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AI Chaperone: Awareness Chatbot for Alzheimer's Disease

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Abstract

This project proposes the development of a RAG Chatbot tailored specifically to assist Alzheimer's patients in managing their memory abnormalities and providing them with answers to their queries. The chatbot utilizes state-of-the-art natural language processing techniques to understand and respond to patient inquiries, while leveraging RAG to enhance the relevance and accuracy of its responses. The primary goal of this project is to provide Alzheimer's patients with a supportive and interactive tool that can help mitigate the impact of memory impairment on their daily lives. It acts as an information resource, offering answers to common questions about Alzheimer's disease, treatment options, and lifestyle management strategies. Key features of the RAG Chatbot include personalized conversation histories to track patient interactions and preferences, adaptive dialogue generation to tailor responses to individual needs, and integration with existing healthcare systems for seamless coordination of care. Furthermore, the chatbot undergoes continuous improvement through machine learning algorithms that analyze patient feedback and update its knowledge base accordingly. Overall, the RAG Chatbot represents a promising advancement in Alzheimer's patient assistance, offering a scalable and accessible solution to support individuals living with memory disorders.

Keywords*: Alzheimer's Disease, Chatbot, Large Language Models (LLMs), Retrieval-Augmented Generation (RAG)*

1. Introduction

Alzheimer's disease, a relentless neurodegenerative condition, ravages the brain, causing memory loss, cognitive deterioration, and disruptions in daily functioning. The associated challenges extend to communication hurdles, confusion, disorientation, and profound changes in behavior and personality, not only impacting patients but also placing an onerous burden on their families and caregivers. The pressing need for effective treatments, robust support systems, and heightened public awareness underscores the imperative to enhance the quality of life for those grappling with Alzheimer's. In response to this imperative, our research introduces a novel solution in the form of a chatbot. This innovative tool serves a dual purpose: raising awareness about Alzheimer's and providing valuable information for patients, caregivers, and the general public. Leveraging Natural Language Processing (NLP), the chatbot initiates by converting speech to text, comprehending human language with precision. Subsequently, a sophisticated Query Detection mechanism identifies relevant documents within a comprehensive database, employing the Retrieval Augmented Generator (RAG) module based on the Haystack framework. This open-source Language Model (LM) framework, coupled with the prowess of Hugging Face as an AI model hub, facilitates the seamless integration of advanced technologies.

1.1 Literature Survey

We have conducted a literature survey on two papers, which are presented as follows: Chatbots to Support People with Dementia and Their Caregivers [1] delves into commercially available chatbots designed specifically for individuals with dementia and their caregivers. Initially, 505 chatbots were

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identified, and after rigorous screening, 6 were included in the review. The paper meticulously evaluates these chatbots, considering features, content, functionality, performance, humanity, affect, ethics, and behavior. Each app's strengths and limitations are discussed, providing valuable insights for the development of similar chatbots. Overall, this research serves as a crucial resource for informing the design and features of our own chatbot. Consort Chat-Bot for Alzheimer Patients [2] sheds light on the development and implementation of a mobile application—a companion chatbot—tailored for early-stage Alzheimer's patients. The application aims to assist individuals with Alzheimer's in their daily lives by offering reminders for tasks, tracking their location, and engaging in memory training exercises. Notably, the chatbot provides personalized support, actively monitors activities, and enhances memory skills. What stands out is the innovative integration of technology to address the specific needs of Alzheimer's patients. Insights into the user interface, data security measures, and the overall effectiveness of the chatbot contribute to a comprehensive understanding of its potential impact on the care and well-being of individuals in the early stages of Alzheimer's disease.Both papers underscore the importance of leveraging chatbots to enhance the quality of life and support for those affected by dementia and Alzheimer's.

1.2 Technologies Used

Large Language Models: Large Language Models (LLMs) are advanced Artificial Intelligence Systems designed for understanding and generating human text. These Generative AI models focus on Natural Language Processing (NLP) tasks, interpreting natural language instructions and performing tasks akin to human capabilities. By leveraging extensive data and sophisticated neural network architectures, LLMs generate coherent and contextually relevant text across various NLP tasks. Notably, the publication of the paper "Attention Is All You Need" by Google and the University of Toronto [6] introduced the Transformers Architecture, which significantly impacted AI progress, particularly in NLP. Transformers enable efficient model scaling, parallel computation, and more effective training on large datasets, facilitating the development of foundational models. They excel in understanding language patterns, making accurate predictions, and generating textual content. LLMs, such as GPT2, FLAN-T5, LLaMa, BLOOM, and Google PaLM, are widely used for text generation, summarization, translation, and question answering. Their commercial deployment includes applications like OpenAI ChatGPT, Google Gemini, and Microsoft Copilot.

Retrieval Augmented Generation: Retrieval-augmented generation (RAG) is an advanced approach in natural language processing (NLP) that combines the strengths of retrieval-based and generative models. LLMs (Large Language Models) are highly accurate at answering user queries but may provide outdated or generic information. To address this, RAG augments LLMs with retriever models that fetch relevant facts from an up-to-date database. By integrating contextually relevant information, RAG enhances LLM performance. It has proven effective in tasks like question answering, dialogue systems, and content generation, while minimizing hallucinations.

2. Method

We propose a methodology to implement a Chatbot for spreading Awareness about Alzheimer's Disease, based on the Literature Survey conducted and the technologies considered.

User Query: Input query/question from the user, which serves as the initial context for the generation process.

Retrieval of documents: Utilize dense retrieval or other techniques to extract relevant information from a knowledge base. The knowledge base consists of domain-specific and up-to-date content such as medical documents. This retrieval process aims to gather a comprehensive set of documents that contain valuable context related to the query.

Prompt Generation: Concatenate the retrieved passages with the query, forming an augmented input. This step enriches the input context for the

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generative model, providing it with a broader understanding of the topic.

Generator Model: A Large Language Model (e.g., GPT) for text generation. The model leverages the augmented context to produce a response that incorporates relevant information from the retrieved passages.

Response Generation: A Response is generated by the generator model based on the augmented input, leveraging the context from the retrieved passages to ensure coherence and relevance [3].

Output Presentation: Present the generated response to the user, providing them with an informative and contextually relevant answer to their query. To improve the model's further performance, we suggest the following steps:

Response Refinement: Optionally, refine the generated response using additional steps such as reranking or filtering. This step helps to ensure that the generated response meets specific criteria, such as accuracy or conciseness.

Multi-turn Interactions: If the interaction involves multiple queries or a conversation, iterate the process to handle subsequent inputs and generate responses accordingly.

Iterative Training: Continuously train the RAG model using supervised learning with human-labeled data. This iterative training process helps optimize the model's performance over time, improving its ability to generate high-quality responses.

Performance Evaluation: Assess the performance of the model based on metrics such as relevance, coherence, and in formativeness. Adjust the model's architecture or training data as needed to enhance its capabilities and address any shortcomings. System Architecture shown in below Figure 1.

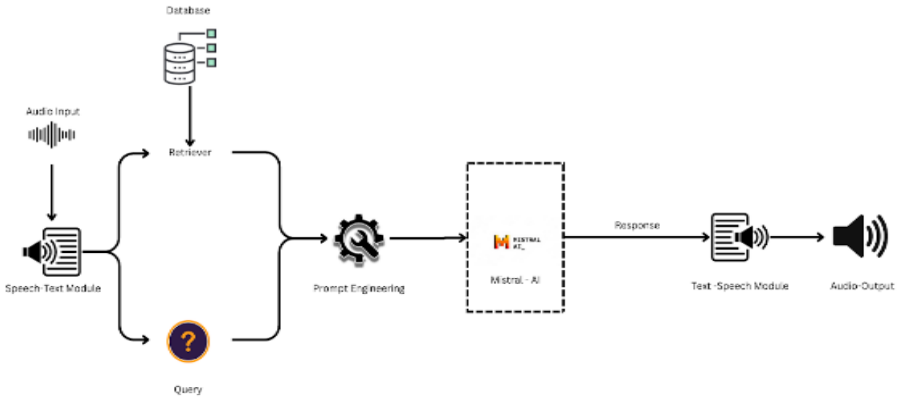

Figure 1 System Architecture

3. Results and Discussion

3.1 Results

Based on the above methodology, we propose an architecture, implementing the entire chatbot. The architecture of the product contains three modules:

Speech Recognition: Speech recognition using Python's SpeechRecognition library focuses on capturing audio from a microphone helps us to cognize the speech using the initialized recognizer instance. By setting appropriate parameters for recognition such as language, energy threshold, etc appropriate requirements are gathered, such that errors can be handled easily. Next is to convert recognized speech into text and utilize them for desired purpose (in order to create response for feedback).

Implementation of RAG using Haystack framework: Documents are indexed in a retrievable format using Haystack's in-memory document store. Using a keyword-based algorithm, relevant documents based on user query are retrieved [4]. The retrieved passages and the user query are combined to form a prompt. Figure 2 represents Uml Diagram of the Chatbot.

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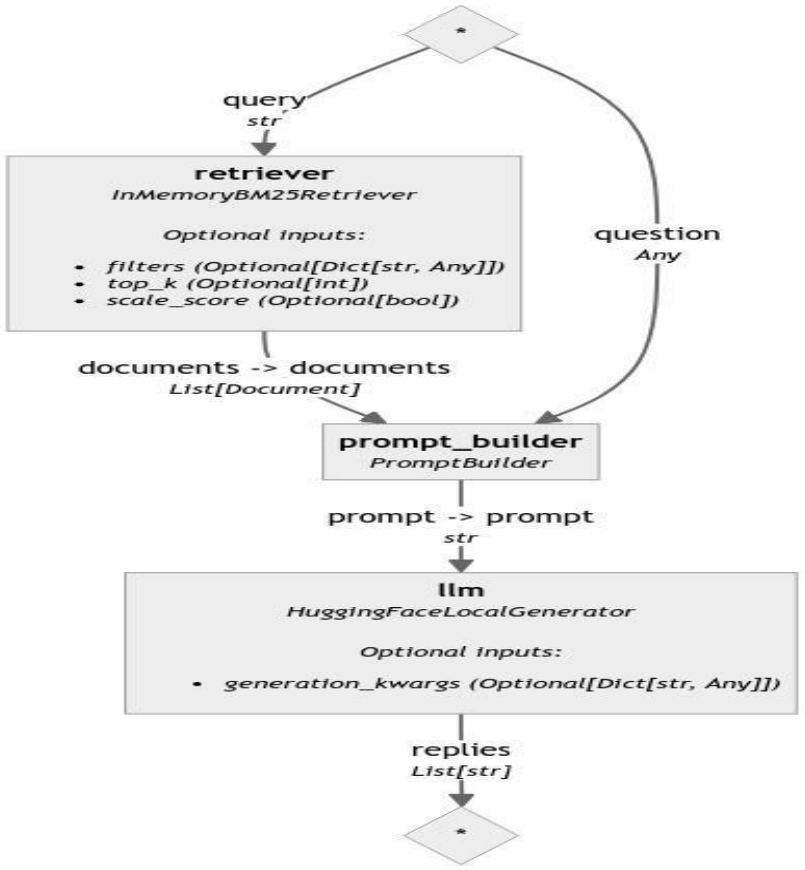

Figure 2 Uml Diagram of the Chatbot

Using the Haystack Interface for Generative Language Models with Hugging Face models, responses are generated based on prompt [5]. The generated output is passed to the next module.

Text to speech conversion: Text to speech conversion is done using python's pyttsx3 library. After initializing the text-to-speech engine, input text is converted to speech using the say () method. Optional properties like speech rate and volume are set and the speech is executed using runAndWait() method. Then the speech is converted to audio file.

3.2 Discussion

Extensive Experimentation has been performed to implement the above methodology. The results of the experiments led to the proposed architecture for the Chatbot, given above. The speech recognition and text-to-speech modules are introduced for integrating Voice Assistance Feature in the product.With RAG being a new framework, there exists only a few libraries that contain a practical implementation. After an intensive research for libraries, we have settled with Haystack Framework for RAG implementation. For our Generator LLM, we have tried multiple open-source LLMs designed for text generation. After evaluation on the models, we have decided to integrate MistralAI's Mistral-7B model as our Generator. Mistral-7B, a key component in our approach, aids in extracting content and features from the model, ensuring the generation of informative and contextually rich responses. The final output, a culmination of this intricate process, undergoes a transformation from text to speech, providing a user-friendly and accessible interface. Through this comprehensive methodology, our chatbot not only fosters awareness but also empowers users with a wealth of information, contributing to a more informed and supportive environment for those affected by Alzheimer's.

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Conclusion

In conclusion, our research paper successfully demonstrates the implementation of a medical chatbot using the RAG framework. The chatbot exhibits the capability to provide accurate information about Alzheimer's disease, leveraging a regularly updated database. Incorporating the LLM ensures the generation of human-like responses in natural language, further enhanced by the integration of a text-to-speech module for voice output. Looking forward, our future endeavors include integrating the chatbot into a mobile application, aiming to contribute to the holistic development of Alzheimer's patients by serving as a supportive companion in their daily lives.

Acknowledgements

Ms. Akshaya Thulasi Sathyanarayana expertise in Alzheimer's Disease is instrumental in the development of the RAG Chatbot project, which aims to provide tailored assistance to Alzheimer's patients. Her insights enrich the chatbot's knowledge base, ensuring accurate information dissemination and effective management of memory abnormalities. By leveraging Ms. Akshara's understanding of the disease's pathophysiology and therapeutic interventions, the chatbot can offer comprehensive responses to patient queries, enhancing its role as a supportive and interactive tool for individuals living with Alzheimer's. Her contributions further strengthen the chatbot's ability to adapt to individual needs, track patient interactions, and continuously improve through machine learning algorithms, ultimately advancing patient care and support in managing memory disorders.

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