

**BINDURA UNIVERSITY OF SCIENCE EDUCATION
FACULTY OF SCIENCE AND ENGINEERING
DEPARTMENT OF COMPUTER SCIENCE**



**DESIGN AND IMPLEMENTATION OF AN ARTIFICIAL INTELLIGENT COUNSELLOR-
ASSISTANT CHATBOT FOR UNIVERSITY STUDENTS USING MACHINE LEARNING
AND NATURAL LANGUAGE PROCESSING.**

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DECLARATION

I, Liberty Alois Chandiwana hereby declare that, except for references to other people's work which have been duly acknowledged, this dissertation is the result of my own research and has neither in part nor in whole been presented in another education programme.

Signed: Liberty Alois Chandiwana

Date: 09.12.2022

(Student)

This research work was undertaken under the supervision of Mr. Mhlanganiso

Signed:

Date:

DEDICATION

I dedicate this dissertation to my family and all people who have contributed in different ways to my growth and development.

ACKNOWLEDGEMENTS

I would like to offer special thanks to my family for the unwavering support throughout my academic life at Bindura University of Science Education (BUSE).

I am indebted to BUSE particularly my supervisor Mr. Mhlanganiso, other Faculty of Science lectures such as Messrs. Chaka, Chikwiriro, Zano and Ndumiyana for helping me appreciate computer science field especially with regards to bridging the gap between theory and practice.

ABSTRACT

Background: In 2018 the cabinet minister of Higher and Tertiary Education, Science and Technology Development, Minister Amon Murwira, confirmed disturbing development of a spike in suicide cases in Zimbabwean tertiary institutions and acknowledged the need to improve the counselling systems at tertiary institutions to deal with 'mental health issues'.

Objectives: The first research objective was to analyse the different techniques used when developing an artificial intelligent chatbot for psychotherapy. The second objective was to design and implement an artificial intelligent chatbot using machine learning and natural language processing for addressing depression in university students. The third objective was to measure the effectiveness of machine learning and natural language processing in providing relevant feedback to students' queries.

Methods: Qualitative approach was employed due to the subjective nature of the domain particularly content analysis to determine whether the obtained data set could help achieve set objectives. The dataset is presented in CSV format and has 31 topics with more than 100 questions under depression while the least number of questions were under military issues topic (less than 10). Additionally, the researcher went on to explore the distribution of responses in the dataset. It was found that the dataset had more responses given to depression questions. 317 responses were given to depression questions with the military issues being the topic with the least number of responses

Results: The model performance is ranked on its ability to classify whether user query is depressive and the ability to give relevant feedback. The researcher thus carried out 100 tests to determine the system's effectiveness: Tests count (total number of tests performed) = 100. Total Yes (number of feedback responses that were relevant) = Test count – Total No (number of feedback responses that were not relevant) = 100 - 6 = 94. Therefore, system accuracy is set at $94/100 = 94\%$.

Conclusion: Using machine learning and natural language processing have the potential of reducing depression in university students as it addresses limitations embedded in the traditional counselling set up thus the proposed model encourages students to seek counselling services and nourish their therapeutic needs.

Recommendations: Given that most universities especially in Zimbabwe are primarily using the traditional method of counselling universities can take advantage of the rapid technological advancement and adoption wave especially in young adults to encourage students to seek counselling services using artificial intelligent powered chatbots. Furthermore, education and training for practicing psychotherapists and those in authority in Higher and Tertiary Education is required so that they appreciate the value of counsellor assistant chatbot(s) to reduce uninformed resistance to change.

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CHAPTER 1: THE PROBLEM AND ITS SETTING

1.1 Introduction

This chapter focuses on putting the problem under investigation into context through outlining background of the study, statement of the problem, research objectives, research questions, research hypothesis, significance of the study, assumptions, limitations, scope, definitions of key terms, chapter layout and chapter summary.

1.2 Background of the study

In 2018 the cabinet minister of Higher and Tertiary Education, Science and Technology Development, Minister Amon Murwira, confirmed disturbing development of a spike in suicide cases in Zimbabwean tertiary institutions and acknowledged the need to improve the counselling systems at tertiary institutions to deal with 'mental health issues' (Herald, 2018).

Speaking on the suicide cases minister Amon Murwira said:

"We also want to investigate the cause of these mental health issues which are leading to unfortunate occurrences. Once we understand what is leading to these cases, we can then offer a long-term solution." (Herald, 2018)

Depression is one of the most prevalent mental illnesses worldwide and two-thirds of people in need of counselling have their needs unattended (WHO 2020, 2017). When ignored and/or suppressed depression greatly reduces a person's productivity particularly academic performance for students with the potential of leading to suicide, inhibits the country's economic growth (Rasave & Patil, 2016) and by extension stifles growth and development of the global economy.

University students are confronted with tremendous pressure especially during their transition from home to university life emanating from a wide range of challenges such as new academic demands, new peer groups, distance from direct family support and financial constraints (Bowers, 2002). According to Joan, Finson and Wilson (2021) adapting to the new social and physical environment are the chief challenges faced by students. Counselling is one evidence-based approach that can empower students to navigate challenges they face during university life and beyond.

Unfortunately, it has been documented that only a minority of university students who experience depression seek professional counselling (Khan and Williams, 2003, Raunic and Xenos, 2008) for reasons such as gender of the counsellor, location of the counsellor, social mistrust and stigmatized topics (Kamunyu, Ndungo & Wango, 2016).

Furthermore, considering health workers shortage amid rising global population (Oladeji and Gureje, 2016, Anthes, 2016, Vaidyam, Wisniewski, Halamka, Kashavan and Tororous, 2019) and as universities adjust to increasing demand by accommodating more students the counsellor-student ratio is increasingly becoming strained. As such, lack of access to mental health care becomes inevitable creating a conducive environment for self-defeating behaviours in students such as substance abuse, unhealthy social relationships and suicidal tendencies that can lead to increased mortality (Hester, 2017).

1.3 Statement of the problem

In as much as the government ensures availability of counselling services at universities, it has been documented that only a minority of university students who experience depression seek professional counselling (Khan and Williams, 2003; Raunic and Xenos, 2008) for reasons such as gender of the counsellor, location of the counsellor, social mistrust, and stigmatized topics (Kamunyu, Ndungo & Wango, 2016). The development of an artificial intelligent counsellor-assistant chatbot using machine learning and natural language processing cushions students from the limitations embedded in the traditional counselling set up thereby encouraging students to seek professional counselling and nourish their psychotherapeutic needs.

1.4 Research objectives

- i. To analyse the different techniques used when developing an artificial intelligent chatbot for psychotherapy.
- ii. To design and implement an artificial intelligent chatbot using machine learning (ML) and natural language processing (NLP) for addressing depression in university students.
- iii. To measure the effectiveness of ML and NLP in generating relevant feedback to students' queries.

1.5 Research questions

- i. What different techniques are used when developing an artificial intelligent chatbot for psychotherapy?
- ii. How to design and implement an artificial intelligent chatbot using machine learning (ML) and natural language processing (NLP) for addressing depression in university students?
- iii. How to measure the effectiveness of ML and NLP in generating relevant feedback to students' queries?

1.6 Research hypothesis

The null hypothesis for this study is:

H₀: An artificial intelligent chatbot using machine learning and natural language processing can give relevant feedback with the potential to reduce depression in university students.

This is tested against the alternative hypothesis:

H₁: An artificial intelligent chatbot using machine learning, natural language processing fails to give relevant feedback hence cannot have the potential to reduce depression in university students.

1.7 Significance of the research

1.7.1 University Students.

Students will be the chief beneficiaries of the research as the research is earmarked at addressing their concerns against the traditional mode of counselling such as gender of the counsellor, location of the counsellor, social mistrust, and stigmatized topics.

1.7.2 Ministry of Higher and Tertiary Education, Science and Technology Development.

Findings of the study will inform policy makers particularly in tertiary education to craft policies that support a healthy integration of the state of art in technology specifically artificial intelligence with the traditional mode of counselling.

1.7.3 Zimbabwe Council of Higher Education (ZIMCHE).

ZIMCHE as a regulator of tertiary education may utilise the findings of this research to direct tertiary institutions in ensuring that the psychological needs of students are not ignored.

1.7.4 Professional counsellors.

The effort of professional counsellors will be spared to focus on more challenging issues that the current model of artificial intelligence cannot address without distortion.

1.7.5 Tertiary institutions.

When learners are relieved from depression their state of mental health is improved, empowering learners to excel in their studies thus improving overall student performance and quality of research in institutions of higher learning.

1.8 Assumptions

Below are the assumptions maintained during this project:

- a) The research subjects have an idea of what counselling entails.

- b) The research subjects know how to operate a computer.
- c) The research subjects have a computer device.
- d) The use of a counsellor-assistant chatbot requires that users be in contact with a professional counsellor or be prepared to visit a professional counsellor at some point during their life at the university.

1.9 Limitations

- a) Availability of quality and appropriate therapy data for training and testing the model.

1.10 Delimitation of the research

The researcher shall focus on counselling against depression since it is one most rampant mental disorder in the world (Ferrari, Charlson, Norman, Pattern, Freedman, Murray, Vos and Whateford 2010, Ritchie & Rose, 2018). Due to time limitation other mental disorders such as anxiety will not be dealt with in this study.

1.11 Definition of key terms

Counselling/Psychotherapy

Is a process that involves a client (client) and a counsellor coming together in a relationship of trust and in confidence to explore challenges which may include stressful and or feelings of a client (Krishnan, n.d).

Depression:

According to APA depression “is a common and serious medical illness that negatively affects how you feel, the way you think and how you act. Depression causes feelings of sadness and/or a loss of interest in activities you once enjoyed. It can lead to a variety of emotional and physical problems and can decrease your ability to function at work and at home”.

1.12 Organisation of the study

The current chapter has put the issue under investigation into context, chapter two expose gaps in current literature, chapter three outlines research methodology, chapter four focuses on presentation of results and evaluation of the proposed system, and chapter five is dedicated to conclusion and recommendations.

1.13 Chapter summary

This chapter has put in context the problem under investigation through the discussion of the following: background to the study, statement of the problem, research objectives, research questions,

research hypothesis, significance of the study, assumptions, limitations, scope, definitions of key terms and organisation of the study.

CHAPTER 2: LITERATURE REVIEW

2.1 Introduction

This chapter zeroes on reviewing existing studies aimed at improving psychotherapy using machine learning models and natural language processing. Machine learning and natural language processing can be seen as the part of the building blocks for artificial intelligence models.

2.1.1 Depression

Depression can be defined as a complex mental illness manifesting in a variety of ways in different people and it is largely associated with low mood which can last for days or weeks, it can be recurring and affect one's daily routine (National Health System {NHS}, 2022).

2.1.2 Symptoms

Depression like other forms of illness affects people differently and the symptoms differ in intensity and depression symptoms into two main categories, that is, psychological and physical (NHS, 2022).

Psychological

- Contemplating suicide
- contemplating self-harm
- Low self-esteem
- losing motivation
- continuous sadness or low mood
- feeling anxious
- feeling helpless
- feeling hopeless
- feeling irritable
- feeling intolerant of other people

Physical depression symptoms

- disturbed sleep
- loss of energy
- loss of interest in things one used to enjoy
- losing, or sometimes gaining, appetite or weight
- aches and pains that can't be explained

2.2 Psychotherapeutic treatments implemented in artificial intelligence.

Psychotherapeutic treatments implemented by developers can be broadly categorised into two, that is, cognitive behavioural therapy (CBT) and positive psychology (Sedlakova & Trachsel, 2022).

2.2.1 Cognitive behavioural therapy (CBT)

CBT is a type of psychotherapeutic treatment that empowers people to learn identifying and changing destructive thought patterns which negatively influence their behavior and emotions (Hofmann, Asnaani, Vonk, Sawyer & Fang, 2012). Research supports that among psychotherapeutic treatments CBT has been consistently effective for a wide range of mental illnesses such as depression, addictions and eating disorders (NHS, 2022, David, Cristea & Hofmann, 2018). Additionally, research also supports that CBT has contributed to significant changes in peoples who previously had mild to severe mental illnesses way more than psychiatric medications (APA, 2022).

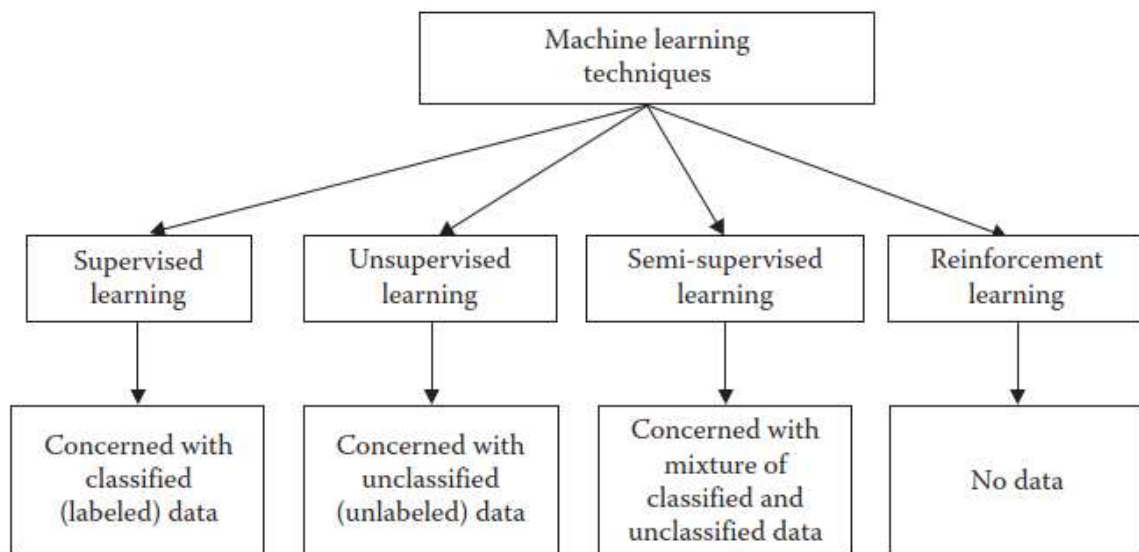
2.2.2 Positive Psychology

Positive psychology is a psychotherapeutic technic that places emphasis on positive aspects of life, for instance, well-being, flourishing and happiness (Walden University, 2021). Martin Seligman, the founder of positive psychology, defines positive psychology as the 'scientific study of optimal human functioning that aims to discover and promote the factors that allow individuals and communities to thrive' (ctd in Positive Psychology, 2022). Positive psychology emerged to address perhaps the overemphasis that was placed on individual shortcomings by other psychotherapeutic techniques and thus directed attention towards human potentials (Positive Psychology, 2022). Interestingly, positive psychology is not interested in solving problems but rather directs attention to reasons that make life worth living (Walden University, 2021).

2.3 Machine Learning

Machine learning is an artificial intelligent branch in which electronic machines are enabled to perform their jobs more efficiently and effectively using intelligent software (Mohammed, Khan, & Bashier, 2016). Statistical learning algorithms form the matrix upon which machine leaning is founded. There is no consensus definition of machine learning as some scholars argue that machine learning should not focus on machines mimicking human intelligence but should rather focus on intelligent behaviour (Janarthanam, 2021). One fundamental contribution brought about by machine learning is the move from working with predetermined algorithms that require change of code to give different input to code that can learn from given input and give different results without recoding (Parmar, Ryu, Pandya, Sedoc & Agarwal, 2022). Machine learning can be classified into supervised, unsupervised and reinforcement learning (Mohammed, Khan, & Bashier, 2016).

Figure 1: Types of machine learning



Adapted from Mohammed, Khan, & Bashier (2016)

2.3.1 Supervised Machine Learning

Under supervised learning labelled data is used for training and the target is for the machine learning algorithm to make inference from the training data (Mohammed, Khan, & Bashier, 2016). Training continues up to the point that the developer is satisfied with the accuracy attained by the model (Chaudhary, 2020). Accordingly, supervised learning algorithms can be classified into "Linear Classifiers, Logistic Regression, Naive Bayes Classifier, Perception, Support Vector Machine; Quadratic Classifiers, K-Means Clustering, Weibull Power, Tree Decision, Random Forest (RF); Neural Networks, Bayesian Networks" (Chaudhary, 2020 pp. 9)

2.3.2 Unsupervised Machine Learning

Contrary to supervised learning that makes use of labelled data, unsupervised learning unearths patterns that were not previously detected from a data set without pre-existing labels and there is minimum human intervention (Siadati, 2018). As indicated in the fig below there is neither supervisors nor the training data. Reasons why the data may be unlabelled range from availability of funds for manual labelling or the nature of the data itself (Mohammed, Khan, & Bashier, 2016).

2.3.3 Semi-supervised Machine Learning

Semi-supervised machine learning is a combination of labelled and unlabelled data used to come up with a model for the classification of data (Mohammed, Khan, & Bashier, 2016). Given the scarcity of labelled data and the abundance of unlabelled data, developing a model that will better predict

future data set more than is possible with a model trained with only labelled data becomes the target for semi-supervised learning.

2.3.4 Reinforcement Machine Learning

In reinforcement learning emphasis is placed on using observations gathered from the model's interaction with the environment with the aim of maximising the reward or minimising the risk (Dridi, 2021). Accordingly, the model learns from past experiences from the environment and captures the most relevant feedback to give the best accurate feedback to future user query.

2.4 Natural Language Processing (NLP)

Natural language is a critical area of computer science where machine learning together with computational linguistics are employed. The focus is to smoothen computer and human interaction in the most efficient manner possible. Like a child the computer is trained to master syntax and semantics of human language (Jain, Kulkarni, Gandhar & Shah, 2018).

Natural language algorithms developed include sequence 2 sequence model and word embedding model. NLP also standardizes user input that could be text or audio using a variety of ways such as stemming. What is of particular interest under NLP is the WordNet, an English lexical database (Tutorialspoint, 2022). It is one of the Natural Language Tool Kit (NLTK) corpus developed by Princeton and it is especially designed to group nouns, adjectives, verbs, and adverbs into sets called synsets (Jain et al, 2018). Another chief function of WordNet in NLP is word-sense disambiguation and automatic text classification (Tutorialspoint, 2022).

2.5 Empirical Review

The most prevalent mental illness worldwide is depression and about two-thirds of patients suffer from unmet needs (WHO 2017, 2020). Additionally, according to the World Health Organization (WHO 2019), “mental disorders are one of the most significant public health challenges in the European Region, as they are the leading cause of disability and the third leading cause of overall disease burden.” The chief reason why majority of people with mental illness have their needs unmet stems from the fact that the demand for psychotherapy far outstrips the number of psychotherapists, and the situation is worse in the third world countries. As such, while there is no consensus on the use and effectiveness of chatbots, the general wave is supporting the development and implementation of artificial intelligent powered chatbots to ensure that people have their psychological needs somewhat addressed.

In the context of universities, as the world population continue to increase with more students being enrolled the student-counsellor ratio also continues to be strained leaving more students with unmet

psychological needs to the detriment of their own lives (Liu et al, 2022) and ultimately from an economic perspective, debilitating student performance which in turn reverberate in reduced quality and quantity of production when the students join industry (Rasave & Patil, 2016). As such the traditional method of counselling also known as the gold standard remains necessary but not sufficient to address psychotherapeutic needs of students (Kapoor, Agrawal & Ahmad, 2021).

There is an interesting debate on whether chatbots in psychotherapy can replace the traditional psychotherapists. Some scholars such as Moore (2006) contend that with the machine learning state of art it is not possible and not soon will the traditional mode of counselling be replaced by chatbots. Echoing the words of Moore recently scholars such as Ward (2021) maintain that AI chatbots will only be able to replace the traditional mode of counselling when the state of art in machine learning has been redefined enough to cater for the current shortcomings, for instance, the inability of AI to account for cultural differences in normative behaviour. Additionally, other scholars argue that artificial intelligent chatbot mimic human conversation and does not have human features such as empathy or intentionality and cannot be a bearer of responsibility as humans (Sedlakova & Trachsel 2022). According to Laffin (2022) chatbots struggle with context understanding hence they are best suited for narrow scope conversations and one way address context challenges is to work with high-quality and large volume datasets.

Literature suggests that the use of computer aided interventions in psychotherapy has the potential to reduce depression (Burr and Floridi 2020; Rubeis 2021; Fiske, Henningsen, and Buyx 2020). Nevertheless there is precaution needed to avoid generalisations with regards to the effectiveness and efficiency of current chatbots as the research in this field is still at its embryonic stage (Bendig et al. 2019; Thieme, Belgrave, and Doherty 2020; Torous, Cerrato, and Halamka 2019). The area is need of more research as the current therapy chatbots have their limitations. Furthermore, literature also suggests that there is even greater need for more indepth studies, holistic and human-centred approaches and research focused on long-term societal and individual impacts of the artificial intelligent powered therapy chatbots (Bendig et al. 2019).

Computer aided interventions used for managing depression

Popular machine learning chatbots include Eliza, Woebot, Tess, Replika, Wysa and Lissa (Alrazaq et al, 2019). Chatbots such as Woebot were developed to deliver cognitive behavioural therapy for patients with depression and anxiety but however these chatbots have their limitation such as (Alrazaq et al, 2019)

Eliza

In the 1960's ELIZA was built to emulate human conversational abilities of a psychotherapist. The idea was for the machine to simulate human conversation while allowing the patient to do most of the cognitive work of interpretation (Bassett, 2019). The program was intended only for research purposes involving natural language processing experiments, and ultimately led to the rapid expansion of the conversation on artificial intelligence (Pham et al, 2022)

Woebot

Woebot is a machine learning conversational application available via Facebook, Messenger or mobile applications with tools that enable cognitive behavioural therapy (CBT) process. The tool was mainly meant to monitor symptoms and help patients undergoing episodes of anxiety and depression through acquired skills particularly identifying and challenging cognitive distortions (Friske, 2019). In a separate study 70 subjects were chosen randomly into Woebot and an e-book reading for depression. The results demonstrated that there was a significant decrease in depression compared to the e-book group Fitzpatrick (2017).

Tess

Tess is another machine learning application available that makes use of text messaging to assist individuals undergoing difficult times and emotional distress. As such the user can access therapeutic conversations as though they were having face to face conversations with a psychotherapist. The user at the end of the day benefits from emotional awareness and gains strategies for coping with difficult times and depression. This tool enables the user to have similar therapeutic conversations as though they were conversing with a psychologist and delivers emotional wellness coping strategies (Fulmer, 2021).

Replika

Replika is a positive psychology-based smartphone application that enables users to have conversations about themselves, empowering users to develop an understanding and appreciation of their good qualities (Murphy, 2021). Accordingly, Replika reconstructs a footprint of a user personality from the conversation the user would have had with the avatar. One greatest advantage of Replika is that without fear of judgement a user can have vulnerable conversations with their avatar throughout the course of interaction. Like therapy sessions with a psychotherapist or personal conversations with a friend, the avatar can have therapeutic sessions with the user and help the user gain insight of their personality (Pham, Nabizadeh & Selek, 2022).

Implementation of therapy chatbots

With regards to the implementation of therapy chatbots it is recommended that chatbots be web-based and not stand alone due to data privacy issues breaches likely to occur when users need to install an

the chatbot application to get counselling services. Surprisingly more than 70% of chatbots were standalone raising private and confidentiality threat and risks (Alrazaq et al, 2019). Alrazaq et al (2019) further argues that web based chatbots are more accessible compared to stand alone chatbots.

2.6 Chapter summary

This chapter outlined the theoretical framework which formed the basis through which the study was conducted. It is clear from the preceding sections that the chatbots built thus far have limitations such as context and hence there is need for more studies to further improve the state of art in artificial intelligent powered chatbots. The researcher has thus been able to identify the knowledge gaps to be filled by the study. The next chapter focuses on research methodology, which will guide data generation, presentation, analysis, and interpretation.

CHAPTER 3: RESEARCH METHODOLOGY

3.1 Introduction

The previous chapter focused on the theoretical framework that guided the study and reviewing relevant literature with the aim of identifying knowledge gaps. The current chapter outlines research design, methods, requirements analysis, system development, system design, summary of how the system is going to work and implementation.

3.2 Research design

McCombes (2019) defines research design as the framework for planning research and answering research questions. In addition, research design helps the researcher in planning, structuring and execution of the research to maximise trustworthiness of the findings (Kothari, 2004). Due to the subjective nature of psychotherapy qualitative approach was employed.

3.3 Methods

The researcher used content analysis qualitative method for the study.

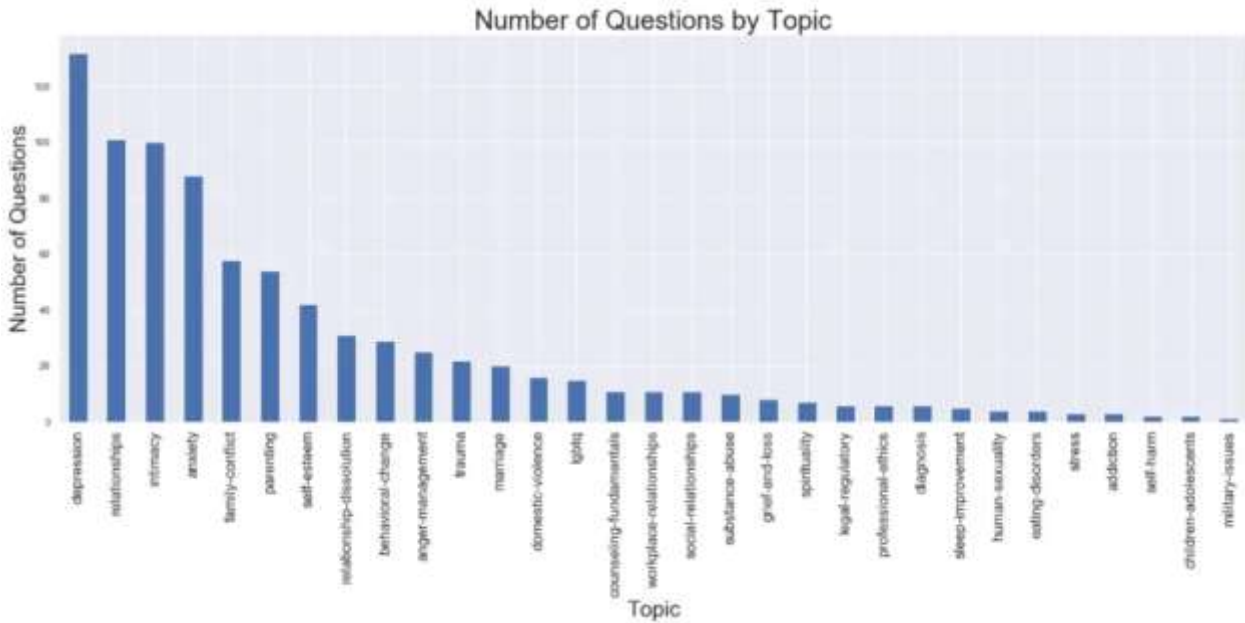
Content analysis

The dataset was obtained from CounselChat which is an online expert community in which only qualified practicing psychotherapists give assistance to patients. CounselChat has more than 307 active psychologist contributors providing feedback to patients (CounselChat, 2022). As indicated in chapter two that psychologists normally make use of a hybrid of therapeutic methods it can thus be concluded that the dataset from CounselChat would come with reasonable domain knowledge to ensure the model gives relevant feedback to users.

This data was chosen as it was of better quality compared to other free datasets and because the dataset is anonymized therefore data privacy and confidentiality is maintained.

The dataset is presented in CSV format and has 31 topics with more than 100 questions under depression while the least number of questions were under military issues topic (less than 10) as depicted in the fig below:

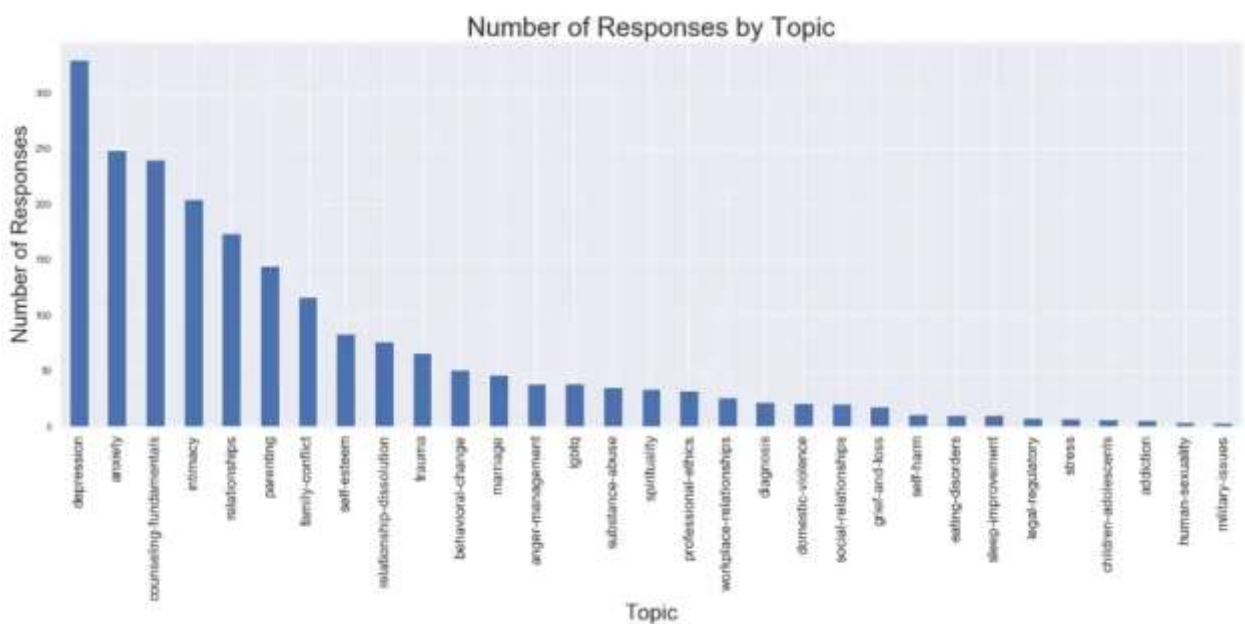
Figure 2: Visualisation of questions per topic



Adapted from Counsel Chat: Bootstrapping High-Quality Therapy Data | by Nicolas Bertagnoli | Towards Data Science

Additionally, the researcher went on to explore the distribution of responses in the dataset. It was found that the dataset had more responses given to depression questions. 317 responses were given to depression questions with the military issues being the topic with the least number of responses as depicted in the fig below:

Figure 3: Visualisation of responses per topic



Accordingly, the dataset was appropriate for the researcher since it contained more data on the researcher's topic of interest.

3.4 Requirements analysis

Critical to the success or failure of any project is requirement analysis in which the functional and non-functional requirements are clearly stipulated. It is crucial however that the requirements be realistic in terms of resources and time, testable, measurable, must speak to identified business needs and are as detailed as possible such that system design is actionable (Abram Moore, Bourque, & Dupuis, 2004). It is also critical to be flexible, for instance, the nature and type of dataset that the researcher will obtain has a huge effect to requirements analysis.

3.4.1 Functional requirements

Querying:

- The chatbot must be able to classify query as depressive or not depressive.
- The chatbot must provide relevant feedback to depressive queries.
- The system will alert the user of any spelling errors

Logs:

- The chatbot must keep a record of all user queries

Administrative system:

- The admin must be able to add, update and delete queries

3.4.2 Non-functional requirements

Accuracy:

- System overall accuracy of the chatbot responses should be greater than 90% and will be measured using a developer-made testing (dividing total number of correct answers by the number of questions asked).

Performance:

- Response time, resource utilisation and throughput.

User interface:

- Intuitive and user-friendly user interface.

Security:

- The system must prevent unauthorised access to the administration system.
- The admin should be able to change password and password setting must be enforced.

Ethics:

- The system must not keep personal data about users

3.4.3 Hardware requirements

Below are the minimum hardware specifications required in building the proposed model:

- Coi3 processor
- 500GB HDD/SSD

3.4.4 Software requirements

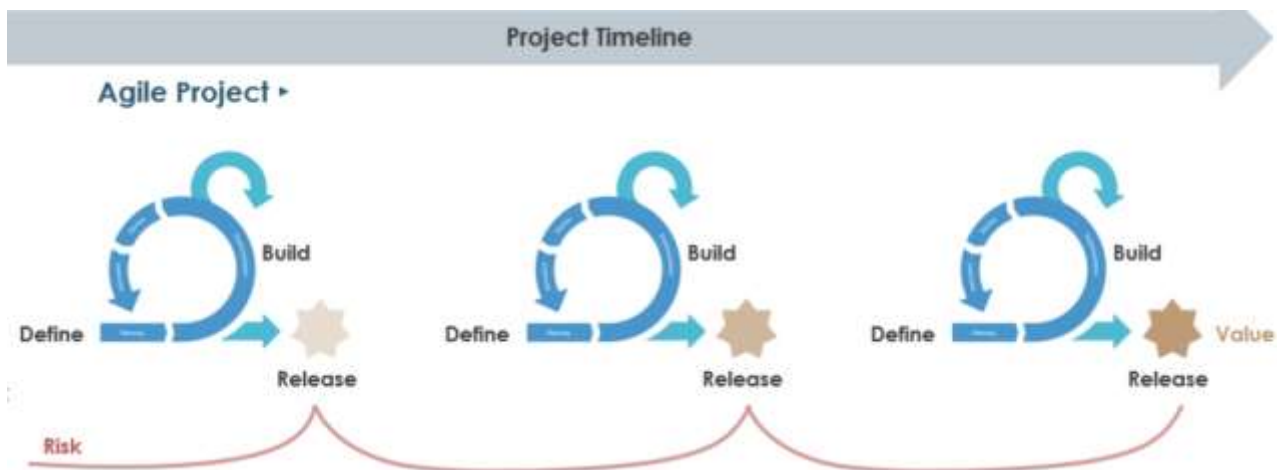
- Windows 10 operating system
- Software development tools
 - ✓ **Visual studio code**
 - ✓ **Python 3.9** - the researcher chose python programming language because most machine learning tools are implemented using python. Among other programming languages, python boasts of multi-features such as being a high-level built-in data structures, dynamic binding and typing which makes it suitable for Rapid Application Development (Python Software Foundation, 2021).
 - ✓ **Pytorch** - this is a machine learning open-source framework useful in accelerating research from prototyping to deployment.
 - ✓ **Django framework** - Django is another open-source web framework used to speed up web application being built in the python.
 - ✓ **Keras** - It is a powerful and easy-to-use free open-source Python library for developing and evaluating deep learning models. It wraps the efficient numerical computation libraries Theano and TensorFlow and allows you to define and train neural network models in just a few lines of code.
 - ✓ **NLTK** - Natural Language Tool Kit will be used by the author in natural language processing and in helping the system to pick the appropriate response particularly **WordNet**.

- ✓ **TensorFlow**- Is a free and open-source software library for machine learning and artificial intelligence. It can be used across a range of tasks but has a particular focus on training and inference of deep neural networks.

3.5 System development

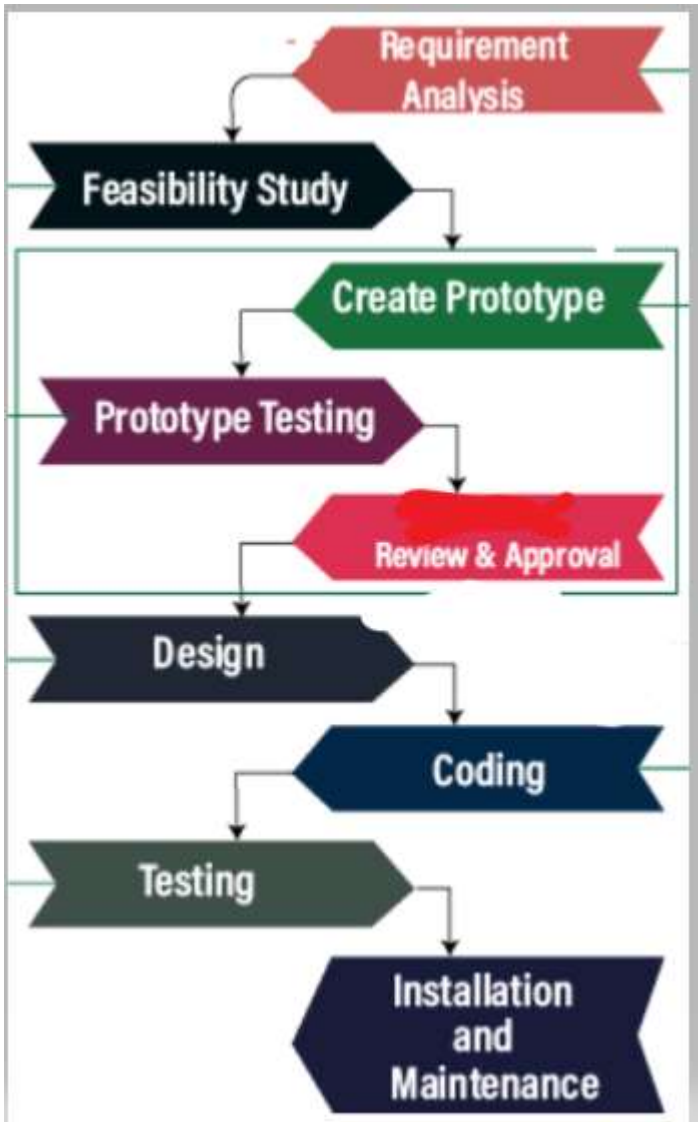
Agile development was employed in building the proposed model as the system needed to be tested with limited functionalities. Since this was the researcher's first model, it was appropriate to use incremental prototyping to ensure that every component is tested in the process to assess whether objectives and functional requirements are met. Below is a demonstration of the agile development process.

Figure 4: Agile development process



Adapted from <https://www.visual-paradigm.com/scrum/what-is-agile-software-development/>

Figure 5: Prototyping model



Adapted from <https://www.javatpoint.com/prototype-model>

➤ **Requirement Analysis**

The first stage is to understand requirements that enabled the researcher to meet outlined objectives and ensuring that these requirements as detailed.

➤ **Feasibility study**

The researcher decided on the cost of the product, resources needed, and appropriate technology needed to develop the proposed model including time allocation to the point of delivering a working model.

➤ **Create a prototype**

After feasibility study, based on the data collected the researcher went on to develop a prototype.

➤ **Prototype testing**

The researcher tested the prototype mainly focusing on the user interface and frontend components.

➤ **Review and approval**

After testing the researcher checked whether the results are in line with expectations. When the researcher was not satisfied with the results, then the prototype was changed, and the process continued till the researcher was satisfied with the results. The process is time consuming but worthwhile.

➤ **Design**

Once the researcher is happy and the supervisor has approved the model then high and low-level design for the final proposed model begins considering all the suggestions.

➤ **Coding**

After design then actual coding begins using python programming.

➤ **Testing**

At this stage the researcher starts testing functionality of the application inputs and outputs.

➤ **Installation and maintenance**

When the final product is built and tested successfully, the model will be deployed to production environment.

3.6 System design

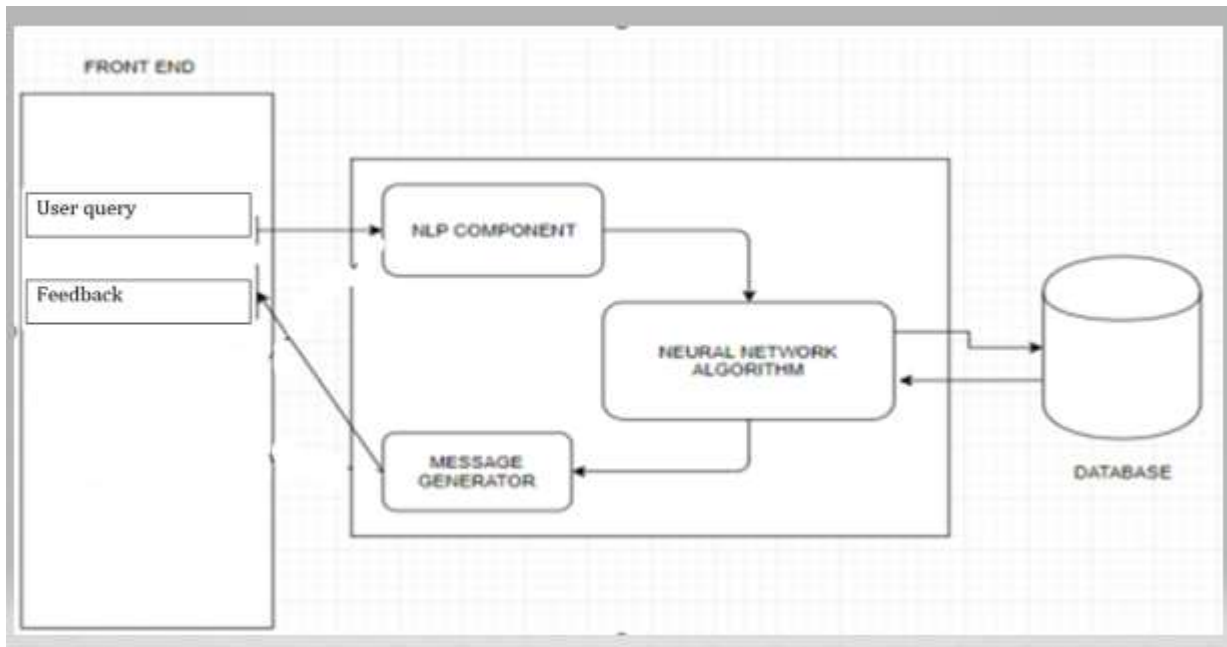
Requirements specification document is analysed, and this stage defines how the system components and data for the system satisfy specified requirement. Below is the proposed dataflow diagram:

System block diagram

A block diagram demonstrates in schematic form and at high level, the general arrangement of the system's components or process. In the diagram below, the researcher has presented a simplified block diagram for the system focusing on the three main parts, that is, frontend, processing unit and the database/corpus. Firstly, input is taken from the user from the website dialogue box. The text is broken down and with NLP at work keywords are extracted and processed. Secondly, the output of NLP is then given to the neural network algorithm. After being derived the key words are matched with the appropriate outputs from the database. The output is generated to the output window using Message Generator. To implement the NLP component in our system, we need to import NLTK

library, particularly WordNet. In NLP component we implement tokenization and stemming for the given input.

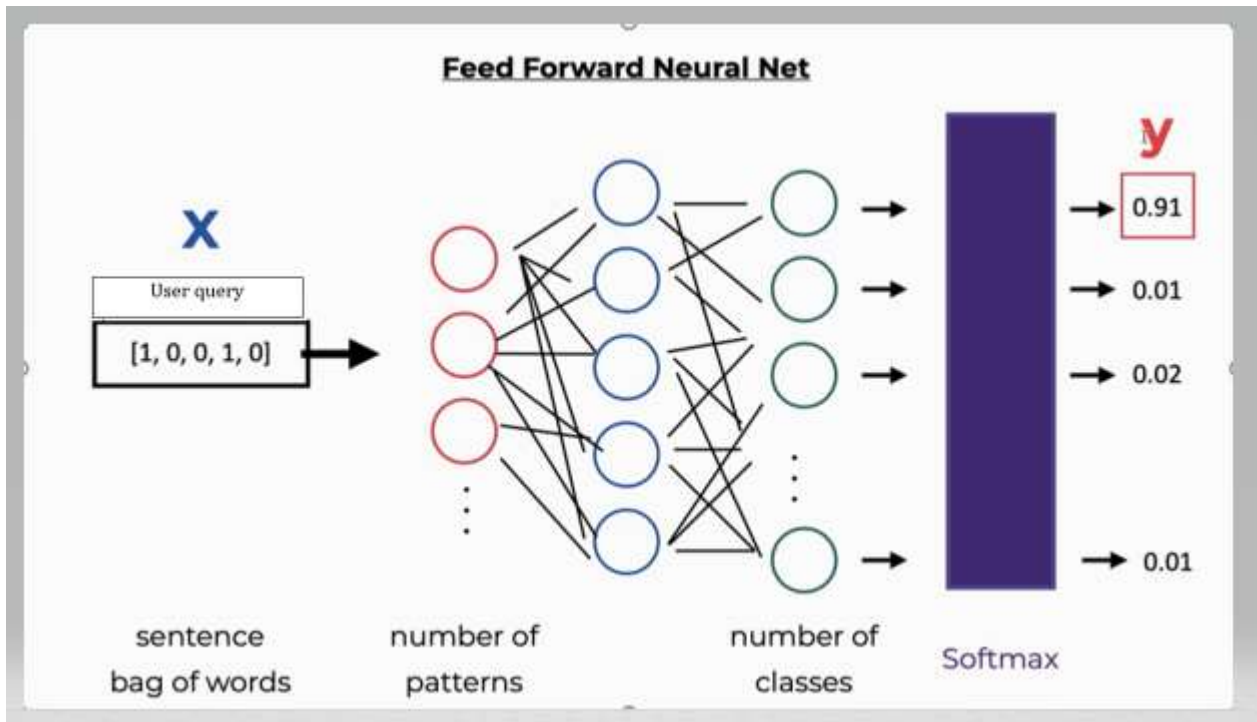
Figure 6: Block diagram



Feed-Forward Neural Net

A neural network is a series of algorithms that endeavours to recognize underlying relationships in a set of data through a process that mimics the way the human brain operates (Michael J Boyle, 22 December 2020). Neural Networks (DNNs) are typically Feed Forward Networks (FFNNs) in which data flows from the input layer to the output layer without going backward. The links between the layers are one way which is in the forward direction, and they never touch the same node twice. The outputs are obtained by supervised learning with datasets of some information based on what is required by the user through back propagation. We use two hidden layers, each consisting of two nodes, and the output consisting of six nodes, which are the total number of tags in our json file. After determining the tag, that is, the tag with the highest similarity, the response is fetched from the tag. For instance, in the figure below the tag with 0.91 will be fetched as the response. The admin manages the corpus and has privileged access rights to all system components.

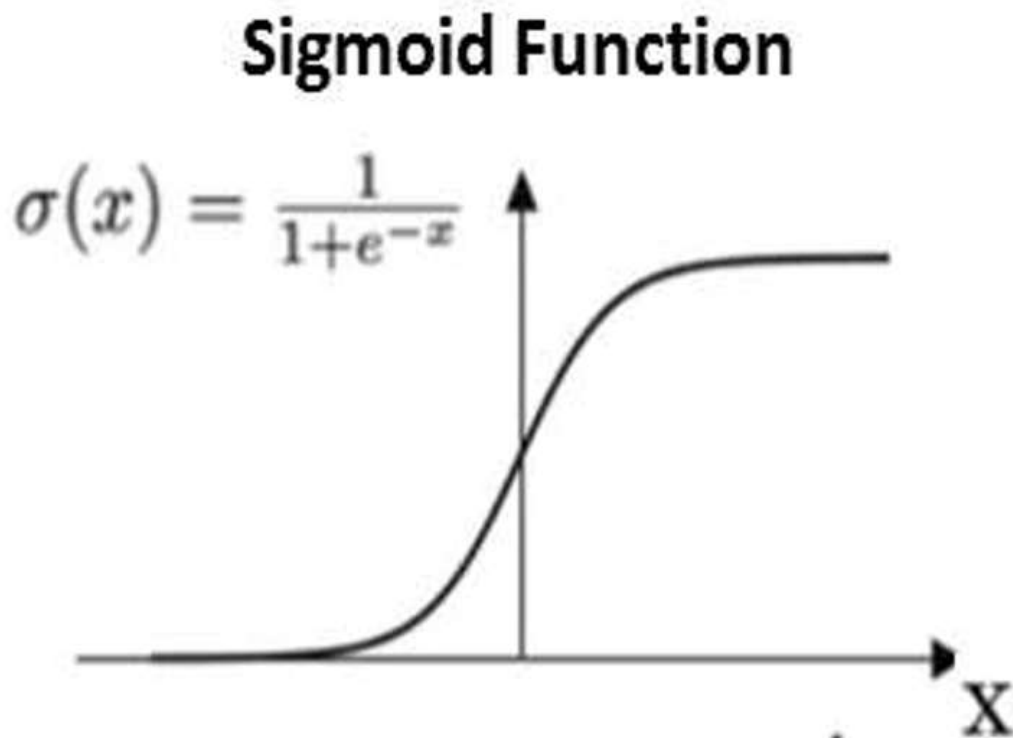
Figure 7: Feed-Forward Neural Net



Adapted from https://www.researchgate.net/figure/Sample-of-a-feed-forward-neural-network_fig1_234055177

The activation function used in this model is Binary Sigmoid Function which is a S-shaped function that have output values as either binary or 0 to 1.

Figure 8: Sigmoid activation function



Adapted from <https://www.analyticsvidhya.com/blog/2022/01/feedforward-neural-network-its-layers-functions-and-importance/>

Tokenization

The process of tokenizing or breaking a string of text into a list of tokens is known as tokenization. Tokens can be thought of as components, for example, a word in a sentence is a token, and a sentence is a token in a paragraph. We also use stemming in NLP component.

Stemming

Stemming is a process of producing morphological variants of a root/base word and stemming programs are commonly referred to as stemming algorithms or stemmers. A stemming algorithm reduces the words such as “like”, “likes”, “likely”, “liking” are reduced to the root word “like”. These stemmed words are given to the neural network. In our project we’re using deep neural networks to implement the neural network algorithm. Now this neural network algorithm takes the stemmed words and matches with the appropriate responses in the database. Now, in this database, there is a response for each pattern. The corpus/dataset is in CSV format. The appropriate response is given to the message generator which displays the response as the output on the output screen.

3.7 Summary of how the system is going to work

The proposed system allows the user to query the chatbot. Using NLTK, particularly WordNet the system can determine whether the response is depressive. When the user query is not depressive then the query is not passed TensorFlow, and the feedback (not depressive) is given the user in 5 seconds. Otherwise, if the query is depressive the query is passed to the TensorFlow and TensorFlow assigns the percentage of similarity to all queries in the dataset. The feedback given in about 50 seconds to the user query is taken from the data set query assigned the highest percentage of similarity to user query.

3.8 Implementation

The system is now going through the negotiation process using machine learning and natural language processing. Below are the implementation codes used in the development of the system.

Figure 9: Prompting user to enter query and determining whether query is depressive

```
import re
str = input('Enter Your Message: ')
print("-----")
strings = ["I am very sad, I feel like killing myself", "I don't know why to live",
           "I am very very happy.", "really excited"]
examples = str

a = preprocess(examples)

example_counts = vectorizer.transform([a])
prediction = mnbc.predict(example_counts)
prediction[0]

if prediction[0]==0:
    print('Positive')

elif prediction[0]==1:
    print('Depressive')
```

In the figure above the vectorizer is making use of the WordNet to determine whether a given query is depressive. If the query is not depressive the user is immediately given the feedback, not depressive otherwise the query is passed to the TensorFlow which now searches for the similarity between the query with queries in the dataset and assigning percentage of similarity as shown in the figure below.

Figure 10: TensorFlow searching for similarity between the query and queries in the dataset.

```
from sentence_transformers import SentenceTransformer, util
# model = SentenceTransformer('multi-qa-MiniLM-L6-cos-v1')
model_path = 'sentence_model'
model = SentenceTransformer(model_path)
query_embedding = model.encode('I am feeling high')
# pip install sentence-transformers

passage_embedding = model.encode(['I am feeling down',
                                  'I am feeling great'])
model.save(model_path)

print("Similarity:", util.dot_score(query_embedding, passage_embedding))

Similarity: tensor([[0.6113, 0.6194]])
```

3.9 Chapter summary

The current chapter outlined a systematic development of the proposed system as well as the software methodology employed by the researcher. Several techniques were employed by the researcher to come up with the proposed model. System functionalities and how the system data flows from the start to the end are as well illustrated in this chapter. Chapter four is dedicated to presentation, analysis and interpretation of results obtained from the proposed model.

CHAPTER 4: DATA PRESENTATION, ANALYSIS, AND INTERPRETATION

4.1 Introduction

This section presents research findings from study and analysis of results obtained from the model. The researcher managed to develop a model that uses machine learning and natural language processing in tandem with objectives outlined in chapter one. Efficiency and effectiveness of the system was determined by accuracy and performance. The model's performance was observed with different user queries and results presented in tabular format.

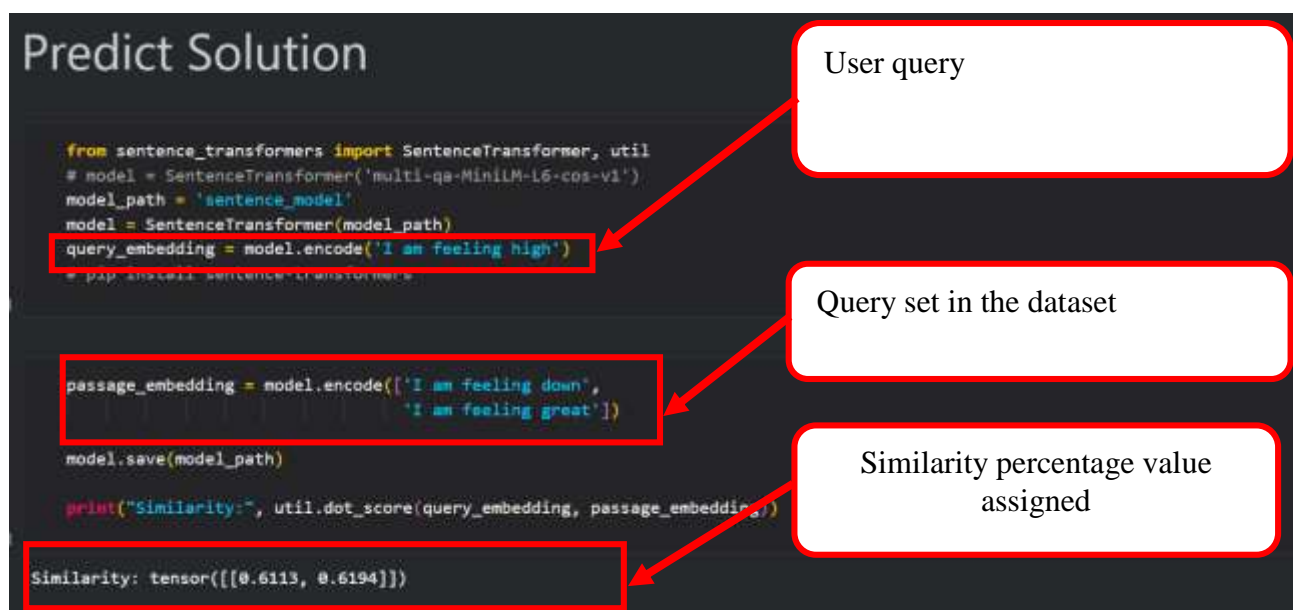
4.2 Testing

White box, black box, unit and performance testing were carried out to ensure that the model is performing as intended, that is, in line with the objectives set out in chapter one. Testing is of paramount importance in the development of software and this chapter is dedicated to demonstrating the tests that were carried out together with results produced. The model performance is measured against stated functional and non-functional requirements set out in chapter three.

4.2.1 White box testing

Under this form of testing the implementation or internal logical structure is known by the one testing and the impact of code is also tested (GeeksforGeeks, 2022). The researcher performed the test to observe how the code was able to match user query to a limited sample of queries in the dataset.

Figure 11: white box testing



The image shows a terminal window titled "Predict Solution" containing Python code for testing a sentence transformer model. Three red boxes with arrows point to specific parts of the code, each with a label in a white box:

- User query:** Points to the line `query_embedding = model.encode('I am feeling high')`.
- Query set in the dataset:** Points to the line `page_embedding = model.encode(['I am feeling down', 'I am feeling great'])`.
- Similarity percentage value assigned:** Points to the output line `Similarity: tensor([[0.6113, 0.6194]])`.

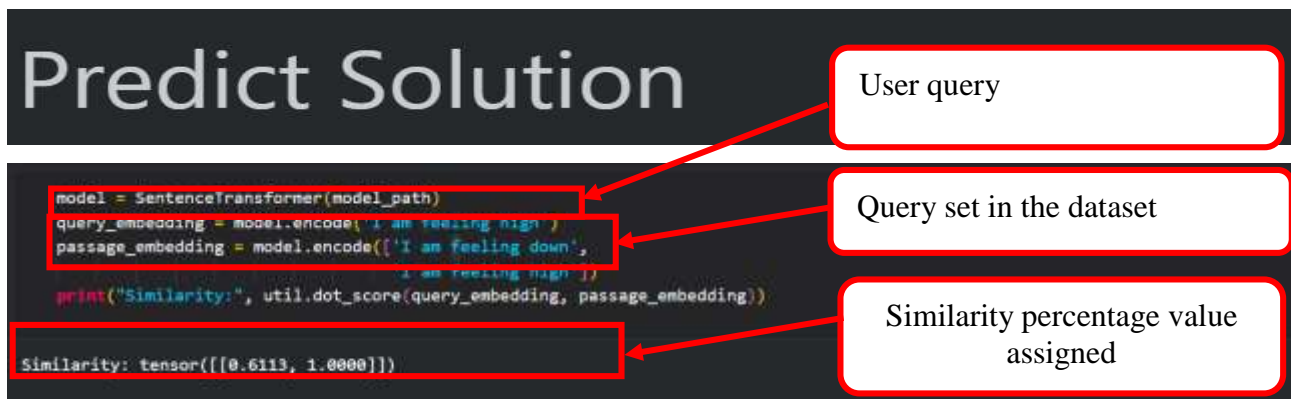
```
from sentence_transformers import SentenceTransformer, util
# model = SentenceTransformer('multi-qa-MiniLM-L6-cos-v1')
model_path = 'sentence_model'
model = SentenceTransformer(model_path)
query_embedding = model.encode('I am feeling high')
# page_embeddings = model.encode(['I am feeling down', 'I am feeling great'])
page_embedding = model.encode(['I am feeling down',
                               'I am feeling great'])
model.save(model_path)
print("Similarity:", util.dot_score(query_embedding, page_embedding))

Similarity: tensor([[0.6113, 0.6194]])
```


White box testing

Fig 11 demonstrates the model's accuracy given a user input. The model takes user query ("I am feeling high") and assigns similarity percentage to the two queries in the dataset ("I am feeling down" and "I am feeling great"). "I am feeling down" is given 0.6113 level of similarity while "I am feeling great" is given 0.6194 level of similarity.

Figure 12: White box testing 1



The image shows a terminal window titled "Predict Solution" containing Python code for a sentence transformer model. Three red boxes with arrows point to specific parts of the code and its output:

- User query:** Points to the line `query_embedding = model.encode('I am feeling high')`.
- Query set in the dataset:** Points to the line `passage_embedding = model.encode(['I am feeling down', 'I am feeling high'])`.
- Similarity percentage value assigned:** Points to the output line `Similarity: tensor([[0.6113, 1.0000]])`.

```
model = SentenceTransformer(model_path)
query_embedding = model.encode('I am feeling high')
passage_embedding = model.encode(['I am feeling down',
                                  'I am feeling high'])
print("Similarity:", util.dot_score(query_embedding, passage_embedding))

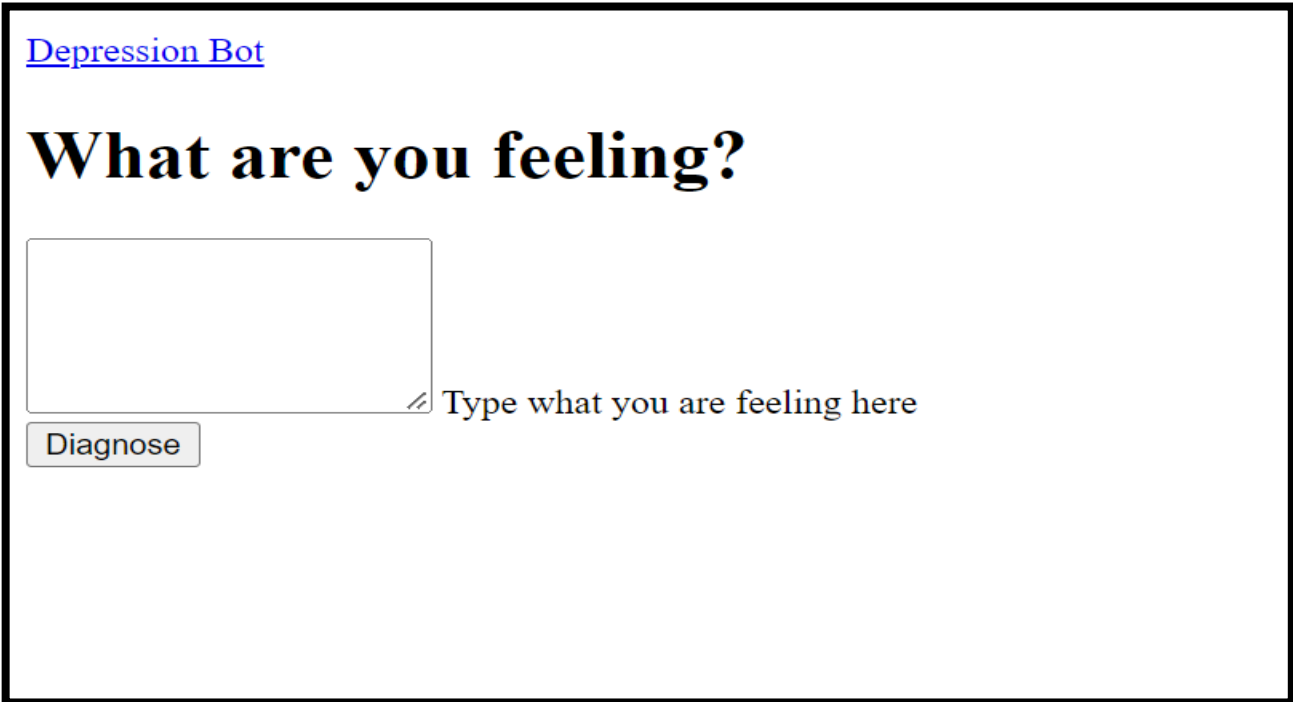
Similarity: tensor([[0.6113, 1.0000]])
```

Fig 12 also demonstrates reliability of the model's accuracy given a user input. The model takes user query ("I am feeling high") and assigns similarity percentage to the two queries in the dataset ("I am feeling down" and "I am feeling high"). "I am feeling down" is given 0.6113 level of similarity while "I am feeling high" is given 1.0000 level of similarity. The similarity level 1.0000 assigned to the query "I am feeling high" demonstrates that the model is working effectively and is reliable.

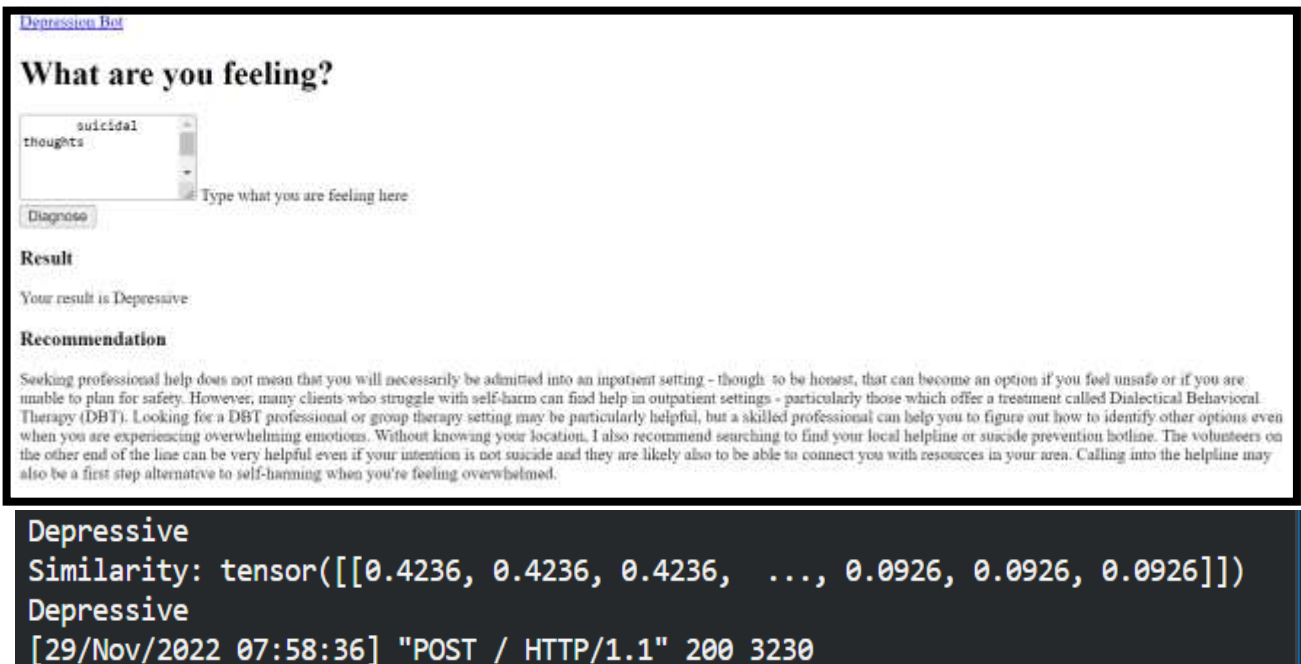
4.2.2 Black box testing

This method of software testing can be taken as the opposite of white box testing. Accordingly, during black box testing the code implementation or the internal logical structure is hidden from the one testing (GeeksforGeeks, 2022). Users without programming knowledge can perform this test. Some students carried out black box testing for the model and below are some of the tests that were carried out.

Screenshot of the system waiting for input



Test run 1



Test run 2

[Depression Bot](#)

What are you feeling?

I want to kill my girlfriend

Type what you are feeling here

Diagnose

Result

Your result is Depressive

Recommendation

New York, what would it mean about you if you got her back? Is that the only way you can like or forgive yourself...if she forgives you and takes you back? Your self respect doesn't need to rely on this working with her. She simply doesn't want to be with you, and every day that you refuse to honour her decision is another day that you hurt her all over again. Move on and heal, perhaps with the help of a therapist.

```
Depressive
Similarity: tensor([[ 0.2138,  0.2138,  0.2138, ..., -0.0387, -0.0387, -0.0387]])
Depressive
[29/Nov/2022 08:14:35] "POST / HTTP/1.1" 200 2579
```

Test run 3

[Depression Bot](#)

What are you feeling?

I feel sad

Type what you are feeling here

Diagnose

Result

Your result is Depressive

Recommendation

It sounds like you are noticing that you are drawn towards sad and negative content and it's hard to understand why. This may sound counter-intuitive, but sometimes we do things that on the surface may look problematic (or even cause us some real problems) because it serves us in some unseen way. A simple example would be somebody who is addicted to a substance; their addiction may be causing serious problems in their life, and they may even know it, but the addiction serves them by helping them to avoid painful feelings that they anticipate having if they quit using. Now I am not saying that what you describe is an addiction, it is just a really illustrative example of the unseen benefit. One thing I would be wondering about is what is the unseen benefit of seeking out sad and negative content? I'd also be wondering what your relationship is to other feelings. These are things you may benefit from exploring with a competent therapist.

```
Depressive
Similarity: tensor([[ 0.3485,  0.3485,  0.3485, ..., -0.0710, -0.0710, -0.0710]])
Depressive
[29/Nov/2022 07:35:34] "POST / HTTP/1.1" 200 3130
```

Test run 4

[Depression Bot](#)

What are you feeling?

I am feeling excited

Type what you are feeling here

Diagnose

Result

Your result is Not Depressive

Recommendation

No recommendation for this input

```
Not Depressive
Not Depressive
[29/Nov/2022 07:29:14] "POST / HTTP/1.1" 200 2203
```

Test run 5

[Depression Bot](#)

What are you feeling?

I hate everyone around me

Type what you are feeling here

Diagnose

Result

Your result is Depressive

Recommendation

My first reaction to this is that It sounds like you rely alot on the impressions and projections of the outside world, that you need validation from other people to compensate for a lack of something on the inside, build yourself up on the inside, work on yourself, use positive affirmations daily, it would be wise for you to research some self-construct theory and do some self-concept work.Hope this helps.C

```
Depressive
Similarity: tensor([[ 0.4085,  0.4085,  0.4085,  ..., -0.1213, -0.1213, -0.1213]])
Depressive
[29/Nov/2022 07:39:13] "POST / HTTP/1.1" 200 2599
```

Test run 6

[Depression Bot](#)

What are you feeling?

I feel bored and tired

Type what you are feeling here

Diagnose

Result

Your result is Not Depressive

Recommendation

No recommendation for this input

```
Not Depressive
Not Depressive
[29/Nov/2022 07:44:32] "POST / HTTP/1.1" 200 2236
```

Test run 7

[Depression Bot](#)

What are you feeling?

I feel pessimistic

Type what you are feeling here

Diagnose

Result

Your result is Depressive

Recommendation

Maybe you have depression. The name of your condition matters much less than the descriptions you wrote of how you feel. Since you've observed how you sometimes interact with people and realize you aren't happy with the result, you've a very solid starting point for reflecting on your deeper wishes in relating to others. Start with asking reasons of yourself about the puzzling aspects of how you're engaging with others. Theorizing as to "why" you feel that pushing people away is "easier", and easier than what? Googling the keywords of how you feel, may open a starting point for ideas on knowing yourself and what you wish for.

```
Depressive
Similarity: tensor([[ 0.3671,  0.3671,  0.3671,  ..., -0.0720, -0.0720, -0.0720]])
Depressive
[29/Nov/2022 08:07:43] "POST / HTTP/1.1" 200 2803
```

Test run 8

[Depression Bot](#)

What are you feeling?

I lack motivation

Type what you are feeling here

Diagnose

Result

Your result is Depressive

Recommendation

Anxiety and Depression are challenging experiences to live with and to manage on a daily basis. I would say that both are challenges to overcome but solutions to living healthy and well exist. Step 1: Talk about it. With friends, family, partners, counselors, and other trusted people in your life. Step 2: Create a plan with a counselor to learn new skills that help you recognize and manage your symptoms. Step 3: Don't give up. Working on yourself can be difficult and hard at the beginning. Stick with it and you will be able to find exercises, tools, and resources that help you live well.

```
Depressive
Similarity: tensor([[0.4145, 0.4145, 0.4145, ..., 0.1054, 0.1054, 0.1054]])
Depressive
[29/Nov/2022 08:24:35] "POST / HTTP/1.1" 200 2733
```

Test run 9

[Depression Bot](#)

What are you feeling?

difficulty in making decisions

Type what you are feeling here

Diagnose

Result

Your result is Not Depressive

Recommendation

No recommendation for this input

```
Not Depressive
Not Depressive
[29/Nov/2022 08:28:15] "POST / HTTP/1.1" 200 2183
```

Test run 10

[Depression Hot](#)

What are you feeling?

low self-esteem


Type what you are feeling here

Diagnose

Result

Your result is Depressive

Recommendation

You've already taken the first step. You want to not hate yourself. Self-acceptance is hard! And it's on a spectrum. On one side we have self-hate, on the other extreme: self-love. And then, there is all this stuff in the middle. It kind of looks like this:  And working toward self-love often means moving around through all these. Becoming aware of your emotions, exploring the parts of you that easier and harder to accept, self-kindness, self-forgiveness, self-compassion and ultimately self-love. It is a recovery process and has to be an active thing each day. Meeting with a counselor can give you a partner in that process. Your counselor can also help you to recognize pieces that may be more difficult to see from your eyes as they have an outside view. And with self-acceptance, confidence comes naturally although you may need to practice behaviors that show assertiveness, confidence and boundaries that protect you. Wishing you the absolute best with this!

```

Depressive
Similarity: tensor([[0.4082, 0.4082, 0.4082, ..., 0.0191, 0.0191, 0.0191]])
Depressive
[29/Nov/2022 08:33:09] "POST / HTTP/1.1" 200 3114
    
```

4.2.3 Unit Testing

During unit testing individual software components or module is tested independently to verify whether they are suitable for use. It can be taken as a software test that ensures the functional correctness of independent software modules or components (GeekforGeeks, 2022).

Table 1: System unit testing

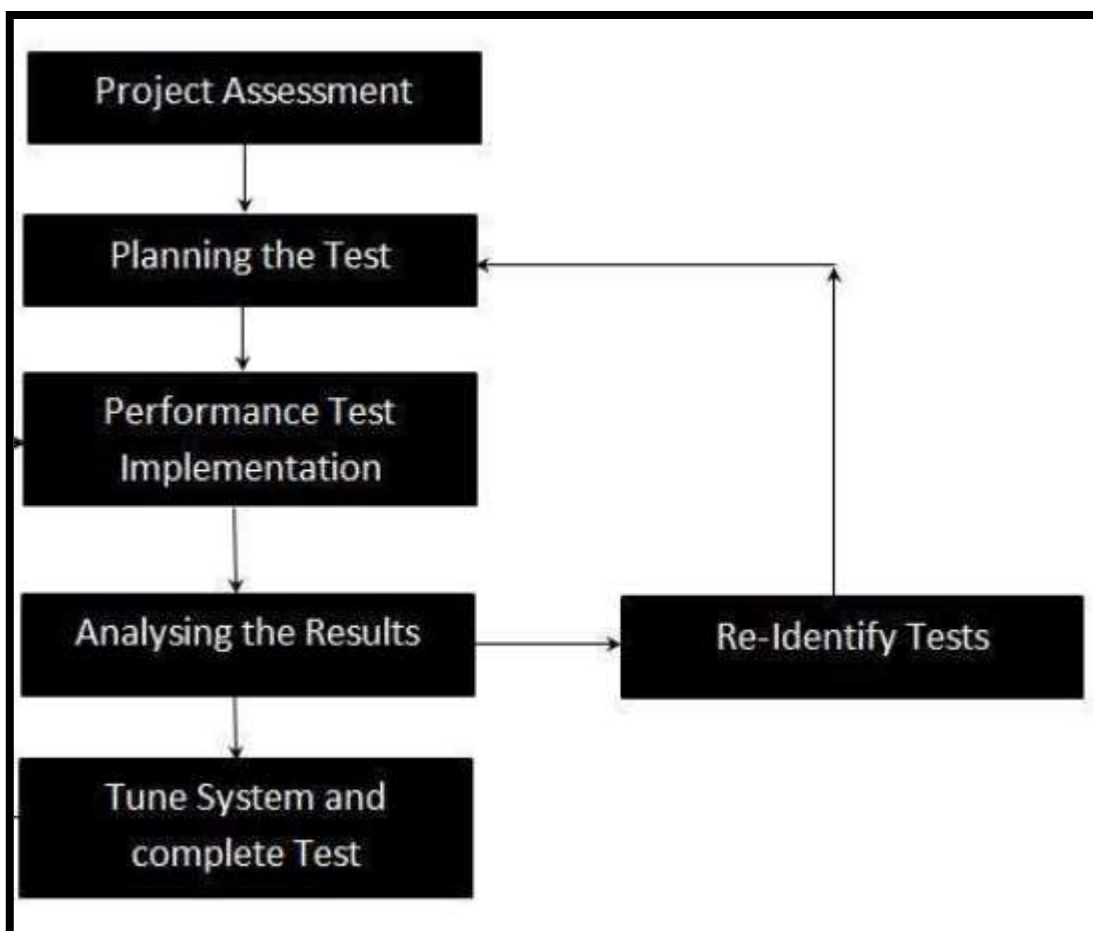
Test ID	Assessment Description	De-Result pated	Antici-Real Outcome	Result
Test run A	Pose a query	Provide solution	Answer provided	PASS
Test run B	Pose a query	Provide relevant feedback	Answer provided	PASS
Test run C	Ask a question with a spelling error	Spell error identified by NLTK	NLTK identified the error	PASS
Test run D	Enter an invalid sentence	Sentence parser identified the error	Sentence parser identified the error	PASS
Test run E	Administrator adds new information	Information added successfully	Information added successfully	PASS

Test run F	Administrator views information	Information displayed successfully	Information displayed successfully	PASS
Test run G	Administrator updates information	Successfully updated information	Successfully updated information	PASS
Test run H	Administrator deletes information	Successfully deleted information	Successfully deleted information	PASS

4.2.4 Performance testing

The system was tested on speed, stability, and reliability. Every software component was put to performance test to ensure the system met expected performance criteria. Each component of the system after unit testing was then integrated with other components for the proposed solution to undergo performance test. Below is an example of performance test process:

Figure 13: Performance testing



Adapted from [Performance Testing \(tutorialspoint.com\)](http://tutorialspoint.com)

4.3 Evaluation measurement and results

To determine whether the model built is effective and efficient it requires gathering and analysing data.

4.3.1 Overview

Research with regards to the effectiveness and acceptability of chatbots in mental health illnesses is at its embryonic stage (Alrazaq, Alajlani & Alalwan, 2019). As mentioned in chapter three and as Janarthanam argues, metrics such as precision, recall and accuracy scores employed in the evaluation of statistical models in performing certain tasks such as sentiment analysis, intent classification, emotion detection, entity recognition fall short as they cannot measure a chatbot holistically (Janarthanam, 2022). Additionally, the counsellor-assistant chatbot does not necessarily need to pass the Turing test not only because it is not intended to replace a traditional psychotherapist, but it can still be useful without passing the Turing test.

4.3.2 Query categories

Queries users can ask are divided into two categories:

- **Depressive:** A depressive query has passed the first test performed using wordnet dataset to determine whether it qualifies as a depressive based on the words used. Once the query passes the first test the best solution is then retrieved from the second dataset to give the most relevant feedback based on the set of feedback in the database.
- **Not Depressive:** A query classified as non-depressive has failed the first step, that is, according to wordnet dataset it does not carry depressive feelings(s).

4.4 Measuring system performance

The model performance is ranked on its ability to classify whether user query is depressive and the ability to give relevant feedback. The researcher thus carried out 100 tests to determine the system's effectiveness:

Table 11: Measuring system performance

Test	System provided relevant feedback
1	Yes
2	Yes
3	Yes
4	Yes

5	No
6	Yes
7	Yes
8	Yes
9	No
10	Yes
11	Yes
12	No
13	Yes
14	Yes
15	Yes
16	Yes
17	Yes
18	Yes
19	No
20	Yes
.	Yes
.	Yes
75	No
76	Yes
77	Yes
78	Yes
79	Yes
80	No
.	Yes
.	Yes
100	Yes

Tests count = 100

Total Yes = Test count – Total No

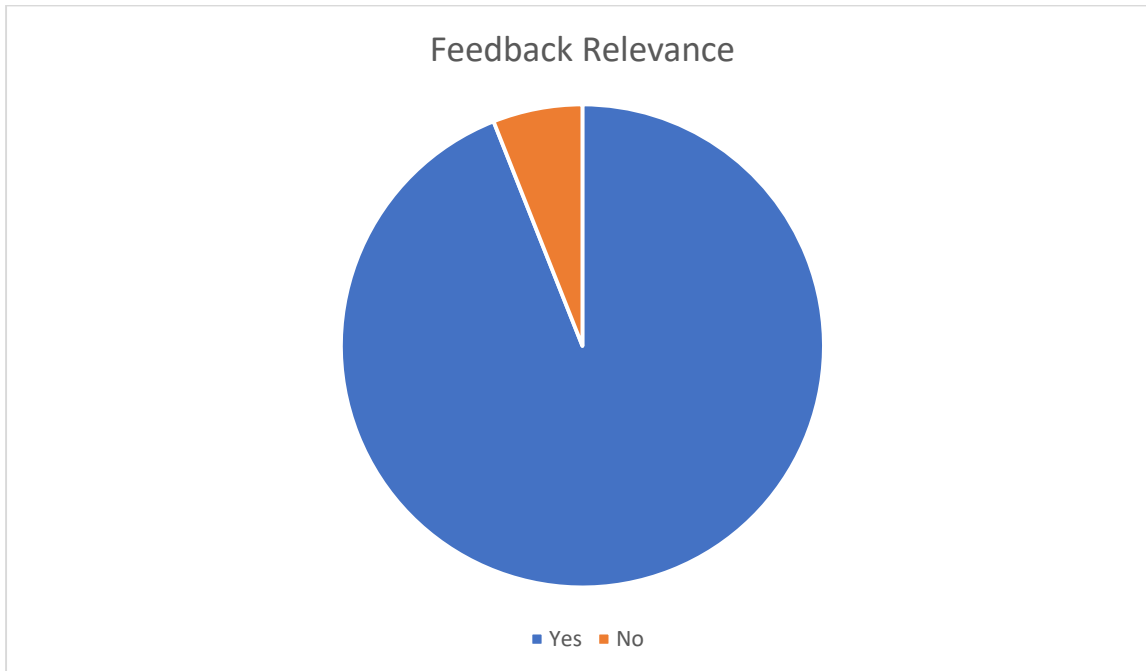
$$= 100 - 6$$

$$= 94$$

Therefore, system accuracy can be set at $94/100 = 94\%$.

In addition, the researcher also noted that when user query is not depressive it takes 5 seconds for the model to provide feedback otherwise when the query is depressive it takes about 50 seconds to give feedback.

Fig 24: Measuring system performance



4.5 Chapter Summary

From the tests and results presented the researcher concluded that the system querying process passed by 96%, demonstrating the effectiveness and efficiency of the proposed model. The proposed model has also satisfied the null hypothesis stated in chapter one, that is, an artificial intelligent chatbot using machine learning and natural language processing can give relevant feedback with the potential to reduce depression in university students.

Moreover, the researcher also observed that while the model has archived the set objectives, the tensor flow similarity was mostly below 0.5 for all the tests performed. The observation points to the fact that the model can be improved with a relatively large volume and high-quality data set.

CHAPTER 5: SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.1 Introduction

The previous chapter presented, analysed, and interpreted findings in response to the research questions posed in chapter one. This chapter now summarises the study highlighting the conclusion, recommendations and proposes future work on counsellor-assistant chatbots.

5.2 Aims and objectives realisation

The chief aim of the study was to develop a model using machine learning and natural language processing and determine the model's effectiveness based on relevance of feedback provided for a user query with the potential to reduce depression in university students. The objectives outlined by the researcher were accomplished.

- The first research objective was: to analyse the different techniques used when developing an artificial intelligent chatbot for psychotherapy. This objective was satisfied in chapter two where the researcher looked at the psychotherapeutic treatments implemented in artificial intelligence.
- The second objective was to design and implement an artificial intelligent chatbot using machine learning and natural language processing for addressing depression in university students and this objective was achieved in chapter four.
- The third objective was to measure the effectiveness of machine learning and natural language processing in providing relevant feedback to students' queries and this objective was also met in chapter four where tests were carried out. The proposed model thus cushions students from the limitations embedded in the traditional counselling set up such as gender of the counsellor, location of the counsellor, social mistrust and stigmatized topics thereby encouraging students to seek professional counselling and nourish their psychotherapeutic needs.

5.3 Conclusion

Using machine learning and natural language processing have the potential of reducing depression in university students as it addresses limitations embedded in the traditional counselling set up. The system has proven to be accurate in terms of providing relevant feedback to user queries.

5.4 Recommendations

Based on the research findings the researcher made the following recommendations:

- A machine with greater computation power is needed to train the model to reduce training time especially when using a better quality and large volume data set. The large dataset will significantly improve the efficiency of the model as the model will be able to give more relevant feedback not only to depression but other mental illnesses as well such as anxiety, addiction, and stress.
- Given that most universities especially in Zimbabwe are primarily using the traditional method of counselling universities can take advantage of the rapid technological advancement and adoption wave especially in young adults to encourage students to seek counselling services using artificial intelligent powered chatbots.
- Training and education for practicing psychotherapists and those in authority in higher and tertiary education is required so that they appreciate the value of counsellor assistant chatbot(s) to reduce uninformed resistance to change.

5.5 Areas for further research

For data security and privacy, the best practice recommends that the counsellor assistant chatbot be implemented on websites such as university websites with the assumption that the website has passed minimum security standards and keeps updating security. Since the model must not contain user personal data, the queries stored on the log can be used to find more relevant feedback thus continuously improving the accuracy of the feedback for the better of students' mental health.

The model should be trained by the best dataset available and must comply with the best ethical standards in psychotherapy.

5.6 Challenges faced

Obtaining a dataset was the biggest challenge faced as the counselling data is commercialised and due to data protection laws, it's also hard to find. As such the researcher had to change the model design to suit the dataset to ensure that the set objectives can be met. The model also requires significant input from practicing psychotherapists to bridge the gap between theory and practice.

5.7 Chapter summary

This chapter gave a summary of the project, conclusion to the project, outlined recommendations, challenges faced by the researcher and areas for further study.

References

- Anthes, E. (2016) Mental health: there's an app for that, *Nature News*, 532 20.
- APA (American Psychiatric Association). What is Depression? . [Online] [Available at <https://psychiatry.org/patients-families/depression/what-is-depression>] [Accessed 09 December 2022.]
- Chaudhary, S.. (2020) Supervised Machine Learning Algorithms: Classification and Comparison: GRD Journals- Global Research and Development Journal for Engineering. 5(6), pp. 8-10. [Online] Available at https://www.academia.edu/43953599/Supervised_Machine_Learning_Algorithms_Classification_and_Comparison [Accessed on 09/12/2022].
- David, D., Cristea, L. & Hofmann, S. (2018) Why Cognitive Behavioural Therapy Is the Current Gold Standard of Psychotherapy: *Frontiers in Psychiatry*. 9(1), pp. 1-2. [Online] [Available at <https://www.frontiersin.org/articles/10.3389/fpsyt.2018.00004/full>] [Accessed 09 December 2022.]
- David, D., Cristea, I & Hofmann, S.G. (2018) Why cognitive behavioural therapy is the current gold standard of psychotherapy. 9(4) doi:10.3389/fpsyt.2018.00004
- Ferrari, A. J., Charlson, F. J., Norman, R. E., Patten, S. B., Freedman, G., Murray, C. J., Vos, T & Whiteford, H. A. (2010) Burden of depressive disorders by country, sex, age, and year: findings from the global burden of disease study *PLoS medicine*, 10 (2013) e1001547.
- Hester, R. D. Lack of access to mental health services contributing to the high suicide rates among veterans. *Int J Ment Health Syst* 11, 47 (2017). [Online] [Available at <https://doi.org/10.1186/s13033-017-0154-2>] [Accessed 09 December 2022.]
- Hofmann, S. G., Asnaani, A., Vonk, I. J., Sawyer, A. T & Fang, A. (2012) The efficacy of cognitive behavioral therapy: A review of meta-analyses. *Cognit Ther Res*. 2012;36(5):427-440. doi:10.1007/s10608-012-9476-1
- Jones, S. P., Pastel, V., Saxena, S., Radcliffe, N., Ali Al-Marri, S., & Darzi, A. (2014) How Google's 'ten things we know to be true' could guide the development of mental health mobile apps, *Health Affairs*, 33 (2014) 1603-1611.
- Laranjo, A.G., Dunn, H.L., Tong, A.B., Kocaballi, J., Chen, R., Bashir, D., Surian, B., Gallego, F., Magrabi, A.Y. (2018) Conversational agents in healthcare: a systematic review, *Journal of the American Medical Informatics Association*, 25(1), pp 1248-1258.

- Murray, C. J., Vos, T., Lozano, R., Naghavi, M., Flaxman, A. D., Michaud, C., Ezzati, M., Shibuya, K., Salomon, J. A., Abdalla, S. (2010) Disability-adjusted life years (DALYs) for 291 diseases and injuries in 21 regions, 1990–2010: a systematic analysis for the Global Burden of Disease Study 2010, *The Lancet*, 380(2012) 2197-2223.
- Oladeji, B. D & Gureje, O. (2016) Brain drain: a challenge to global mental health, *BJPsych International*, 13 (2016) 61-63.
- Pham, K.T., Nabizadeh, A. & Selek, S. (2022) Artificial Intelligence and Chatbots in Psychiatry. 93(1), pp. [Online] [Available at <https://link.springer.com/article/10.1007/s11126-022-09973-8#citeas>] [Accessed 09 December 2022]
- Ritchie, H & Roser, M. (2018) Mental Health, Our World in Data
- Vaidyam, A. N., Wisniewski, H., Halamka, J. D., Kashavan, M. S., & Torous, J. B. (2019). Chatbots and Conversational Agents in Mental Health: A Review of the Psychiatric Landscape. *Canadian journal of psychiatry. Revue canadienne de psychiatrie*, 64(7), 456–464. <https://doi.org/10.1177/0706743719828977>
- Vos, T., Flaxman, A. D., Naghavi, M., Lozano, R., Michaud, C., Ezzati, M., Shibuya, K., Salomon, J. A., Abdalla, S., Aboyans, V., Abraham, J., Ackerman, I., Aggarwal, R., Ahn, S. Y., Ali, M. K., Alvarado, M., Anderson, H. R., Anderson, L. M., Andrews, K. G., Atkinson, C., ... Memish, Z. A. (2012). Years lived with disability (YLDs) for 1160 sequelae of 289 diseases and injuries 1990-2010: a systematic analysis for the Global Burden of Disease Study 2010. *Lancet (London, England)*, 380(9859), 2163–2196. [https://doi.org/10.1016/S0140-6736\(12\)61729-2](https://doi.org/10.1016/S0140-6736(12)61729-2)