International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 10 Issue: 11 | Nov 2023 www.irjet.net p-ISSN: 2395-0072

Optimizing Hospital-Patient Interactions through Advanced Machine Learning and NLP Methodologies

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Abstract - *This research presents an innovative approach to streamline the patient journey within the healthcare ecosystem, leveraging the capabilities of DialogFlow and Feedforward Neural Network(FNN) model. Users interact with Google Assistant, detailing their symptoms which intelligently recommends relevant departments in nearby hospitals using Google Maps API and classifies them to a department based on symptoms. The integration of BERT-based NLP techniques in analyzing and summarizing patient-doctor conversations reduces diagnostic errors, aligning the doctor's diagnosis with the model's insights. This innovation streamlines the hospital experience, ensuring a more accurate and efficient diagnosis. The future implications extend towards the evolution of patient-centric, technology-driven healthcare experiences, marking a significant advancement in the convergence of artificial intelligence and medical services.*

Key Words: **DialogFlow, FNN, Machine Learning, Google Assistant, Maps API, BERT, NLP**

1. INTRODUCTION

The modernization of healthcare systems is imperative for ensuring optimal patient experiences and efficient clinical workflows. This paper introduces a comprehensive intelligent appointment system designed to streamline various aspects of the healthcare journey. By integrating cutting-edge technologies such as natural language processing, machine learning, and QR codes, the system aims to optimize the appointment booking process, enhance hospital check-in procedures, and augment doctor-patient interactions.

It is crucial to acknowledge the existing drawbacks in some of the current literature. Many studies lack a holistic approach, often focusing on isolated aspects of healthcare management. This literature review critically examines these limitations in current papers and sets the stage for proposing a more integrated and inclusive intelligent appointment system and seeks to bridge these gaps by identifying shortcomings, and proposing avenues for further exploration and improvement in intelligent healthcare systems.

1.1 LITERATURE REVIEW

[1] Kyambille and Khamisi (2015) conducted a study on improving patient appointment scheduling through mobile technology. The research introduces a mobile application system that enables patients to conveniently register and schedule appointments using their phones at their preferred time. The system, developed using MySQL, WAMP server, and PHP, facilitates efficient appointment management. However, a limitation of the system is its inability to redirect appointment requests to other hospitals with doctors possessing similar expertise.

[2] This paper emphasizes the importance of prioritizing health using Artificial Intelligence (AI) to deliver convenient and affordable healthcare services. It discusses the role of high-tech gadgets and AI applications, particularly disease prediction through big data analysis. The study introduces an online medical services platform with a chatbot for disease prediction, employing Natural Language Processing and Decision tree algorithms for effective communication and accurate predictions.

[3] The literature highlights the positive impact of technology on healthcare, emphasizing its role in improving efficiency and accessibility. It advocates for AI-driven healthcare services, showcasing how technology enhances medical guidance through tools like disease prediction chatbots, contributing to overall well-being.

[4] This paper highlights a comprehensive, integrated information system designed to manage the administrative, financial, and clinical aspects of a hospital. Developed as an area of medical informatics, the system aims to achieve the best possible support of patient care and administration through electronic data processing. It provides an intelligent front desk information service for patients at the hospital entrance and software assistance for doctors to diagnose patients quickly and accurately. The system is designed to handle paper-based information processing as well as data processing machines.

2. SYSTEM DESIGN

The overall workflow of the system is as follows - The user (patient) interacts with Google Assistant in a language of

their choice to book an appointment based on the symptoms they are facing. Under the hood, this interaction happens with DialogFlow which has NLP capabilities to identify the symptoms of the patient depending on the information that the patient provides to the assistant.

Based on the user's current location, Google Maps API, is used to determine the nearest hospitals to the user. A FNN(Feedforward Neural Network) based machine learning model was used to analyze the symptoms and predict the correct department within the nearest hospital for the user to go to, along with a list of available doctors, which the user can use to book an appointment.

Subsequently, a unique QR code, containing appointment details and user information, is generated and emailed to the user for convenient check-in at the hospital.

Upon arrival at the hospital, the user scans the QR code using a barcode reader at the check-in counter. The system retrieves information, displaying real-time wait times and room details for the selected doctor within the department This can help to expedite the check-in process, minimizing wait times and enhancing overall efficiency. Furthermore,users can actively monitor live waiting times and the number of patients in the queue based on the website.

A HealthScribe is used to record the conversations between the patient and the doctor. This can be useful when the doctor needs to diagnose the disease and can be useful to keep the conversation on file.

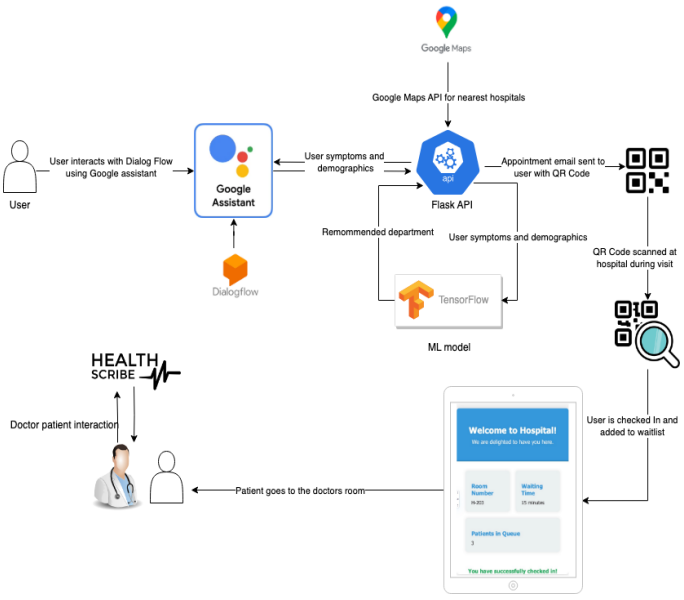

Diagram -1: Workflow diagram

During the consultation, a health scribe system plays a pivotal role in supporting the doctor-patient interaction. Utilizing natural language processing and speech-to-text technologies, the health scribe transcribes and analyzes the conversation. This assistance aids the doctor in diagnosing the patient's condition, mitigating human error, and providing valuable insights.

Additionally, the health scribe system contributes to comprehensive documentation, ensuring future reference and analysis of the conversation for continuous improvement and patient care enhancement.

2.1 IMPLEMENTATION

- **Techstack**: Flask, Keras, Google Maps API, AWS Health Scribe, DialogFlow

- **Identifying patients symptoms** : DialogFlow was used in order to identify patients symptoms by defining specific intents. Intents could be 'Cough', 'Headache', 'Fever' etc. Each intent is trained with a variety of training phrases that users might use to describe their symptoms. DialogFlow uses NLP internally which allows for a more nuanced understanding as it analyzes the context and extracts entities from the user's input. Entities represent specific details within an intent, which could be severity of a symptom, duration etc.

- **Locating Hospitals + department :** Google Maps API was used to locate the hospitals near the user. FNN was trained to predict medical departments in these hospitals based on the identified symptoms. FNN is used due to their ability to learn complex patterns in medical data, capture nonlinear relationships between symptoms and diseases, and automatically extract relevant features through hidden layers, enabling effective and accurate predictions. The Sequential model, built using Keras, features enhanced capacity with 128 neurons in the initial hidden layer, fostering a deeper understanding of intricate patterns in symptom data. The addition of a second hidden layer with 32 neurons further refines the model's ability to discern nuanced relationships. The final layer, with softmax activation ensures accurate and comprehensive predictions for disease identification. The Flask webhook retrieves information about the nearest hospitals with high ratings for the predicted department based on Google reviews.

- **Generating QR Code :** When the user selects a department, DialogFlow communicates with the Flask to generate a QR code without sensitive patient data using the 'qrcode' library in Python. This QR code is sent to the user via an email client. The user then scans the QR code at the hospital, where there is no human receptionist, automating the entire workflow. The unique ID in the QR code is mapped to the hospital database.

Using the doctor's history of time taken for consultation, and the room where the doctor is located, the current wait time for the patient is displayed on the hospital screen. The user also receives an email to click on the link to the website which has real time updates regarding the wait time.

This website is designed to provide seamless updates and transparency for both healthcare providers and patients. The frontend of the platform is developed using React, and the backend using Flask. Patient data and queue information are stored securely in Firebase along with current status, room numbers, and waiting times. The system also integrates with electronic health records (EHR) through APIs, ensuring synchronization with the latest patient data.

The system calculates and updates the waiting times dynamically, allowing both healthcare providers and patients to stay informed about the current status, optimizing resource allocation and enhancing overall patient experience.

- **Healthscribe:** The doctor-patient conversation is analyzed using pyAudioAnalysis library to identify whether the speaker is doctor or patient. This is sent to a BERT based text summarizer that summarizes the conversation. BERT's contextual embeddings enable the generation of a concise summary of the entire conversation. This summarized dialogue acts as a comprehensive reference for the doctor during future interactions with the patient, contributing to efficient and accurate diagnoses. The seamless integration of audio analysis and text summarization enhances the overall documentation process in medical practice.

3. RESULTS

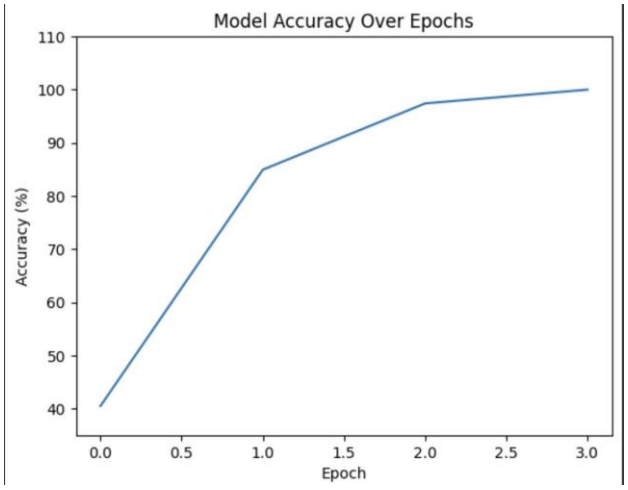

Diagram -2 : Model accuracy over epochs for predicting departments based on symptoms

Diagram -3: User's conversation with Google Assistant in regional language (Hindi)

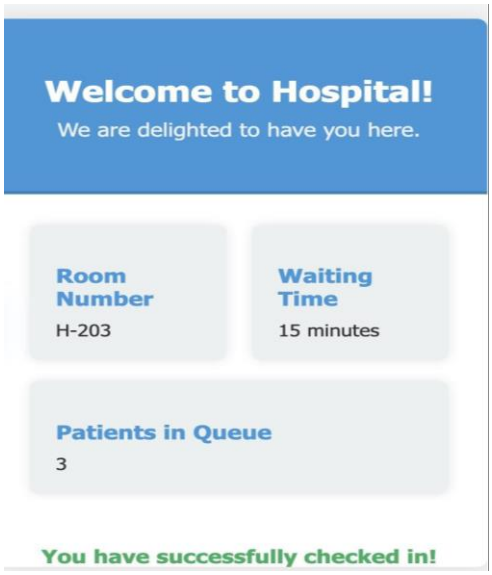

Diagram -4: Website for real-time updates of patient wait time

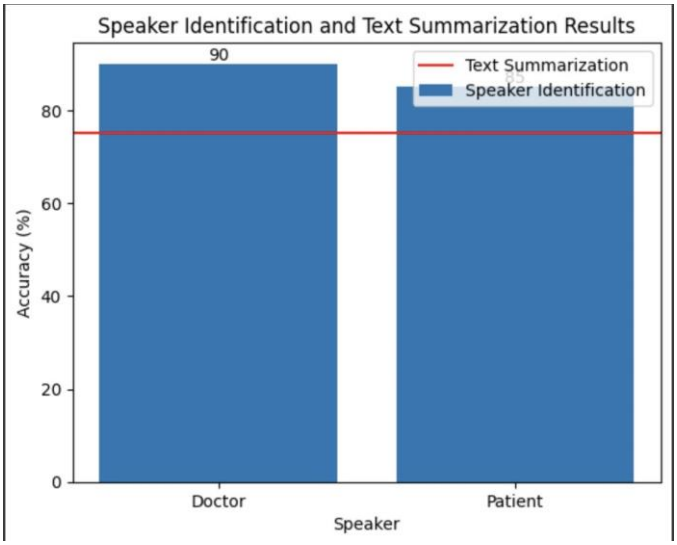

Diagram -5: Speaker Identification and Text Summarization Results

Diagram 4 showcases the evolving accuracy of the FNN based ML model to predict the department based on the patients symptoms throughout training, reaching a peak accuracy of 98.6%. This illustrates the model's proficiency in accurately predicting patient departments based on provided symptoms, promising improved healthcare diagnostics. Our speaker identification system achieved 90% accuracy for doctors and 85% for patients. Integrated with a BERT-based text summarizer, our system yielded a remarkable 75% accuracy in generating concise summaries. These results underscore the effectiveness of our approach in enhancing medical documentation and doctor-patient interactions.

4. CONCLUSION

This holistic solution orchestrates a seamless patient journey from symptom-based appointment booking using Google Assistant to accurate hospital and department predictions via Google Maps API and FNN models. Automated QR code generation and real-time updates reduce wait times, while the health scribe system ensures thorough documentation and aids in precise diagnosis. The tech stack, including Flask, TensorFlow, and DialogFlow, forms a robust foundation for this patient-centric approach. The system's adaptability to multiple languages and its integration of cutting-edge technologies represents a significant improvement in healthcare efficiency and patient care.

5. FUTURE SCOPE

1. Integration of the system with IVR (Interactive Voice Response) to help patients book appointments even without a smartphone.

2. Support preliminary assessments by enabling teleconsultations so that patients can get certain lab tests done prior to the consultation.

3. Integrate ML to predict hospital resource requirements based on historical wait times and patient data.

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