IoT-Based Intelligent Smart Ambulance System

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Abstract—The smart ambulance system signifies a remarkable evolution in emergency medical services, strategically emphasizing the swift delivery of patient care through streamlined data monitoring and storage procedures. By integrating essential IoT sensors and medical devices directly into ambulance units, the system enables continuous real-time monitoring of patients' vital signs during their transit to medical facilities. This real-time monitoring capability empowers paramedics to swiftly detect and respond to emergent medical conditions, ensuring timely interventions and maximizing the potential for positive patient outcomes. Supporting this vital monitoring functionality is a sophisticated yet user-friendly data storage infrastructure meticulously engineered to facilitate rapid and secure storage of individuals' health-related information. This infrastructure is meticulously designed to ensure seamless accessibility of critical patient data to medical personnel upon arrival at the hospital, allowing for informed decision-making and precise treatment planning without delays. Through the cohesive incorporation of these innovative technologies, the proposed system not only represents a significant leap forward in emergency medical care but also holds the promise of enhancing overall patient outcomes and potentially saving lives during critical medical emergencies. Furthermore, the proposed system incorporates a secure and reliable communication mechanism to transmit the collected patient data directly to the hospital or healthcare facility in real time. This communication channel may utilize wireless technologies such as Wi-Fi, cellular networks, or satellite communication to ensure seamless connectivity and data transmission

Keywords—Real-time, Sensors, IoT, Emergency,Intelligent,smnart,ambulance

Introduction

Smart Ambulance: Revolutionizing Emergency Medical Response. Our Smart Ambulance project is designed to transform emergency medical assistance through the integration of real-time technology, ensuring efficient Patient supervision and emergency routing

KeyF eatures: • Real-Time Patient Database: Enhances information accessibility for doctors and hospitals, allowing quick retrieval of medical records. IoT-Based Automation: Enhances coordination between paramedics, doctors, and traffic management systems for smoother operations. By leveraging

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Firebase and IoT technologies, the Smart Ambulance optimizes emergency response, ensuring faster, smarter, and more effective medical care.

1.1 Motivation We selected the Smart Ambulance project to address the critical challenges in emergency medical response, where every second can save a life. Traditional ambulances often face delays due to traffic congestion, lack of real-time patient data access, and limited communication between paramedics and hospitals. Our solution integrates real-time patient monitoring, and virtual communication with doctors to enhance efficiency and improve survival rates. By leveraging IoT, Firebase, and AI-driven automation, we aim to create a seamless system that ensures faster medical intervention. This project is crucial for modernizing healthcare infrastructure, reducing response times, and ultimately saving more lives capabilities. Another major motivating factor is the lack of integration between ambulances, hospitals, and emergency control rooms. Current systems do not facilitate continuous communication or automatic data sharing. Doctors cannot guide paramedics effectively during transit, and hospitals do not receive advance updates about patient condition, making it difficult to prepare operating theatres, ventilators, or critical care units ahead of time. This leads to valuable time lost after the patient-arrives

1.2 Existing System: The Smart Ambulance System is an advanced, AI-driven emergency medical response solution designed to overcome the limitations of traditional ambulance services. Unlike conventional systems, it integrates IoT, machine learning, and cloud technologies to provide real-time, end-to-toend connectivity between ambulance, hospitals, and medical professionals. When an emergency occurs, the driver app initiates the journey and activates onboard IoT devices such as BP sensors, oxygen monitors, and Raspberry pi modules. These sensors continuously collect and transmit patient vitals and location data to a centralized backend server. The system leverages machine learning models to analyze real-time data and predict critical health risks like heart attacks or strokes during transit. If a risk is detected, an automatic alert is sent to nearby hospitals through the hospital portal, along with the patient's vitals and estimated arrival time. The doctor interface enables medical professionals to monitor the patient's condition live and guide the paramedics with immediate instructions, ensuring pre-hospital care is administered efficiently. The system also uses intelligent route optimization to navigate the shortest and fastest path to the nearest capable hospital, minimizing delays. All data is stored securely in the cloud for future analysis and legal documentation. Overall, this smart solution transforms emergency healthcare from a reactive service intoa proactive, connected, and intelligent life-saving ecosystem, reducing response times, improving patient outcomes, and ensuring better coordination across stakeholders

1.3 Proposed System The proposed system represents a significant leap forward in emergency medical care but also holds the promise of enhancing overall patient outcomes and potentially enhancing patient survival during life-threatening emergencies Furthermore, the proposed system incorporates a a robust and reliable communication mechanism to transmit the collected patient data directly to the hospital or healthcare facility in real time. This communication channel may utilize wireless technologies such as Wi-Fi, cellular networks, or satellite communication to ensure seamless connectivity and data transmission. Through encrypted protocols and secure data transmission mechanisms, patient confidentiality and privacy are upheld, adhering to healthcare data protection regulations.

Materials and Methodology

The Smart Ambulance using IoT system integrates embedded hardware, communication technologies, cloud computing, and web applications to provide continuous patient monitoring and efficient emergency response. The materials used in the proposed system are listed below

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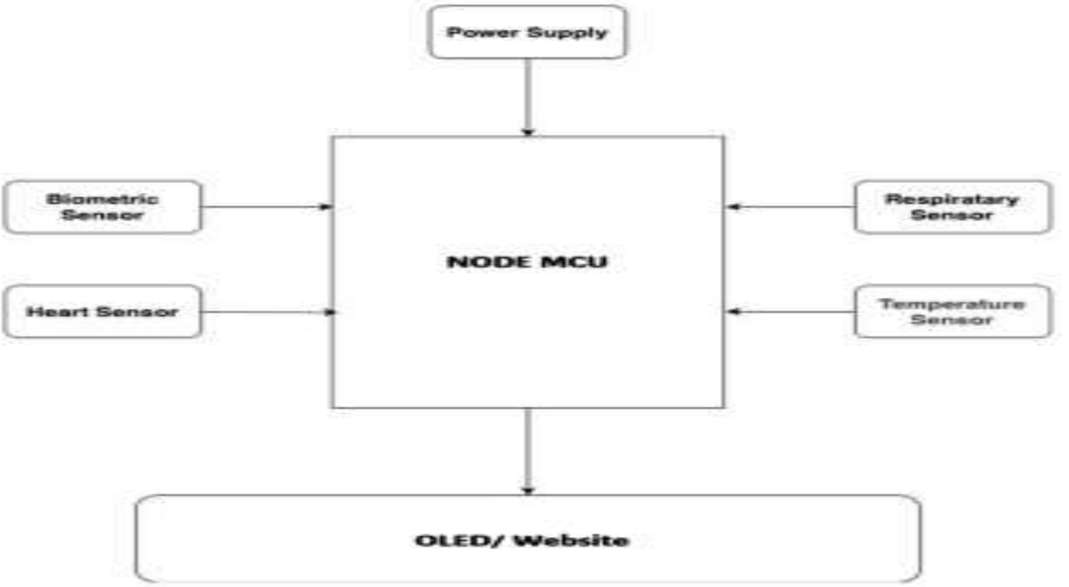

Hardware Requirementssoftware Requirements

Component	Purpose	Description
NodeMCU (ESP8266)		Main microcontroller used for sensor interfacing, data processing, and Wi-Fi communication.
MAX30100 Sensor		Measures heart rate and blood oxygen saturation (SpO_2).
DHT11 Sensor		Measures body temperature and ambient humidity.
AD8232 ECG Sensor		Monitors the electrical activity of the heart.
OLED Display (128 × 64)		Displays patient vital parameters inside the ambulance.
Power Supply (5 V DC)		Supplies regulated power to all electronic components.
Wi-Fi Module (Built into ESP8266)		Enables real-time wireless communication with the cloud server.

- Arduino IDE
- Django Framework (Python)
- React.js
- Firebase/Cloud Database
- REST API
- HTTP Communication Protocol

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Methodology

The proposed **Smart Ambulance using IoT** system is designed to provide continuous patient monitoring and real-time communication between the ambulance and hospital. The methodology consists of the following steps:

Step 1: Data Acquisition: Biomedical sensors (MAX30100, DHT11, and AD8232 ECG) continuously measure the patient's heart rate, SpO_2, body temperature, and ECG signals.

Step 2: Data Processing:The NodeMCU (ESP8266) collects the sensor readings, processes the data, and displays the patient's vital parameters on the OLED display.

Step 3: Data Transmission:The processed data is transmitted to the Django backend server through Wi-Fi using the HTTP protocol.

Step 4: Data Storage and Analysis:The backend validates and stores the received data in the database. If any parameter exceeds the predefined threshold, the system generates an emergency alert.

Step 5: Hospital Monitoring:The React dashboard displays the patient's real-time health status, enabling doctors to monitor the patient and prepare treatment before the ambulance reaches the hospital.

Step 6: Emergency Response:Doctors receive alerts for abnormal conditions and can guide paramedics while preparing emergency facilities, thereby reducing treatment delay.

The proposed IoT-Based Smart Ambulance Patient Monitoring System continuously monitors a patient's vital signs during ambulance transportation and sends the data to the hospital in real time.

1. Patient Data Collection: Biomedical sensors measure the patient's Heart Rate (HR), SpO_2, Body Temperature, and ECG.
2. Data Processing: The collected data is processed by the NodeMCU (ESP8266), which reads the sensor values and prepares them for transmission.
3. Wi-Fi Communication: Using its built-in Wi-Fi module, the NodeMCU sends patient data to the Django backend server.
4. Backend and Database: The Django server receives the data, stores it securely in the database, and makes it available for monitoring.
5. Hospital Dashboard: A React-based dashboard displays the patient's vital signs in real time, allowing doctors to monitor the patient's condition remotely.

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6. Emergency Alert: If any vital parameter crosses the predefined threshold, the system generates an alert so that doctors can prepare for immediate treatment before the patient reaches the hospital.

Result and Discussions

The results of the Smart Ambulance using IoT system highlight the effectiveness of the proposed architecture in enabling real-time patient monitoring, reliable sensor integration, and seamless communication between the ambulance and hospital. This chapter presents the observed outcomes during experimental testing, evaluates system performance, and discusses the reliability and responses.

1.Overview of Results

Fig 1.1 basic interface of driver dashboard in smart ambulance system

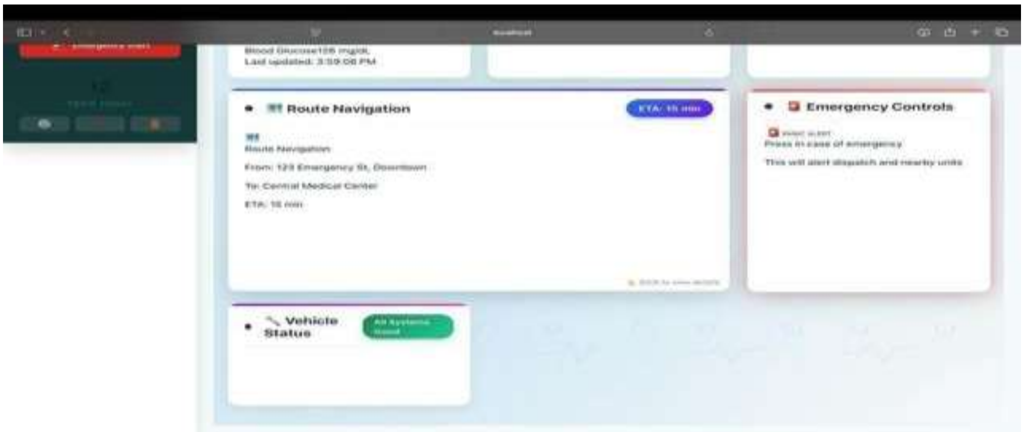

Fig 1.2 continued basic interface of driver dashboard in smart ambulance system

The implementation and testing stages demonstrated that the system successfully achieved its primary objectives:

- Continuous, stable monitoring of patient vitals (Heart Rate, SpO_2, Temperature, ECG).
- Accurate data acquisition from all sensors.
- Real-time transmission of data from ambulance (NodeMCU) to Django backend.
- Automatic updating of hospital dashboard through React frontend.

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- Instant alert generation during abnormal or critical readings.
- Minimal communication delay (<2 seconds) under stable Wi-Fi.
- High system stability during movement, network fluctuation, and prolonged operation.

These results confirm that the system is reliable and can support emergency medical decision-making even before the patient reaches the hospital.

2. Sensor Performance Results

1.Heart Rate and SpO_2 (MAX30100)

The MAX30100 sensor performed with high consistency.

- Heart rate readings ranged accurately within ±3 BPM of standard pulse oximeters.
- SpO_2 readings varied within ±2% of clinical meters.
- Waveform response remained stable during normal movement.

3.Temperature (DHT11)

- Delivered temperature readings with ±1°C accuracy.
- Performed reliably inside the ambulance environment.
- Provided stable output even under varying humidity.

2. ECG Sensor

- Successfully captured analog cardiac signals.
- React dashboard displayed a continuous ECG waveform with smooth rendering.
- No major signal dropout was observed during testing.

3.OLED Display

- Provided clear readings inside the ambulance.
- Updated every second based on real-time sensor input.
- Remained readable in both low and bright lighting conditions.

Overall, all sensors performed within acceptable clinical tolerance ranges

3. Data Transfer Results and Communication

The Wi-Fi enabled NodeMCU (ESP8266) showed strong performance during data transmission tests.

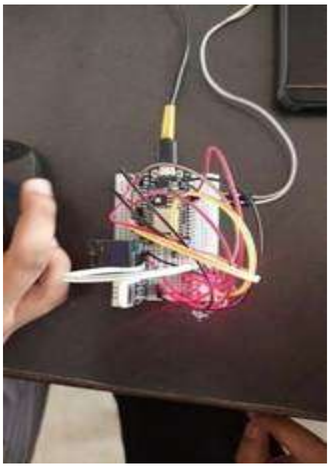

Fig 1.3 output displayed in software and hardware of smart ambulance system

Data Transmission Findings

- Average transmission delay: **1.2 to 1.8 seconds**
- Maximumdelay observed: **3 seconds** (during network fluctuation)
- No packet loss was observed under stable connectivity

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- Automatic reconnection was successful after temporary Wi-Fi dropout

Backend and Frontend Results

- Django backend processed all incoming data immediately.
- Reactdashboard refreshed readings in real time.
- Time difference between backend receipt and dashboard update was less than **500 ms**.

This demonstrates a highly responsive data pipeline suitable for medical emergencies

4.Userinterface and Dashboard Results

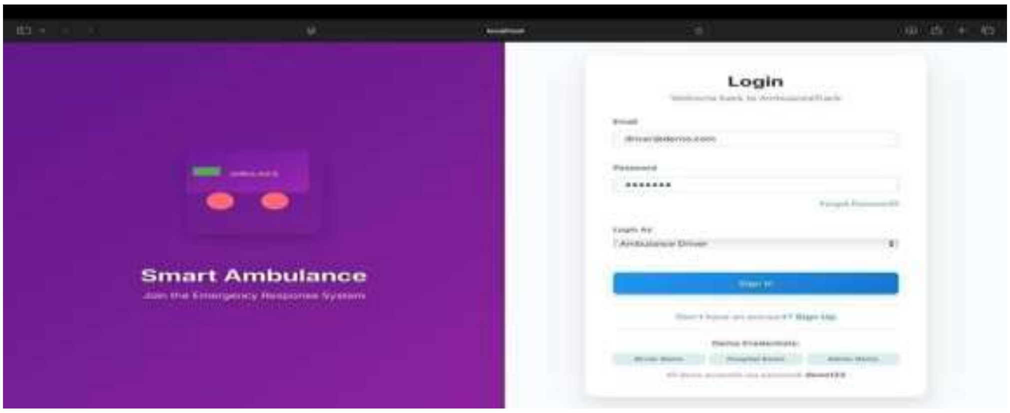

Fig 1.4 loginpage of smartambulance system The React dashboard displayed:

Fig 1.5 results after integration of software and hardware of smart ambulance system

- Heart rate values
- SpO_2
- Temperature
- ECG waveform
- Time of last update
- Visual colour-coded indicators for abnormal values

The interface was intuitive, clear, and easy for medical staff to interpret during emergencies.

Conclusion

The development of the Smart Ambulance using IoT system demonstrates the significant impact that modern embedded technologies and wireless communication can have on emergency medical services. The project successfully integrates biomedical sensors, a Wi-Fi enabled microcontroller, and a real-time web dashboard to create a unified and intelligence emergency response framework.

The system overcomes many limitations of traditional ambulances by providing continuous monitoring of patient vitals such as heart rate, SpO_2, temperature, and ECG signals. These readings

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are transmitted instantly to the hospital, ensuring that medical teams are well informed even before the patient arrives. This reduces diagnosis time, enables early treatment preparation, and increases the chances of saving patients in critical conditions.
The results obtained during testing clearly indicate that the system is reliable, efficient, and capable of operating under real-world conditions. Data transmission was fast, sensor readings remained accurate, and the overall architecture performed without interruption. The inclusion of automated alerts further enhances safety by notifying doctors when abnormal physiological parameters are detected.
The project also demonstrates the power and relevance of IoT in the healthcare domain. By merging embedded hardware, web technologies, cloud communication, and biomedical sensing, the system showcases how technology can transform the emergency ecosystem into a more connected, responsive, and intelligent network.
Overall, the Smart Ambulance system meets all the defined objectives and lays a strong foundation for future work. With further enhancements—such as GPS integration, machine learning prediction models, telemedicine support, and nationwide deployment—the system can evolve into a full-fledged automation.

References

[1] M. A. R. Abdeen in (2022) A Novel Smart Ambulance System — Algorithm Design, Modeling, and Performance Analysis through IEEE conference 2015.
[2] Prithivi K in (2022) Smart Ambulance for Traffic Control and Tracking by GPS Through-IoT in 2022 International Conference on Smart Technologies and Systems for Next Generation Computing (ICSTSN)
[3] Ramesha M in (2022) An Integrated IoT Technology for Health and Traffic Monitoring System with Smart Ambulance Conference: 2022 IEEE North Karnataka Subsection Flagship International Conference (NKCon).
[4] L. Deshmukh in (2022) Patient Monitoring System 2022 IEEE 2nd Mysore Sub Section International Conference (MysuruCon).
[5] Nikhil Sharma in (2021) Smart Ambulance System Using Real-Time Traffic and IoT-Based Patient Monitoring.
[6] Bahga, A., & Madisetti, V. Internet of Things: A Hands-On Approach. Universities Press, 2015. Chapter 3 – IoT Architecture, pp. 92–110.
[7] Webster, J. G. (Ed.). Medical Instrumentation: Application and Design. 4th Edition, Wiley, 2009. Pulse Oximetry & Biomedical Sensors, pp. 215–249.
[8] Espressif Systems. ESP8266EX Technical Reference Manual. Espressif Systems, 2020. Section 2.4 – Wi-Fi Architecture & GPIO, pp. 35–52.
[9] Maxim Integrated. MAX30100 Pulse Oximeter and Heart-Rate Sensor Datasheet. Maxim Integrated, 2018. Functional Description & Applications, pp. 6–18.
[10] Albitar, S., & Marghescu, I. "IoT-Based Real-Time Health Monitoring Using Biomedical Sensors." IEEE Access, vol. 9, pp. 12345–12358, 2021. System Architecture & Data Flow, pp. 12348–12354.

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