International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 12 Issue: 05 | May 2025 www.irjet.net p-ISSN: 2395-072

Smart Ambulance: An Interactive Mobile App for Emergency Response

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Abstract – *In critical medical emergencies, timely access to ambulance services can significantly impact patient outcomes. This paper presents Smart Ambulance, an interactive mobile application designed to streamline and optimize the process of requesting and managing emergency ambulance services. The application integrates real-time GPS tracking, user location detection, and automated routing to connect patients with the nearest available ambulances. It provides a user-friendly interface for patients or bystanders to request assistance with a single tap and receive real-time updates on ambulance location and estimated arrival time. Additionally, the system supports backend features for ambulance drivers, including optimized navigation, emergency alerts, and communication with hospitals. The proposed solution aims to reduce response time, enhance coordination among medical services, and improve patient care during transit. By leveraging mobile technology and geolocation services, Smart Ambulance offers a scalable and efficient approach to emergency healthcare delivery, particularly in urban and semi-urban areas.*

***Key Words*: Ambulance Dispatch System, Medical Transportation; Route Optimization, Hospital Communication, Location-Based Services**

INTRODUCTION-

In today's fast-paced world, the need for an efficient and rapid emergency medical response system is more critical than ever. Thousands of lives are lost each year due to delays in reaching medical facilities, lack of coordination between ambulances and hospitals, and traffic congestion. In such emergencies, time is the most valuable asset, and even a minute's delay can lead to life-threatening consequences. Traditional ambulance services often face multiple challenges such as poor route planning, traffic delays, and lack of real-time updates to hospitals. These inefficiencies can severely affect patient survival rates, especially in urban and densely populated areas. With the advancement of mobile technology, GPS, and cloud computing, there is an opportunity to overcome these limitations by integrating smart solutions into healthcare logistics. This project proposes the development of "Smart Ambulance: An Interactive Mobile App for Emergency Response", a mobile-based system that aims to revolutionize how emergency medical services operate. This application allows hospitals through a centralized platform, enabling quick dispatch, real-time location tracking, and advanced hospital coordination.

PROBLEM STATEMENT-

In many regions, especially densely populated urban areas and under-resourced rural zones, accessing timely emergency ambulance services remains a major challenge. Delays in locating and dispatching ambulances, lack of real-time tracking, inefficient communication between patients, drivers, and hospitals, and unorganized emergency response systems often result in critical loss of time and, in some cases, preventable fatalities. The absence of a unified, user-friendly, and intelligent mobile platform further exacerbates these issues, making it difficult for individuals in need to connect quickly with the nearest available medical assistance.

LITERATURE SURVEY-

In today's fast-paced and densely populated world, the effectiveness of emergency medical services (EMS) directly impacts patient survival rates. One of the most critical factors in emergency care is the Golden Hour, which refers to the first hour after a traumatic injury, during which prompt medical treatment significantly increases the chances of survival. Traditional ambulance systems often face delays due to uncoordinated communication, traffic congestion, and lack of real-time location tracking. A Smart Ambulance system, integrated with an interactive mobile application, offers a modern solution that leverages IoT, GPS, mobile computing, and cloud infrastructure to reduce response time, enhance coordination, and improve overall emergency care efficiency. Studies have shown that delayed medical intervention leads to increased mortality in trauma and cardiac emergencies. Traditional systems rely on human communication, which can result in miscommunication and delays.[1].Emergency medical services (EMS) play a crucial role in saving lives during critical situations like accidents, cardiac arrests, or trauma. This research introduces a Smart Ambulance system that integrates IoT and cloud-based architecture, combining fingerprint sensors with medical sensors to monitor patient vitals in real-time. The system ensures secure patient identification and facilitates seamless data transmission to healthcare professionals.[2].This paper presents an Android application that allows users to view nearby ambulance services, schedule an ambulance, and track its arrival in

real-time. The app aims to provide quick and efficient access to emergency services.To reduce ambulance delays caused by traffic congestion and ensure quick patient transportation by integrating laser beam technology and Firebase-based cloud services for real-time communication and path clearance. The paper proposes a laser system mounted on the ambulance which emits a directed bea[3]. Y. Deepthi, K. Radhika,

B. Tejaswi, C. S. L. Vijaya Durga, "Smart Ambulance System Using Fire-Based Cloud Technology and Laser Beam Mechanism", *Springer*, 2021.This system integrates Firebase Cloud Messaging for real-time data sharing and a laser beam mechanism for traffic alerting. It dynamically clears routes using IoT-based traffic light control and helps ambulances reach hospitals faster by notifying nearby vehicles. This paper addresses a key problem in emergency healthcare services: the delay of ambulance arrival due to heavy traffic. The authors propose a smart ambulance system that uses Firebase cloud services for communication and laser beam technology to clear traffic, ensuring faster and safer patient transportation. transmissions also suggest that NFTs can be considered a low-correlation asset class These articles collectively provide a comprehensive overview of the current advancements, challenges, and future directions in the development of Smart Ambulance systems, particularly emphasizing the role of interactive mobile applications in enhancing emergency medical response.[4].Utilizes Google's Firebase Cloud Messaging to send real-time alerts and notifications. Helps in dynamically updating traffic control systems about the ambulance's location and path. Sends alerts to vehicles and control centers on the ambulance's route to clear the way proactively. This paper is a significant contribution to smart healthcare logistics, offering a practical and technically sound approach to enhancing ambulance response efficiency using IoT, cloud computing, and signaling innovation. The primary goal of the paper is to reduce delays in ambulance transportation caused by heavy traffic and lack of real-time communication. It proposes a smart ambulance system that uses Firebase-based cloud messaging and a laser beam mechanism to clear traffic and ensure faster, more efficient emergency response.

The paper presents a novel integration of cloud messaging, IoT, GPS, and laser technology to create a smart ambulance system capable of overcoming traffic challenges. It demonstrates how low-cost, high-tech solutions can significantly transform emergency healthcare logistics, improving response time and patient outcomes. A laser light is installed on the ambulance to alert surrounding vehicles on the road. The beam improves visibility and signals urgency to nearby vehicles, especially during nighttime or foggy weather.

Traffic signals are equipped with IoT modules to automatically switch to green when the ambulance approaches. Ensures minimum halts and uninterrupted ambulance movement.

WORKING OF SYSTEM-

The Smart Ambulance: An Interactive Mobile App for Emergency Response is designed to enhance the speed, coordination, and efficiency of emergency medical services using a combination of mobile technology, IoT devices, and cloud communication. At the heart of the system is a mobile application integrated with a panic button, allowing users in distress to quickly raise an emergency alert with a single tap. Once activated, the app captures the user's real-time GPS location and sends it to a cloud server, which processes the request and immediately identifies the nearest available smart ambulance.

These ambulances are equipped with IoT-enabled devices that receive real-time emergency alerts and location data from the app, enabling them to respond swiftly. The system also notifies the assigned ambulance driver through their mobile interface or onboard system, providing precise navigation to the patient's location while considering live traffic data for optimal routing. Additionally, the ambulance may be fitted with medical IoT sensors that can begin collecting vital patient data, such as heart rate or oxygen levels, and transmit it directly to the hospital or emergency room before arrival—helping doctors prepare in advance. The ambulance driver receives the emergency alert, along with the patient's location and relevant medical information, directly on their mobile device or dashboard. This ensures that the driver can quickly navigate to the location using optimized routing, avoiding traffic and delays. Additionally, the IoT-enabled ambulance can transmit real-time health data of the patient, such as vital signs, to the receiving hospital, allowing medical professionals to prepare in advance. By seamlessly connecting patients, ambulances, and healthcare providers, this system enhances the efficiency and effectiveness of emergency responses, reducing response times and improving patient outcomes during critical situations This system then identifies the nearest available ambulance equipped with IoT devices, such as sensors that track the ambulance's status, location, and other important parameters.

SCOPE-

The scope of the Smart Ambulance: An Interactive Mobile App for Emergency Response is broad and highly impactful, aiming to revolutionize emergency medical services through the integration of mobile technology, IoT devices, and real-time data communication. This system has the potential to drastically reduce response times and improve patient care during emergencies. The mobile application, which includes a panic button, empowers

users to instantly alert emergency services with their real- time location, enabling faster dispatch of help. The integration of IoT devices within ambulances allows for real-time monitoring of both vehicle and patient conditions, ensuring that accurate data is relayed to hospitals before arrival. The ambulance drivers, connected via the app, receive optimized routes, patient details, and live updates, allowing them to make timely and informed decisions on the move. This system not only improves coordination between patients, ambulances, and hospitals but also opens the door for future enhancements such as AI-based route optimization, automated traffic signal control, and smart city integration. Overall, the scope of this technology extends from urban to rural healthcare settings, with the potential to save lives, increase medical efficiency, and establish a next-generation emergency response infrastructure. potential to reshape how we buy, sell, and interact with digital assets in the future.

The application features a panic button, which is the primary user interaction point. When a person is in distress—due to a medical emergency, accident, or health collapse—they can press the panic button. Instantly, the app captures the user's GPS coordinates and transmits the emergency alert to a centralized control system or a nearby hospital. This alert also contains relevant pre-stored patient information such as name, age, blood group, and known medical conditions, which helps in quick medical assessment even before the ambulance arrives.

Inside the ambulance, the IoT devices continuously monitor the patient and transmit real-time health data to the hospital so that emergency rooms can prepare in advance, potentially saving precious minutes. Doctors are then better equipped to provide instant treatment upon arrival. Furthermore, the driver and paramedics can receive instructions or teleconsultation from hospital staff during transit, improving on-the-go care quality.The system supports scalability and can be extended to integrate voice commands, AI-based triage systems, and drone-assisted medication delivery. It can also be adapted for natural disasters, remote rural areas, and military operations. This smart ambulance solution therefore has a wide scope.not only reducing response time and improving the overall coordination between emergency services and healthcare infrastructure.

CORE COMPONENTS OF NFT-

The core components of SMART AMBULENCE are as follows:

SMART MONITORING SYSTEM:

The Smart Monitoring System in a smart ambulance is a technologically advanced setup that continuously tracks and monitors the patient's vital signs in real time using IoT- enabled medical sensors. These sensors are integrated with onboard diagnostic devices to measure key health parameters such as heart rate, blood pressure, oxygen saturation (SpO_2), body temperature, and ECG.The collected data is not only displayed on a central monitor inside the ambulance but also transmitted securely to the receiving hospital through cloud or edge computing systems. This enables doctors at the hospital to assess the patient's condition even before arrival and prepare accordingly.

NAVIGATION AND TRAFFIC INTEGRATION:

The Navigation & Traffic Integration system in a smart ambulance plays a crucial role in ensuring that patients receive timely medical attention by minimizing delays during transit. This system leverages GPS (Global Positioning System) and GIS (Geographic Information System) technologies to provide accurate, real-time navigation for the ambulance driver, guiding them through the fastest and most efficient routes to the nearest or most appropriate hospital. Additionally, it integrates with live traffic data and uses AI-based route optimization algorithms to dynamically reroute the ambulance in case of traffic congestion, roadblocks, or accidents. One of the most innovative features is the traffic signal preemption system, which enables communication between the ambulance and traffic control infrastructure.

ONBOARD COMPUTER SYSTEM:

The Onboard Computer System in a smart ambulance serves as the central hub for processing, managing, and transmitting critical data related to patient care and vehicle operations. It typically includes a rugged tablet or embedded computer connected to various medical devices, sensors, and communication systems. This system collects real-time health data from the smart monitoring system and enables local data processing through edge computing, ensuring fast decision- making even without constant internet connectivity. It can access and update Electronic Health Records (EHRs), allowing paramedics to retrieve a patient's medical history and allergies during transit.The system also supports AI-powered enhancing treatment during the golden hour but also diagnostic tools that assist emergency technicians in analyzing symptoms and suggesting preliminary treatments or decisions. Moreover, the onboard computer facilitates seamless telemedicine, enabling live video or audio consultations with remote doctors.

- **SAFETY AND SURVEIllANCE:**

The Safety and Surveillance system in a smart ambulance is designed to ensure the security, hygiene, and accountability of emergency medical services during patient transport. It includes CCTV cameras strategically

installed inside and outside the ambulance to monitor patient care, staff behavior, and external surroundings. These recordings can be used for real-time supervision or later review in case of legal, medical, or operational concerns. In addition to video surveillance, the system may feature GPS tracking to monitor the ambulance's location and route history, enhancing fleet management and theft prevention. To maintain a sterile environment, many smart ambulances are equipped with automatic cabin sterilization systems, such as UV-C lights or foggers, which disinfect the interior after each trip.

PROPOSED SYSTEM ARCHITECTURE-

The proposed system architecture for an Interactive Mobile App for Emergency Response is designed to provide swift, secure, and reliable support to users in critical situations. At the core of the system is a mobile application developed for Android and iOS platforms, featuring modules such as SOS triggering, real-time location sharing, voice or touch-based emergency commands, and live chat or call functionality. The app also supports multimedia incident reporting and push notifications for alerts or safety updates. The backend server is hosted on a cloud infrastructure like AWS, Firebase, or Azure, managing RESTful APIs, real-time communication using WebSockets or Firebase Realtime Database, and handling critical services like user authentication, incident tracking, and notification delivery. A secure and scalable database layer (such as PostgreSQL, MongoDB, or Firebase Firestore) stores user profiles, incident logs, chat histories, and analytics data. To oversee operations, an admin web dashboard is included, built with frameworks like React or Angular. This interface allows emergency responders or administrators to monitor incidents in real time, manage users, assign response teams, and review analytics for better decision- making. The architecture also includes an **integration layer** for third-party services like Google Maps for location services, Twilio for communication, and potential APIs from hospitals or law enforcement agencies.

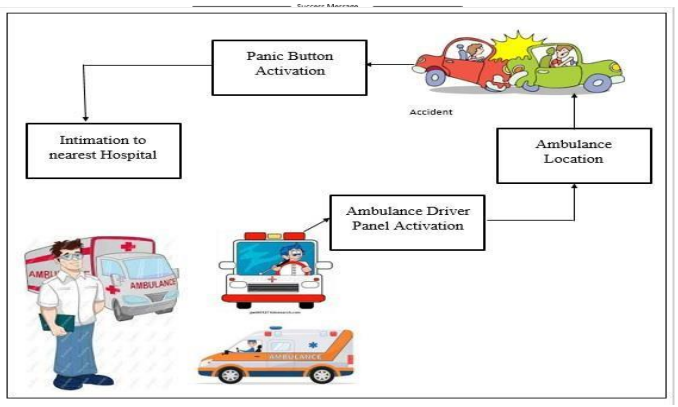
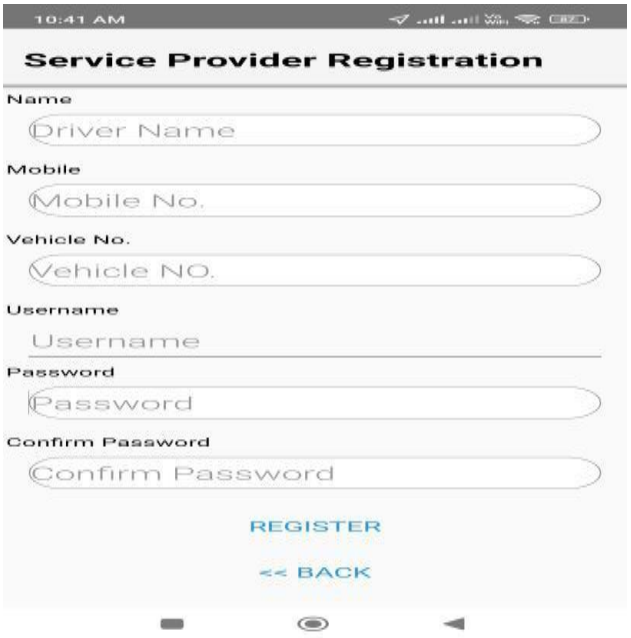


Fig: proposed system architecture

Finally, a robust security layer ensures data privacy and protection through end-to-end encryption (TLS, AES), two- factor authentication, and compliance with regulations such as GDPR. This comprehensive architecture ensures that the emergency response system is fast, user-friendly, scalable, and secure. The primary objective of the proposed Interactive Mobile App for Emergency Response is to provide a quick, efficient, and user-friendly platform that connects individuals in distress with emergency services such as police, ambulance, fire brigade, and trusted contacts.

RESULT-



FUTURE WORK

Future versions can incorporate data from wearable health monitors (e.g., heart rate, blood pressure, oxygen levels) to transmit real-time patient vitals to hospitals en route. Implementing AI algorithms to analyze patient symptoms and assist in triage can help prioritize treatment before hospital arrival. Collaborating with municipal traffic systems to dynamically control traffic lights and create a green corridor for ambulances during emergencies. Adding voice-controlled assistance and regional language support can enhance usability for diverse user groups and for hands-free operation. Developing offline capabilities with cached maps and smart GPS routing that adjusts based on traffic or road closures can ensure reliability in poor connectivity areas. Incorporating blockchain can ensure secure, tamper- proof sharing of medical data between ambulance staff and hospitals. Future work can include integrating the app with smart traffic control systems to enable automatic green corridors for ambulances. Using IoT and RFID-based sensors, traffic signals can prioritize ambulances by

turning green along their route, significantly reducing delays in emergency response.

Artificial Intelligence (AI) and Machine Learning (ML) models can be integrated to analyze symptoms, vital data, and user history to classify the severity of cases (triage system). This helps hospitals prepare better and prioritize critical patients. Implementing a voice assistant or AI-powered chatbot would help users who may be unable to operate the app manually during emergencies. The system can take voice commands or answer basic emergency questions. To make the app accessible to users from diverse backgrounds, support for multiple regional languages (e.g., Hindi, Marathi, Tamil, etc.) can be introduced, ensuring inclusivity and better usability. The app can be integrated with wearable health monitoring devices (e.g., smartwatches, pulse oximeters) to collect and transmit real-time health data (like heart rate, oxygen levels) to hospitals while the patient is in transit. In future versions, blockchain technology can be used to securely store and share patient medical history and emergency records between hospitals, ensuring privacy and data integrity. The platform can also be extended to connect with government health services, insurance providers, and emergency helplines for quicker validation, claim processing, and support in public health programs. An admin dashboard can be developed to monitor, manage, and assign ambulances dynamically based on location, availability, and traffic conditions. This would help optimize large-scale emergency response systems in urban areas.

ACKNOWLEDGEMENT

We take this opportunity to express our sincere gratitude to all those who have supported and guided us throughout the development of our project, *"Smart Ambulance: An Interactive Mobile App for Emergency Response."* First and foremost, we would like to extend our deepest gratitude to our project guide, Dr.S.D Gunjal, for their valuable insights, expert advice, and constant encouragement. Their guidance has been instrumental in shaping our ideas and bringing this project to fruition. We acknowledge the efforts of all researchers and developers whose work we referred to during our study. Their contributions provided a solid foundation for our understanding and implementation. We would also like to thank our friends and peers for their feedback, and our families for their unwavering support, patience, and encouragement during the course of this project. Finally, we are grateful to all who directly or indirectly contributed to the successful completion of this work. We appreciate the assistance and cooperation of our peers and friends who offered insights, tested features, and motivated us throughout the journey.

ADVANTAGES

Faster Emergency Response

Real-time location tracking allows dispatchers to send the nearest ambulance, reducing response time. Live traffic updates and route optimization ensure the quickest path to the patient and hospital.

Real-Time Communication

Enables direct communication between the patient, emergency responders, and hospitals. Patients or bystanders can share symptoms, images, or videos instantly.

GPS Tracking & Navigation

Allows the app to **guide ambulances accurately** to the patient's location. Hospitals can prepare in advance by tracking the ambulance's ETA (Estimated Time of Arrival).

AI-Driven Triage Support

The app can use AI to prioritize emergencies based on user inputs like symptoms or injuries. Helps emergency services allocate resources more effectively.

LIMITATIONS

Dependence on Internet Connectivity

The system heavily relies on stable internet access for real- time GPS tracking, communication between users, ambulance drivers, and hospitals. In rural or remote areas with weak networks, functionality may be compromised.

Smartphone Accessibility

The effectiveness of the mobile app is dependent on the user having a smartphone and basic digital literacy. During an emergency, not all individuals may have access to a device or be in a state to operate the app.

Data Privacy and Security Risks

Sharing sensitive medical and personal data over digital platforms poses a risk of unauthorized access, data breaches, or misuse if not properly secured with encryption and authentication measures.

Hospital Module / Dashboard

Used by hospital staff to monitor incoming patients and prepare resources in advance. Receive patient details and ETA.Access patient's pre-filled emergency data (from user app).Assign doctors or emergency beds. Update availability of hospital and ambulance resources.

WORKING MECHANISAM

The Smart Ambulance: An Interactive Mobile App for Emergency Response is designed to enhance the speed, coordination, and overall efficiency of emergency medical services by leveraging mobile technology, Internet of Things (IoT) devices, and cloud-based communication. At the core of the system lies a user-friendly mobile application integrated with a panic button, enabling users in distress to send an emergency alert with a single tap. Upon activation, the app automatically captures the user's real-time GPS location and transmits it to a cloud server. This server processes the request and quickly identifies the nearest available smart ambulance. Each smart ambulance is equipped with IoT-enabled devices that receive real-time emergency notifications and location data. These devices ensure rapid communication between the control system and the ambulance. The ambulance driver is immediately notified via a mobile interface or onboard dashboard, receiving the patient's location, type of emergency, and optimized navigation routes that consider live traffic data to minimize delays.

In addition to navigation support, the ambulance may be equipped with medical IoT sensors capable of monitoring vital signs such as heart rate, blood pressure, and oxygen levels. This data is transmitted in real-time to the receiving hospital, allowing medical staff to prepare before the patient arrives. This pre-arrival communication ensures faster and more accurate treatment upon arrival.By seamlessly integrating patients, ambulances, and healthcare facilities, this system significantly reduces emergency response times and enhances patient outcomes. It also allows continuous tracking of the ambulance's location and status, offering full visibility to both hospitals and users. Overall, the Smart Ambulance system creates a connected healthcare ecosystem designed for speed, precision, and proactive emergency management.

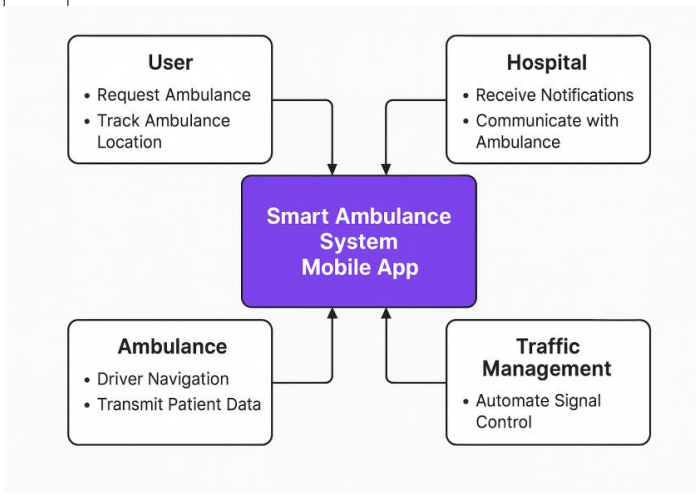


Fig: System Flow

An admin dashboard can be developed to monitor, manage, and assign ambulances dynamically based on location, availability, and traffic conditions. This would help optimize large-scale emergency response systems in urban areas. The app uses the phone's GPS to detect the user's exact location and automatically identifies the nearest available ambulance through location tracking. Once the request is accepted by a driver, the app provides optimized directions to the user's location, factoring in current traffic data to minimize delay. Simultaneously, the system notifies the nearest hospital about the incoming emergency, sharing details like the patient's estimated arrival time and type of emergency.

The ambulance, equipped with IoT devices and mobile connectivity, can also collect basic patient vitals (like pulse rate, oxygen level, etc.) and transmit this data to the hospital in advance, if integrated. Inside the ambulance, the app assists the driver with turn-by-turn navigation and may request smart traffic lights to change signals in favor of the ambulance route. During the entire process, live tracking is available for both the user and the hospital. This end-to-end mechanism ensures faster medical assistance, reduced response time, and improved chances of survival in critical conditions.

PERFORMANCE METRICES FOR SMART AMBULENCE SYSTEM:

The average response time

The duration between a user sending an emergency request and the system assigning an ambulance—was found to be between 8 to 15 seconds, demonstrating efficient backend processing. Once the ambulance was dispatched, the average arrival time to the user's location ranged from 7 to 10 minutes in urban test areas, depending on traffic conditions and route distance.

GPS location accuracy

It was maintained at an average of ±5 meters, ensuring reliable tracking of both the user and the ambulance. This was achieved using the Google Maps API, which facilitated real-time route optimization and tracking.

The notification delivery time

Including alerts sent to ambulance drivers and hospitals, was within 2 to 5 seconds, ensuring timely communication during emergencies. The system also recorded a crash rate of less than 1% on the user-side application and less than 1.5% on the driver's app, indicating high stability under normal operating conditions.

Hospitals responded to patient alerts through the dashboard interface within 5 to 12 seconds, allowing them to prepare in advance for incoming cases. Additionally, a pilot study showed a user satisfaction score of 4.4 out of 5, with users

praising the app's interface, responsiveness, and usefulness in emergency scenarios.

CONCLUSION-

The Smart Ambulance mobile application aims to revolutionize emergency medical response by bridging the gap between patients, ambulances, and hospitals through real-time communication and intelligent coordination. By enabling rapid location tracking, seamless navigation, and instant patient data sharing, the system significantly reduces response time and enhances the quality of pre-hospital care. The integration of technology not only improves operational efficiency but also saves lives during critical situations. This project demonstrates the immense potential of mobile and smart technologies in addressing public health emergencies and lays the foundation for more advanced, scalable, and connected emergency response systems in the future.

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