Article

SchizoBot: Delivering Cognitive Behavioural Therapy for Augmented Management of Schizophrenia

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Abstract: According to WHO, about 1.86 million people in Nigeria and about 24 million people worldwide are living with schizophrenia, having symptoms varying from hallucination to delusion, and distorted speech and thinking. Schizophrenia is a life-long disorder with no cure and thus, patients need continuous management with medications and psychotherapy. However, due to various factors such as the cost of therapy, time consumption, lack of adequate health workers, the unwillingness of patients to engage, and the pandemic, there is a need for an effective alternate medium for providing cognitive behavioural therapy (CBT) to schizophrenia patients. This research aims to develop a chatbot, which is called SchizoBot, delivering CBT for augmented management of schizophrenia. CBT for schizophrenia details, along with FAQs of schizophrenia patients were collected and adopted into a conversational format for pre-processing and model development. The model was developed with artificial neural network (ANN) and trained with the dataset which was split into train-test data to optimize the performance of the model. The result of the ANN showed an accuracy score of 93.97% at 60:40 train-test data split with 200 epochs. This robust system which provides an optimized chatbot platform using ANN as the model classifier for CBT delivery is foreseen to be a windfall to clinicians and patients as an augmentative management tool for schizophrenia. This, therefore, is a relatively low-cost and easily accessible means to significantly improve the health of schizophrenia patients while assisting clinicians in therapy delivery and compensating for the lapses in the administration of CBT to schizophrenia patients.

Keywords: cognitive behavioural therapy; schizophrenia; SchizoBot; artificial neural network; artificial intelligence

1. Introduction

Schizophrenia is a severe debilitating cognitive disorder affecting an individual's thoughts and behaviour. It is a complex severe mental illness without cure, characterized by positive symptoms (delusion and hallucination), negative symptoms (apathy, avolition and social withdrawal) [1] and cognitive symptoms (disorganized speech, disorganized thoughts, passive control, psychomotor disturbance, and catatonic behaviour). The cause of schizophrenia is yet to be fully pinpointed however, it has been established to be of multifactorial causes of social, psychological, and biological, based on the stress-vulnerability model [2]. The biological factor is thought to stem from the frontal, temporal and mesostriatal regions of the brain [3], having an effect on the dopamine and glutamate neurotransmitters in the body which results in its symptoms. The World Health Organization estimates schizophrenia to be the 10th most common non-fatal disease worldwide with a prevalence of 1% and a reduced life expectancy with a great burden to society [4]. A high risk of suicide at about

8% and intentional self-harm is associated with schizophrenic individuals and, although the risk is small, it is still of concern as they are prone to violence that may extend to the public because of their hallucinations [4].

The current management procedure for schizophrenia involves the use of pharmacological treatments and psychotherapy administered by health professionals. The pharmacological treatment includes the use of antipsychotic medications with the operational mechanism of blocking the dopamine D2 receptor which could contribute to the adverse effects of schizophrenia [5]. The major effective form of psychotherapy administered for schizophrenic patients is cognitive behavioural therapy (CBT) for schizophrenia [5]. This is a form of talk therapy targeting the positive symptoms such as delusion and hallucination as well as the cognitive symptoms and other allied symptoms including depression and anxiety.

Generally, cognitive models opined that a person's opinion is inclined by several factors such as genetic susceptibility, early childhood experiences and environmental factors [6]. Cognitive behavioural therapy (CBT) for schizophrenia follows the general model of CBT and further draws a connection between the thoughts, emotions and behaviour of the patient while administering treatment that helps patients focus on the attributed meaning of their psychotic experiences, their understanding as well as ways of coping with their symptoms [7]. This is done in order to reduce the effects and distress resulting from their psychosis while guiding towards accurate deduction with unbiased evidence.

Although antipsychotic medication is the first line of treatment for schizophrenia, the role of CBT as an augmented line of treatment cannot be overemphasized in other to enable schizophrenic patients to live a well-rounded quality of life with higher life expectancy. However, due to several factors such as the cost of therapy, time consumption, lack of adequate health workers, unwillingness of patients to engage, stigmatization, treatment resistance and the pandemic (COVID-19), alternate supportive forms of administering CBT for patients' therapy is imperative to augment the work of health professionals.

With the rise of technology in the world, a chatbot can be utilized to cover the lapses in the administration of CBT for schizophrenia patients to improve patients' well-being. A chatbot is an application that provides online support to its users through audio-visual and text mediums.

SchizoBot is an artificial intelligence (AI) based mental health application proposed to provide automated psychoanalysis and online CBT therapy as well as support to schizophrenia patients through the medium of chatting. The chatbot utilizes artificial neural networks (ANN) which can learn complex functions and make accurate deductions from data, like the workings of the human brain. It is designed using deep network and machine learning algorithms that can process large sets of data from inputs, learn from it and produce an accurate output. The deep learning model used evaluates based on the ANN for predicting accurate responses from a collection of cognitive behavioural therapy models already collated into sentences. The model used machine learning algorithms to incorporate only the relevant responses, and the system architecture was designed to provide a text response to inputs. We assessed the model complexity based on the accuracy and loss against the epoch size to investigate the accuracy of the predicted responses contrary to inputs to provide guidance on optimal model design and assessment across a range of different data splits.

A recent study examined the feasibility, acceptability, and preliminary efficacy of a fully automated conversational agent to deliver a self-help program for college students who self-identify as having symptoms of anxiety and depression. The study employed the use of a Woe bot, as the fully automated text-based conversational agent as well as a National Institute of Mental Health e-book on "Depression in College Students", as the control group with the outcome favouring conversational agents as a feasible, engaging, and effective way to deliver CBT [8].

Another study aimed to present a preliminary real-world data evaluation of the effectiveness and engagement levels of an AI-enabled, empathetic, text-based conversational mobile mental well-being app (WYSA) on users with self-reported symptoms of depression. The impact, engagement as well as experience of the app was measured to show a result of an average mood improvement in users [9].

Research on the acceptability and effectiveness of Youper, an artificial intelligence therapy for depression and anxiety, deem it fit as a low-cost, fully self-guided treatment that is available to users who may not have access to mental health care [10]. These further support the acceptability of chatbots as an effective and promising alternative to psychotherapy.

A research [11] proposed an intelligent social therapeutic chatbot interacting with users in other to avert negative actions and reconstruct more beneficial thoughts. The chatbot allocates the text input into eight

emotional labels including Happy, Joy, Shame, Anger, Disgust, Sadness, Guilt, and Fear. The chatbot then uses the emotion label, to recognize the users' mental state such as stress or depression based on the users' chat data. Deep learning classifiers such as the Convolutional Neural Network (CNN), Recurrent Neural Network (RNN), and Hierarchical Attention Network (HAN) were deployed for emotion detection. The results showed that CNN has an accuracy of up to 75% with high consistency for 15 epochs while RNN and HAN achieved up to 70% accuracy for 15 epochs. However, the results were not consistent enough throughout all the datasets. Also, as RNN takes previous input into consideration, it takes a longer time for the execution as compared to CNN and HAN. Hence, it is not preferable, for the huge dataset, in terms of time intricacy. CNN model was seen to have outpaced the other two models (RNN and HAN) in terms of training time on the phrase dataset [12].

Deep learning has been applied in many healthcare realms such as in pharmaceuticals, personalized medicine, drug manufacturing, radiology and radiotherapy, healthcare prediction, chatbot support systems and smart electronics records, amongst others. Chatbots are designed based on algorithms that find relationships among features of a dataset. These algorithms convert information derived from the datasets into meaningful results. Examples of such algorithms include Decision Trees, Naïve Bayes or Gaussian, Linear Regressions, Neural Networks, Support Vector Machines (SVM), and K-nearest neighbour (KNN) [13]. A larger percentage of chatbot algorithms can be seen in programming software such as R, Python, Java, and WEKA. These techniques have all stood as the core of present times advancement in the health industry acting as virtual assistants to augment the role of health practitioners.

Nwoye et al. [13] presented a study on a cost-sensitive pruned Decision Tree J48 model for fast and accurate diagnosis of schizophrenia exploiting supervised learning procedures with a 10-fold cross-validation resampling method as well as using the unstructured filter to substitute missing values in the data with the modal values of corresponding features. The cost matrix was designed to lessen the tendencies of the J48 algorithm to predict false negative outcomes. This consequently decreased the error of the model in diagnosing a schizophrenia intrant as free from the disease. The model was found to significantly diagnose Schizophrenia with 78% accuracy, 89.7% sensitivity, 57.4% specificity and an area under the Receiver Operating Characteristic (ROC) curve of 0.895. The ROC curve was also seen to distinguish schizophrenia from other conditions with similar symptoms.

In 1972, a psychologist developed PARRY, a conversational-based chatbot, which imitated a person with schizophrenia [14]. With an expansive collection of pre-established rules and scripts, it used a text-based method to converse with users. Logical responses were then produced with the rule-based system aiming to simulate language patterns as well as cognitive processes of a person with paranoid schizophrenia. PARRY was tested by 33 human psychologists using the Turning test which was able to deceive the psychologist 52% of the time. This was a significant milestone in the history of deploying chatbots in the mental health space and yielding positive useful results.

Lahoz-Beltra et al. (2020) designed a model of a virtual patient using a chatbot to simulate a changed state of mind which could lead to chronic inflammation and subsequently abstract cancer in humans [15]. The chatbot was amalgamated with differential equations that simulated the hormones involved in the process of cellular inflammation.

Following the observed inability of chatbots to detect and respond to the emotional states of an interlocutor, Lahoz-Beltra *et al.* (2021) designed an emphatic chatbot, LENNA. LENNA aimed to quantitatively evaluate the analysis of the conversation between an empathic chatbot and an interlocutor. It used Shannon entropy as well as multiple artificial intelligence techniques such as Bayesian classifiers to assess the changes in emotional disposition during conversations [16].

One of the major challenges with chatbots, however, is the difficulty in their ability to mimic natural human language and process it in the machine language of 0s and 1s to produce relevant output, especially notwithstanding the copious amount of input at a go. Deep learning using Artificial Neural Network (ANN) has the potential to cover this lapse due to its architectural characteristics of having numerous neurons and layers that can process many inputs within a short timeframe and accurately, given the advantage of being able to tweak the weights as appropriate to yield desired results. This gives rise to the development of Deep Neural Network (DNN).

This gives room for DNN being a worthy alternative to explore for better results in the realm of deep learning classifiers. However, with DNN being a worthy alternative as mentioned, the most appropriate neural network has to be applied for every work. In the case of SchizoBot, the Artificial Neural Network (ANN) applying

natural language processing (NLP) is more applicable for chatbots because of the form of data input which is text in which CNN is not applicable because it requires pictorial inputs in the form of images.

2. Materials and Methods

2.1. Ethics

Ethical approval for this study was obtained from the Lagos University Teaching Hospital (LUTH), Nigeria with approval number ADM/DSCST/HREC/APP/4602 and Federal Neuro-psychiatric Hospital with approval number HREC 2022/01/001/002.

2.2. Study Design

The dataset for this study was collected from LUTH, ISEAR emotion detector data, journals from PubMed and frequently asked questions by schizophrenia patients on the NCBI website. The dataset was sorted into three (3) categories of tags, patterns and responses. The tags refer to the class of words, patterns are the possible ways a tag can be input while the response is the structured CBT output to the pattern. The dataset consists of 40 categories in total, sorted into intents containing details of cognitive behavioural therapy (CBT) for schizophrenia patients in a conversational format. The chatbot is a retrieval-based model with predefined patterns and responses. The dataset description depicts a string value for all data and the features. The SchizoBot design involves the use of categorical data on deep learning library which is a binary classification supervised learning problem. The data was pre-processed by applying a natural language processing toolkit (NLTK) for tokenization, lemmatizer and bag of words array development. Exploratory Data Analysis (EDA) was carried out to understand the size, type and constituent of the data. The data consists of strings with the data shape depicting 40 categories with a total of 289 documents, 441 unique lemmatized words, and 41 classes for the internet data.

2.3. Training and Hyperparameters Optimization

The datasets were split into training and testing data in ratios of 50:50, 70:30, 90:10, 80:20, 30:70, 40:60, 10:90 and 60:40 ratio for training and testing respectively. The chatbot uses the feedforward neural network model in training the dataset. This model of ANN has been proven to be reliable in accurate response prediction based on probability score as shown in a study that designed and implemented an autoreply to bot, proficient in providing answers to queries associated with the field of engineering at the university level. NLP techniques were applied to their university data, developed in the JSON format and the feedforward neural model was used for training the dataset. The result depicted the probability scores of the correct responses were improved to 0.72 in the second phase from 0.46 in the first phase after developing further training phrases and keywords to the dataset [11].

The network was trained using the Stochastic Gradient Descent (SGD) optimizer with a Nesterov accelerated gradient, 0.5 dropout rate, 12 batch size and a learning rate of 0.001 over 200 epochs. Categorical cross-entropy was used to classify the loss function, for class encoding and feature selection. This was applied along with the accuracy metrics while the Softmax function was used as the activation function to fire the output. The network hyperparameters producing the highest accuracy and lowest root mean squared error in the validation set were chosen as the final network architecture.

2.4. Data Analysis

The signals and statistical analysis as well as the agreement between the predicted and directly predefined response were conducted in Python version 3 on jupyter notebook provided by Anaconda Integrated Development Environment with numerous inbuilt libraries such as TensorFlow, Nltk, kera, NumPy, pandas, Scikilearn, tkinter, graphviz, matplotlib, softmax, hdf5, seaborn. Numpy is used for linear algebra operations and array arrangement while softmax provide probability function of word selection. Due to the categorical nature of the dataset crossentropy was used along with the accuracy metrics while the root mean square error, RMSE measures the accuracy of the model predicting a response.

2.5. Mathematical Components

The mathematical analysis of the network's information computing process is expressed by the following architecture based on DNN consisting of 4 layers as shown in Equations (1) and (2):

$$x_i^{(n+1)} = f^{(n)}\left(\sum_j w_{ij}^{(n)} x_j^{(l)} + b_i^{(n)}\right), n = 1,2,3. \tag{1}$$

$$y_i = x_i^{(4)}, \forall i \tag{2}$$

where l denotes the layer number, $x_j^{(n)}$ is the j-th input at the n-th layer, $w_{ij}^{(n)}$ is the weight of the n-th layer connecting the j-th node to i-th node in the next layer, $b_i^{(n)}$ is the bias term of the n-th layer connecting to i-th node, $f^{(n)}(\cdot)$ is the n-th layer activation function, and y_i is the i-th output of the DNN. The activation function used in the work given by the rectified linear units (ReLU) in Equation (3) and the softmax function in Equation (4) is as follows:

$$\text{ReLU:} \qquad f_{ReLU}\left(x_j^{(n)}\right) = \max\left(0, x_j^{(n)}\right) \tag{3}$$

$$\text{Softmax:} \qquad f_{softmax}(x_j^{(n)}) = \frac{exp\left(x_j^{(n)}\right)}{\sum_i exp\left(x_i^{(n)}\right)} \tag{4}$$

In this work, we have used ReLU for the first two hidden layers i.e., $f^{(1)}(\cdot) = f^{(2)}(\cdot) = f_{ReLU}(\cdot)$ while for the output layer, the softmax is used i.e., $f^{(3)}(\cdot) = f_{softmax}(\cdot)$. The input to the DNN i.e., $x_j^{(1)}$, is the bags-of-words computed from the tokenized words after the stemming and tokenization. The DNN works by going into the intent files and getting the tag, responses and patterns from the intent's files and from there, it trains the model. For it to increase its accuracy and decrease the rate of errors, batch normalization and dropout of 20% have been used.

The output of each neuron is calculated by multiplying each input feature by the corresponding weight. The network structure of the SchizoBot model is an artificial neural network of one input layer with 442 nodes, two hidden layers with 222 nodes and one output layer with the number of nodes equal to the number of intents used to predict the output.

3. Results

3.1. Experimental Setup

The Chatbot architecture was constructed utilizing the Python Library framework, specifically Python version 3, within the Jupyter notebook environment of the Anaconda IDE. This setup facilitated the development of artificial neural networks (ANNs) responsible for generating responses and processing text. These networks operate across three layers: an input layer, hidden layers, and an output layer.

A three-layer architecture allows for a moderate level of model complexity, to capture meaningful patterns and relationships in the input data, with each layer capturing complex features enabling the model to understand the different expressions of user inputs and to generate more accurate responses.

The input layer receives the text input from the user which is then processed by the hidden layer and an output (response) is given from the output layer. The ANN model was built using the optimal number of layers (1 input layer, 2 hidden layers and 1 output layer) based on the number of intent categories (40 intent sections). The model was trained using the predefined question tags and responses as the features. The sentences were broken down into individual words and then assigned an array of numbers for the model to compute the probabilistic value to predict the accurate response.

As depicted in Figure 1, the architecture of the artificial neural network utilized by SchizoBot involves a structured series of interconnected layers. This configuration enables the processing of text inputs through

successive layers aimed at extracting relevant features and facilitating linear activation, ultimately leading to the prediction of response.
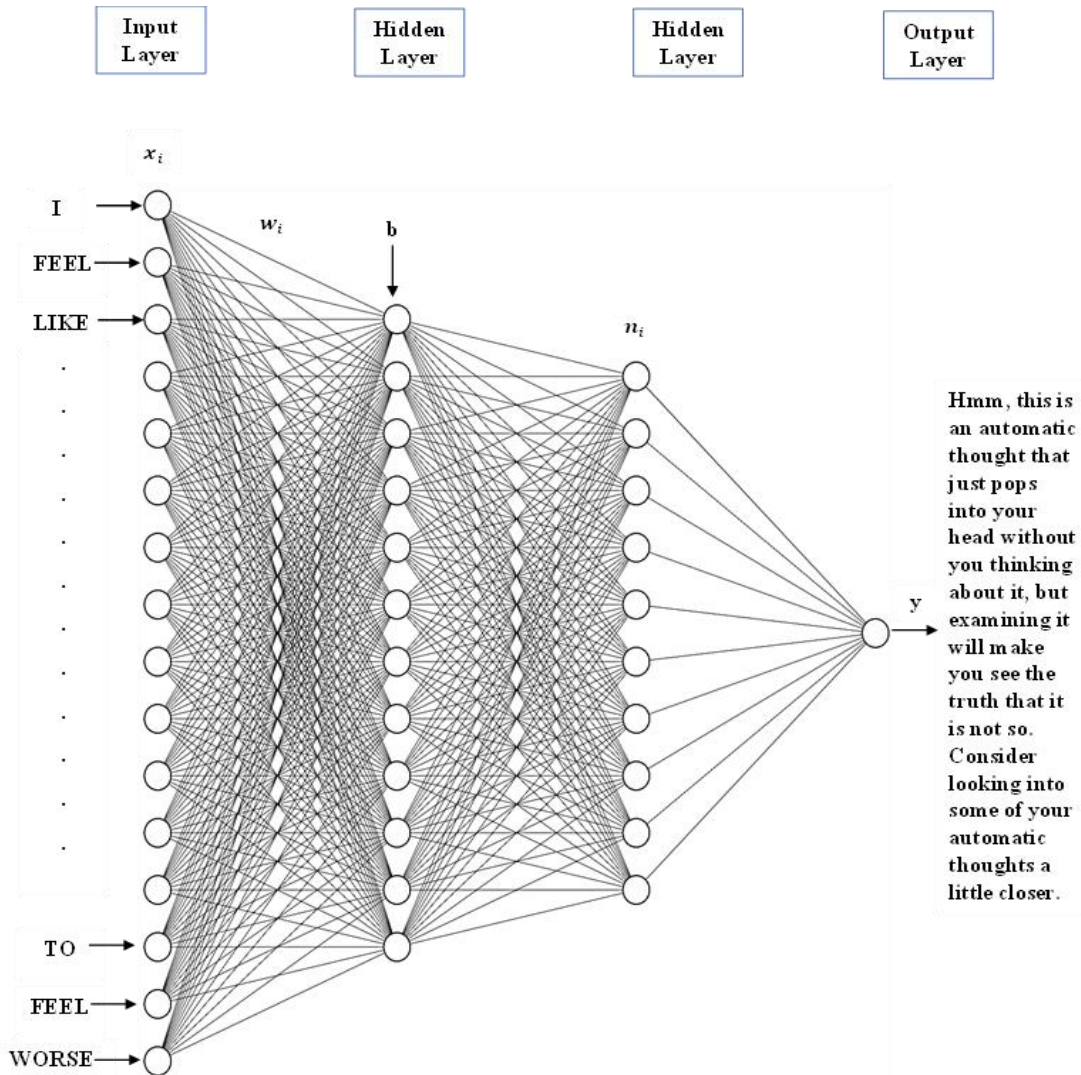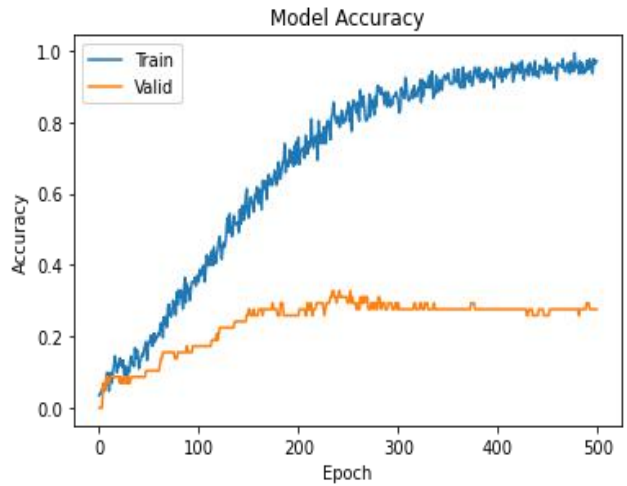

Figure 1. Artificial neural network architecture for SchizoBot prediction of response to input. The text input in a sentence is processed through a series of connected layers for feature extraction and linear activation to predict a response.

3.2. Hyperparameters

Figure 2 shows the effect on model accuracy and fitness by modifying the epoch size. Graph lines were generated for visualization purposes. With a higher epoch size of 500, the model was seen to be overfitted. The optimum hyperparameter that produced the smallest overfitting or underfitting was an epoch size of 200 using a batch size of 12.
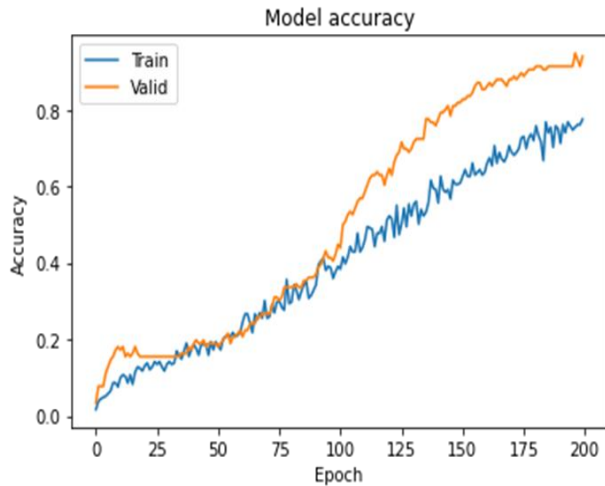
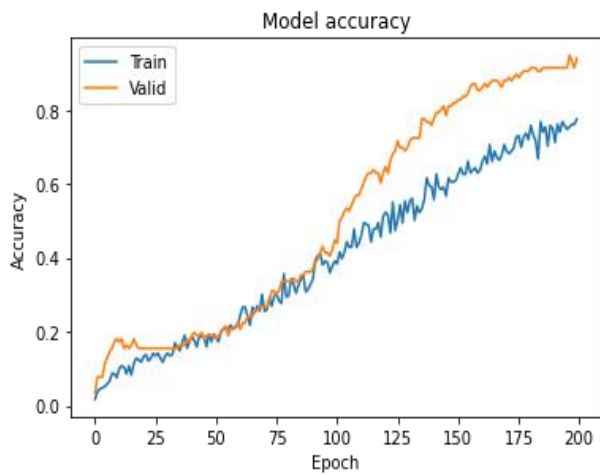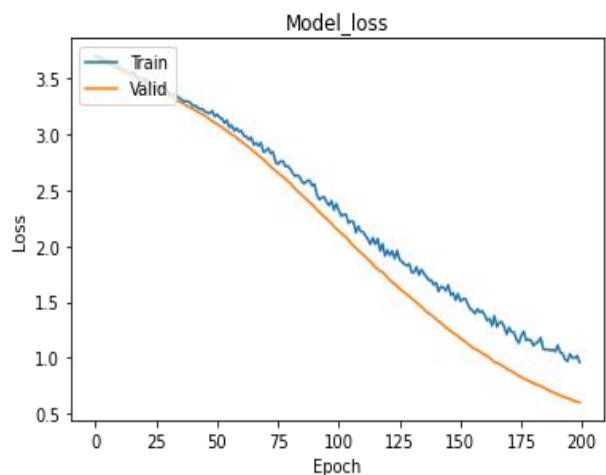(a) Image showing the model with 200 epochs.   (b) Image showing the model with 500 epochs.

Figure 2. Model performance across different epoch sizes. Graph lines to observe the fitting of the model were plotted for visualization purposes the optimal model hyperparameters were 200 epochs and a batch size of 12.

3.3. Network Performance

We assessed the performance of the model using local data and internet-derived data over the three layers in the ratio of 1:2:1 (1 input, 2 hidden and 1 output layer). The model was further assessed based on eight data split ratios and their results were compared as in Table A1. Figures 3 and 4 show the best performing model with the internet data was the 60:40 split with 93.97% testing accuracy following the training accuracy of 87.86% while the best model for the local data was also the 60:40 split with 93.75% testing accuracy following the training accuracy of 80.70% and with the least over-fitting. Table A1 shows a summary of the local data against internet-derived data train-test split accuracy across various ratios.
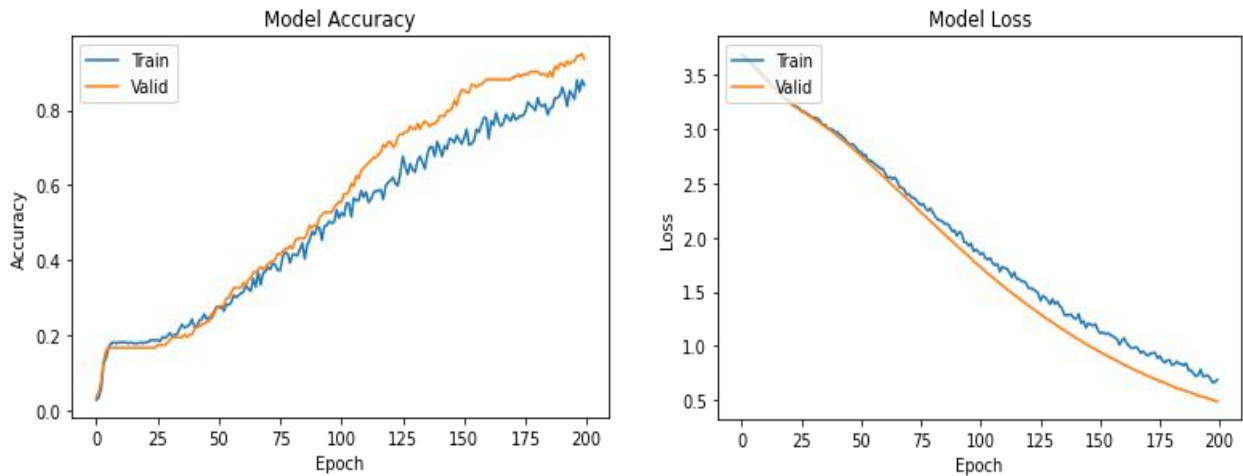

(a) Image showing the plot of accuracy.   (b) Image showing the model with 500 epochs.

Figure 3. Plot of accuracy versus epoch compared to the plot of loss versus epoch of the 60%:40% training model using the internet data. Graph representation shows the accuracy and loss of the model based on its predictions.

Figure 3 shows that training accuracy increased from 50% at 100 epochs to above 80% at 200 epochs while the validation accuracy increased from 50% at 100 epochs to 90% at 200 epochs with the internet-derived data. Overfitting of the model was also observed with the validation accuracy overlapping the training accuracy. The training accuracy is 87.86% and the test accuracy is 93.97%. The root mean squared error (RMSE) for the training data is 0.077 which is a good indicator that the model predicts the output accurately as the lower the RMSE the better the accuracy of a model predicting a response. The training loss above shows a significant reduction along with the validation from 25 epochs to 200 epochs. There was a slight overfitting observation from 50 epochs. However, the constant reduction of training and validation signifies the model learnt till the end of the epoch.

(a) Image showing the plot of accuracy.　　　　　(b) Image showing the plot of loss.

Figure 4. Plot of accuracy versus epoch compared to the plot of loss versus epoch of the 60%:40% training model using the local data. Graph representation shows the accuracy and loss of the model based on its predictions.

Figure 4 shows that training accuracy increased from 50% at 100 epochs to above 80% at 200 epochs while the validation accuracy increased from 50% at 100 epochs to 90% at 200 epochs with the locally derived data. Overfitting of the model was also observed with the validation accuracy overlapping the training accuracy. The training accuracy is 90.70% and the test accuracy is 93.95%. The root mean squared error (RMSE) for the training data is 0.0692. The training loss above shows a significant reduction along with the validation from 25 epochs to 200 epochs. There was a slight overfitting observation from 50 epochs. However, the constant reduction of training and validation signifies the model learnt till the end of the epoch.

3.4. GUI Images for the SchizoBot Dialog

In Figures 5–7, a conversation between the SchizoBot and the user can be observed in various capacities with the SchizoBot producing a relevant and accurate response to the input from the user. The responses were retrieved from the pre-programmed data the model has been trained upon and were given based on the predicted meaning of the user's input. The responses are observed to be accurate in delivering CBT in a natural human language to prevent rigidity and monotonous dialogue.
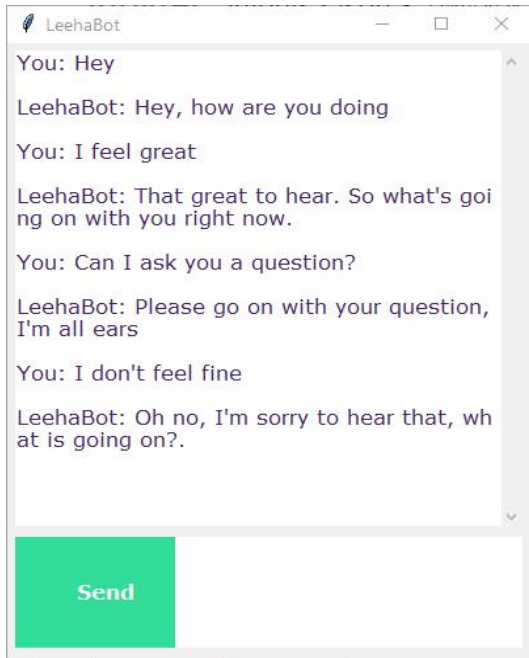
(a) Initial conversation transcript to encourage user engagement.
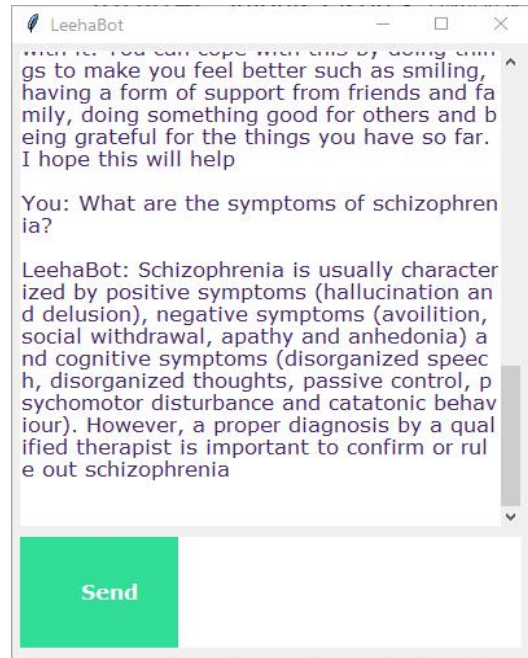
(b) SchizoBot GUI dialogue on schizophrenia knowledge.

Figure 5. SchizoBot dialogue boxes on initial conversation between the bot and user; and shows a printout/screenshot of the conversation between the user and the SchizoBot on initial conversation covering greetings and follow-up dialogue to make the user open up more to aid treatment, while b. is GUI of SchizoBot dialogue on general knowledge of schizophrenia with the conversation between the user and the SchizoBot on general knowledge of schizophrenia.
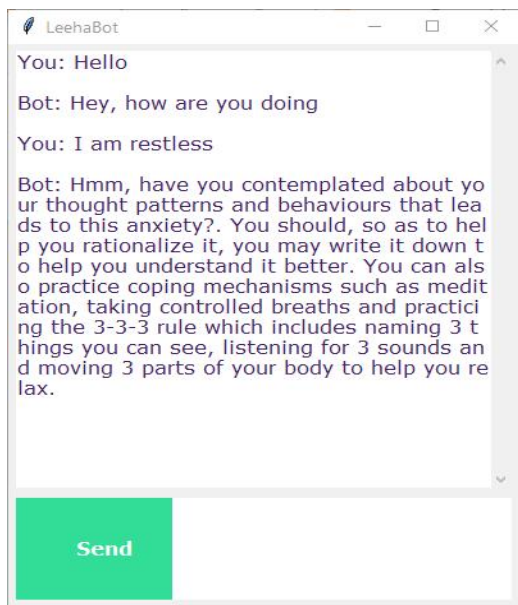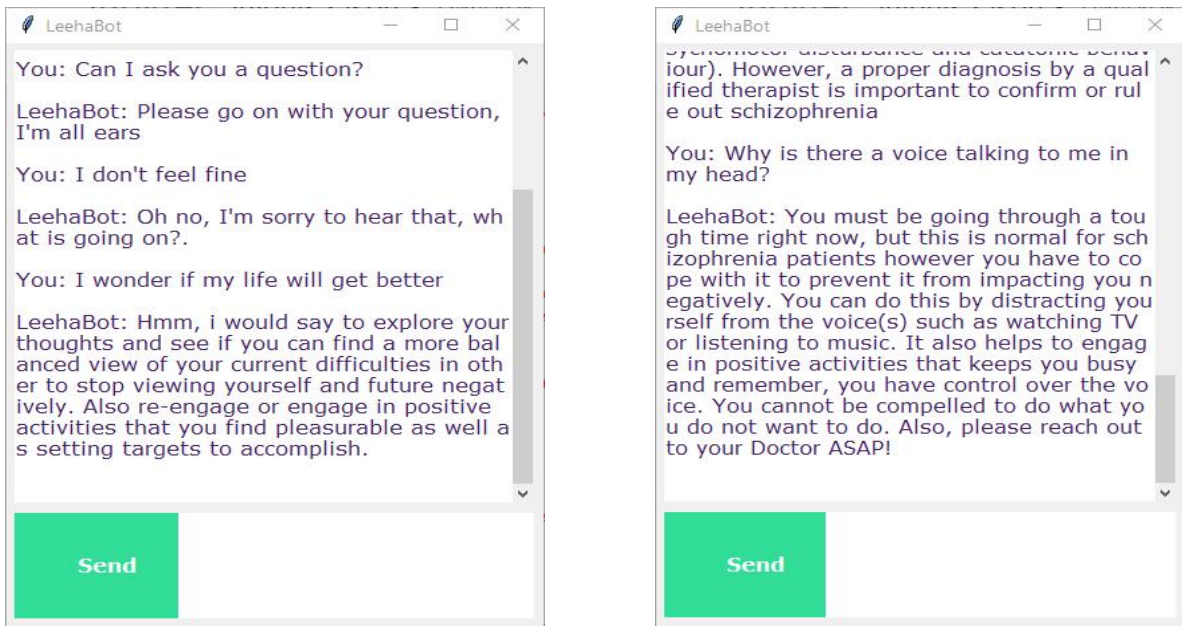

(a) SchizoBot conversation: Anxiety dialogue and therapy response.
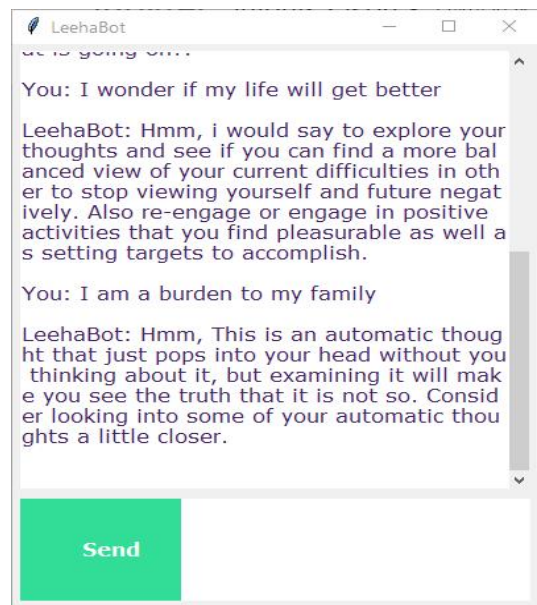
(b) SchizoBot: Automatic Thoughts Dialogue & Therapy.

Figure 6. The conversation dialogue on anxiety; shows the conversation between the user and the SchizoBot on anxiety with the SchizoBot categorizing the user's input as anxiety and delivering an appropriate human-like cognitive behavioural therapy response; and b. is the dialogue box on automatic thoughts, showing the

conversation between the user and the SchizoBot on automatic thoughts with the SchizoBot categorizing the user's input and delivering the appropriate response of cognitive behavioural therapy to assist the patient.

(a) SchizoBot: Hallucination Dialogue & Therapy.

(b) SchizoBot: Depression Dialogue & Therapy.

Figure 7. This is the dialogue boxes on hallucination; a. shows the conversation between the user and the SchizoBot on hallucination with the SchizoBot categorizing the user's input as this and delivering an appropriate human-like cognitive behavioural therapy response to help the user manage the issue at hand; while b. is the SchizoBot dialogue box on depression, showing the conversation between the user and the SchizoBot on depression with the SchizoBot categorizing the user's input as this and delivering an appropriate human-like cognitive behavioural therapy response.

4. Discussion

The results obtained from the experimental setup, hyperparameter tuning, and network performance evaluation provide valuable insights into the performance of the SchizoBot model. In this section, we discuss these findings in the context of existing studies and working hypotheses, aiming to extract meaningful interpretations and implications.

4.1. Experimental Setup and Neural Network Architecture

The artificial neural network (ANN) architecture demonstrated efficiency in processing user inputs and generating appropriate responses. The three-layered design, comprising the input layer, hidden layers, and output layer, proved effective for handling the complexity of intent categorization. Our model, guided by the optimal number of layers (1 input layer, 2 hidden layers, and 1 output layer), successfully processed predefined question tags and responses.

The utilization of word embedding, converting sentences into numerical arrays, contributed to the model's ability to compute probabilistic values for accurate response prediction. This aligns with previous studies emphasizing the importance of word embeddings in natural language processing tasks.

4.2. Hyperparameters Tuning

The impact of hyperparameters on model accuracy and fitness was systematically explored, particularly focusing on the epoch size. The visualization in Figure 2 revealed that an epoch size of 500 led to overfitting, emphasizing the significance of selecting appropriate hyperparameters. The optimal configuration, determined at 200 epochs with a batch size of 12, balanced training and testing accuracy.

4.3. Network Performance and Data Split Ratios

The evaluation of network performance across different data split ratios sheds light on the model's robustness concerning local and internet-derived data. Notably, the 60:40 split demonstrated superior testing accuracy for both data sources, indicating a balanced generalization ability.

Comparing local and internet-derived data across various split ratios (Table A2) provides a nuanced understanding of the model's adaptability. Future investigations could delve deeper into the nuances of data characteristics influencing model performance.

4.4. GUI Images for SchizoBot Dialogue

The graphical user interface (GUI) images presented in Figures 5–7 showcase the SchizoBot's dialogue capabilities. The accurate categorization of user input and the delivery of contextually relevant cognitive-behavioral therapy responses reflect the model's potential to provide meaningful interactions.

4.5. Theoretical Advancement

The development of SchizoBot represents a significant theoretical advancement by integrating cognitive behavioral therapy (CBT) principles with artificial intelligence (AI) technologies for schizophrenia management. By leveraging artificial neural networks (ANNs) and deep learning methodologies, SchizoBot offers personalized and accessible CBT interventions, transcending geographical and temporal limitations. This integration expands mental health care services' reach and underscores the importance of patient-centered care in achieving positive clinical outcomes. Additionally, SchizoBot contributes to theoretical frameworks by providing insights into symptom management mechanisms and treatment efficacy through data analytics and machine learning algorithms. Ultimately, SchizoBot's innovative approach signals a new era of personalized, data-driven mental health care delivery.

4.6. Implications and Future Direction

The successful performance of the SchizoBot model holds promising implications for digital mental health interventions. The natural language dialogue, coupled with accurate response generation, contributes to user engagement and effectiveness. Future research directions could explore expanding the model's capabilities to handle additional mental health domains and refining the training dataset for enhanced generalization.

5. Conclusions

This research provides an optimized chatbot platform for CBT delivery, to augment the management of schizophrenia using artificial neural network as the model classifier. This mode of CBT delivery will significantly improve the health of schizophrenia patients while assisting clinicians in cognitive behavioural therapy delivery and compensating for the lapses in the administration of CBT to schizophrenia patients.

This work has shown that cognitive behavioural therapy can be accurately delivered to schizophrenia patients using a deep learning model across a range of text inputs. Following the conclusion of the experiment with various train-test data split of 90:10, 50:50, 80:20, 70:30, 60:40, 10:90, 30:70 and 40:60 on both internet data as well as local data, a comparison of both data sources is necessary. Their accuracy percentage was determined after each iteration to rate the performance of the ANN model. It was observed that the best model for the internet data was the 60:40 split with 93.97% testing accuracy following the training accuracy of 87.86% and with the least over-fitting.

The next is the 70:30 split with a training accuracy of 91.03% and testing accuracy of 90.80%. This is followed by the 30:70 split with a testing accuracy of 90.15% and training accuracy of 89.53%. It was also observed that the best model for the local data was the 60:40 split with 93.75% testing accuracy following the training accuracy of 80.70% and with the least over-fitting. The performance of the model was enhanced and optimized with the stochastic gradient descent (SGD) as well as the introduction of a dropout technique for regularization, intending to prevent overfitting of the model while improving its accuracy. While the data obtained from the internet were sufficient to train the algorithm, the local data required augmentation due to the low amount of data available for training as well as testing of the algorithm. In light of this, the model used in

training and testing the local data had to be fine-tuned to ensure the hyperparameters were accurately sufficient as necessary. Whereas the online data required the use of 442 nodes of 1 input layer and 222 nodes of 2 hidden layers with a dropout of 0.5 for regularization, the local data model involved the use of 200 nodes of 1 input layer, 100 nodes of 2 hidden layers and 0.2 dropout for regularization. This ensured the model obtained was a good fit for the data used. Furthermore, from the graphs of the model, it is observed that the model trained and tested with local data showed less overfitting compared to the model used in training and testing the online data.

Although there is room for improvement as can be seen from the graphical representation of the model training and testing results which showed a slight unrepresentativeness between the training and validation line due to the nature of the data as well as the model build, the result obtained showed that the model can be relied upon for cognitive behavioural therapy (CBT) deployment to schizophrenia patients via the chatbot interface with the correction to the model by adjusting weights and hyperparameters of the neural network for improvement. While the chatbot is not only specific to schizophrenia, encompassing other mental disorder management and emotional issues such as anxiety, depression, fear, guilt as well as sadness, further work is required to validate these initial findings in real time, determining the user's satisfaction as well as an improvement while covering larger datasets over a longer period. Other suggested methods of validating the efficiency and accuracy of the model involve the use of questionnaires to judge the efficacy of the chatbot CBT delivery on schizophrenia patients employing the use of patient health questionnaire-9 (PHQ-9) for depression screening, diagnosis, monitoring and measurements; generalized anxiety disorder 7-item (GAD-7) to measure or assess the severity of anxiety as well as one-on-one clinician consultation with schizophrenia patients.

Appendix

Table A1. Intents showing the patterns and response.

S/N	TAGS	PATTERNS	RESPONSE
1	Greeting	Hi, hey, hello.	Hello there, how are you?
2	Reply_greetings_good	I'm fine, I feel amazing, I'm okay.	That great to hear. So what's going on with you right now.
3	Reply_greetings_bad	Not really, I don't feel fine.	Oh no, I'm sorry to hear that, what is going on?
4	Goodbye	Bye, later, goodbye.	Until next time.
5	Thanks	Thanks, thank you.	You are welcome.
6	Question	I would like to know something; can I ask a question?	Ask away! I am here for you.
7	Ask_more_question	One more thing, can I ask another question?	Hmm? It seems that you are curious about more things? What is your question(s)?
8	Userbility	How do you work, what do you do?	I am a chatbot specifically meant for Health purposes, delivering cognitive behavioural therapy (CBT) for psychotherapy to schizophrenia patients.
9	Diseases_question	I am sick, something is wrong, I don't feel good.	Hmm, I'm sorry to hear that, but could you explain with more details what exactly seems to be the problem?
10	Disease_automatic_thoughts	I feel like a failure because I was reprimanded, I feel angry because they know I feel bad but wants me	Hmm, this is an automatic thought that just pops into your head without you thinking about it, but examining it

		to feel worse, I am a burden to my family.	will make you see the truth that it is not so. Consider looking into some of your automatic thoughts a little closer.
11	Symptoms_of_schizophrenia	What are the symptoms of schizophrenia?, How do you know you have schizophrenia?, Do I have schizophrenia?, I think I have schizophrenia.	Schizophrenia is usually characterized by positive symptoms (hallucination and delusion), negative symptoms (avolition, social withdrawal, apathy and anhedonia) and cognitive symptoms (disorganized speech, disorganized thoughts, passive control, psychomotor disturbance and catatonic behaviour). However, a proper diagnosis by a qualified therapist is important to confirm or rule out schizophrenia.
12	What_is_schizophrenia	What is schizophrenia?, Define schizophrenia, What do they mean by schizophrenia?	Schizophrenia is a severe debilitating cognitive disorder affecting an individual's thought and behaviour. It is a complex severe mental illness without cure.
13	CBT	What is CBT?, What is cognitive behavioural therapy?, What do you know about cbt?, How can schizophrenia be controlled?, How to manage schizophrenia?	Cognitive behavioural therapy (CBT) for schizophrenia is a cognitive model that draws connection between the thoughts, emotions and behaviour of a patient while administering treatment that helps patients focus on the attributed meaning of their psychotic experiences, their understanding as well as ways of coping with their symptoms.
14	Cause_of_schizophrenia	Why do I have schizophrenia?, Can I contact schizophrenia?, What causes schizophrenia?, What is the cause of scizophrenia?, Where do the voices in my head come from?, What are the voices in my head?	The cause of schizophrenia is yet to be fully pinpointed however, it has been established to be of multifactorial causes of social, psychological and biological issues.
15	Treatment_of_schizophrenia	How can schizophrenia be treated?, What is the treatment for schizophrenia?, Can schizophrenia be treated", Can schizophrenia be cured?	Although schizophrenia cannot be cured, the current management procedure for schizophrenia involves the use of pharmacological treatments and psychotherapy administered by health professionals.
16	Hallucination	There's a voice in my head, I can hear someone talking to me mentally, Why is there a voice talking to me in my head?, He told me to hit him, Punch her, Push them, Drink bleach, Slash your	You must be going through a tough time right now, but this is normal for schizophrenia patients however you have to cope with it to prevent it from impacting you negatively. You can do this by distracting yourself from the

		wrists, Do not use your medications, Walk in front of the car, Take an overdose of your drugs, Strangle him, Attack them, Attack your doctor, Knock them down, You need enough spiritual power to cast out evil from your family, We will kill you and your family members.	voice(s) such as watching TV or listening to music. It also helps to engage in positive activities that keeps you busy and remember, you have control over the voice. You cannot be compelled to do what you do not want to do. Also, please reach out to your doctor ASAP!
17	Emergency	I need help, Help me, Please, help me.	AHH!!! EMERGENCY detected! Please call 112 or your doctor for urgent help! Contact your family members if possible, immediately!
18	Jokes	Do you know a joke?, Can you be funny?, Tell me something funny, I need a stress relief, I want to laugh, I need something to make me smile, Do you play?, Do you have any games?	Why do we tell actors to break a leg?, because every play has a cast, What do lawyers wear to court?, Lawsuits!, Why did the picture go to jail?, Because it was framed!
19	Noanswer		Sorry, I can't understand you. Please give an input, Please give more details, Please give more information to process your request, I am not sure I understand you.
20	How_to_use_app	How do I use this application?, How can I get the most benefit from this?, How does this work to help me?"	SchizoBot provides cognitive behavioural therapy (CBT) to schizophrenia patients and although this is not a substitute for therapy with health professionals, it can help schizophrenia patients manage their symptoms and provide immediate help within its capacity. You can input your text and SchizoBot will respond to the best of her capabilities. However, make sure to reach out to your doctor to ascertain the information received here.
21	Delusion	How do I know I am having delusions?, What can I do to control my delusions?, Am I delusional?, They said these things are not real, how do I control it?, They are poisoning my food with memory loss poison because I recently starts forgetting things easily, The neighbours are cheating, They are recording me with an android phone, My siblings are responsible for my predicament, I hear things before they happen, They are	Delusion is normal and there is no need to beat yourself about it, it is not fault. However, you can cope with it by rationalizing the incident via inference chaining, thinking of the incident step by step in order to separate what is real and true from what isn't. Ask yourself questions that can help to ascertain the validity of your thoughts, how did you come about that and reach out to your doctor for help as well.

plotting against me, They don't
want me to know what they are
doing, I won 1 billion and my
brother deleted the message while
conniving with bank so it will not
reflect in my account, They stole my
money, My brother is swindling me,
They are not my real family.

Table A2. Summary of the local data VS internet data train-test data split accuracy.

	Local Data		Internet Data	
Train/Test Split	**Training Accuracy**	**Testing Accuracy**	**Training Accuracy**	**Testing Accuracy**
90/10	88.85%	89.66%	91.95%	91.67%
10/90	92.86%	88.51%	85.71%	92.59%
70/30	91.09%	90.80%	91.63%	91.67%
30/70	89.53%	90.15%	92.53%	91.67%
60/40	87.86%	93.97%	90.70%	93.95%
40/60	93.04%	88.50%	93.70%	89.81%
80/20	90.91%	93.10%	90.94%	91.67%
50/50	88.89%	90.34%	91.62%	91.67%

Author Contributions

The contributions of the authors to the research and manuscript are as follows:
1. Ephraim O Nwoye, Abdulgafaar A Muslehat, Okodeh O Samuel:
    *   Conceptualization of the study.
    *   Designing the artificial neural network architecture.
    *   Leading the implementation and training of the ANN model.
    *   Analysis and interpretation of the model results.
    *   Drafting and revising the manuscript.
    *   Active involvement in the experimental setup.
    *   Contribution to the development of hyperparameters.
    *   Conducting experiments and collecting data.
    *   Collaborating on the analysis of model performance.
    *   Assisting in the drafting and revision of the manuscript.
2. Charles Umeh:
    *   Providing expertise in neural network design and architecture.
    *   Offering guidance on the selection and tuning of hyperparameters.
    *   Participating in the evaluation of model performance.
    *   Reviewing and providing critical feedback on the manuscript.
3. Wai Lok Woo:
    *   Offering insights into deep learning methodologies.
    *   Reviewing and advising on the experimental setup.
    *   Collaborating on the interpretation of results.
    *   Providing valuable feedback during manuscript revision.

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Informed consent was obtained from all subjects involved in the study.

Data Availability Statement

The data supporting the findings reported in this article are not publicly available. For inquiries regarding the data presented in this study, please contact the corresponding author:

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We will make every effort to address any requests or queries regarding the data.
In cases where new data were not created or data is unavailable due to privacy or ethical restrictions, we affirm this limitation.

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Conflicts of Interest

The authors declare that there are no conflicts of interest associated with this research. They affirm that no personal circumstances or interests have inappropriately influenced the representation or interpretation of the reported research results.

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