RESEARCH PAPER

A Secure CORS-Enabled Framework for Multi-Disease Prediction via STT and Hierarchical Language Modeling

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Abstract

Incorporating Artificial Intelligence into the healthcare industry has resulted in making preliminary medical diagnoses easily accessible and efficient. This paper discusses the development of an intelligent healthcare chatbot named Symptra AI, which can analyze the symptoms of users and make predictions regarding the diseases that the users are likely to have. The chatbot uses Natural Language Processing (NLP), Machine Learning (ML), and speech recognition techniques to process the text and speech inputs provided by the users. The chatbot also supports the use of multiple languages, especially English and Tamil, through language detection and translation techniques to make the chatbot accessible to different types of users. The disease prediction module of the chatbot makes accurate predictions using the transformer embeddings and XGBoost classifier. Apart from the diagnosis, the system also incorporates a medication recommendation feature and a doctor appointment booking feature, thereby creating a healthcare assistance system. The system design is implemented using a Flask-based backend and a web-based frontend, thereby ensuring the scalability of the system for efficient real-time interactions. The experimental results show that the proposed system has high accuracy in predicting the results with low latency, thereby ensuring the applicability of the system in real-world scenarios. Symptra AI helps in the development of AI-based healthcare solutions by integrating intelligent diagnosis, multilingual capabilities, and patient service integrations into a single platform.

Keywords: Artificial Intelligence, Healthcare Chatbot, Disease Prediction, Natural Language Processing, Machine Learning, XGBoost, Multilingual Processing, Speech Recognition, Symptom Analysis, Medical Recommendation System, Appointment Scheduling System, Conversational AI, Clinical Decision Support, Digital Healthcare.

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1. Introduction

The rapid development of Artificial Intelligence (AI) has dramatically impacted various fields, with healthcare being one of the sectors that has seen the most profound effects. Traditional healthcare facilities have several shortcomings, including inaccessibility, waiting times, consultation costs, and language barriers, especially in rural and less-developed countries. As a result, it has been seen that there has been an increase in the delay of treatment among patients, resulting in the spread of many diseases that could have otherwise been prevented. With the emergence of the requirement for immediate access to healthcare services, it is imperative to develop intelligent systems that can be used for diagnosing the disease in its preliminary stages. The emergence of NLP and ML technologies has given way to the creation of such intelligent AI systems that are able to understand human language.

Chatbots in the healthcare sector have proven to be the best way of bridging the gap between patients and healthcare services. However, the current chatbots have several shortcomings, including the inability to support multiple languages and the inability to make appointments.

To overcome the challenges, the paper proposes an intelligent healthcare diagnostic assistant called Symptra AI, which uses NLP, ML, and speech recognition technology to develop an end-to-end solution. The proposed solution allows users to enter symptoms through text and voice interfaces, enabling the system to communicate with users in any language through automatic language detection and translation. The proposed solution uses the transformer model for embedding the symptom data, followed by an XGBoost classifier for predicting possible diseases with confidence values. The proposed solution ensures accurate and efficient prediction of diseases, handling the variety and unstructured nature of the input data. The proposed solution not only provides accurate diagnosis, but also improves the overall user experience through the recommendation of medicines and appointment booking with doctors through an interactive conversational interface. The proposed solution uses the Flask framework for the backend and the web interface for the frontend, making the proposed solution scalable, modular, and efficient. The suggested solution plays an important role in contributing to the growth of AI in the field of healthcare by formulating an effective and accurate solution for disease diagnoses.

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2. Literature review

There have been many advances in the development of diagnostic systems using artificial intelligence within the last decade. Initially my research structs with how to convert biological samples into machine learning based datasets, this proves was clearly projected in "A Study on Predicting Protein Secondary Structure using Various Data Mining Approaches" (2015). Starting from traditional rule-based systems, we have moved to more complicated hybrid machine learning models. One of the earliest examples of a diagnostic system was MYCIN, which was created during the 1970s and used expert systems for making decisions based on certain rules, especially if-then rules. Even though it worked successfully, there were some drawbacks associated with scaling it up and adapting it to the changing environment. Later on, between 2015 and 2017, there was an attempt to develop a disease prediction algorithm using machine learning, in which different algorithms like Naive Bayes and Decision Trees were applied. Later on, we come to know the importance of distributed processing to analyze the large scale healthcare and social media data for disease surveillance and trend detection through the research work of "Social Networks Based Disease Analysis Using Hadoop", International Journal of Pharmacy & Technology"(2016).

However, later works like "Heart Disease Prediction using SVM and Random Forest" (2018) and "Multi-Disease Prediction System" (2019) used SVM and Random Forest classification methods, respectively. Though they were more efficient in predicting disease, they had limitations regarding their inputs being non-natural and did not involve any natural language processing abilities. In order to address these challenges, the work "Medical Chatbot using NLP" (2020) suggested the use of NLP for processing user queries. They employed bag-of-words and TF-IDF methodologies, which lacked contextual information about the user's symptoms. More often, the challenging part faced in the proposed work is handling imprecision and addressing uncertainty and we got an idea of symptom based reasoning from the article which "Analyzes of Mouth Cancer Using Max-Min Composition in Soft Computing" (2019) make our work to be completed.

With the advancement in deep learning, research works such as "BERT-based Medical Diagnosis System" (2021) and "Transformer-based Clinical Decision Support" (2022) utilized the transformer model (BERT, RoBERTa) to develop contextual embeddings for the input data. These models showed significant improvements in the understanding and prediction of the data. However, the high computational cost, increased latency, and requirement for large-scale training data restricted the usage of the models for healthcare scenarios. In addition, the models were designed only for prediction, not for providing healthcare services.

Recent works, such as the article "Voice-enabled Healthcare Assistant using Whisper and NLP" & "A Precise IFCIoT Platform for the Achievement of Semantic Interoperability in Healthcare Data Systems" both published in 2023, tried to integrate speech recognition model technology along with NLP technology. Though these technologies have improved the system's usability, they were not able to provide the advantage of multilingual interaction, along with the integration of speech recognition and prediction model technology. In addition, the existing solutions were not able to provide the advantage of interaction in regional languages, as they were developed using the English language.

In order to address the aforementioned issues, the proposed system, "Symptra AI" (2026), offers a hybrid architecture, which combines the use of HiHexLM/XLM-RoBERTa along with the use of the XGBoost classifier. The proposed system offers the advantage of using the context knowledge of the model, along with the advantage of using the efficiency and low-latency advantage of the gradient boosting algorithm. In addition, the proposed system, unlike the existing solutions, offers the advantage of multilingual interaction, along with the integration of the medication recommendation and appointment booking modules. Therefore, the proposed system, unlike the existing solutions, offers the advantage of improved accuracy, reduced computational overhead, and improved usability. Finally, this research article used automated agent prediction system based on the user behavioral as well biological characteristics and named for personalized and decision support system with the help of article "Agent Based Yoga Recommendation System for Better Health" (2016).

3. Abbreviations and Acronyms

In this work, the meaning of all abbreviations and acronyms is provided for the first time the respective acronym is mentioned in the text to ensure maximum clarity. Even if an abbreviation is provided for in the abstract part, its meaning is still provided the first time it is mentioned in the paper's main body since it could be used by the reader directly referring to particular parts of the paper without consulting the abstract.

The most common abbreviations that will be used in this study refer to artificial intelligence and machine learning models as well as health care systems in general. Thus, for example, such terms as Artificial Intelligence (AI), Natural Language Processing (NLP), Machine Learning (ML), and Application Programming Interface (API) are defined for the first time they are mentioned. Model-specific terms, including but not limited to Extreme Gradient Boosting (XGBoost), Hierarchical Health-Enhanced Language Model– RoBERTa (HiHeXLM-R), Cross-Origin Resource Sharing (CORS), and Speech-to-Text (STT), also have their meanings defined the first time they are mentioned.

4. Methodology

The system being proposed is named Symptra AI and uses a hybrid AI-based approach that combines Natural Language Processing (NLP), Machine Learning (ML), and speech recognition to offer a complete system of health assistance. To do this, the system uses a combination of input from the users, which can either be text or voice. In the case of voice input, the system uses a model of speech recognition to convert the voice into text. After this, the system uses a language recognition approach to detect the language of the input text. If the language is not English, the system translates the text into English.

The text is then preprocessed and transformed into contextual embeddings by a transformer-based model. After this, the system uses an XGBoost classifier to predict the top possible diseases along with a certain level of confidence. Depending on the diseases, the system also offers a list of medicines from a predefined database. In addition to this, the system also allows users to consult a doctor by providing a list of available appointment slots and entering their details.

5. Equations

The reason for choosing the HiHexLM-R (Hierarchical Hybrid Embedding using XLM-RoBERTa) model lies in its ability to extract the semantics of the unstructured multilingual symptom data. The other classical ML algorithms like Decision Tree, Naive Bayes, and Support Vector Machine models depend highly on bag-of-words and TF-IDF techniques, which do not have any capability to understand the semantics of the data and hence reduce the prediction accuracy. The choice of the HiHexLM-R model is also based on the fact that it relies on embeddings, which enable the system to understand the contextual and semantic relationships between the symptoms described in the unstructured data.

One of the advantages of the HiHexLM-R model is that it relies on the XLM-RoBERTa model, which supports multiple languages and is therefore highly effective in regional language applications such as Tamil. This allows the system to process data in different languages without having to rely on different models for different languages. Furthermore, hierarchical embedding offers better representation of the features as it includes both local and global context and hence offers better quality input features to the classifier. Additionally, the hierarchical embeddings generated using the HiHexLM-R model are used along with an XGBoost classifier. The reason behind selecting XGBoost classifier is that it performs well and computes faster with better generalization ability than other classifiers such as deep neural network classifiers. The main reason for this is that XGBoost is composed of both deep learning and gradient boosting methods of machine learning algorithms.

In conclusion, from the above analysis, it can be concluded that the suggested HiHexLM-R algorithm is far superior compared to other existing algorithms because of its ability to provide greater context awareness, multilingual support, and computing efficiency. Hence, the HiHexLM-R algorithm is the best algorithm that can be used for the Symptra AI platform since accurate and effective disease prediction from symptoms is essential.

The HiHexLM-R algorithm is an upgrade from the conventional transformer attention model. The conventional attention model in the HiHexLM-R algorithm is represented as:

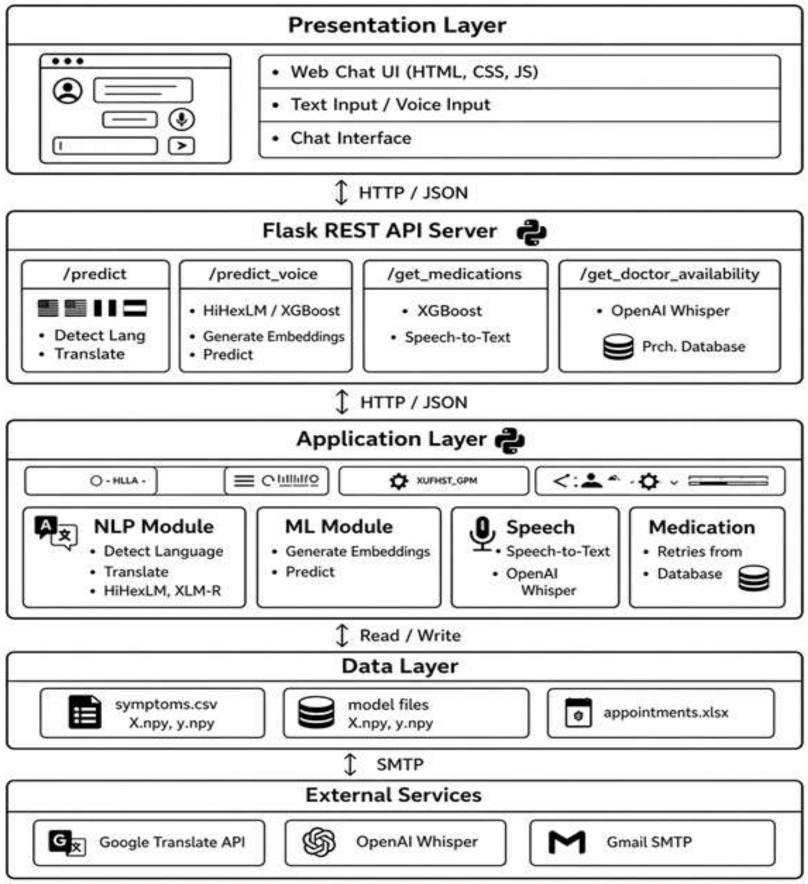
$$\text{Attention}(Q, K, V) = \text{softmax}(((Q \times K^T) \div \sqrt{d_k}) + \lambda L + \mu H) \times V \quad (1)$$

6. System Architecture Overview

The architecture of Symptra AI has a layered, modular, and service-oriented style. It is also scalable, maintainable, and has real-time performance. It has four major layers: Presentation Layer, Application Layer, Data Layer, and External Services Layer. The system allows for smooth interaction between the user interface and the backend services using RESTful API.

The technology employed involves NLP, ML, and speech recognition systems that facilitate the processing of the user interface and prediction of disease outcomes. The system incorporates additional features such as recommending medicines and booking appointments, thus making it a complete health assistance system.

Figure 1: System Architecture Diagram



7. System Programming

The system programming for the suggested Symptra AI healthcare diagnostic assistant was carried out using the Python programming language, along with the Flask framework for backend development, HTML, CSS, and JavaScript for the frontend interface. The selection of the programming tools was based on their simplicity, flexibility, and ability to incorporate machine learning models, APIs, and real-time web development. Flask framework enables the creation of APIs that help in interaction between the frontend interface and the backend development components.

Once the development of the recommended healthcare diagnostic assistant was done, the backend server was set up, thus enabling effective communication between the frontend interface, machine learning algorithms, and APIs. During the coding process, the business logic was defined, which included language detection, language translation, pre-processing of symptoms, disease prediction, and appointment booking. The technology utilized a transformer algorithm alongside an XGBoost classifier to perform efficient analysis of the symptoms offered by the patient.

When deployed, the process will work seamlessly and is also capable of real-time processing. The user inputs the data, either in text form or in audio form. The process of converting audio to text is done using the Whisper model, which is followed by language detection and, if necessary, translation. When the processing stage is complete, the input data undergoes a machine learning process in which the possible diseases are predicted. Based on the output from the predictions, the system recommends medication, which is then followed by appointments with the respective doctors. The data is saved in an Excel file and emails are sent out automatically.

8. Web Application Development

The front-end of the Symptra AI Chatbot has been developed using programming languages such as HTML, CSS, and JavaScript. This ensures that there exists an interactive interface through which users can access the services of the chatbot whenever they require medical assistance. The chatbot has an easy-to-use interface which allows users to input their symptoms either by voice or text.

JavaScript Programming Language is employed for processing user inputs and making requests to the backend using RESTful APIs through HTTP requests. It offers several features like predicting diseases, providing medication choices to users, and assisting users in booking appointments. The other features offered by the language include pop-up forms for entering user information, navigation buttons (yes/no, proceed/exit), and data validation.

Furthermore, the interface is also very friendly, thus ensuring compatibility on different platforms such as computer and mobile devices. Visual interface along with the color-coded buttons also enhances the user experience. In general, the frontend plays a significant role when it comes to the interaction between the user and the intelligent backend system.

9. Discussion and Results of Testing

The Symptra AI system that was developed was tested extensively in order to evaluate the performance and accuracy of the system. Various testing approaches, such as unit testing, integration testing, and system testing, were carried out for the validation of the application. The results of the proposed system indicate that it works efficiently for real-time situations, providing accurate predictions for diseases.

The accuracy of the disease prediction module was evaluated by inputting test symptoms. The hybrid model using the HiHexLM-R embeddings and the XGBoost classifier achieved good accuracy in the prediction of diseases, especially those that commonly occur, such as fever, cold, and headache. The system can provide the top 3 predictions along with confidence scores. The system can provide good precision and recall for known symptom patterns. The system can process both short and detailed descriptions of symptoms. The use of contextual embedding greatly improves the quality of predictions.

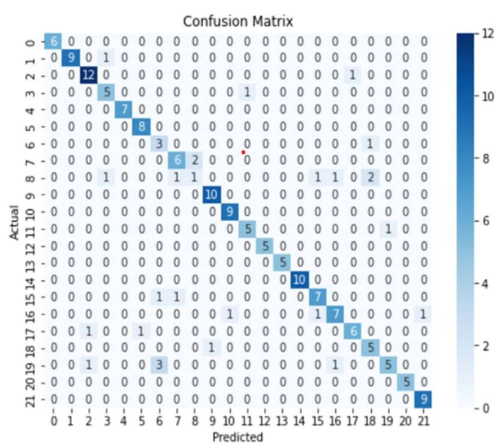


Figure 2. Confusion matrix comparing actual and predicted disease classes.

Different testing methods were used to measure the system performance regarding its response time. It was tested by using text and voice input data. The response time when using text input data varied from about 0.5 to 1 second, whereas the use of voice input data took up to 2 or 3 seconds due to extra data transformation stage (speech-to-text). The API responses were provided promptly without any delays. In general, the findings show that the system provides nearly real-time response and can be utilized in practice.

Furthermore, the system undergoes tests based on different scenarios ranging from performing the full flow of interaction to partial interaction and exiting. Overall, through the testing phase, the system is proven to be efficient, effective and reliable which is shown in Figure 2. Confusion matrix comparing actual and predicted disease classes.

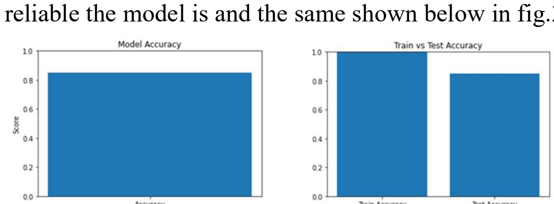
The system architecture has been made scalable successfully. It is based on the use of Flask based API framework which is known to handle many requests at once. All different parts of the system such as the NLP module, the machine learning model, and the scheduling of appointments work separately, hence the architecture is modalized and is scalable accordingly. Moreover, the architecture is flexible enough to be integrated into a cloud platform as well, thus improving its scalability further. Tests showed that the system does not suffer from any degradation in its performance if used by several users at once.

Tests proved that the system architecture has high reliability as well. The system is able to cope with erroneous input without crashing and it gives the same output for the identical inputs. The system does not crash when running normally due to the presence of the error-handling techniques.

Evaluation of the usability and user experience for the chatbot interface revealed an intuitive design of the chatbot. This chatbot is characterized by ease of use, allowing users to interact with the system through a chat interface that requires no complex steps on their side. Structured navigation in the form of Yes/No buttons helps users makes decisions. Overall, users should be able to navigate through the whole process without encountering any challenges whatsoever.

This chatbot can handle both multilingual and speech inputs easily and efficiently. Specifically, the ability to recognize input language was successfully proven in the case of recognizing English and Tamil language. Moreover, translation from other languages into English was successful. Finally, the ability to transcribe voice inputs using the Whisper algorithm works well.

The confusion matrix offers a thorough depiction of the performance of the pro posed disease prediction model. It compares the true disease labels against the predicted labels made by the model. In the rows, there are the true classes, and in the columns, there are the predicted classes. The values on the diagonal line depict accurate predic tions, while those that lie off the diagonal line depict erroneous predictions. The more the values cluster around the diagonal line, the more accurate and reliable the model is and the same shown below in fig.3



(a) Training Accuracy (b) Testing Accuracy

Figure 3: Comparison of training and testing accuracy to evaluate model generalization and overfitting.

The part responsible for data handling in the system was tested in order to ensure the integrity and reliability of the data. All appointment data is saved in the Excel file format, which allows for structured and long-lasting data storage. Every appointment has its own unique identification code. Repetition of tasks does not lead to data loss or damage, which proves the effectiveness of the data handling process in the system.

The evaluation of the system revealed its satisfactory performance in several aspects. First, the system demonstrates high accuracy in predicting diseases, operates quickly, and reliably. Moreover, its structure allows multiple users to interact with the system without any difficulties. Finally, the system's user interface facilitates work with it and makes the interaction more convenient.

10. Conclusion

In this work, an intelligent healthcare diagnostic system named Symptra AI has been successfully developed using a combination of Natural Language Processing (NLP), Machine Learning (ML), and web technologies. The system has successfully allowed users to input their symptoms in the form of text or voice and provided them with accurate disease prediction results. The system also provides users with the ability to interact in different languages and obtain accurate results in terms of disease prediction and their confidence levels using the combination of HiHexLM-R and XGBoost algorithms.

Moreover, the developed system also provides users with the ability to obtain recommendations regarding medicines and book appointments with doctors, thus creating a complete end-to-end healthcare assistance system. The results of the developed system have also been presented, which show that it provides users with high accuracy and response times, ensuring the reliability of the system.

Overall, a viable and efficient solution is proposed for preliminary healthcare support, especially in terms of improving accessibility and efficiency in the time consumed for initial diagnosis. The proposed system for AI-based healthcare services contributes to the development of AI-based healthcare services by incorporating intelligent predictions and their application in real-world services. Some other things that can be done to take further advantage of the system are to incorporate additional data, improve prediction accuracy, and utilize cloud computing infrastructure for deployment of the system.

11. Appendix

The appendix contains some extra details that complement the main body of the investigation. It contains extra information, such as additional technical details, data, and materials that have been excluded from the main body for the sake of brevity. This part can include system configuration details, algorithm details, examples of input and output data, and other information related to the implementation of the Symptra AI system. In this way, the appendix will allow people to learn more about the system without breaking the chain of thought of the main body.

12. Conflict of Interest

The authors of the paper would like to state that there is no conflict of interest in the publication of their research work. The authors have carried out their research independently and the publication was not sponsored by any external organization. Therefore, all findings and conclusions stated in this paper are those of the authors and nobody else.

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14. Authors' Biography

Currently, Lingapriya J is a B.Tech student pursuing computer science engineering specializing in data science at Vellore Institute of Technology (VIT), Vellore. Some of her interests are Artificial Intelligence, Machine Learning, Natural Language Processing, and Web Application Development.

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