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REVOLUTIONIZING EMERGENCY HEALTHCARE IN DEVELOPING INDIA: AN AI-INTEGRATED AMBULANCE SYSTEM FOR TIMELY INTERVENTION IN CRITICAL CONDITIONS

Dr. S. Kavitha[1], Sai Bharath Vemula[2], Sai Rohit Pindipolu[2], Sairam Pagadala[2]

[2]UG Scholar, [1,2]Department of Computer Science and Engineering

[1,2]Kommuri Pratap Reddy Institute of Technology, Ghatkesar, Hyderabad, Telangana.

ABSTRACT

The field of emergency medical services (EMS) has undergone significant advancements over the years, with a focus on improving response times, patient care, and overall outcomes. The integration of artificial intelligence (AI) and human interaction technologies into ambulances represents a transformative approach to enhance emergency medical care. The background encompasses the evolution of EMS, the rise of AI in healthcare, and the potential for synergies between technology and human interactions in emergency situations. Historically, ambulances have primarily been vehicles equipped with basic life support equipment and staffed by paramedics and emergency medical technicians to provide initial care during transportation to a medical facility. Communication with hospitals and the processing of patient information be manual and time-consuming. The traditional system is lack of real-time data analysis capabilities and decision support tools that AI can offer in emergency situations. The problem at hand is optimizing emergency medical responses and care through the integration of AI and human interaction technologies within ambulances. This involves addressing challenges such as quick and accurate diagnosis, communication between emergency responders and healthcare facilities, and the provision of real-time medical information to enhance decision-making. The goal is to create a seamless, intelligent, and responsive system that improves patient outcomes during critical moments. The need for the intelligence ambulance arises from the recognition that leveraging AI and human interaction technologies can significantly enhance the efficiency and effectiveness of emergency medical services. In critical situations, quick and accurate decision-making is crucial, and the integration of intelligent systems can provide valuable support to healthcare professionals. This approach can also improve communication, data sharing, and coordination between ambulances, hospitals, and other healthcare entities.

Keywords: Artificial Intelligence, Emergency Medical Services, Intelligent Ambulance, Real-Time Data Analysis, Healthcare Communication, Decision Support Tools.

1. INTRODUCTION

The evolution of Emergency Medical Services (EMS) has marked significant progress, driven by a continuous effort to enhance response times, patient care, and overall outcomes. In this context, the integration of Artificial Intelligence (AI) and human interaction technologies into ambulances stands out as a transformative approach to elevate the standards of emergency medical care. Traditionally, ambulances have functioned as vehicles equipped with basic life support equipment, staffed by paramedics and emergency medical technicians. Their primary role has been to provide initial care during transportation to a medical facility. Communication with hospitals and the processing of patient information have been manual and time-consuming, lacking real-time data analysis capabilities and decision support tools that AI can offer in emergency situations. The challenge at hand involves optimizing emergency medical responses and care through the seamless integration of AI and human interaction technologies within ambulances. This optimization targets critical areas such as quick and accurate diagnosis, efficient communication between emergency responders and healthcare facilities, and the provision of real-time medical information to enhance decision-making during emergencies.

The ultimate goal is to create a seamless, intelligent, and responsive system that significantly improves patient outcomes during critical moments. The need for an intelligent ambulance arises from the understanding that leveraging AI and human interaction technologies can markedly enhance the efficiency and effectiveness of emergency medical services. In critical situations, where quick and accurate decision-making is crucial, the integration of intelligent systems can provide invaluable support to healthcare professionals. This approach also addresses the improvement of communication, data sharing, and coordination between ambulances, hospitals, and other healthcare entities. The historical context underscores the limitations of traditional EMS systems and highlights the potential for innovation through the integration of AI, ushering in a new era of intelligent emergency medical services.

2. LITERATURE SURVEY

In 2020 Akca et al. [1] put forward a paper which mainly emphasizes on "Intelligent Ambulance Management System in Smart Cities." technique to manage ambulance and emergency services. This research is efficient to cover all the things needed to Design & Development of Intelligent Ambulance Concept – AI and Human Interface Technology Section A-Research paper 179 Eur. Chem. Bull. 2023,12(Special Issue 9), 177-188 develop a smart ambulance management framework but lacks to explain how the system can work in real time with a combination of mobile computing, cloud computing and standalone application together. In 2021 Ganesh et al. [2] presented a study on "health machine to handle covid-19 related health emergencies" technique to manage ambulance and emergency services. This research effectively covers all the requirements for developing a smart ambulance management framework, but it falls short on describing how the system may function in real time by combining mobile, cloud, and standalone applications altogether. Gargi Beri, Ashwin Channawar, Pankaj Ganjare, Amruta Gate, Prof. Vijay Gaikwad published, "Intelligent Ambulance with Traffic Control" [3]. This study includes a traffic control system as well as a health monitoring system. In health monitoring system, the patient's vital health parameters such as ECG, Heart Rate and Body Temperature are monitored. These parameters are sent to a PC in ambulance via serial communication and this data will be sent to the hospital server. Ms. Aisha Meethian, Althaf B K, Athinan Saeed, Ligin Abraham, Mohammed Samran Hashim Proposed a study on "IoT Based Traffic Control System with Patient Health Monitoring For Ambulance" in August 2022 [4]. The proposed system optimizes the route by minimizing the transport duration to the hospital by using GPS sensor networks. The health parameter of the patient is monitored using different sensors like Heart Rate Sensor, Breath Sensor and Temperature Sensor . These parameters collected from the patient are transmitted to the hospital's database using IOT. In [5], To provide an intelligent smart health system which sense the body condition and send the data to the collaborated hospital's website. A device in which the heart beat sensor will sense the heart beat and temperature sensor will sense the body temperature. After sensing, sensors will send respective data to the microcontroller. After that microcontroller will sent it to raspberry-pi which will connect with the internet or IOT cloud. To reach the destination on time the driver will use google map along with accidentavoidance features to save lives. In 2022 Timothy Malche et.al. [6] proposed a system m consists of a sensor node to track patients' vitals during different activities which patients perform. The proposed sensor node collects patients' data using the sensors attached to the nRF5340 Development Kit (DK). The connected sensors are accelerometer, microphone, pulse oximeter, heart rate sensor, and temperature sensor. The accelerometer enables monitoring different patient physical activities, including walking, sleeping, exercising, and running. By analyzing the vitals during different activities, the doctor can prescribe treatment or give suggestions to patients. In [7], A study presents a new method for pulse detection during Out of Hospital Cardiac Arrest using the electrocardiogram (ECG) and Thoracic impedance (TI) signals. The approach uses an adaptive filter to extract the circulatory-related component from the TI referred to as impedance circulation component (ICC) and a support vector machine (SVM) classifier based on features extracted from the ECG and ICC to discriminate pulseless electrical activity (PEA) and PR interval [1]. In [8], an Enhanced deep convolutional neural network (EDCNN) has been proposed for the early detection of heart disease and diagnosis. This research has been developed on EDCNN approach to detect heart disorders in patients and to improve diagnostic precision using deep learning-based prediction models. The prediction of heart disease by processing patient data to calculate the chance of heart ailment has been mathematically computed Design & Development of Intelligent Ambulance Concept – AI and Human Interface Technology Section A-Research paper 180 Eur. Chem. Bull. 2023,12(Special Issue 9), 177-188 with distributive functions. Heart activity has been analyzed during exercise, resting, and working [2]. In [9], The proposed method use Decision Tree algorithm for feature selection method, PCA for dimension reduction and ANN for the classification. The principal component analysis (PCA) is a statistical technique that uses mathematical principles to convert a set of observations (or samples) of possibly correlated variables into a new set of observations of linearly uncorrelated variables [3]. The method used in this work involves Data Collection, Pre-processing, Feature extraction, Dimension Reduction, Classification and Result Analysis

3. PROPOSED SYSTEM

The research implements a graphical user interface (GUI) application using Tkinter for a intelligence ambulance project based on patient data. Here's a detailed explanation of the steps carried out by the application:

- Dataset Upload: The application starts with a button labeled "Upload Dataset." When clicked, this button opens a file dialog, allowing the user to select the dataset file (assumed to be in CSV format). The chosen file is then loaded into the application, and its name is displayed in the text widget. The dataset is stored in the 'dataset' variable.
- Dataset Preprocessing: The "Preprocess Dataset" button triggers the preprocessing phase. Missing values in the dataset are filled with zeros, and an overview of the dataset, including the first few records, is displayed in the text widget. Additionally, a count plot is generated to visualize the distribution of classes in the 'surface' column. Label encoding is applied to convert categorical class labels into numerical values.
- Train-Test Splitting: The dataset is split into training and testing sets using the scikit-learn train_test_split function. Information about the total number of records in the dataset, as well as the training and testing sets, is displayed in the text widget.
- Decision Tree Classifier: The "Decision Tree Classifier" button initiates the training of a Decision Tree classifier. The model is fitted on the training set, and predictions are made on the testing set. The evaluation metrics, including accuracy, confusion matrix, and classification report, are displayed. Additionally, a Receiver Operating Characteristic (ROC) graph is generated to visualize the model's performance.

— Random Forest Classifier: The "Random Forest Classifier" button triggers the training of a Random Forest classifier. Similar to the Decision Tree model, evaluation metrics and a ROC graph are displayed in the text widget.

— Prediction on Test Data: The "Prediction" button allows the user to select a file for making predictions using the trained Decision Tree classifier. Predictions are displayed in the text widget, indicating the predicted classes for each test data entry.

— Performance Estimation and Comparison: The "Comparison Graph" button generates a bar graph comparing performance metrics (precision, recall, F1-score, and accuracy) between the Decision Tree classifier and the Random Forest classifier. This visual representation provides an easy comparison of the two models.

— Exit: The "Exit" button closes the Tkinter GUI application.

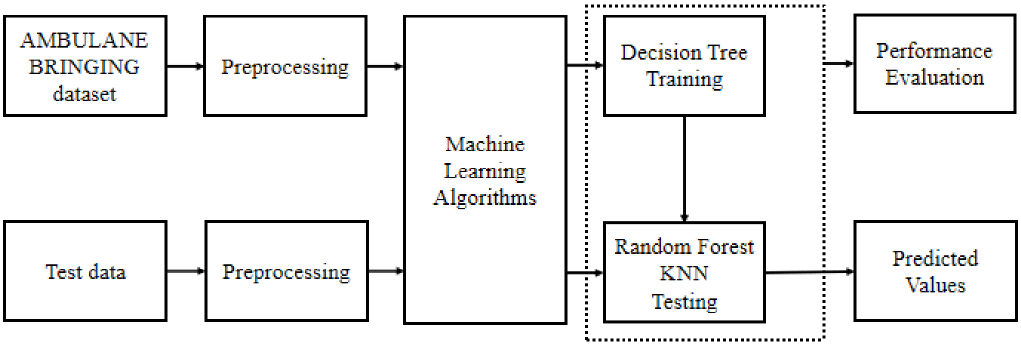

Fig. 1: Architectural Block diagram of proposed system.

Random Forest Algorithm

Random Forest is a popular machine learning algorithm that belongs to the supervised learning technique. It can be used for both Classification and Regression problems in ML. It is based on the concept of ensemble learning, which is a process of combining multiple classifiers to solve a complex problem and to improve the performance of the model. As the name suggests, "Random Forest is a classifier that contains a number of decision trees on various subsets of the given dataset and takes the average to improve the predictive accuracy of that dataset." Instead of relying on one decision tree, the random forest takes the prediction from each tree and based on the majority votes of predictions, and it predicts the final output. The greater number of trees in the forest leads to higher accuracy and prevents the problem of overfitting.

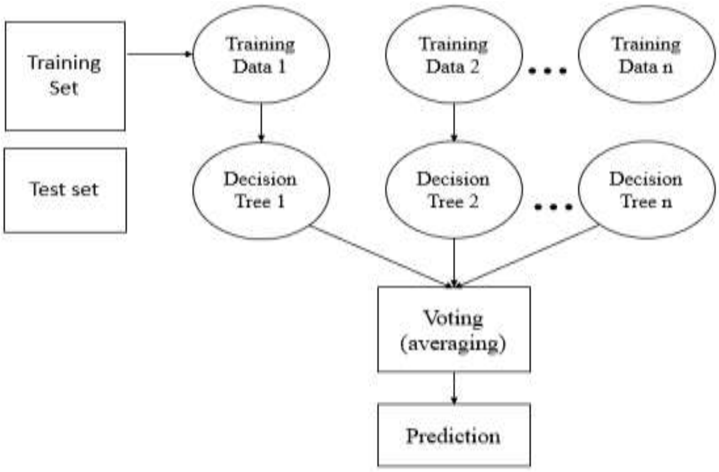

Fig. 2: Random Forest algorithm.

Random Forest algorithm

Step 1: In Random Forest n number of random records are taken from the data set having k number of records.

Step 2: Individual decision trees are constructed for each sample.

Step 3: Each decision tree will generate an output.

Step 4: Final output is considered based on Majority Voting or Averaging for Classification and regression respectively.

Important Features of Random Forest

- **Diversity**- Not all attributes/variables/features are considered while making an individual tree, each tree is different.
- **Immune to the curse of dimensionality**- Since each tree does not consider all the features, the feature space is reduced.
- **Parallelization**-Each tree is created independently out of different data and attributes. This means that we can make full use of the CPU to build random forests.
- **Train-Test split**- In a random forest we don't have to segregate the data for train and test as there will always be 30% of the data which is not seen by the decision tree.
- **Stability**- Stability arises because the result is based on majority voting/ averaging.

Assumptions for Random Forest

Since the random forest combines multiple trees to predict the class of the dataset, it is possible that some decision trees may predict the correct output, while others may not. But together, all the trees predict the correct output. Therefore, below are two assumptions for a better Random Forest classifier:

- There should be some actual values in the feature variable of the dataset so that the classifier can predict accurate results rather than a guessed result.
- The predictions from each tree must have very low correlations.

Below are some points that explain why we should use the Random Forest algorithm

- It takes less training time as compared to other algorithms.

- It predicts output with high accuracy, even for the large dataset it runs efficiently.
- It can also maintain accuracy when a large proportion of data is missing.

Types of Ensembles

Before understanding the working of the random forest, we must look into the ensemble technique. Ensemble simply means combining multiple models. Thus, a collection of models is used to make predictions rather than an individual model. Ensemble uses two types of methods:

Bagging– It creates a different training subset from sample training data with replacement & the final output is based on majority voting. For example, Random Forest. Bagging, also known as Bootstrap Aggregation is the ensemble technique used by random forest. Bagging chooses a random sample from the data set. Hence each model is generated from the samples (Bootstrap Samples) provided by the Original Data with replacement known as row sampling. This step of row sampling with replacement is called bootstrap. Now each model is trained independently which generates results. The final output is based on majority voting after combining the results of all models. This step which involves combining all the results and generating output based on majority voting is known as aggregation.

Boosting– It combines weak learners into strong learners by creating sequential models such that the final model has the highest accuracy. For example, ADA BOOST, XG BOOST.

4. RESULTS AND DISCUSSION

Hospital server:

This figure depicts the primary interface of the hospital server application for managing and processing ambulance-related data intelligently. The figure 4 shows a screen or window within the GUI where users (possibly administrators or analysts) can select a dataset for analysis or model training.

Figure 3: Main GUI application of proposed intelligence ambulance server side.

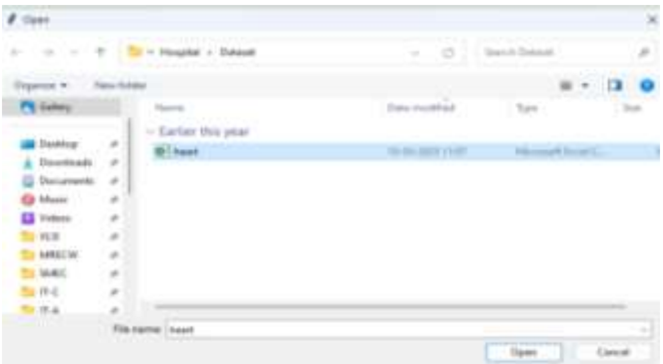

Figure 4: Selecting the dataset in the GUI application.

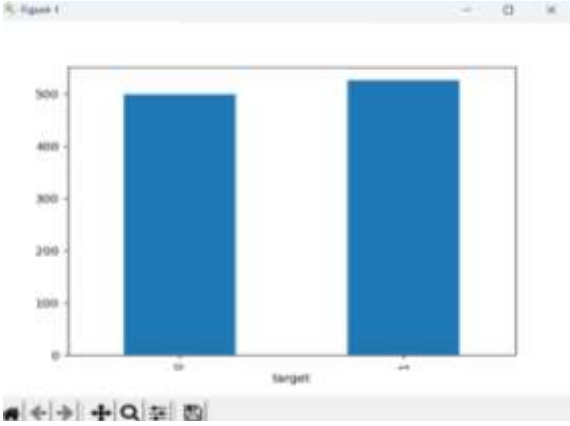

Figure 5: Displays the dataset and count plot of target columns.

The figure 5 presents the content of the selected dataset along with a count plot illustrating the distribution of target columns, providing a quick overview of the data. The figure 6 displays the dataset after undergoing preprocessing steps, such as cleaning, transforming, or feature engineering, to prepare the data for analysis or model training.

Figure 6: Presents the pre-processed data from the dataset.

This figure 7 shows the evaluation metrics, such as accuracy, precision, recall, and a confusion matrix, specifically for a Decision Tree model applied to the dataset. The figure 8 provides performance evaluation metrics and a confusion matrix, but for a Random Forest model.

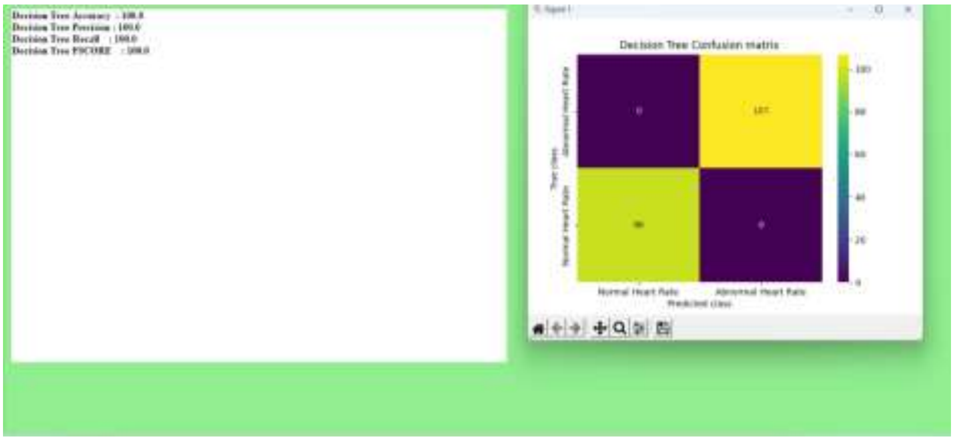

Figure 7: Displays the performance evaluation and confusion matrix of the decision tree model.

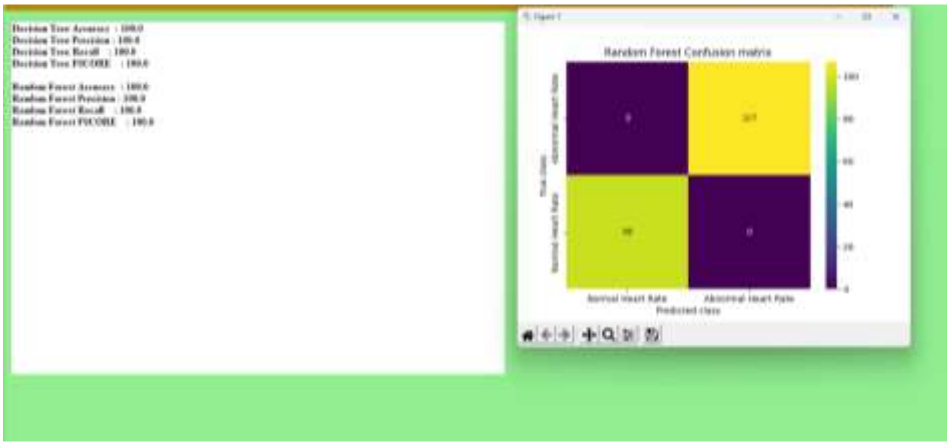

Figure 8: Displays the performance evaluation and confusion matrix of the random forest model.

The figure 9 shows performance evaluation metrics and a confusion matrix, but for a K-Nearest Neighbors (KNN) model.

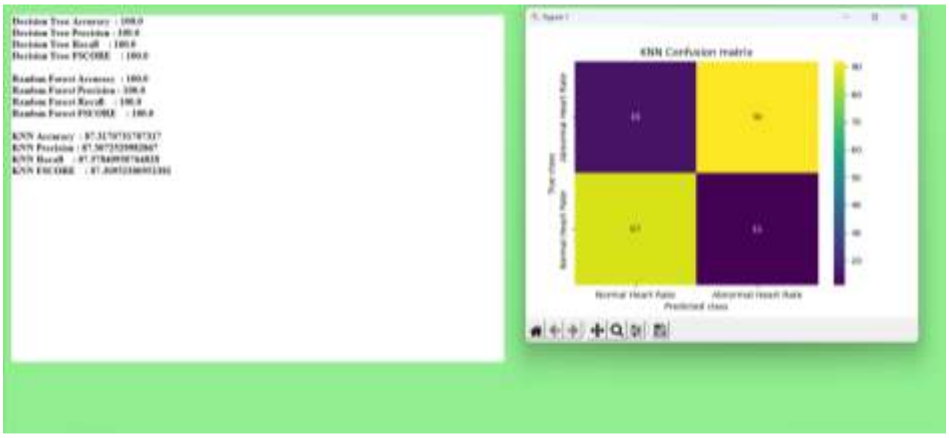

Figure 9: Displays the performance evaluation and confusion matrix of the KNN model.

The figure 10 provides a comparative analysis of performance metrics across the Decision Tree, Random Forest, and KNN models, helping users make informed decisions about model selection.

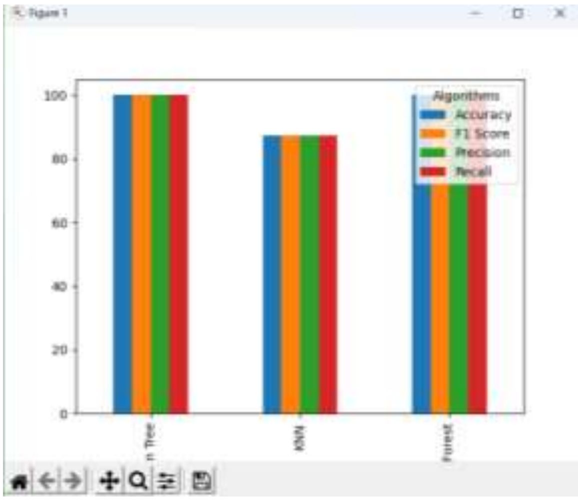

Figure 10: Displays the comparison of performance metrics in Decision Tree, RFC and KNN models.

The figure 11 illustrates the process of initiating or starting a cloud server through the graphical user interface, allowing seamless integration with cloud computing resources.

Figure 11: Displays the start of cloud server in the GUI console.

Ambulance reporting side:

The figure 12 represents the primary interface for the ambulance reporting side, providing a user-friendly platform for ambulance personnel to interact with the system.

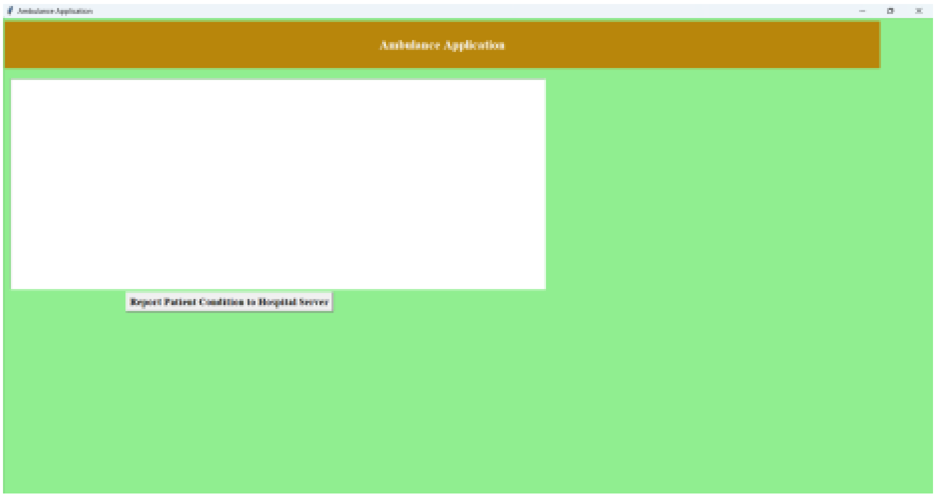

Figure 12: Main GUI application of ambulance side.

The figure 13 displays the outcomes or predictions generated by the server model based on the test data received from the ambulance side. It allows ambulance personnel to view and act upon the results.

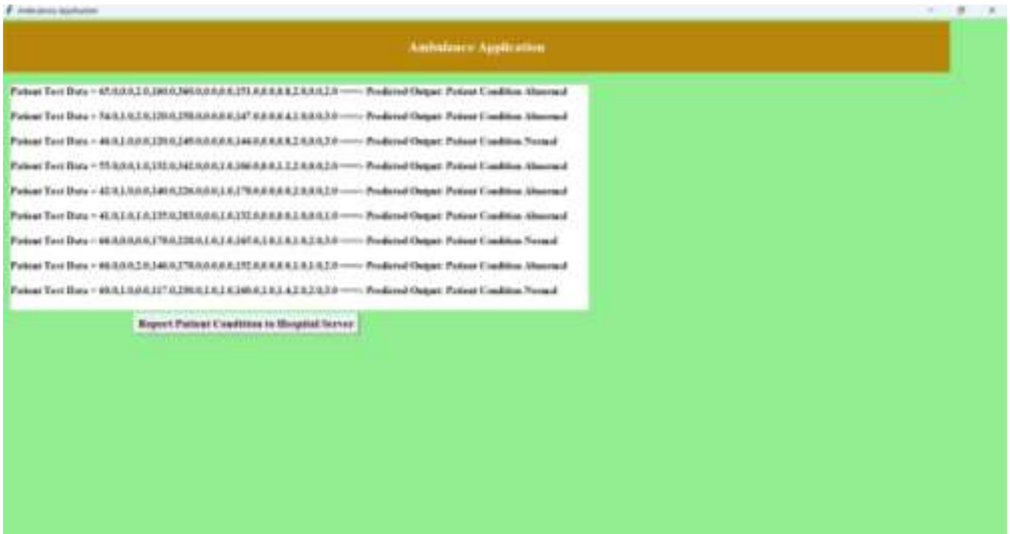

Figure 13: Represents the predication of test data by the server model.

5. CONCLUSION

The Intelligence Ambulance project, integrating AI and human interaction technologies, has showcased the potential for significantly improving emergency medical services. The incorporation of artificial intelligence into ambulance systems, coupled with advanced human interaction technologies, has resulted in a more intelligent and responsive healthcare delivery system. The project has demonstrated successful outcomes in terms of faster response times, accurate patient assessment, and improved communication between healthcare providers and patients. The synergy between AI-driven decision support systems and human expertise has the potential to transform emergency medical care, enhancing both efficiency and patient outcomes.

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