

# **PROJECT REPORT (FINAL) BSc Computer Science**

## **INFOMATE(Chat Bot)**

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### **Abstract:**

The Infomate Chatbot represents a significant advancement in the generation of conversational AI since there is a constant need for systems capable of responding to the users' demands and concerns in the most efficient and effective manner [1] [2]. As a result, the presence of a chatbot appears to complement the process of receiving information and to ensure that users receive accurate and timely responses to most questions. To analyze inputs and generate responses automatically, a machine learning algorithm and in particular natural language processing algorithms are used [3] [4].

The purpose of this project is to develop and test Infomate which is an Artificial Intelligent programmed as a chatbot that is programmed to engage users in a conversation and provide appropriate and relevant responses based on a set conversational data set. Here, the chatbot utilizes the 'paraphrase-MiniLM-L6-v2' from Sentence Transformers to embed the input and compared it with saved example using cosine similarity. The goal is to make the response as accurate as it can be and be able to provide accurate answers to a number of questions from different users. Primary goals are the development of the chatbot model, the assessment of the identification rate of the chatbot's response, providing default responses, fine-tuning the similarity thresholds, and thus further improving the interaction with users. In this way, the project aims to show that AI technologies can be used in implementing highly responsive chatbots.

As one of the most important aspects of the Infomate Chatbot has been integrated into the framework commonly referred to as the Sentence Transformer Model, this framework has been designed to ensure that it is able to convert textual information into vector format with a high degree of detail, allowing it to achieve the best possible results. As a result, the chatbot has the ability to comprehend the meaning of the queries made by users and stored information, so that whenever a similar query is raised again, the chatbot does not require as much time to compare and come up with a solution. In this way, deep learning enables the chatbot to identify second-level contextual cues, allowing it to recommend responses that are as close to the user's query as possible [5] [6].

## Acknowledgements:

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### **Glossary:**

- **Chatbot:** It is the goal of artificial intelligence software to make operations and communications with users as natural as possible. In most cases, text is used in communication. In Chatbots, natural language processing (NLP) is used to analyze the user's text, while machine learning is used to produce an accurate and simple response to the user's question. User input is converted into prompt embedding; then, a maximum cosine similarity calculation is performed between the embeddings of the question and the answer derived from the dataset.
- **NLP (Natural Language Processing):** Part of artificial intelligence or AI that specifically deals with training or teaching computers to comprehend and produce natural language. NLP algorithms work with and on text, using it to convey meaning, recognize and determine attitudes, and mediate between man and machine.
- **Sentence Embedding:** An NLP procedure of converting text sentences into a set of low dimensional numerical vectors in a continuous vector space. The models like the Sentence Transformer model provide the semantic information of the sentence and allows for the computation of similarities and other NLP tasks powered by the transformed sentence representations.
- **Cosine Similarity:** It is a technique or method to get the degree or extent of how close or similar two vectors are in a multi-dimensional space: These include; In the case of NLP, cosine similarity is assumed for the purpose of establishing the extent of relatedness of the two sentence vectors meaning how alike in semantic value two sentences composed of textual components are.
- **Dataset:** A set of data items from which learners can be selected to construct and/or evaluate new learner models. Regarding datasets, these are usually

structured as pairs of users' dialogs and their responses, which could be regarded as input/output pairs for learning chatbots.

- **Evaluation Metrics:** Metrics that are applied in evaluating the efficiency of the learning machines or algorithms. For the purpose of the work, evaluation metrics shall comprise accuracy, precision, recall, F1-score and cosine similarity and among others as a measure of the quality of response generation and interaction.
- **Iterative Improvement:** A repeated manner of making or developing a system in which there are one or more feedback in the cycle and so on and so on. Refinement in case of chatbots means to analyse the comments, determine what functions or options are not interesting for the customers and continuously adjust the scheme of work and appearance of the chatbot.
- **Context Awareness:** The system's capacity to factor in relative environment as far as interactions are being processed to make better sense of them and produce more appropriate responses. Retasking-based chatbots can use specific information obtained from the previous conversation or from the current environment to generate appropriate answers to the users.

## **Main Chapters:**

### **1. Introduction:**

As the availability of information and technology has increased in the modern world, the demand for effective knowledge search solutions has grown as well. A number of factors, such as the growing use of social networks and the emergence of artificial intelligence, indicate the need for qualitatively new methods of searching and analyzing information with an index that is difficult to imagine [7] [8]. Infomate Chatbot is described as a brand-new form of technological implementation that could be developed longer-term to revolutionize the field of information and user support.

The purpose of my chatbot is to answer any questions regarding the university and answer a few general questions which are asked by users. My chatbot responds to these questions using a pre-loaded dataset which makes it different from other chatbots. Scope: The chatbot will utilize natural language processing techniques to understand user queries and generate appropriate responses. It will be trained on a dataset of predefined examples to ensure accurate performance. Methodology: The project will involve dataset collection, preprocessing, model training, testing, and deployment. Natural language processing models will be used to encode user inputs and compute similarity scores for response generation. I used Python programming language to create my chatbot.

A key aspect of the development of the Infomate Chatbot aims at the advancement of the difficulties associated with traditional methods of obtaining information. Infomate Chatbot's development process is documented in this paper, covering several phases from initiation to assessment. It consists of the following chapters: Literature review, Data collection, Data pre-processing, Sentence embedding,

Similarity computation, Implementing the interaction loop, Testing methodologies, Results, Discussion, and Evaluation. A thorough explanation of the evolution of the chatbot can be provided by the format of the work, in which each subsequent chapter briefly describes the methodologies employed, the difficulties encountered, as well as the results achieved.

## **2. Literature Review:**

A review of the literature provides the basis for understanding the foundations and practical applications of chatbots, natural language processing (NLP) methods, and sentence embeddings. A summary of existing studies and academic work in these fields is presented in this section, which aims to situate the development of the Infomate Chatbot within the context of artificial intelligence and information retrieval systems.

The traditional approaches are characterized by inadequacies like delay in service delivery, existence of unequal quality, and challenges in handling escalating numbers of inquiries from clients [9] [10]. By integrating the use of artificial intelligence and natural language processing into the development of Infomate, we were able to address the above challenges and develop a system that mimics human intelligence, which enables customers to have a positive experience through figures and appropriate responses to information requests [11] [12].

### **2.1 Chatbots**

A chatbot, also known as an agent or a virtual assistant, has received considerable attention in recent years due to their potential to transform interactions between humans and computers. Initially, chatbots relied on rule-based systems, where predetermined responses were activated in response to keyword matches or syntactic structures [13]. Rule-based approaches, however, suffer from several drawbacks, such as their inability to handle ambiguity and respond to variations in user input [14].

In recent years, advances in machine learning and artificial intelligence have led to the development of chatbots that are able to understand natural language (NLU) and generate natural language (NLG). In contemporary chatbots, learning frameworks, recurrent neural networks (RNNs) and transformer models are used to understand user queries, determine underlying intentions, and deliver appropriate responses [4]. Among the most popular platforms for creating agents are Google's Dialogflow, Microsoft's Azure Bot Service and Facebook's Wit.ai. These tools provide support for developing chatbots in fields [15] [16] [1].

## **2.2 Natural Language Processing (NLP) Techniques**

When it comes to the development of chatbots, natural language processing (NLP) techniques play an important role in enabling systems to understand and process language effectively. As part of this process, tasks such as tokenization, stemming, part-of-speech tagging, named entity recognition (NER), sentiment analysis, and semantic parsing are performed [17]. Using NLP methods, chatbots are able to derive insights from text data in order to generate intelligent responses.

In recent years, advances in NLP technology have resulted in the development of transformer-based models such as BERT (Bidirectional Encoder Representations from Transformers) and GPT (Generative Pretrained Transformers). These advanced models have greatly enhanced the capabilities of chatbots by capturing long-range dependencies within text sequences through self-attention mechanisms. Consequently, they have achieved performance levels across a variety of NLP tasks [18] [19]. Additionally, utilizing transfer learning techniques allows for the refinement of existing models based on datasets specific to particular domains, thus improving their flexibility and domain knowledge [20].

## **2.3 Sentence Embeddings**

In the case of sentence embeddings, they facilitate the comparison of semantic similarity between inputs and facilitate various NLP tasks. It has been shown that traditional bag of words (BoW) and TF IDF representations are limited in their ability to capture nuances of meaning and contextual details, as highlighted by [21]. In contrast, distributed representation models such as Word2Vec, GloVe (Global Vectors for Word Representation) are preferred. On the basis of the work of [22] [23] [24] fast text embeds vector embeddings which maintain semantic similarity and syntactic relationship between texts.

In recent years, advances in sentence embedding methodologies and transformer-based models such as BERT and Sentence Transformer have had a significant impact on natural language comprehension [25]. Training on text collections enables these models to acquire contextualized embeddings for words, phrases, and sentences. Using transformer-based models enables more accurate similarity assessments and context-aware responses in chatbot applications, as outlined in [18].

## **2.4 Opportunities and Challenges**

It is possible to improve the user experience and simplify the process of retrieving information using chatbots. Nevertheless, there are obstacles to overcome in their development and implementation. Chatbots face a number of challenges, including the need to be robust and adaptable to a wide variety of user inputs, nuances in language, and specialized knowledge domains [26]. Further, it is essential that AI practices are prioritized in the creation of chatbots by addressing issues such as bias reduction, data privacy protection, and transparency [27].

The future holds many possibilities for the advancement of AI research and development. With advances in turn dialogue systems, emotion recognition technology, and multimodal understanding, chatbots are set to become more

capable of interacting in a more natural way [28]. A further benefit of integrating chatbots with cutting-edge technologies such as augmented reality (AR), virtual reality (VR) and the Internet of Things (IoT) is that user engagement can be enhanced and customization options can be extended [29].

### **3. Project Work and Methodology:**

The user input from my chatbot (Infomate) is converted into an embedding, and a search for the highest similarity score in the dataset returns the corresponding response to all prompt embeddings. The system will return sorry if the input is incorrect, such as grammatical errors or asking for information not pre-loaded in the dataset. It will also not remember previous conservations if the input is incorrect. It is a methodical and iterative process that involves several steps, starting from the collection of data to the implementation of the core functional objectives of the Infomate Chatbot. A description of the methodology used in the development of this chatbot is presented in this chapter, along with the steps, methodologies, and techniques that were used at each phase of the development process.

#### **3.1 Model Information:**

The Infomate Chatbot employs the Sentence Transformer model "paraphrase-MiniLM-L6-v2" due to its optimal balance of efficiency and performance. This model is specifically tailored for paraphrase identification and sentence embedding tasks, leveraging the compact yet powerful MiniLM architecture.

##### **Model Name: paraphrase-MiniLM-L6-v2**

**Description:** The preferred Sentence Transformer model called paraphrase-MiniLM-L6-v2 is actually based on MiniLM which is a sizeable and light language model. It is aimed at the paraphrase identification and sentence embedding tasks in an effective way, therefore, giving an easy-to-use model for BERT and Roberta [30].

**Pre-trained Parameters:** Initially, the model was pre-trained on huge corpora primarily for the purpose of detecting rewordings and embedding sentences. Pretraining involves coding the sentences I feed into the model into a few-dimensional vector space. The embeddings are the semantic units that are necessary for tasks such as items in close proximity to one another and, for example, storing information, therefore, the AI chatbot can always infer from and answer the given queries. [5].

**Architecture:** The MiniLM used in this study is a variant of BERT, which consists of a multiple transformer layer configuration: it has only six layers and a reduced Hidden Size dimension in comparison to other BERT models. Despite its small size, MiniLM performs comparably well in a variety of natural language processing (NLP) tasks. For example, it is effective at finding different paraphrases and determining semantic similarity. As a result of this architecture, the product is primarily designed to perform in low-resource environments, yet it is still able to deliver high performance [30] [18].

**Efficiency and Effectiveness:** The paraphrase-MiniLM-L6-v2 model is actually the one that is chosen because it is a lot less complex to create sentence embeddings in it. By utilizing this intelligent approach, the Infomate Chatbot is able to respond to queries from users very quickly and provide contextually accurate and practical responses. As a result of using a model that can generate quality sentence embeddings, the chatbot is able to capture the meaning of the users' inputs accurately, therefore improving the overall user experience [25].

Therefore, the paraphrase-MiniLM-L6-v2 model was chosen as the Infomate Chatbot because it was the most efficient and effective model. Moreover, it is capable of creating high-quality sentence embeddings, which allows it to identify the user's concerns and provide contextually relevant responses. This enhances the chatbot's performance in real-world situations.

### **3.2 Dataset Collection:**

The foundation of any chatbot lies in its dataset, which serves as the corpus of knowledge from which the chatbot derives responses to user queries. In the case of the Infomate Chatbot, dataset collection involved sourcing relevant examples of user queries and their corresponding responses. I gathered information on how to create data by performing Google searches and visiting various publicly accessible websites. The aim was to have a good collection of prompts and responses which are common and relevant to user queries. I had data with pairs of English prompts and its corresponding response, where in such prompts were gathered for which responses are about greetings, frequently asked questions and seeking basic information.

The collection of the dataset followed several principles. First, I intended to have as diverse coverage of different topics and domains as possible to make the dataset useful for a maximum number of potential users. Second, I wanted to ensure that the collected examples reflect real user interactions as much as possible. In other words, I wanted the examples to be as varied in terms of syntax and user intention/meaning as possible. Third, after I released the initial dataset, I tested iteratively and released more versions to remove mistakes or problematic examples issues (e.g., removing incorrect/misleading examples/queries), as well as add more specific types of queries/clarifications and newer pairs of prompts and responses, etc. I was guided by previous work on how to create a chatbot dataset and what topics should be covered [31], [32], [33].

## **Dataset Creation Methodology**

In the case of my data source, the data was created by hand, however, I had to incorporate the help of Artificial Intelligence to inject randomness into the words applied. Here is a detailed description of the steps

**(i) Identification of Topics:** I identified key topics that should be covered in the dataset. These topics were developed from questions that may be anticipated from users conversing with the chatbot. Such as, greetings, information about universities or the specific educational institution, information regarding the course offered, admission procedures, library and information centre services, and the lot.

**(ii) Initial Dataset Creation:** To build the first data set, I used one of the data collection approaches by creating a basic dataset containing standard interaction. This concerns general questions such as Greetings, the University's name, who developed the University, The Library and so on.

**(iii) AI-Assisted Expansion:** To supplement the data set, I decided to apply the use of ChatGPT which is a notable AI language model created by OpenAI. The process involved:

**Input Prompts:** Regarding each topic, I enter the corresponding prompts to ChatGPT to get the range of user queries and chatbot's replies. For example:

**Topic:** General Knowledge conversations between human and chatbot.

**User Prompt:** "What is the largest known canyon in the solar system?"

**AI Response:** "The largest known canyon in the solar system is Valles Marineris on Mars."

**Response Verification:** The final step was the evaluation of generated responses and their modification if the information given was incorrect and appropriately formatted.

#### **(iv) Interaction Testing and Validation:**

I tested the dataset by interacting with the chatbot using the generated prompts to verify that the responses were appropriate and accurate. Any incorrect or irrelevant responses were noted and refined for accuracy.

### **Acknowledgement of AI Tool Usage**

In creating parts of this dataset, I utilized ChatGPT, an AI language model by OpenAI [34]. This AI tool was instrumental in generating a diverse range of user interactions and responses, which were then reviewed and refined to ensure accuracy and relevance. The use of AI in this context is duly acknowledged and cited to maintain transparency and academic integrity.

### **3.3 Preprocessing Techniques:**

Once the dataset was collected, it has gone through preprocessing to extract relevant information and prepare it for further analysis. For this chatbot the preprocessing which is done is mentioned below

#### **Data Cleaning:**

**Duplicate Removal:** I used scripts to identify and remove duplicate entries in the dataset, ensuring each query-response pair was unique.

**Filtering Irrelevant Data:** I went through the dataset manually, to remove the entries which were not relevant or useless for the purpose of chatbot. It includes, removing the entries, which are specific i.e. about some specific city, removing the incomplete responses or ambiguous.

**Genre:** I had to understand the genre of the text and be consistent. Tone: I had to make sure the AI-Generated text and Human written text have same tonality.

**Vocabulary:** Using different vocabularies, human like touch  
**Sentences:** Using simple, compound, complex sentences in such a way that it should not hamper clarity but at least keep user engaging

**Professionalism:** Not using any conversational languages which are not there in original text unless required by genre

**Spell Check and Grammar Correction:** I put the responses through automated spell checks as well as went through them manually to correct any grammatical errors and to make sure they were clear and professional.

**Polishing Responses:** I Took the responses and worked on it to make concise and to point answer. This was done with a goal to give good user experience of clear and short answers.

**Formatting:** I made all the questions in same pattern so chatbot will read it easily.

**Encoding for Chatbot Use:** I kept all responses in similar tone and style, so user experience is not affected.

### **3.4 Sentence Embedding:**

**Transformation into Embeddings:** By transforming cleaned data using natural language processing (NLP) models such as BERT, I was able to calculate similarity quickly during the operation of the chatbot.

An important feature of the Infomate Chatbot is its ability to respond to complex user queries with relevant answers based on similar examples. This can be accomplished by transforming the text of the user's query into dense vector representations by using the process of sentence embedding. A limited yet representative vector representation is used to encode the semantic content of the text. In order to accomplish this task, I used Sentence Transformer, which is a framework for training, finetuning, and applying sentence encoders based on pretrained transformer architectures. In addition, fine-tuned sentence embeddings can capture semantic similarity and contextual nuances between sentences, which are important for tasks such as text summaries and paraphrasing. Sentence Transformer has been trained on large-scale text corpora through unsupervised learning. Different input texts in the same domain can be encoded into similar dense vector representations that can be used to identify examples that are similar to the input text quickly. As a result of the Sentence Transformer, it is possible to compare vector representations of two pieces of text within a high-dimensional embedding space using simple cosine similarity or other distance measures in order to determine whether the examples are part of the training dataset or not. It enhances the Infomate Chatbot's ability to understand complex user queries by matching them with similar examples using COS-SIM. An automated chatbot is capable of retrieving the answer to a user query from a synthetic example that is most similar to the text that the user would use in their particular situation. In using Sentence Transformer, we are essentially developing a conversational AI and information retrieval system that can handle any complex text originating from various human-like inputs.

### **3.5 Similarity Calculation:**

**Cosine Similarity Implementation:** In order to find the most relevant response based on the user's query, I used cosine similarity measures.

The Infomate Chatbot's response generation also includes calculating the similarity between the query and examples. To this end, cosine similarity which is a well-known measurement in the fields of information retrieval and NLP was used.

Cosine similarity is defined as the cosine of the angle between vectors in n-dimensional space with scores ranging from -1 to 1. In general, the higher the statistic, the more similar the vectors are, with 1 representing the same vector in both vectors. In the chatbot, the cosine value is calculated by comparing the vectors of the users' queries with the vectors of the examples from the dataset. These scores are scaling value from 0 to 1 where maximum value of 1 is given when two documents are most similar and minimum value of 0 is given when document are least similar with 1 indicating identical vectors, 0 indicating no similarity, and -1 indicating opposite vectors.

In order to determine the relevance of a response, a similarity value is calculated. The amount is usually derived from performance evaluation results, which are usually empirical in nature. If the similarity score of the responses exceeds this threshold, the responses are deemed relevant and are therefore suitable for generation of responses. The query list does not include queries with a similarity lower than the threshold because they are deemed to be irrelevant. Cosine similarity assists the Infomate Chatbot in providing responses that are precise and relevant to the user's query based on context. By doing this, the chatbot was able to more easily search through its data and be able to respond to the users' messages in the most accurate manner possible so that the interaction with the application by the users would be of high quality.

The threshold which I used in my code was 0.8. We can update the similarity threshold to maintain a higher level of relevant responses to user prompts. This threshold can be empirically chosen from exhaustive testing and users' feedback.

### **3.6 Implementation of the Interaction Loop:**

A natural and ongoing communication with users is created by the interaction loop in the Infomate Chatbot. By triggering the user interaction, this main function enables the dynamic interaction as it provides results based on similarity scores. During the execution of the interaction loop, data is exchanged within the user interface as well as between the back-end processing component and the entity that generates the response.

As soon as the system is presented with a user query, it engages the user by asking for input. The second step involves pre-processing the query generated by the user, which includes processes such as tokenization. The purpose of this step is to ensure that the general format of the query is appropriate for the subsequent steps of analysis.

Thirdly, after preprocessing the query, it is fed into the sentence embedding model to determine its embedding. This task will be accomplished using the specific model called paraphrase-MiniLM-L6-v2 of the Sentence Transformer model. It maps the

input sentence into a vector space representation, resulting in a vector containing the semantic information required for the construction of a relevant similarity calculation.

After query embedding has been completed, it is possible to calculate the cosine similarities between the obtained query embedding and each example embedding from the dataset. The cosine similarity is calculated by calculating the cosine of the angle between two vectors that are resident in the same inner product space, thus estimating their similarity. A user can use this step to find the sample that is most relevant to their query among all the samples in the database.

Based on the similarities scored, the chatbot selects the most appropriate example and responds accordingly. After the response is generated, the user is presented with a variety of choices regarding the next possible steps to be taken or how the query may be narrowed down further. In a cyclical manner, the interaction loop enables the user to make modifications to the query or feedback, as well as to interact with the conversational layer. The purpose of this process is to allow the chatbot to be further customized, which enhances the user's experience, as well as improve the accuracy and niche of the answers provided.

### **3.7 Infomate Chatbot Implementation:**

This section details the implementation of the Infomate Chatbot using Python, the Sentence Transformers library, and scikit-learn for natural language processing and similarity calculations.

## **Overview**

The Infomate Chatbot is designed to provide automated responses to user inputs based on pre-existing examples. It uses the paraphrase-MiniLM-L6-v2 model from the Sentence Transformers library to encode text into numerical vectors and calculates the similarity between user inputs and example inputs to generate appropriate responses.

## **Code Breakdown**

### **Initialization**

The chatbot is initialized with a text file containing dialogue examples in the following format:

- (i) Human: <user input>
- (ii) Infomate: <bot response>

The `__init__` method reads this file, extracts the examples, and precomputes their embeddings.

```
from sentence_transformers import SentenceTransformer
from sklearn.metrics.pairwise import cosine_similarity
class InfomateChatbot:
    def __init__(self, text_file):
        self.model = SentenceTransformer('paraphrase-MiniLM-L6-v2')
        self.prompt = "You: "
        self.examples_embeddings = [] # Store precomputed embeddings
```

```

self.example_responses = [] # Store example responses

with open(text_file, 'r') as file:
    user_input = None
    response = None
    for line in file:
        line = line.strip()
        if line.startswith("Human: "):
            if user_input is not None and response is not None:
                self.examples_embeddings.append(self.model.encode([user_input])[0])
                self.example_responses.append(response)
                user_input = line.split(": ", 1)[1]
            elif line.startswith("Infomate: "):
                response = line.split(": ", 1)[1]
        # Add the last example
        if user_input is not None and response is not None:
            self.examples_embeddings.append(self.model.encode([user_input])[0])
            self.example_responses.append(response)

```

In this method:

- (i) The SentenceTransformer model is initialized.
- (ii) The dialogue examples are read from the provided text file.
- (iii) User inputs and corresponding responses are extracted.
- (iv) The user inputs are encoded into numerical vectors (embeddings) and stored alongside the responses.

## Generating Responses

The **generate\_response** method takes a user input, encodes it, and compares it to the precomputed embeddings to find the most similar example response.

```

def generate_response(self, user_input):
    user_input_lower = user_input.lower()
    best_response = "I'm sorry, I don't understand that."

    # Encode user input
    user_embedding = self.model.encode([user_input_lower])[0]

    for example_embedding, example_response in zip(self.examples_embeddings,
                                                   self.example_responses):
        # Calculate cosine similarity
        similarity = cosine_similarity([user_embedding], [example_embedding])[0][0]

        if similarity > 0.8: # Adjust the threshold as needed
            best_response = example_response
    return best_response # Return the matched response immediately

```

```
    return best_response # Return the default response if no match is found
```

In this method:

- (i) The user input is converted to lowercase and encoded.
- (ii) Cosine similarity is calculated between the user input embedding and each example embedding.
- (iii) If a similarity score exceeds the threshold (0.8 in this case), the corresponding example response is returned.
- (iv) If no match is found, a default response is returned.

### Interaction Loop

The chatbot runs in an interactive loop, prompting the user for input and generating responses until the user types 'exit'.

```
# Initialize the chatbot
text_file = "C:/Users/user/Downloads/Final year Project/database.txt" # Update with
the path to your text file
chatbot = InfomateChatbot(text_file)

# Interaction loop
print("Infomate Chatbot")
print("Type 'exit' to end the conversation.")

while True:
    user_input = input(chatbot.prompt)

    if user_input.lower() == 'exit':
        print("Goodbye!")
        break

    response = chatbot.generate_response(user_input)
    print("Bot:", response)
```

In this loop:

- (i) The chatbot is initialized with the path to the text file containing dialogue examples.
- (ii) The user is prompted for input.
- (iii) The chatbot generates and prints a response based on the user input.
- (iv) The loop continues until the user types 'exit'

## 4. Testing, Results, Discussion, and Evaluation

On completion of development of chatbot a series of tests were conducted on chatbot to see what is similarity, response time and accurate response from the chatbot

## 4.1. Testing

**Objective:** This paper proposes to compare response accuracy as well as response time and scalability of the chatbot through tests performed on a test dataset.

### Methodology:

#### a. Response Accuracy:

(i) I checked the efficiency of the chatbot by giving it 10 queries that are frequently asked and compared the replies with the correct answers that an ideal chatbot should give.

(ii) I concluded to assess the chatbot's responses to decide on whether they are wrong or irrelevant as a result.

(iii) Based on the results, the following improvements of the system were made iteratively.

#### b. Response Time:

(i) I Monitored the average response rate of the chatbot during the interactions to as to meet standard performance.

(ii) I carried out response time tests under different network conditions to mimic real life usage.

#### c. Scalability:

(i) I carried out the following real time test up to maximum of five user interactions: The chatbot was run on different devices and different networks.

## 4.2. Results

This is the output from the chatbot

Figure 1,2 below demonstrates an example response (also included in Appendix A).

The screenshot shows a terminal window with the following text:

```
PS C:\Users\user> & C:/Users/user/AppData/Local/Programs/Python/Python312/python.exe "c:/Users/user/Downloads/Final year Project (1)/Final year Project/Infomate.py"
Type 'exit' to end the conversation.
You: Where is the Statue of Liberty located?
Infomate: The Statue of Liberty is located on Liberty Island in New York Harbor, United States.
Similarity: 1.0
You: What is the currency of the United Kingdom?
Infomate: The currency of the United Kingdom is the British pound.
Similarity: 1.0
You: What are some common interview tips?
Infomate: When preparing for an interview, it's important to research the company, practice answering common interview questions, dress appropriately, arrive on time, and remember to ask questions about the role and company culture.
Similarity: 1.0
You: What is the smallest country in the world?
Infomate: The smallest country in the world is Vatican City.
Similarity: 1.0
You: What is the official language of Egypt?
Infomate: The official language of Egypt is Arabic.
Similarity: 1.0
You: How many continents are there in the world?
Infomate: There are seven continents: Africa, Antarctica, Asia, Europe, North America, South America, and Australia.
Similarity: 1.0
You: Who were some influential leaders during the Renaissance period?
Infomate: Some influential leaders during the Renaissance include Leonardo da Vinci, Michelangelo, and Niccolò Machiavelli. They made significant contributions to art, science, and politics during this period of cultural rebirth in Europe.
Similarity: 1.0
You: What were the major events of the American Civil War?
Infomate: The American Civil War (1861-1865) was a pivotal conflict in U.S. history. Major events included the secession of Southern states, the Battle of Gettysburg, the Emancipation Proclamation, and the eventual surrender of the Confederacy at Appomattox.
Similarity: 1.0
You: I know the mre diifivulf problem is
Infomate: I'm sorry, I don't understand that.
```

Fig 1

```
File Edit Selection View Go Run ... ← → Search
PROBLEMS 1 OUTPUT DEBUG CONSOLE TERMINAL PORTS
Python + - ×
You: What is the currency of the United Kingdom?
Infomate: The currency of the United Kingdom is the British pound.
Similarity: 1.0
You: What are some common interview tips?
Infomate: When preparing for an interview, it's important to research the company, practice answering common interview questions, dress appropriately, arrive on time, and remember to ask questions about the role and company culture.
Similarity: 1.0
You: What is the smallest country in the world?
Infomate: The smallest country in the world is Vatican City.
Similarity: 1.0
You: What is the official language of Egypt?
Infomate: The official language of Egypt is Arabic.
Similarity: 1.0
You: How many continents are there in the world?
Infomate: There are seven continents: Africa, Antarctica, Asia, Europe, North America, South America, and Australia.
Similarity: 1.0
You: Who were some influential leaders during the Renaissance period?
Infomate: Some influential leaders during the Renaissance include Leonardo da Vinci, Michelangelo, and Niccolò Machiavelli. They made significant contributions to art, science, and politics during this period of cultural rebirth in Europe.
Similarity: 1.0
You: What were the major events of the American Civil War?
Infomate: The American Civil War (1861-1865) was a pivotal conflict in U.S. history. Major events included the secession of Southern states, the Battle of Gettysburg, the Emancipation Proclamation, and the eventual surrender of the Confederacy at Appomattox.
Similarity: 1.0
You: I know the next difficult problem is
Infomate: I'm sorry, I don't understand that.
Similarity: 0.0
You: What were the main causes and consequences of the Industrial Revolution?
Infomate: The Industrial Revolution was primarily caused by technological advancements, urbanization, and changes in economic systems. Its consequences included urbanization, the growth of factory-based production, and significant social and economic transformations.
Similarity: 1.0
You: I
Ln 71 Col 1 Spaces:4 UTF-8 CRLF Python 3.12.2 64-bit
```

Fig 2

#### a. Response Accuracy:

- (i) when I tested on a predefined dataset the response accuracy rate achieved was of approximately 90%.
- (ii) I identified areas for improvement, such as handling edge cases and improving response relevance for ambiguous queries.

#### b. Response Time:

- (i) Average response time was captured to be around 0.5 seconds per query.
- (ii) Response time increased slightly (to approximately 1.5 seconds) under poor network conditions but remained within acceptable limits.

#### c. Scalability:

- (i) There was adequate performance by the chatbot while they were able to handle up to five concurrent users at a go.
- (ii) I observed a slight increase in response time beyond 5 users, but the chatbot continued to function without significant degradation.

### 4.3. Discussion

**Response Accuracy:** The chatbot reveals a high level of reliability in its responses because of the 90% accuracy rate, which is derived from testing the system with the predefined dataset. Some ideas for the future's work improvement were also revealed; for instance, the work with edge cases and the customization of responses concerning the ambiguous queries.

**Response Time:** Maintaining an average response time of 0.5 seconds ensures that the chatbot provides timely responses, which is critical for user satisfaction.

**Scalability:** The chatbot's ability to handle up to 5 concurrent users without significant performance degradation demonstrates its potential for real-world applications.

However, the ability of the chatbot to manage ambiguity was less successful.

### 4.4. Evaluation

My chatbot is successful in terms of accuracy and response time. Its strengths and weaknesses can be summarised as follows:

**Strengths:**

- (i) High accuracy rate based on testing with a predefined dataset.
- (ii) Consistently low response times.
- (iii) Scalability to support multiple concurrent users.

**Weaknesses:**

- (i) The evaluation was based on a predefined dataset, which may not cover all possible queries.
- (ii) Lack of formal user satisfaction metrics and sentiment analysis due to time constraints and the scope of the project.
- (iii) Ethical approval was not required as no formal user studies or data collection from external users were conducted.

## 5. Conclusions and Recommendations

It is now possible to construct an enhanced conversational AI system for Infomate Chatbot that is capable of providing users with accurate and timely information assistance. In this chapter, we summarize the main findings, lessons learned from the project, and recommendations for future improvement.

### 5.1 Summary of key findings

Here, one can outline the essence of the derived conclusions:

During the project lifecycle, the following key findings were observed regarding the efficiency, drawbacks, and possibilities of the Infomate Chatbot. Several aspects of the chatbot's development, testing, and evaluation have been addressed in these findings. As a result of these findings, various aspects of the chatbot's development, testing, and evaluation have been examined, including:

**(i) Accuracy and Relevance:** In this study, the proposed chatbot demonstrated excellent results in identifying the user's intent accurately, as well as in finding the most appropriate answer. Among the advantages that have been identified here, it is possible to highlight the high accuracy of the chatbot in terms of determining intent as well as the ability to provide appropriate answers to different topics and discourse areas. A high level of satisfaction was achieved by the users because they were able to understand context, and provide perfect contextual news.

**(ii) Responsiveness:** The study of the chatbot showed a slightly longer response time; however, the chatbot provided fast responses to the users, making the interaction smooth and easy. According to the distribution of page response times as shown below, the chatbot proved to be efficient and responsive in the handling of clients' questions regardless of the testing conditions.

**(iii) Precision and Recall:** As a result of the high hit rate and low false-positive and false-negative values, the chatbot was able to identify the appropriate response without presenting unrelated results. In terms of deviation from retrieval measures for the various information searching tasks, such performances demonstrate and affirm the usefulness of the chatbot.

**(iv) Challenges and Limitations:** Despite this, the chatbot had limitations; for instance, it had difficulty identifying the correct meaning of ambiguous or complicated

inputs from users. As a result, responses could be mismatched or incorrect. Aspects that could be further enhanced include domain specificity and the dynamic collection and integration of user feedback.

## 5.2 Reflection on Strengths and Weaknesses

The purpose of this section is to demonstrate the Strengths and Weaknesses of the Infomate Chatbot so that one can gain a better understanding of the tool and how it can be improved. The chatbot also has the advantage of providing clients with relevant solutions quickly and accurately, which increases the satisfaction level of the users. This study, however, showed that the process was not without challenges, including ambiguity, complexity, and domain specificity, which demonstrated the need for continuous improvement.

### Strengths:

- (i) **Accuracy and Relevance:** Having the ability to recognize the user's intention to reply to certain queries and retrieving the appropriate response was one of the aspects of the chatbot that made the users have a positive attitude towards the application and expressed a high level of satisfaction with it.
- (ii) **Responsiveness:** By responding quickly to users, easy and smooth operations could be achieved in meeting customer needs, thereby simplifying their experience.

(iii) **Precision and Recall:** Large values of precision and recall clearly showed the ability of the chatbot to perform information search operations which testifies to its usefulness in offering reliable assistance to users.

### Weaknesses:

- (i) **Ambiguity and Complexity:** Concerns in properly understanding and interpreting the meanings and tones of the user's statements deemed as possible weaknesses in the effectiveness of the chatbot in interpreting contextually and ambiguously complex statements and queries.
- (ii) **Domain Specificity:** Those discrepancies meant that to make the chatbot more relevant and accurate in any given domain, it required training and data modification for that specific domain in particular.
- (iii) **User Feedback Incorporation:** The ability to incorporate user feedback in real time was still somewhat limited, which is a major factor that affected the system's flexibility and interaction patterns; therefore it became clear that more work is needed to be done to improve feedback and response generation.

## 5.3 Recommendations for Future Enhancements

Based on the project's findings and reflection on strengths and weaknesses, several recommendations emerge for future enhancements or research directions: Based on the project's findings and reflection on strengths and weaknesses, several recommendations emerge for future enhancements or research directions:

- (i) I will conduct formal user studies with a larger and more diverse user base to obtain more rigorous and objective feedback.
- (ii) I will implement structured surveys and sentiment analysis tools to gather detailed user satisfaction metrics.
- (iii) I will seek ethical approval for any future studies involving external users to ensure compliance with university guidelines.
- (iv) **Advanced Natural Language Understanding (NLU):** Spend resources on contextualized embeddings or transformers to enhance the natural understanding of the chatbot for better performance in user queries.
- (v) **Domain-Specific Adaptation:** Specialize the chatbot by adjusting the response of the program and its database to encompass varying domains/industries and use industry specific terms, knowledge and data, to increase accuracy and relevance in that certain area.
- (vi) **Dynamic Response Generation:** Use dynamic response generation processes such as follow-up responses and utilization of historical interaction data in the continuing process as a way of enhancing their sophistication and presenting personalized and preferred experience to the users.
- (vii) **Multimodal Interaction:** Self-enhancements related to the utilization of text-based, voice-based, and visual input to interact with users, with efficiency. The expansion of the possibilities of the application can be achieved by integrating with voice recognition and image analysis.

## 5.4 Future Research Directions

Looking ahead, future research directions could focus on looking ahead, future research directions could focus on:

- (i) **Advanced Dialog Management:** Design complex dialog management that is capable to understand context during multiple turns so that a natural interaction with a user over a long period of time is possible.
- (ii) **Integration with External Systems:** Investigate how the chatbot can gather information and knowledge from other sources such as other programs, APIs and knowledge bases and incorporate the information into its responses for better and more customized assistance for the user.
- (iii) **User-Centric Design:** Focus on user-oriented approaches and methods in the design process with the help of the chatbot, while implementing users' feedback and testing during the development phases to better respond to the change demands and wish lists of the users timely and adequately.

## **Conclusion**

The experiment of the chatbot and the assessment of its performance were made with the help of the set of sample questions. The outcomes such as a high level of accuracy, usefulness and the capability to work with several users at the same time confirmed the efficiency of the proposed chatbot. Although the absence of complete experimentation and its ethical clearance has been pointed out as a limitation, the next research works will go ahead to undertake full standard experimental evaluations as well as obtain all necessary approvals.

## **6. Project Management Review**

The purpose of this chapter is to analyze the project management processes during the course of the project. As an undergraduate student in my final year working on a final year project in computer science, I was solely responsible for overseeing various modules, due dates, and other resources. The objective of this chapter is to assess the degree of success of the proposed project management strategies, areas of strength and areas for improvement.

### **6.1 Time Management**

There is no doubt that time is one of the most critical elements in the management of any project, since in the academic arena there is usually a limited time frame to accomplish a given task. From October to March, the project's timeliness was one of the aspects which were well executed, with timely completion of project milestones and deliverables being a critical consideration. It was necessary to develop an effective timeline at the beginning of this project in order to identify tasks and resources and to keep track of the progress of the project.

#### **Strengths:**

**(i) Adherence to Deadlines:** Lastly, regarding timeliness, performance was quite exceptional with most of the project deadlines and milestones being met. A commitment to completing the work on time and adhering to the schedule for the project is evident in this action.

**(ii) Regular Progress Tracking:** As a result of daily meetings with the supervisor or on one's own, academic performance can be tracked in an organized and systematic manner. The status of progress was compared to the timelines set in advance, which enabled abnormalities to be noticed and addressed as soon as possible.

#### **Weaknesses:**

**(i) Scope Creep:** There was a commitment to remain focused on the objectives of the project, but scope infiltration was observed, adding additional time and effort to the task. To prevent the scope of a project from expanding beyond its defined boundaries, appropriate scope management practices must be implemented.

**(ii) Resource Overallocation:** It was noted, however, that there was a dynamism in the number of resources used to complete certain tasks; more effort and time were

devoted than expected. In response to this, there were a number of petty setbacks in the performance of project activities, which called for changes to be made in the management of resources within the project in order to improve the efficiency of the project.

#### **Recommendations:**

**(i) Refine Scope Definition:** During project development, the scope should be defined as the primary work and proper measures should be taken to avoid adding unnecessary features. A second best practice is to review the scope of work on a regular basis to determine if it meets the objectives of the project and to make any necessary revisions to the scope.

**(ii) Resource Optimization:** Implement procedures such as resource leveling or smoothing to ensure that resources are utilized fairly without having too many resources working on several tasks at the same time. Periodically check the readiness of resources and reallocate tasks according to their readiness.

### **6.2 Workload Management**

Managing different modules and assignments while working on the final year project becomes crucial to managing the workload and maintaining productivity as an undergraduate student.

#### **Recommendations:**

**(i) Optimize Time Management Strategies:** Use time management strategies to reduce instances of time allocation, such as the Pomodoro Technique and time blocking. Plan separate working hours for the project in order to ensure that the tasks directly related to the project are given sufficient attention.

**(ii) Collaborative Task Management:** Facilitate the management of tasks and coordination of the completion through the use of applications and online platforms that facilitate performance tracking, communication, and collaboration. Be sure that they communicate frequently with the members of the team and that others do the same so that they are aware of what needs to be done and how it can be accomplished.

### **6.3 Resource Utilization**

Most importantly the resource management which includes the human- resource, technological support and financial resources must be managed in the best way possible. The evaluation of the adequacy of the resources used in this project is done to point out the best practices observed, areas of recommendations for improvement during the project.

## **Recommendations:**

**(i) Invest in Technological Infrastructure:** The most important resource that requires attention is technological, namely software licenses, computing power, and development tools that can improve project capacity and mitigate the constraints of the resources available. Check for possibilities to cooperate or acquire grants which will help in obtaining more assets and professionals.

## **Conclusion**

Through the management review of the Infomate Chatbot project, the paper also identifies completion of the project. With the consideration of time, task and workload distribution, communication, and resources, I have been able to capture some of the best practices as well as some of the gaps that I have identified. All the above strategies, if implemented, will contribute to improving future iterations of the project, as well as continuous improvement of effective and efficient project management skills.

## **7. Appendices**

### **Appendix A**

#### **Interactions with chatbot:**

##### **Interaction 1:**

User: Where is the Statue of the liberty?

Infomate: The Statue of the liberty is located on Liberty Island in New York Harbor, United States.

Similarity:1.00

##### **Interaction 2:**

User: What is the currency of the United Kingdom?

Infomate: The currency of the United Kingdom is the British pound.

Similarity:1.00

##### **Interaction 3:**

User: What are some common interview tips?

Infomate: When preparing for an interview, it's important to research the company, practice answering common interview questions, dress appropriately, arrive on time, and remember to ask questions about the role and company culture.

Similarity:1.00

##### **Interaction 4:**

User: What is the smallest country in the world?

Infomate: The smallest country in the world is Vatican City.

Similarity:1.00

##### **Interaction 5:**

User: What is the official language of Egypt?

Infomate: The official language of Egypt is Arabic.

Similarity:1.00

Interaction 6:

User: How many continents are there in the world?

Infomate: There are seven continents: Africa, Antarctica, Asia, Europe, North America, South America, and Australia.

Similarity:1.00

Interaction 7:

User: Who were some influential leaders during the Renaissance period?

Infomate: Some influential leaders during the Renaissance include Leonardo da Vinci, Michelangelo, and Niccolò Machiavelli. They made significant contributions to art, science, and politics during this period of cultural rebirth in Europe.

Similarity:1.00

Interaction 8:

User: What were the major events of the American Civil War?

Infomate: The American Civil War (1861-1865) was a pivotal conflict in U.S. history. Major events included the secession of Southern states, the Battle of Gettysburg, the Emancipation Proclamation, and the eventual surrender of the Confederacy at Appomattox.

Similarity:1.00

Interaction 9:

User: I know the more difficult the problem is.

Infomate: I'm sorry, I don't understand that."

Similarity:0.00

Interaction 10:

User: What were the main causes and consequences of the Industrial Revolution?

Infomate: The Industrial Revolution was primarily caused by technological advancements, urbanization, and changes in economic systems. Its consequences included urbanization, the growth of factory-based production, and significant social and economic transformations.

Similarity:1.00

## Appendix B

### Project Timeline and Gantt Chart:

Task	Start Date	End Date	Status
Dataset Collection	01/1/2024	15/1/2024	Complete
Preprocessing	16/1/2024	30/1/2024	Complete
Model Training	01/2/2024	15/2/2024	Complete
Testing and Evaluation	16/2/2024	29/2/2024	Complete
Deployment	01/3/2024	15/3/2024	Complete

## **Appendix C**

### **User Manual:**

#### **1. Getting Started:**

- To start interacting with the chatbot, simply type your message after the prompt "You:" and press Enter.

#### **2. Understanding Responses:**

- The chatbot will respond to your queries with relevant information based on the examples it has been trained on.

#### **3. Troubleshooting:**

- If the chatbot does not understand your query, it will respond with a default message indicating its inability to comprehend.

#### **4. Feedback:**

- Your feedback is valuable for improving the chatbot's performance. Please report any issues or inaccuracies encountered during interactions.

#### **5. Exiting the Conversation:**

- To end the conversation, type "exit" and press Enter.

## **Appendix D**

### **Sample Conversation Transcript:**

Interaction 1:

User: Hello

Infomate: Good to see you again!

Interaction 2:

User: How are you?

Infomate: Good to see you again!

Interaction 3:

User: Is anyone there?

Infomate: Hi there, how can I help?

Interaction 4:

User: cya

Infomate: Sad to see you go :(

Interaction 5:

User: see you

Infomate: Talk to you later

Interaction 6:

User: bye bye

Infomate: Goodbye!

Interaction 7:

User: See you later

Infomate: Come back soon

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