Chatbot System for Mental Health in Bahasa Malaysia

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Abstract

Chatbot has been the driving force of modern communication for business, customer service and even mental healthcare. At the same time, there are not many research and project regarding mental health chatbots in Bahasa Malaysia. This project focuses on developing a chatbot application for mental healthcare in Bahasa Malaysia. This chatbot system is integrated with artificial intelligence and natural language processing. This chatbot utilize the feedforwardneural network model to train the datasets. Apart from the backend of the application, Kivy and KivyMD are used to create the app's graphical user interface.

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INTRODUCTION

Through the mist of the COVID-19 outbreak, mass numbers of health issues, including mental illness, rise rapidly, such as depression and anxiety disorders. In 2015, The National Health and Morbidity Survey (NHMS), which the Ministry of Health organizes, declared that one in three Malaysians have mental health issues, which amounts to 29.2% for those aged 16 and above.

Communication is essential for individuals to improve mental well-being as different perspectives and answers can be obtained. With that in mind, some individuals may not enjoy the act of conversing. Thus,this is where an application like a chatbot comes in handy. Most chatbots use the concept of pattern matching using predefined words, which are stored in the system's database. It is initially designed to act as a conversational agent for humans. However, for a non-native English speaker, conversation with the chatbot can often be complex or pointless.

This research conducted has eased the process for patients with mental health issues to interact with a chatbot, particularly in Bahasa Malaysia, through the creation of okBot. okBot is a chatbot system that is designed in Python for mental health conversations in Bahasa Malaysia. This approach is the novelty presented in this study. With the help of machine learning [1] and natural language processing (NLP) [2], this chatbot is capable of providing accurate responses. Through this, individuals without proper medical attention can access some guided therapy processes and acknowledge them.

MATERIAL AND METHOD
Past Research

A systematic study of past research on mental health issues and the usage of chatbots in the field is reviewed in this project. Depression or depressive disorder is a mood disorder which provokes a constant feeling of sadness and loss of interest [3]. On the other hand, anxiety disorders share the features of extreme and unreasonable fear and anxiety and related behavioral disturbances. Therefore, it is necessary to have a background on mental illness when creating the chatbot as it provides a sense of concept for the conversational flow of the app.

This chatbot is inspired by many different mental health chatbots from past research. Among them is Woebot, an automated conversational agent created to provide cognitive behaviour therapy in the format of short and concise daily conversation and mood tracking [4]. Each conversation with the app begins with a general inquiry of the user's mood with provided responses.

In addition, there is another mental health chatbot that uses the native language, such as Shim, which is in Swedish. Like Woebot, Shim is an automated conversational agent with positive psychology and well-being themes such as expressing gratitude, practising kindness, and replaying positive energy [5]. Chatbot as a system has the potential to be a useful tool for a patient with mental disorders, specifically those who are hesitant to seek therapeutic help due to stigmatization around it.

Data Collection and Intents Creation

For the purpose of creating a chatbot that utilizes a neural network in Python, the primary approach is to gather the data. Without any data, there will not be any input towards the neural network model. Neural network modelling will be explained in detail in later sections.

Mental Health Assessment (MHA)

This dataset consists of a list of individual expressions and their current state of emotion throughout the weeks. In addition, this dataset contains the Patient Health Questionnaire (PHQ-9) and General Anxiety Disorder (GAD-7) questionnaire scores from different individuals. The PHQ-9 questionnaires are used as a measurement for severity of depression, while the latter is for measurement of anxiety level.

Statistical Package for the Social Science (SPSS)

The SPSS datasets [6] have different structures for determining mental well-being. Among the data useful for creating this chatbot is the mental well-being scores using the Short Warwick Edinburg Mental well-being scale. Besides, similar to the MHA datasets, this dataset contains a list of individuals expression throughout the day.

Counsel Chat

This dataset is obtained from the Counsel Chat website [7]. It contains a vastly different topic that a professional therapist asked. The topics are depression, anxiety, relationships, parenting, and trauma. To create this chatbot, questions asked on anxiety and depression are used as sample training data, along with the respective responses from the therapist. The selected data is first cleaned and translated into Bahasa Malaysia to prevent inconsistencies in a dataset.

Intents JSON File

After gathering these datasets, an intent file is created in JSON format. This file will contain all the tags, patterns, and responses of the conversational flow of the chatbot. The patterns and responses are the user input and the responses given by the chatbot respectively while the tags hold the classification of each. The bigger the data inside the intent file, the more accurate the chatbot will be as there will be multiple different paths of conversations available for the chatbot to work with when interacting with users.

Natural Language Processing

Natural Language Toolkit (NLTK) python package is used to implement NLP. NLP is one of the ways for computer programs to understand human language [8, 9, 10]. Figure 1 shows the pipeline for NLP, which consists of tokenization, lowercase conversion, stemming and lemmatization, and removal of special characters.

The first technique, which is tokenization will tokenize sentences into individual words. For instance, sentences like "I feel sad" will be tokenized into "I", "feel", "sad". Lowercase conversion will simply change the cases in a text. Stemming and lemmatization turns supported words into their root form, like organizations toorgans. Finally, special characters like "!" and "?" are removed.

Feedforward Neural Network

Neural networks are a set of algorithms modelled loosely after the human brain and are designed to recognized patterns [11][12]. As a neural network requires numerical data as its input, the processed text needs to be vectorized using the bag of words (bow) function, which sets a word to either zero or one according to its occurrence in a particular pattern.

The vectorized words are then fed into the neural network, which is a feedforward neural network. Feedforward neural networks are also artificial neural networks in which the connections between units do not form a cycle [13, 14, 15]. This type of neural network is chosen for its simplicity and because data in this chatbot is processed in one direction: from the input to the output layer.

To achieve the highest accuracy possible in the neural networks, a lot of modification and tweaking have to be done to change the hyperparameters of the neural network. The most obvious one, which can be seen in Figure 2, is the number of hidden layers. The two hidden layers in our neural network comprised 128 and 64 neurons, respectively. In addition to the number of hidden layers, different activation functions inside the layers will have their usage.

This chatbot utilizes Rectified Linear Unit (ReLU) activation function for the hidden layers, a piecewise linear function that will output the input directly whenever the result is positive. Else, it will output zero. As for the output layer of the neural network, the Softmax activation function will be used as it is suitable for single-label classification, which is important in creating this chatbot. For instance, labelling a set of sentences into their appropriate tags.
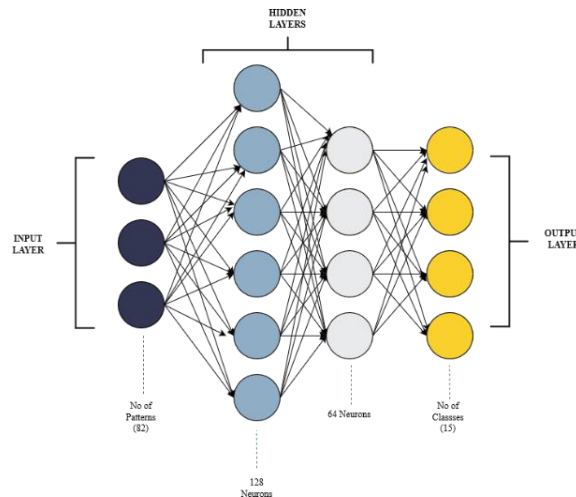

Figure 1. NLP Preprocessing Pipeline

Figure 2. Neural Network Model Visualization

Aside from that, dropout layers are implemented between the hidden layers and the output layers. The dropout hyperparameters are the probability that some nodes are disconnected during the training process. For example, Figure 2 shows that the input layer consists of 82 neurons while the output layer consists of 15 neurons generated from the number of classes and patterns inside the JSON file.

In order to develop the best neural network mode, two deep learning frameworks are used for this chatbot: TensorFlow and PyTorch. While the two frameworks implement the same concepts of feedforward neural networks, they have different hyperparameters of the optimizers, hidden layers, learning rate, epochs, and loss function. These hyperparameters are changed gradually throughout training performance. If, for instance, the accuracy of the training data is decreasing, increasing the number of hyperparameters may help improve the model's accuracy. The condition is called underfitting.

Chatbot

Following the chatbot's training process, the program's main functionality, which is the chatbot conversation, is created. A few notable functions used inside the Python file are the bag of words function, which converts words into 0 or 1 vectors, as mentioned previously. Aside from that, other function definitions are used to predict the classes from user input and predict the correct responses with the implementation of an error threshold. This chatbot will first check for classes with an error threshold lesser than 0.25 to give out the responses.

SQLite

SQLite is an embedded Structured Query Language (SQL) database engine with no separate servers like most other SQL databases like MySQL [16]. The usage of SQLite database will ease the usage of the chatbot on mobile devices like iOS and androids as it is a cross-platform database. The database is implemented to store the conversation history between users and the chatbot. This enables admins to analyze the chatbot performance along with the accuracy of each intent's classification. okBot will store user's login information and chat history as in Figure 3 and Figure 4.

The primary key in the chatbot database is the username generated through the registration form, which is stored in the account table. On the other hand, the username in the chat table is used as a foreign key that references the primary key in the account table. With this, the two tables can be linked together to provide a one-to-many relation.

Figure 3. Accounts Table in okBot Database

	DATE	INPUT	OUTPUT	USERNAME
	Filter	Filter	Filter	iffah
1	2022-06-15 15:16:32.230247	hello	Hi, awak okay tak?	IffahJo
2	2022-06-15 15:16:39.151773	saya rasa sangat tertekan harini	Hai, ini adalah permulaan yang baik ! Saya ...	IffahJo
3	2022-06-15 15:16:52.552870	saya rasa seperti kehilangan diri saya!	Mungkin pemikiran awak memerlukan perhatian ...	IffahJo
4	2022-06-15 15:17:08.398608	saya nak bunuh diri!	OkBot mendapati situasi ini melebehi kebatasan ...	IffahJo

Figure 4. Chat Table in okBot database

Graphical User Interface

Kivy and KivyMD are used to create the chatbot application's graphical user interface (GUI). They are both python packages useful for developing portable user interfaces [16]. Kivy allows the creation of a cross-platform application with multi-touch user interfaces. KivyMD, on the other hand, is a collection of material design widgets for use with Kivy hence the name. Although there are numerous ways to create a GUI, for example, using flutter or android studio, Kivy is chosen as it is based on Python, which is applicable in this project. Besides, Kivy is not an operating system (OS) dependent nor device dependent. Meaning that the code written in Python can be used for different mobile devices such as iOS and Android.

The official documentation of Kivy and KivyMD provides a great way for inexperienced developers to jump into the codebase [17][18]. Those with experience in HTML and CSS might have a jumpstart in understanding the syntax for Kivy. Similar to web page designing using HTML and CSS, there are multiple layouts to choose from when creating the chatbot interface. The ones used in this application are float layout, box layout, and grid layout. The layout here can be described as how pages and widgets are structured. Without them, the applications will not be well-defined, and widgets might be all over the place. Kivy and KivyMD provide various widgets for developers to choose from, which are the base building block of the application. Widgets are able to receive events and respond accordingly.

Additional Features

The user experience with the application is enhanced through other features such as 1) welcome page, 2) about section, 3) helpline section, 4) PHQ-9 test section, and 5) GAD-7 test section. As the application boot up, the welcome page is shown with a login and registration button so that the user's credentials can be stored. The about section will go through briefly what the app is and what is the main usage of the chatbot. The helpline page consists of a list of emergency contacts. There will be instances where the chatbot will not be able to handle the severity of an individual's issues due to the digital nature of the application. For the lasttwo sections, users can get an early assessment of their current mental health condition in terms of depression and anxiety.

Overview of Application

Figure 5 illustrates the overview of the whole application created in this project. The opening page starts with the application page, which will prompt users for their login information or registration queries. The app will then direct user to a chat screen where they can exchange conversations with the chatbot. Then, through the neural network model that has been trained, the chatbot will give out an accurate response based on the user's input sentence. Finally, the navigation menu on the top left of the app will direct user to other sections of the app, as mentioned in the previous section.

RESULTS AND DISCUSSION

This section will walk through the descriptive analysis of the MHA and SPSS dataset gathered using Jupyter Notebook and the machine learning analysis of the chatbot. The GUI flow of the chatbot will be illustrated near the end to provide a clear view of what has been created for this particular mental health chatbot.

Descriptive Analysis of Mental Health Assessment

From the mental health assessment questionnaire, a distribution graph is created two identify the average scores of depression and anxiety through PHQ-9 and GAD-7 tests. Figure 6 illustrates a pie chart of students' average PHQ-9 and GAD-7 scores at International Islamic University Malaysia (IIUM). It can be observed that 61.6% of students participating in the questionnaires have moderate to severe depression, while 38.4% range from minimal to mild depression. The second pie chart shows that 46.1% of the respondents have moderate to severe anxiety, while the other 53.9% range from minimal to mild anxiety.
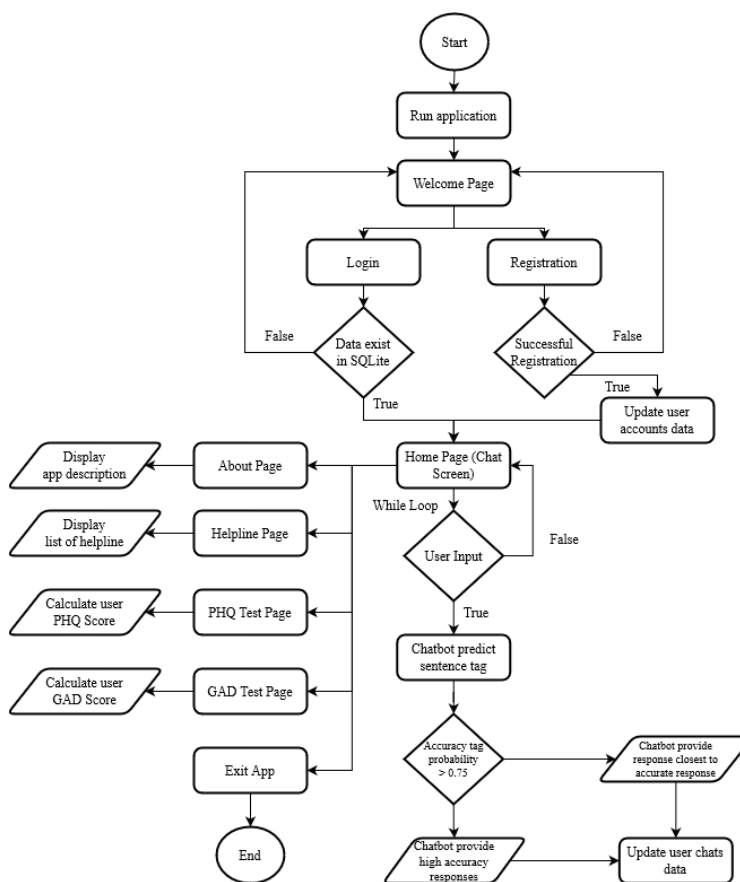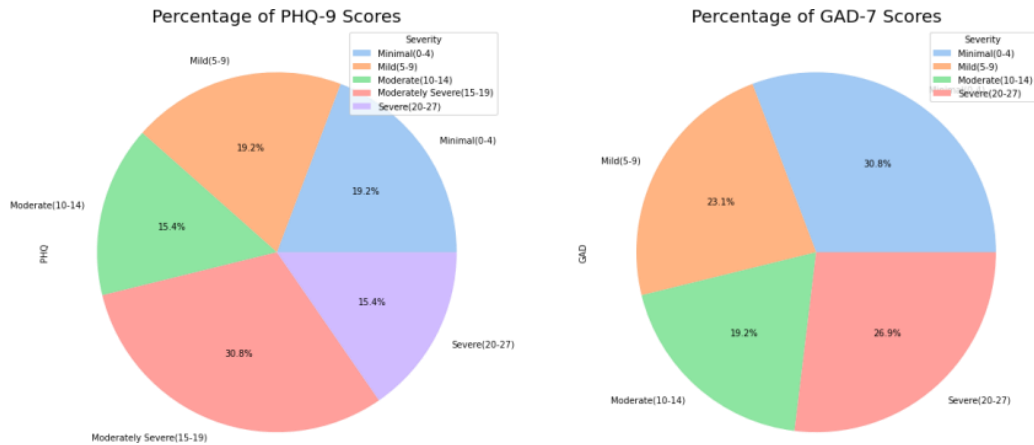

Figure 5. okBot Flowchart

Figure 6. Average PHQ-9 and GAD-7 scores Among Students in IIUM

Descriptive Analysis of SPSS

A descriptive analysis is also made for the SPSS dataset provided. Figure 7 displays the distribution data of students across IIUM. These three bar charts are illustrated to get a clearer picture of their background when analyzing their mental well-being scores. The mental well-being scores are calculated using the Short Warwick Edinburg Mental Well-Being Scale. As for developing a mental health chatbot, it is important to know other underlying factors that affect mental well-being.

Figure 8 and Figure 9 display a stacked bar chart which shows the relationship between self-esteem and resilience against mental well-being. The obvious pattern that can be concluded is that the higher the level of self-esteem and resilience, the higher the level of mental well-being. In other words, students who can adapt better to their hardships have a higher chance of developing better mental well-being. Figure 10 analyzes the correlation matrix between numerical data in the SPSS dataset. The correlation matrix shows that total self-esteem and total resilience have a positive correlation of 0.72 and 0.74 to mental well-being, respectively.
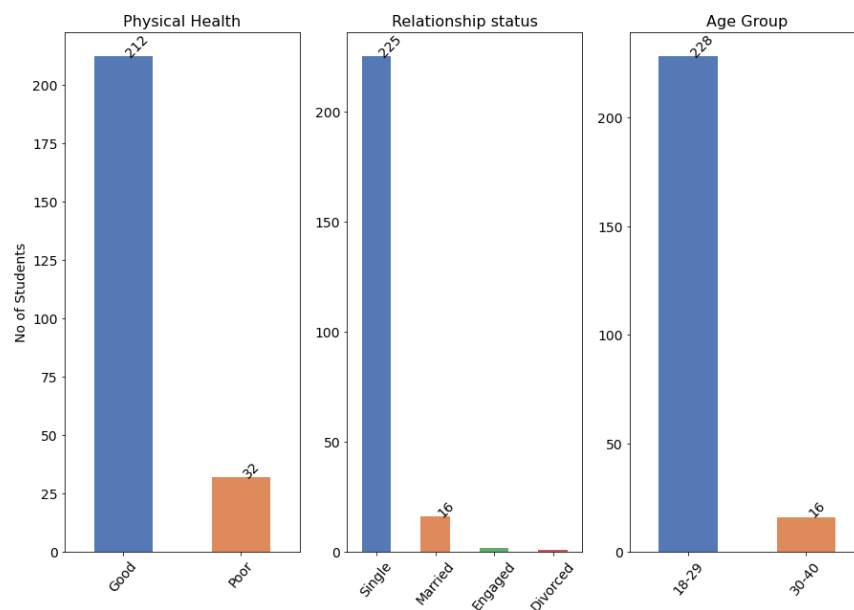

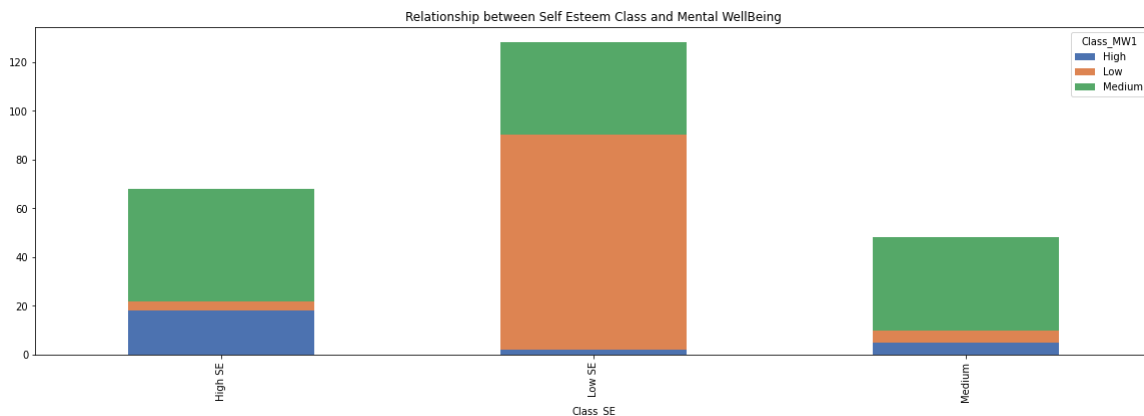Figure 7. Relationship between Self-Esteem and Mental Well-Being

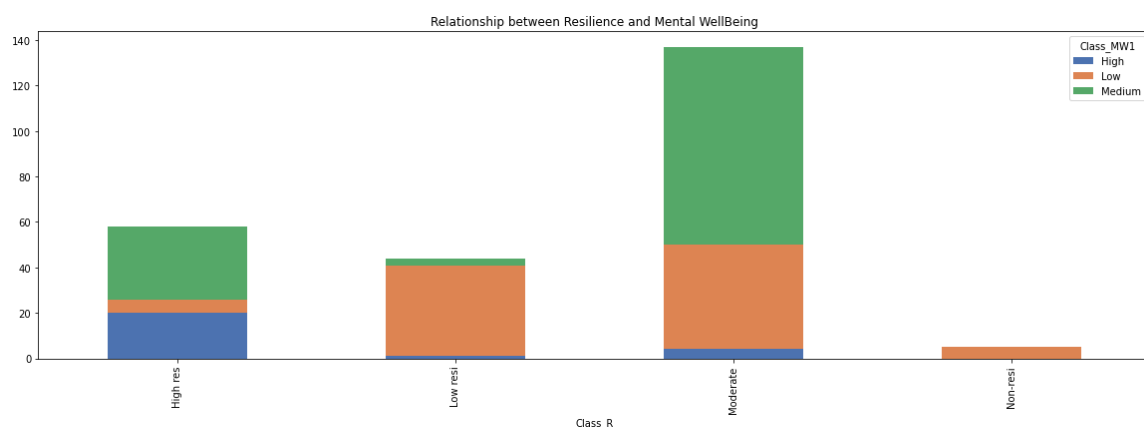Figure 8. Relationship between Self-Esteem and Mental Well-Being

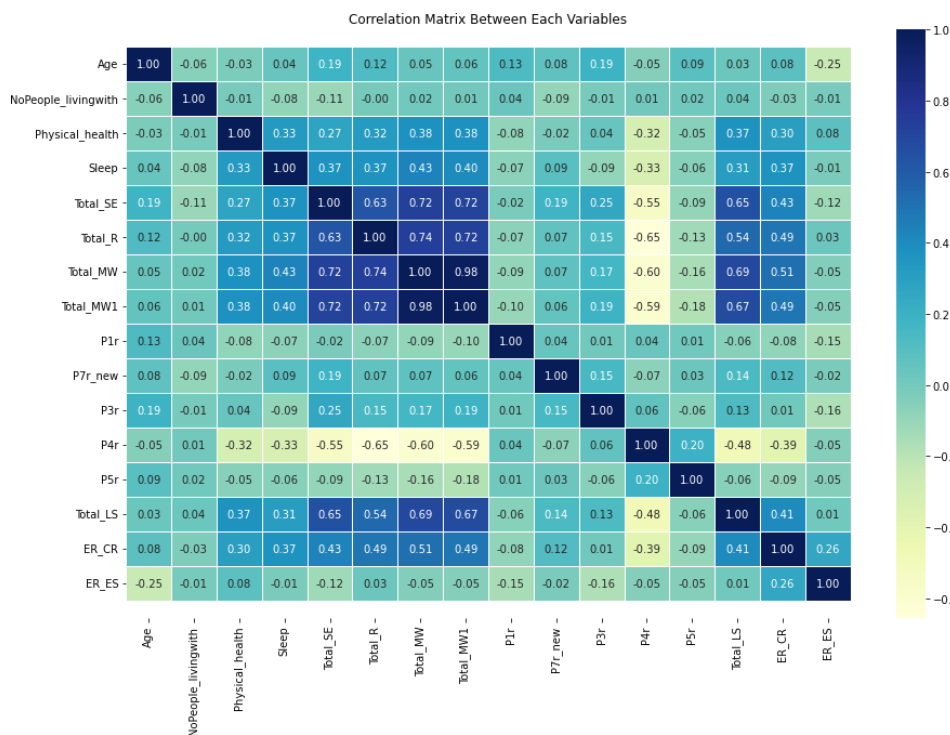Figure 9. Relationship between Resilience and Mental Well-Being

Figure 10. Correlation Matrix of SPSS Datasets

Natural Language Processing

Figure 11 illustrates the raw data inside the JSON file before the text-processing techniques mentioned in section IV. In order to clean the initial patterns inside the JSON file, NLP techniques such as tokenization, lemmatization and stemming, lower case conversion and special case removal are used. Figure 12 displays the process text after NLP. At the current stage of the chatbot, stemming and lemmatization cannot be achieved because of the lack of support for the Malay language in the NLTK package. The alternative that can be taken is to create a dictionary of stemmers.

Chatbot Evaluation

This chatbot is evaluated using two different deep learning frameworks: TensorFlow and PyTorch. Although the two have a similar architecture of a neural network, the feedforward neural network, different hyperparameters are used. For instance, neural network training using TensorFlow is done through the Stochastic Gradient Descent (SGD) optimizer, while the latter is done through the adaptive moment estimation (Adam) optimizer. Optimizer can be described as the algorithm a neural network uses to update the training. Adam optimizer is one the most popular and efficient optimizer for deep learning due to computational efficiency and its little memory requirement [19][20].

Figure 13 and Figure 14 display the output of the training model, which display the accuracy of each training module. TensorFlow has close to 100% accuracy with a 0.0026 loss percentage, while PyTorch has a loss of 0.0004. The two trained models achieved similar results through 1000 epochs. The runtime performance will be measured during the conversational flow of the user and chatbot.


```
['hello', 'hai', 'hi', 'hey', 'salam', 'apa khabar',
'bye', 'jumpa lagi', 'selamat tinggal', 'goodbye',
'nama awak?', 'Nama awak apa?', 'Thank you', 'terima kasih',
'thanks', 'ty', 'Saya sangat tertekan', 'kehilangan diri saya sepenuhnya',
'bagaimana saya boleh mencari diri saya semula?',
'mengubah perasaan saya yang tidak berharga kepada semua orang?',
'mengidamkan kemurungan?',
'tidak selesa dengan orang lain',
'tidak selesa di tempat awam',
'kuat nervous di tempat awam',
'Apakah cara terbaik untuk mengurangkan kebimbangan?',
'kurangkan anxiety?', 'mengurangkan anxiety',
'kurangkan kebimbangan', 'Saya bimbang tentang sesuatu',
'Adakah saya mempunyai kebimbangan?', 'Saya ada anxiety ke?',
'saya ada kebimbangan ke?',
'Bolehkah saya mengetahui sama ada saya mengalami kebimbangan atau anxiety?']
```

Figure 11. Patterns Before Text-Processing


```
['adakah', 'apakah', 'bolehkah', 'macam', 'nama', 'saya', 'thank',
'ada', 'anxiety',
'apa', 'atau', 'awak', 'awam', 'bagaimana', 'bangunan', 'berharga'
, 'bimbang',
 'boleh', 'bunuh', 'bye', 'cara', 'dengan', 'depression', 'di',
'diri', 'goodbye', 'hai',
'hello', 'hey', 'hi', 'jika', 'jumpa', 'kasih', 'ke', 'kebimbangan'
, 'kehilangan', 'kelar',
'kemurungan', 'kepada', 'khabar', 'kuat', 'kurangkan', 'lagi',
'lain', 'mana', 'mempunyai',
'mencari', 'mengalami', 'mengetahui', 'mengidamkan', 'mengubah',
'mengurangkan',
'nak', 'nama', 'nervous', 'orang', 'perasaan', 'salam', 'sama',
'sangat', 'saya', 'selamat',
'selesa', 'semua', 'semula', 'sepenuhnya', 'sesuatu', 'tahu',
'tangan', 'tempat', 'tentang',
'terbaik', 'terima', 'terjun', 'tertekan', 'thanks', 'tidak',
'tinggal', 'ty', 'untuk', 'yang', 'you']
```

Figure 12. Patterns After Text-Processing

Figure 13. TensorFlow Training Output

Figure 14. PyTorch Training Output

The two deep learning frameworks utilize different learning rates. Learning rate parameters will determine how much the neural network will update each step through the neurons. For example, in the TensorFlow training file, the learning rate is set to 0.01 while the latter is set to 0.001. The implementation of both TensorFlow and PyTorch in this project is to understand which frameworks are better suited for creating something like a chatbot. Table 1 displays the performance of the chatbot through 50 user input tests.

PyTorch and TensorFlow are created by different companies: Facebook and Google. Although Table 1. indicates that the accuracy of TensorFlow is better, PyTorch is often more preferred to Python developers due to its Pythonic syntax, while having a lower learning curve when compared to TensorFlow. Aside from that, different hyperparameters also affect the accuracy of the chatbot. As far as we know, modifying the deep learning model is mostly a lot of testing and trying an error from training performance.

Table 1: Performance Between TensorFlow and PyTorch

Model	Class	Average Word Length	No Input Patterns	Accuracy (%)
TesnorFlow	15	5.829	82	90
PyTorch	15	5.829	82	80

CONCLUSION

Chatbots have become very important in multiple industries, such as online business, customer support and mental health care. Using chatbots as therapy can help patients with mental illnesses improve their conditions. As previously mentioned, chatbot usage for mental health care in Bahasa Malaysia is not popular and less developed. This project introduced okBot, a chatbot specifically in Bahasa Malaysia that supports individuals with mental health problems. This research paper thoroughly analyses the approach taken to create an artificial intelligent chatbot that utilises the concept of a neural network.

The approach to developing the chatbot began with data collection through three different datasets. These help in creating the list of conversational flows in the chatbot and provide training data for the neural network model. With the help of an open-source framework like Kivy and KivyMD, a beautiful and modern design of GUI can be made. Apart from the usual feature in a chatbot, okBot adds multiple features to improve the user experience with the app. Among them is 1) the about page, 2) the helpline page, 3) the PHQ-9 test page, and 4) the GAD-7 test page. The chatbot was evaluated with two different machine learning frameworks: TensorFlow and PyTorch. For the database, okBot implement a structured query language using SQLite.

As the technologies evolved, more and more improvements can be made to the chatbot system. First and foremost, a feedback form can be created using the SMTP library, which stands for Simple Mail TransferProtocol, which can be used to send an email to any devices that are connected with an SMTP listener. This allows chatbot users to provide feedback and suggestions for future changes. Apart from that, the chatbot's overall architecture can be built using a different type of neural network. A recurrent Neural Network (RNN) is another popular network for developing a chatbot. While it has a higher complexity level whencompared with the simple feedforward neural network, it might be able to provide more personalized answers and more specific responses as an RNN can memorise previous data points to help with predictions.

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