. In addition, researchers also managed to get high accuracy.

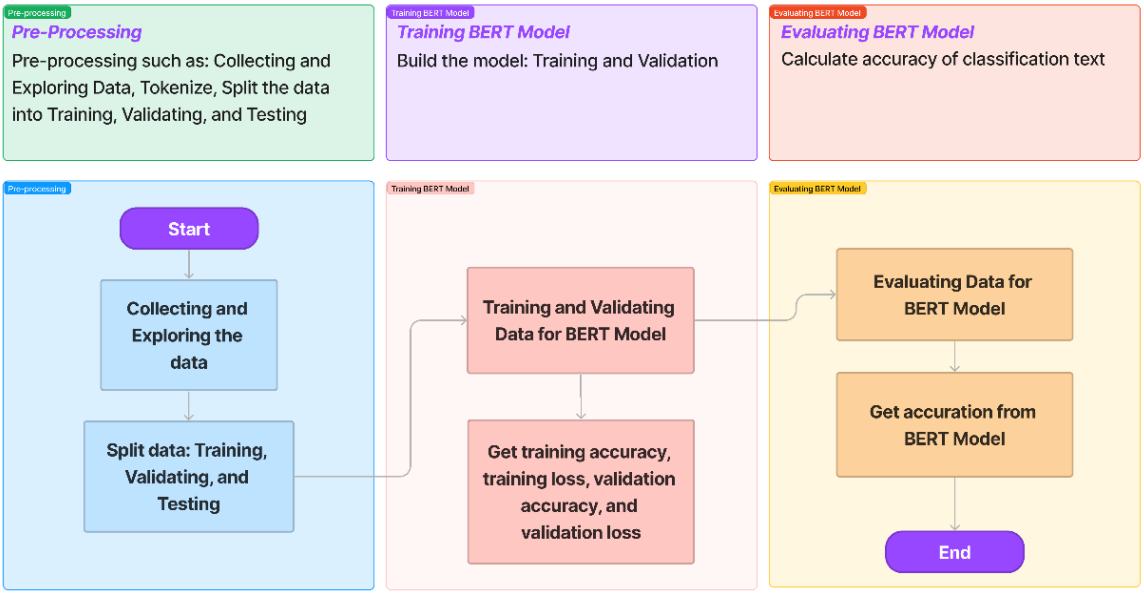

Figure 4. Proposed Methods

6. RESULTS AND ANALYSIS

6.1. Dataset

The dataset used for this research is IMDB Movie Review data. IMDB dataset can be accessed via torchtext. There are 50,000 data. 25,000 data for positive sentiment and 25,000 data for negative sentiment. The data is divided into three parts, namely training data, data validation, and data testing. Where 17,500 data can be generated for training, 7,500 for validation, and 25,000 for testing. After entering the parameters, the data is ready to be trained. However, before dividing the data into three parts, the researcher explored the data by creating a wordcloud for the existing data. Figure 5 is a wordcloud overview in general, Figure 6 is a wordcloud for positive sentiment, and Figure 7 is a wordcloud for negative sentiment.

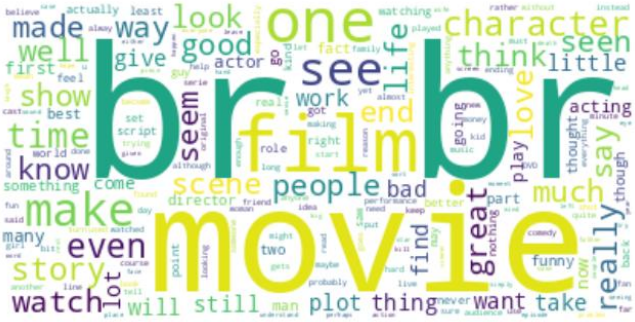

Figure 5. Wordcloud Overview in General

Figure 6. Wordcloud for Positive Sentiment

Figure 7. Wordcloud for Negative Sentiment

For the overview in general, we can see the words such as movie, film, character, and others. For the positive sentiment, we can see the words such as good, great, love, and others. Then on the negative sentiment, we can see the words such as bad, nothing, bad scene, and others. For a review category proportions of IMDB dataset, it can be seen in Figure 8.

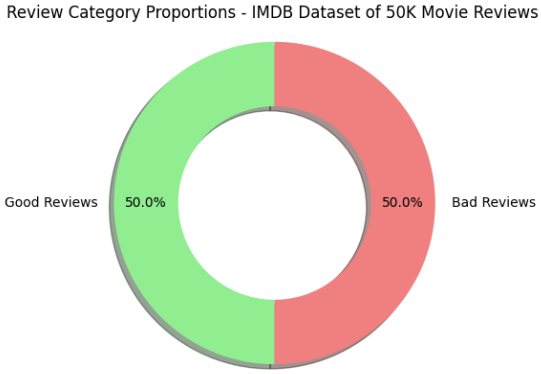

Figure 8. Review Category Proportions - IMDB Dataset

6.2. Results

An explanation of the results that have been examined is in Table 3. Table 3 will explain the results of the accuracy of training, loss of training, accuracy of validation, loss of validation, accuracy of testing, and loss of testing.

Table 3. Results for Training, Validation, and Testing

Name	Detail
Training Accuracy	91.69%
Training Loss	0.187
Validation Accuracy	91.85%
Validation Loss	0.212
Testing Accuracy	91.78%
Testing Loss	0.207

With several steps carried out using the BERT model on the IMDB Movie Review dataset accessed via torch text, it results that by using several parameters and at epoch 5, the train accuracy reaches 91.69%, the train loss is 0.187 and the validation accuracy reaches 91.85%, and the validation loss is 0.212. Then, it can be seen that the result of the test loss is 0.207 and the test accuracy is 91.78%. Based on these results, it can be concluded that the BERT model is very good. In addition, the researcher also predicted several sentences and recorded the resulting accuracy. For example, the sentence "This movie is great", then the result is 0.97. Here we can see that closer to 1 is a positive sentiment. Then if you type the sentence "This movie is the worst thing ever created by human, then the result is 0.007. It can be seen that the result is close to 0, and 0 is represented as a negative sentiment.

7. CONCLUSION

This research uses BERT as its model. The data used is IMDB Movie Review. The data is divided into three parts, namely training data, data validation, and data testing. This study uses several parameters.

The results show that the training accuracy reaches 91.69%, the train loss is 0.187. The validation accuracy reaches 91.85%, and the validation loss is 0.212. Then, the result of testing accuracy is 91.78% and test loss is 0.207. Thus, it can be concluded that sentiment analysis on IMDB film reviews using BERT is a very effective approach and very suitable for sentiment analysis especially for IMDB Movie review. The purpose of this study was achieved because it was successful in carrying out sentiment analysis using the BERT method and producing high-accuracy output so that readers would find it helpful to see more objectively about public opinion on movie reviews that exist on certain platforms. Therefore, researchers or other practitioners can further develop sentiment analysis using the BERT method for further research.

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BIBLIOGRAPHY OF AUTHORS

Rani Puspita is a lecturer at Bina Nusantara University. Focus on artificial intelligence, multimedia technology and software engineering. Her graduate education background is Computer Science at Bina Nusantara University. She can be contacted via email: rani.puspita@binus.ac.id.

Cindy Rahayu is a lecturer at Bina Nusantara University. Focus on artificial intelligence. Her graduate education background is Computer Science at Bina Nusantara University. She can be contacted via email: cindy.rahayu@binus.ac.id.