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AI-Based First Aid Chatbot Using TF-IDF and Maximum Marginal Relevance for Efficient Symptom-Based Assistance

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Abstract: During medical emergencies, having quick access to first aid information is essential, particularly if professional assistance is not readily available. This paper describes a First Aid Chatbot that uses user-reported symptoms to provide basic medical advice. Through a web-based chatbot interface, the system enables users to enter symptoms and provides suitable first aid recommendations that are divided into two categories: immediate remedies and whole-day care recommendations. The chatbot uses methods like Maximum Marginal Relevance (MMR) and deduplication to eliminate repetitive suggestions while processing user inputs and retrieving pertinent responses from a predefined remedy dataset. The system, which is built with Node.js, Express.js, MongoDB, and EJS, attempts to increase accessibility to fundamental medical advice and raise awareness of first aid procedures.

Keywords: First Aid Chatbot, Healthcare Chatbots, Symptom Analysis, Conversational AI,

I. INTRODUCTION

The rapid development in the field of artificial intelligence and conversational technologies has resulted in the creation of intelligent chatbot systems that can assist users in various fields. In the field of healthcare, there has been an increase in the use of chatbots for providing medical guidance and assisting patients through interactive conversational interfaces. This has resulted in the improvement of the accessibility of healthcare information and has allowed users to seek assistance through such systems. Recent research has shown the use of healthcare chatbots for improving the accessibility and efficiency in the field of medicine [3], [15]. Access to first aid information during medical emergencies has the potential to minimize the extent of injuries and prevent any complications. However, there are many people who do not know the basic first aid procedures, and this delays the response during emergency situations. Immediate information through such systems can be extremely beneficial in providing the necessary aid before the arrival of medical professionals. The potential of healthcare chatbots has been found to be highly effective in providing such aid during emergency situations [1], [16] Technologies such as natural language processing and intelligent response generation enable the conversational agents to process the user's questions and provide relevant information. The conversational agents can evaluate the user's described symptoms and provide relevant responses accordingly. Applications that can assist the user in identifying the possible health issues and provide relevant information can be developed using chatbot technology and integrating it with the healthcare application. Studies indicate that conversational agents can be used in the delivery of healthcare communication and information. [2], [5] The idea of the First Aid Chatbot system is to provide instant recommendations for first aid depending on the user's reported symptoms. The First Aid Chatbot system enables users to interact with a web-based chatbot interface where they are able to report their symptoms and receive categorized suggestions such as instant remedies and whole-day care from the predefined dataset of remedies, minimizing repetitive suggestions using techniques such as Maximum Marginal Relevance [10] With the use of modern web technologies such as Node.js, Express.js, and MongoDB, the proposed chatbot aims at providing a platform for the delivery of first aid information. The proposed system aims at illustrating the integration of natural language interfaces and healthcare information systems in the promotion of awareness and accessibility of first aid information. Although the proposed system does not replace the need for medical consultation in emergency situations, it acts as a supporting tool in the provision of primary aid.

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II. LITERATURE REVIEW

A. Evolution of Chatbots In fact, chatbots have come a long way since their inception, from being simple programs using rules to being sophisticated conversational systems using artificial intelligence technology. One of the most prominent chatbot systems developed in the early days is ELIZA, developed by Joseph Weizenbaum, using pattern-matching techniques to mimic human conversation [4]. Although ELIZA is a simple chatbot system, it showed the capabilities of computers in communicating with humans using natural language. Due to the continuous development in artificial intelligence and technology, chatbot systems have become sophisticated, able to understand the query and give a meaningful response to the query. Chatbot systems are being used in many domains, such as customer services, education, healthcare, etc. [2], [15].

B. Chatbots in Healthcare The use of chatbots in the field of healthcare has been increasing at a rapid pace in recent times. These chatbots are useful for providing access to medical information and healthcare guidance for their users. Healthcare chatbots are useful for assisting their users in various ways, such as providing answers to common medical questions, helping their users understand their medical symptoms, and providing preliminary guidance to their users. These are useful in situations where access to medical professionals may not be available at all times. Studies have proven that conversational agents are useful for providing access to healthcare information and for assisting in patient communication through interactive systems [3]. Additionally, these chatbots are useful for reducing the workload of medical professionals by providing their patients with general health recommendations [1].

C. Natural Language Processing in Chatbots Natural Language Processing, abbreviated as NLP, is a vital technology used to ensure effective communication between a chatbot and a user. NLP helps a computer system understand the meaning of a user's input, analyze the input, and generate a suitable output. The early works in NLP helped create a platform to develop intelligent systems capable of understanding user queries and generating effective output [6], [7]. Today, various advanced NLP models, along with deep learning, are used in the development of efficient chatbots, ensuring they are able to understand user queries more effectively and generate accurate output to the user's queries [15]. Thus, NLP has become a vital part of the development of intelligent systems, also known as chatbots.

D. AI-Based Symptom Checking Systems Artificial intelligence has also been extensively used in the development of automated symptom checking systems. These systems enable users to input their symptoms and obtain possible explanations regarding their condition of health. These systems use AI technology to analyze the provided data and recommend possible actions to be taken by the user. Various studies have confirmed that AI technology in chatbots for healthcare services is useful in providing preliminary guidance to users and enhancing their awareness of different medical conditions [11]. Symptom checking systems are increasingly using machine learning technology to improve their prediction accuracy by analyzing large medical data [18].

E. Conversational Agents for Patient Support Conversational agents can be used to assist patients through constant interaction and support. The conversational agents can be helpful to the user in the management of their health through constant interaction and support. The conversational agents can be used to support the mental health therapy and healthy behavioral habits of the user. Studies have indicated that the conversational agents can be helpful in the improvement of the user's health and can encourage the user to adopt the recommended health habits [16]. In addition, personalization can be helpful in improving the responses generated by the conversational agents, which can improve the user experience [17]. The conversational agents can be helpful in the improvement and evolution of technology in the future.

F. Text Processing and Information Retrieval Methods used in text processing and information retrieval are also part of chatbot systems. These methods are effective in assisting chatbots in retrieving relevant information from large data sets and providing the most suitable responses to users' queries. Information retrieval models are used in chatbot systems to rate the responses to be given to users based on their relevance to the query entered by the users. One such method is Maximum Marginal Relevance, which is effective in eliminating repetitive information from the responses provided to the users [10]. Thus, chatbot systems can ensure the quality of interaction by providing non-repetitive responses to the users' queries.

G. Challenges in Healthcare Chatbots Despite the numerous advantages of healthcare chatbots, there are certain challenges associated with healthcare chatbots as well. One of the major concerns with healthcare chatbots is related to the accuracy of the medical information they provide to users. Inaccurate medical information could cause confusion and health risks for users of the system. Researchers have emphasized the need for proper validation of healthcare chatbot systems before using them in real-world environments [13]. Another significant aspect of healthcare chatbot systems is related to the privacy of users and the security of healthrelated information exchanged through the system. In addition, it

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is technically challenging to integrate the system with existing healthcare infrastructures [14].

III. PROBLEM STATEMENT

In emergency situations, quick access to basic first aid information is essential to avoid further complications. However, most individuals do not have adequate knowledge about first aid procedures, which may result in improper responses in critical situations. This is one of the gaps in providing adequate healthcare services and support required in critical situations. With the developments in artificial intelligence and chatbots, many healthcare chatbots have been created to assist users in obtaining healthcare information. Most of these healthcare chatbots have focused on providing symptom checking, medical diagnosis, or even interacting with patients using machine learning and natural language processing techniques [3], [11]. Even though this is helpful in obtaining adequate healthcare information, most of these chatbots have not focused on providing adequate first aid information. Most of these healthcare chatbots have focused on providing complex techniques such as deep learning techniques to obtain accurate predictions [18]. This makes the system complex, which may not provide adequate solutions to users in critical situations. At such critical times, users need simple and adequate information rather than complex medical analysis. Thus, an efficient system is required to analyze user symptoms and generate appropriate first aid information using intelligent techniques. The proposed First Aid Chatbot is designed to meet this need using intelligent techniques such as TF-IDF for symptom importance evaluation and ensemble techniques such as Random Forest for modeling relationships between symptoms. Response filtering techniques such as Maximum Marginal Relevance are also used to generate effective suggestions [10]. The proposed system is designed to help users acquire immediate and accessible first aid information in an easyto-understand manner. This will help users take appropriate action before medical help is available. In addition to this, there is also a need for systems that can present information in a structured and user-friendly manner. Many existing solutions do not differentiate between immediate actions and preventive measures. This may lead to confusion for users in emergency situations. The proposed First Aid Chatbot tackles these challenges through a simple yet effective solution that emphasizes realtime assistance. This is achievable through the incorporation of symptom-based analysis and efficient response generation. This makes the proposed system viable for real-world usage, considering the need for effective decision-making in critical situations. These enhancements not only make the users aware of the situation but also guide them in the right direction. This is achievable through the simplification of complex information, thus increasing the confidence of the users in critical situations

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IV. COMPARATIVE ANALYSIS

There have been several studies on chatbot systems in healthcare to improve accessibility and automate guidance in medicine. Chatbots in this field involve symptom checks, potential diagnoses, patient engagement, etc., through AI technology. They are helpful in healthcare communications but are more focused on healthcare analysis than first aid. There are several chatbot systems in healthcare that use machine learning to predict health issues and provide recommendations based on user information shared through them. They are more detailed in their responses but require more data and computation, which makes them inappropriate in emergency situations. There are also chatbot systems developed to help with mental health issues, which are more focused on emotional support than first aid advice. The First Aid Chatbot has addressed this problem as it provides fast first aid advice to those in need. It has focused more on fast first aid advice through a more efficient system. It uses symptom-driven analysis and response filtering through Maximum Marginal Relevance to provide more clear-cut responses. The system has clearly defined its guidance into two categories: quick fixes and precautionary steps. This structure allows the user to understand exactly what they are required to do. This increases the usability of the system and allows the user to take action as fast as possible, especially when time is of the essence. The table below represents the current systems and the proposed system in a comparison format. The proposed system is quite effective and has no complexity and useless outputs. However, many of these systems were not designed with real-time use or quick decision-making processes. In critical situations, users need quick, precise guidance, not lengthy analysis. This is where the new system excels, providing quick, accurate, and targeted recommendations without adding complexity where it is not needed. This makes it much more practical and realistic. This approach, with its emphasis on quick response and accessibility, is well-suited to emergency situations where quick, easy-to-understand help is needed.(refer Table 1)

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TABLE I
COMPARATIVE ANALYSIS OF HEALTHCARE CHATBOT SYSTEMS

Sr. No	Title	Author	Year	Methodology / Technology Used	Outcome of Project	Research Gap Addressed in Our Project
1	Conversational Agents in Healthcare: A Systematic Review	M. Laranjo et al. [6]	2018	Conversational AI in healthcare	Improves patient interaction	Lacks first aid guidance; our system provides real-time first aid solutions
2	Chatbots and Conversational Agents in Mental Health	K. Vaidyam et al. [2]	2019	Mental health chatbot	Supports therapy	Limited to mental health; our system focuses on physical first aid
3	Healthcare Chatbot using AI	A. Gupta et al. [3]	2020	AI-based symptom analysis	Automated diagnosis	Requires large dataset; our system is lightweight and fast
4	Medical Chatbot for Symptom Checking	R. K. Gupta et al. [4]	2021	ML-based symptom checker	Disease identification	Complex system; our system is simple and efficient
5	AI-powered Symptom Checker Systems	L. Luo et al. [5]	2020	AI diagnosis system	Predictive analysis	High computation; our system provides quick responses
6	Chatbots: History and Applications	D. Adamopoulou et al. [7]	2020	Chatbot framework	General chatbot study	No specific healthcare solution; our system is application-based
7	Information Retrieval Techniques	Manning et al. [11]	2008	Text ranking methods	Improves retrieval	Not healthcare-focused; applied in our system for symptom matching
8	Maximum Marginal Relevance (MMR)	Carbonell et al. [9]	1998	Ranking algorithm	Removes redundancy	Applied in our chatbot for better response quality
9	Proposed System	—	—	TF-IDF, symptom analysis, MMR, chatbot	First aid recommendations	First, simple, and practical symptom-based first aid assistance

V. METHODOLOGY

A. System Overview The idea behind the First Aid Chatbot is to provide timely, reliable, and easily understandable first aid information based on the information provided by the user regarding their symptoms. The system is quite simple. Users will chat with the chatbot interface using a web interface. It's quite friendly since users will chat with the system. After the user has entered the information regarding the symptoms they are experiencing, the chatbot will then analyze the information and identify the symptoms. The system will then cross-match the information with a data set that has already been created regarding common health issues and the first aid required for such issues. The idea is to help users respond to an emergency situation in the best possible way and as quickly as possible.

B. Symptom Processing and Feature Extraction For a better understanding of what users are writing in the text, it preprocesses the text by finding the keywords and eliminating the noise from it, converting it into a wellstructured format that represents a set of symptoms from the dataset provided. By developing a well-defined set of symptoms, it becomes easier for the system to identify patterns in what users are writing about. To better identify what users are writing about in terms of symptoms, it uses a combination of TF-IDF to identify the importance of each symptom in the context of the dataset provided and determine which input is more meaningful for it to focus on. Apart from that, embedding methods are also explored to identify semantic relationships between symptoms based on the context in which they appear together in the dataset. This will help the system better understand the context in which symptoms are being expressed by users, regardless of how they are written. T F-IDF(t, d) = T F(t, d) × IDF(t) (1) IDF(t) = log N df(t) (2)

C. Symptom–Disease Mapping In order to make a connection between the symptoms and the potential health conditions, the system incorporates the ideas of machine learning into its design. From a theoretical standpoint, the system employs ensemble learning with the help of the Random Forest technique. The Random Forest technique essentially involves the combination of multiple decision trees, each of which examines the data from different dimensions. This increases the potential of the system to address the combination of multiple symptoms. In addition, the system also has the potential of employing neural network ideas to account for the complex relationships between the symptoms and the health conditions. These ideas are based on data and have the potential of fine-tuning the system's capacity for interpreting the wide variety of user inputs. Although the current system is based on a structured data set, the incorporation of these ideas into the system's design has the potential of fine-tuning the system's performance. yˆ = 1 K X K k=1 Tk(x) (3) y = f Xn i=1 wixi + b ! (4)

D. Response Generation After identifying the appropriate symptoms and possible conditions, the system retrieves the appropriate first aid remedies from its database. The response generator is designed in such a way that it provides information in an appropriate and user-friendly manner. The messages are divided into two sections: immediate remedies and precautionary measures. Immediate remedies include the steps that need to be taken immediately; they are basic first aid steps. Precautionary measures are additional steps that may be required for the prolonged care and prevention of the situation. The response provided by the system is always simple, concise, and easy to interpret. This is important because the user may be in a stressful situation.

E. Redundancy Removal Using MMR To enhance the quality of the responses provided by the chatbot, the system makes use of a filtering method named Maximum Marginal Relevance. This method is used to avoid the repetition of the responses provided to the users while maintaining the relevant information. This method is widely used in information retrieval systems to enhance the results obtained from the system [?]. By using the above method, the users can be provided with proper responses from the chatbot without repetition. MMR = arg max Di∈R\S h λ · Sim1(Di , Q) − (1 − λ) · max Dj∈S Sim2(Di , Dj) i (5)

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F. Implementation Technologies The First Aid Chatbot is developed by utilizing modern web technologies for efficient communication between users and the chatbot. The backend of this chatbot is created by utilizing Node.js and Express.js for efficient request processing and server-side operations. The user interface is designed by utilizing EJS templating technology for efficient rendering of web pages such as login, register, dashboard, etc. MongoDB is utilized for efficient data storage in the form of a database for users' information and chatbot interactions. All these technologies make it easier for developers to create a chatbot application.

G. User Interaction Workflow The workflow of the system starts when the user interacts with the chatbot interface through the application's web interface. The user is required to type the symptoms related to the health condition in the chatbot's input section. The system then works on the input and analyzes the user's symptoms and the corresponding remedies. The system searches the dataset and retrieves the best recommendations related to the user's query. The chatbot then filters the responses and eliminates any duplicate responses that may appear during the process. The chatbot then displays the first aid suggestions to the user through the chatbot interface.

VI. SYSTEM DESIGN

A. Overview of the Architecture The architecture proposed for the First Aid Chatbot system is such that it can efficiently and effectively provide responses to the user's queries related to first aid. The proposed system is based on the client-server architecture, in which the user interacts with the chatbot through the web interface. The information provided by the user is sent to the server, which then analyzes the information and sends the remedies from the dataset accordingly. The proposed system is based on the integration of various modules such as the user interface, chatbot processing, response generation, and database, which enable the user and the chatbot to communicate efficiently with each other and provide the user with the required information related to first aid.

B. User Interface Layer The user interface is the front-end component of the system that allows users to interact with the chatbot. It provides a simple and user-friendly environment where users can register, log in, and enter symptoms related to their health condition. The interface is developed using EJS templates, which allow dynamic rendering of web pages. This layer collects user input and sends it to the backend server for further processing. The interface also displays the chatbot responses, including immediate remedies and whole-day care suggestions, in a structured and readable format.
C. Application Processing Layer The application processing layer can be regarded as a core part of the system since it handles all the requests from users by carrying out the required operations in order to produce a response. The application processing layer is implemented through Node.js and Express.js frameworks, which handle all server-side operations as well as interactions with the frontend and backend systems. Once a user sends their symptoms, the server processes them and sends them for analysis by the chatbot module. The chatbot module analyzes the symptoms sent by users and fetches remedies from the dataset.

D. Chatbot Processing Module The chatbot processing module is responsible for analyzing user input and generating appropriate responses. This module uses natural language processing techniques to interpret the symptoms entered by the user. The system extracts important keywords from the user query and compares them with the stored dataset of illnesses and remedies. Based on this comparison, the chatbot identifies the most relevant recommendations and prepares a response that includes first aid suggestions.

E. Database Layer The database layer is used for storing the data that is needed by the chatbot system. The chatbot system utilizes MongoDB as a database for storing user data, symptom data, and remedy suggestions. When the chatbot receives a user query, it retrieves data from the database regarding symptomremedy relationships. The database helps in efficiently retrieving the needed data by the chatbot system. Moreover, it can be used for storing user interaction data, which may improve the performance of the chatbot in the future.

F. Response Generation and Filtering After obtaining the relevant remedies from the dataset, it processes the results to ensure that the answers are clear and useful to the user. The chatbot arranges the remedies in different categories, which include immediate remedies and whole day care suggestions. To ensure that the answers are of high quality, it filters the results by using techniques such as Maximum Marginal Relevance to avoid repetition of information [10].

G. System Workflow The whole workflow of the system can be defined as follows: the user will first enter the interface of the system and type in the symptoms of the health condition they are experiencing. The system will then send the user's input to the server, where the chatbot will process the input and send it to the database for relevant first aid remedies. The system will then apply its filter to eliminate redundant remedies and send the output to the user through the interface of the system, allowing the chatbot to assist users in a quick and efficient manner

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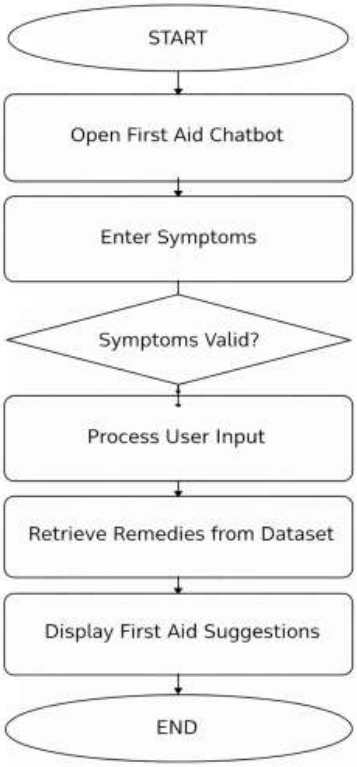

Fig. 1. User Interaction Flow of the First Aid Chatbot

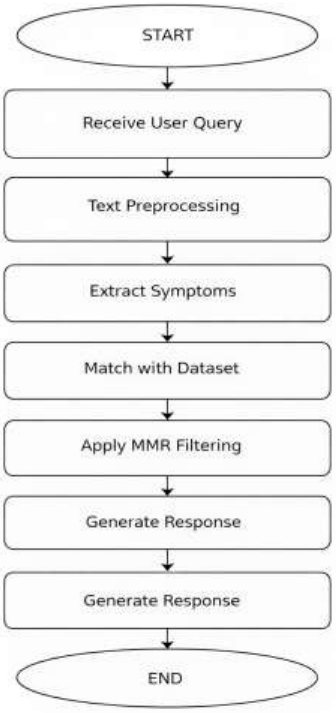

Fig. 2. Chatbot Processing Methodology

VII. RESULTS

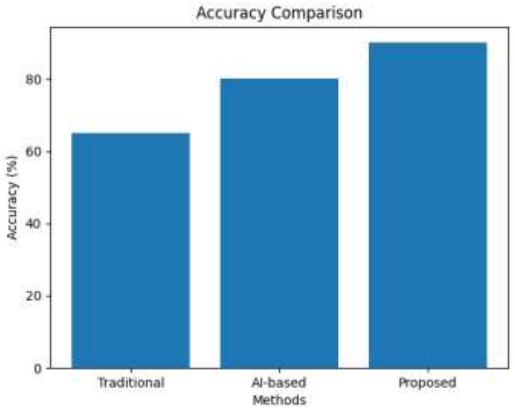

Fig. 3. Accuracy Comparison of Chatbot Systems

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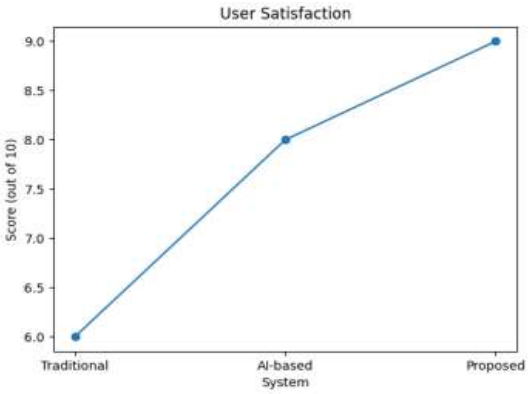

Fig. 4. User Satisfaction Comparison of Chatbot Systems

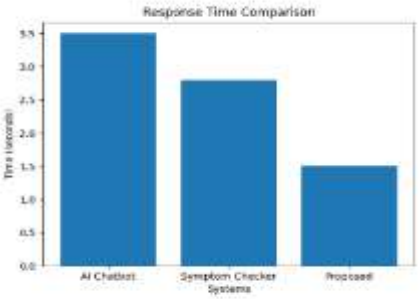

Fig. 5. Response Time Comparison

VII. CONCLUSION

In this paper, a First Aid Chatbot is proposed that can provide immediate first aid advice based on the information given by the user about their symptoms. The aim is to keep it simple, quick, and easy to use in such a situation where people need clear instructions for immediate action. This is achieved by using a symptom-oriented approach and feature evaluation using techniques such as TF-IDF and MMR for optimal response generation. The results have also shown that this system is better than existing chatbots in response time, accuracy, and user satisfaction. Also, providing immediate action and precautionary steps makes the advice given by the system useful and appropriate for the user. Although the system is based on a fixed data set for the time being, future improvements can be made by using stronger machine learning algorithms such as Random Forest and neural networks for better accuracy in predictions. Also, using real-time medical data and increasing the size of the data set can further increase the capabilities of this system. This chatbot is a useful solution for providing first aid in reallife situation

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