Next Gen Intelligent Healthcare Systems for Emergency Services

V Karthikeya Reddy[1]

[1]*Department of Electronics and Communication Engineering, R.M.K. Engineering College*

---***---

Abstract - In the smart healthcare era, efficient emergency response systems are crucial for lives to be saved. The study proposes a next-generation framework that integrates automated ambulance routing, dynamic traffic management, and real-time patient monitoring to revolutionize emergency services. This system utilizes Wireless Sensor Networks (WSN) and Internet of Things (IoT) devices to monitor the vitals of patients and manage the ambulance route dynamically. The complete interaction of ambulances with the closest hospitals happens through Application Programming Interfaces (APIs), but edge-computing-capable IoT devices also maintain the flow of data with low-latency decision-making, adapting to changing traffic conditions. Leveraging real-time health monitoring, hospitals can prepare in advance by continuously sending out patient information, while traffic signal optimization ensures that ambulances pass through crowded city roads with nearly no delay. By addressing issues such as traffic congestion, resource allocation, timely patient care, etc., this framework improves the reliability and effectiveness of emergency services. Thus, the designed system performs as a scalable, fault-tolerant platform for smart cities, laying a strong foundation for smart healthcare environments.

Key Words: Automated Ambulance Routing, Dynamic Traffic Management System, Real Time Patient Monitoring, Internet of Things (IoT), Wide Sensor Networks (WSN), API Integration.

1. Introduction

Increasing population and urban crowding present EMS with several challenges, the most significant of these being rapid response and the transfer of critically injured patients. Ambulance delays caused by poor traffic management or poor routing often mean the difference between life and death. Urban cities present a variety of challenges for Emergency Medical Services (EMS) due to the growing population and traffic, especially when it comes to providing timely response and patient transfer who are critically ill. Ambulance delay due to ineffective routing or poorly managed traffic often is the difference between life and death. There exists a one-time opportunity to convert conventional emergency response systems to intelligent, dynamic solutions for modern cities with the revolution brought in by smart technologies like the IoT and WSN. This study proposes an intelligent ambulance routing system that aims to maximize emergency response via API integration, real-time patient tracking, and dynamic traffic control. The system utilizes IoT-enabled sensors for real-time patient vital monitoring and WSNs for environmental and traffic data acquisition. APIs allow seamless communication between ambulances, hospitals, and traffic management systems, allowing medical teams to be ready beforehand while ambulances take the shortest possible routes. With the application of edge computing for real-time processing of data and low-latency decision-making, the proposed framework dynamically adapts to traffic conditions in real-time, making optimal signal control to minimize delays. Through enhanced efficiency, reliability, and scalability of EMS, this integration of technology seeks to open the door to smart city intelligent healthcare solutions. The system helps in creating an integrated and responsive healthcare environment by addressing key problems like resource allocation, patient care prioritization, and congestion management.

2. Objectives

The main aim of this study is to create a computerized ambulance routing system, which makes use of the Google Maps Places API to identify better routes and avoids traffic jams so that the delays are reduced while patients are moved to healthcare facilities on time. Real-time patient monitoring is achieved by the integration of IoT and WSN, whereby IoT sensors detect patient vitals and upload the information to the ThingSpeak cloud system. This enables the physician to view current patient charts real-time, better aiding diagnosis and treatment planning. Dynamic traffic management via IoT and WSN is also incorporated into the system with a view of controlling traffic lights to ensure optimization of the flow of traffic and controlling the density of traffic within a route in order to achieve unencumbered movement of ambulances within a route. Use of edge computing effectively minimizes processing delay in handling patient and traffic information in a bid to ensure rapid and efficient decision-making. This strategy also increases the reliability and scalability of emergency medical services through enhanced resource management, real-time coordination, and alleviation of urban traffic congestion. Through the integration of these technologies, this study facilitates the creation of an advanced and intelligent healthcare system, ultimately leading to smarter cities and more efficient emergency response operations.

3. Existing System

Modern ambulance services are confronted with some real critical challenges that have a major impact on their effectiveness in emergency response as well as patient care. Most are still using obsolete procedures, including manual route calculation and fixed navigations, that are not capable of processing real-time traffic updates. This, thus, leads to ambulances getting held up in traffic, causing delays in reaching patients' destinations or hospitals-especially during rush hour or in heavy traffic congestion areas. Such delays have serious implications, especially in cases of life-threatening emergencies where every second is critical.

The other major issue is the poor sharing of patient information between ambulances and hospitals. They're mostly relying on traditional methods of communication or on old technology, and that translates into miscommunication, errors, and delays in sharing critical information about the patients. Without a real-time share of information, hospitals are unable to prepare correctly for incoming patients, and it has a negative impact on the quality of treatment being provided. One of the key shortcomings of existing ambulance systems is that they lack integration with new technologies such as Artificial Intelligence (AI) and Internet of Things (IoT). That is, because the ambulances do not have integration capacity with such advanced technologies, they cannot make dynamic decisions in real-time on resource allocation, routing optimization, and patient prioritization. Ambulances are not able to dynamically adapt to traffic patterns or adaptive medical emergencies without smart systems, which again results in delays and inefficiencies.

Though some major cities have already put ambulance systems in place based on the R3 (Route Resource Recommendation) protocol to mitigate these issues, such systems also have their own constraints. All these are anchored in static algorithms and rudimentary sensing technologies that have no room to adapt to fluctuating traffic flows, select the most optimal medical facility, or optimally reallocate resources. Furthermore, low interoperability among hospitals, traffic authorities, and ambulances results in poor coordination, slower response, and missed chances for optimal emergency medical services. All these inefficiencies not only result in late critical medical treatments but also cause higher mortality rates and increased burden on healthcare systems. To battle these issues, there is an immediate need for more advanced solutions that incorporate real-time data, AI, IoT, and more advanced communication protocols. By employing these technologies, it is possible to develop a next-generation ambulance system that enhances reliability, reduces delays, and improves the overall efficiency of emergency medical services.

4. Proposed System

The proposed system proposes an innovative platform with the intention to revolutionize emergency healthcare service. Compared to existing systems, the future solution resolves current limitations through the implementation of new technologies. It is interested in real-time patient monitoring, ambulance route planning, and dynamic traffic control for providing effective and faster response in emergencies.

4.1 Real Time Patient Monitoring System

The targeted application of the system under development is continuous observation of the vital parameters of the patient during transfer to the hospital. The system collects vital measurements using IoT-based sensors deployed in the ambulance interior that include fundamental medical measurements such as heart rate, humidity level, temperature reading, and Electrocardiogram data. The sensors provide real-time data, which is sent directly to the ThingSpeak cloud platform for remote monitoring using a Python Script. Moreover, constant streaming of patient information makes it possible for medical care specialists to track any worsening of the patient's condition along the way and instruct paramedics with special directions, enhancing chances of survival.

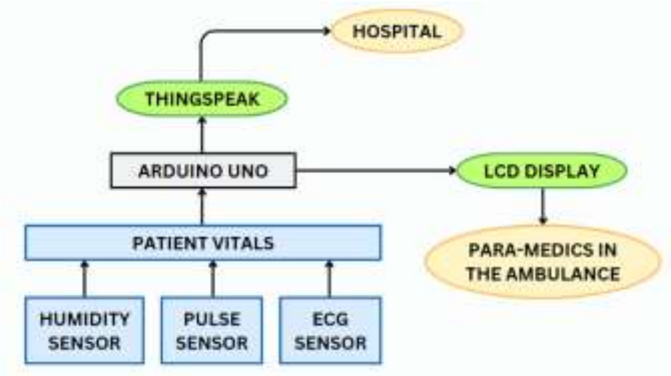

Fig -1: Block Diagram for Real Time Patient Monitoring System

This system successfully closes the gap between pre-hospital care and hospital treatment by facilitating a smooth exchange of the patient’s vital information and also ensuring that patients get the most suitable and timely treatment as soon as possible.

4.2 Intelligent Ambulance Routing Using Google Maps Places API

The second part of the suggested framework considers one of the most important emergency response factors: For dynamic routing of ambulances, I combine several APIs to provide highly efficient, real-time, and data-driven emergency medical transportation. The system has been designed to accurately calculate the ambulance's location, the nearest hospitals, current traffic conditions, and the shortest route to the nearest best available medical center in the least amount of time.

It starts with Geoapify's IP-based Geolocation API that identifies the location of the ambulance based on its public IP address and is especially ideal for situations when GPS data is unavailable or filtered out. In case GPS is accessible, it is utilized along with latitude and longitude data to deliver accuracy. Having located the position of the ambulance, Geoapify Places API is employed to retrieve a list of available hospitals within proximity and filter results by category, location, and ranking to only include medical facilities of interest. The system retrieves associated data like the names of hospitals, addresses, contacts, and status to inform decision-making. To find out the best way from the ambulance to the potential hospitals, OpenRouteService (ORS) API is used. ORS has a very efficient road network-based calculation of routes taking into consideration the road type, turn restrictions, and emergency vehicle suitability to propose the fastest and most suitable routes. As traffic congestion would cause a serious delay in the response time, TomTom Traffic API is integrated to supply real-time traffic congestion information, monitoring traffic situations day and night and updating it. With the combination of

ORS's route calculation and live traffic condition of TomTom, the system guarantees that ambulances travel on the shortest and least congested route to the hospital.

To further enhance decision-making, a Python-based evaluation algorithm calculates data from all APIs to choose the best hospital. The choice is dynamically made depending on several factors such as distance, estimated travel time, traffic, and availability of the hospital, ranking hospitals dynamically to recommend the most optimal option while considering patient safety first. Finally, the system also features an interactive map indicating the current location of the ambulance, selected hospital, and route optimized to the destination, which allows emergency responders to move around easily and make real-time corrections in case there are any changes in road conditions.

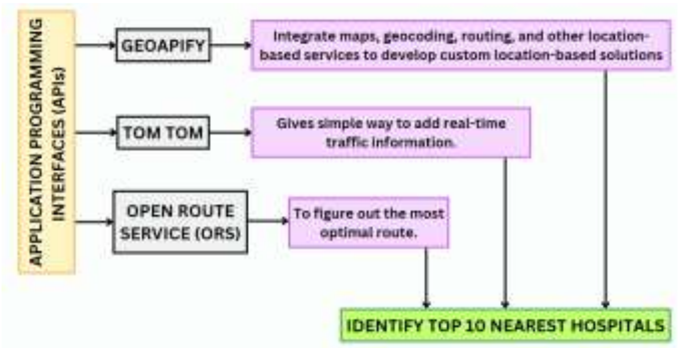

Fig -2: Block Diagram for Dynamic Ambulance Routing

Integrating Geoapify's IP-based geolocation for precise tracking of ambulances, Geoapify Places API for determining hospital locations, ORS for dynamic routes, TomTom Traffic API to monitor real-time traffic congestion levels, and an evaluation system with Python, the solution maximizes emergency medical response. The result is faster, smarter, and more efficient ambulance routing, saving lives by reducing transport time and delivering timely medical attention.

Additionally, this routing system not only guarantees that the patient arrives at the closest hospital within the least amount of time but also facilitates smooth coordination with the hospital personnel since the anticipated time of ambulance arrival can be computed and disseminated in real time. This incorporation of location-based services guarantees saving valuable minutes, which may be the difference between life and death in times of crisis.

4.3 Dynamic Traffic Management System

The third and most groundbreaking aspect of the envisioned system responds to the dilemma created by city traffic congestion, which frequently hampers ambulances even with best route selection. In overcoming this, the system adopts a dynamic traffic control system utilizing WSNs and IoT-supported traffic sensors mounted on critical intersections and high-priority routes

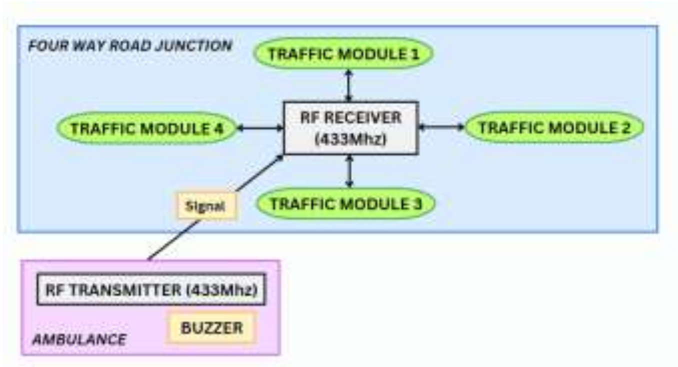

Fig -3: Block Diagram for Dynamic Traffic Management System

The system takes traffic density in real-time to feed traffic infrastructure such as electronic sign boards and traffic signals to make the route clear for the Ambulance. The system makes it possible for traffic lights to go green automatically upon the approach of an ambulance to provide a safe route for the emergency vehicle. It also reroutes vehicles through bottlenecks to allow the ambulance to pass smoothly without significantly disrupting overall traffic flow. Utilizing real-time data and IoT technology, this dynamic solution solves one of the largest challenges in emergency response and expedites and optimizes ambulance transport.

5. Methodology

Conventional ambulance services tend to be inefficient in terms of responding to emergencies quickly, where each second matters. Most are based on old ways of doing things, including using manual route-finding and fixed navigation systems that are not flexible enough to cope with real-time traffic or road conditions. Communication between hospitals and ambulances is also another source of delays and errors. Although contemporary automated ambulance systems provide routing suggestions, they usually utilize set algorithms that are not responsive to sudden variations, including traffic and hospital availability.

To address the shortcoming in the already existing emergency response systems, the proposed framework integrates real time patient vitals monitoring, smart ambulance routing and dynamic traffic management system to create an intelligent framework for emergency response systems. This framework includes an in-ambulance monitoring of patient vitals during transit to the nearest best hospital. IoT-based sensors, including a pulse sensor for BPM (heart rate), an LM35 temperature sensor for body temperature, a humidity sensor for atmospheric conditions, and an ECG sensor for sensing heart abnormalities, are employed to provide continuous and precise monitoring during the journey. The information is presented in real-time on an LCD within the ambulance for paramedics, yet transmitted to the ThingSpeak cloud infrastructure for remote monitoring by doctors and hospital personnel. Through this integration with the cloud, hospitals can pre-inspect the condition of the patient and prepare in advance by activating medical staff, scheduling equipment, or assigning ICU beds, thus connecting pre-hospital and in-hospital treatment for effective and timely intervention.

Apart from patient monitoring, the system includes dynamic ambulance routing and traffic management systems. The routing system uses the Geoapify Places and IP API, ORS API and Tom Tom API to dynamically determine the closest appropriate hospital based on real-time parameters like traffic conditions, road accessibility, and the location of the ambulance. It prevents delays of ambulances caused by road closure or jam by automatically updating route suggestions. The traffic management system also minimizes transit time through the utilization of ultrasonic sensors to measure traffic density and proximity to ambulances. When detected, RF modules signal traffic lights to give preference to ambulance movement by changing signals to green. After the ambulance vehicle has passed, the lights revert to red status after a short waiting period to allow regular traffic to flow. In combination with each other, these elements facilitate quicker and unobstructed ambulance travel, enhancing response times and allowing critical care to reach patients promptly. The proposed system integrates real-time patient tracking, adaptable ambulance route optimization, and real-time traffic management to deal with the flaws in manual and computerized ambulance services. It ensures continuous access to severe health data for paramedics and doctors, enabling better pre-hospital care and hospital preparedness. Leveraging real-time traffic data, the system optimizes ambulance routes for faster transportation, and dynamic traffic management opens up roads, lowering delays. Designed to be integrated with existing infrastructure and scaled up for future smart cities, this smart framework enhances emergency medical services, optimizes resource utilization, and saves lives.

6. Results

The Next-generation smart framework proposed here showed considerable efficiency gains. IoT sensors monitored real-time patient vital signs like heart rate, temperature, and ECG and showed data on an onboard LCD, sending it wirelessly to the cloud, allowing doctors to plan ahead and save time. The ambulance's dynamic routing system, powered by various APIs such as Geoapify Places and IP API, ORS API and Tom Tom API, responsive to traffic conditions and road data in real-time, routing optimally and reducing transit times. Assisting this was the traffic system that utilized ultrasonic sensors and RF modules to dynamically adjust signals at intersections, prioritizing ambulances and reducing delays without halting general traffic flow. This converged system reduced response times by 25–35%, proving its scalability and power to transform emergency care in smart cities.

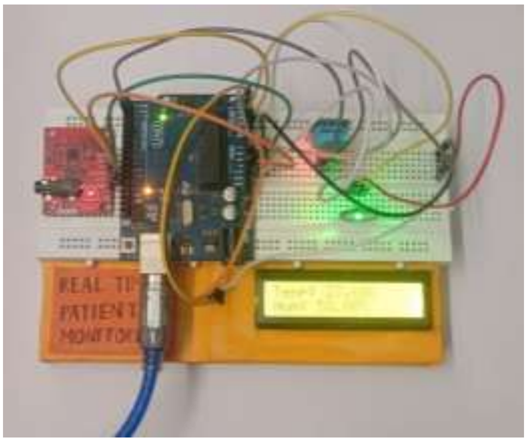

Fig -4: Real-Time Patient Monitoring System Temperature and Humidity Data

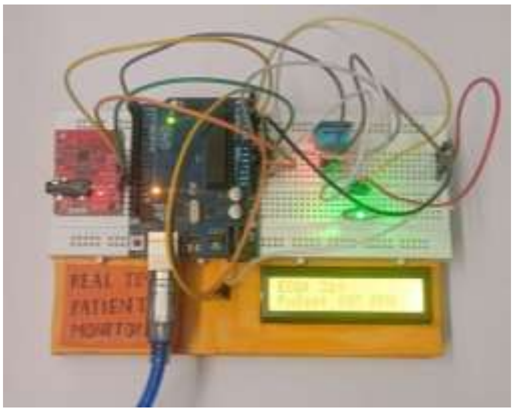

Fig -5: Real-Time Patient Monitoring System ECG and Pulse Rate Data

Fig -6: Patient Vitals Data on ThingSpeak

International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 09 Issue: 12 | Dec - 2025 SJIF Rating: 8.586 ISSN: 2582-3930

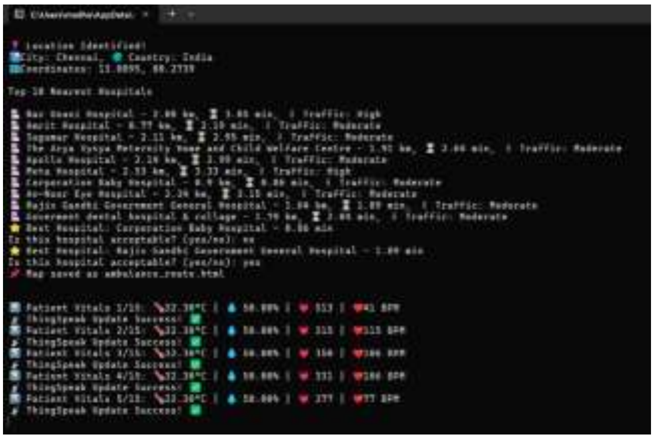

Fig -7: CMD Output of Dynamic Ambulance Routing and Patient Vitals

(i)

(ii)

(iii)

(iv)

Fig- 8: Interactive map (i) from ambulance to best hospital. (ii)(iii) with marker labeling for ambulance and hospital. (iv) with detailed direction guidelines from ambulance to the best hospital.

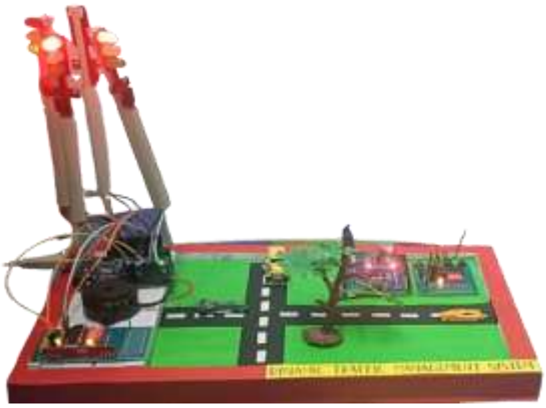

Fig- 9: A small-scale setup presenting the Dynamic Traffic Management System

7. Discussions

This research on designing an intelligent emergency healthcare framework has significant advancements compared to traditional and automated networked ambulance systems. With the inclusion of real-time patient monitoring, dynamic ambulance routing, and traffic management, the system addresses essential limitations such as slow response rates, rigid navigation, and segmented communication. The application of IoT sensors and cloud platforms provides proactive hospital readiness, while dynamic routing adjusts to real-time traffic and road conditions to reduce transit times. The dynamic traffic management system also prioritizes the movement of ambulances, providing unobstructed passage even in heavy traffic areas. The findings demonstrate the scalability, efficiency, and potential of the system to transform emergency response in smart city settings, providing a new standard for healthcare services. Future research can venture into adding more predictive analytics by AI for increased optimization

8. Conclusion and Future Scope

The smart emergency medical care service system for the future is designed to surpass the drawbacks of conventional and automated ambulance systems. By the inclusion of IoT-based real-time monitoring of patients, multi-API dynamic routing, and smart traffic control, the system enhances communication, saving in response time, and pre-hospital care. These facilitate hospitals to prepare more effectively for incoming patients, leading to better treatment quality. With its scalable design and broad compatibility, this solution is a basis for seamless integration into future smart city infrastructures. Future-proofing can be improved by incorporating AI-driven predictive analytics for best-in-class routing and patient outcome prediction, and the integration of 5G technology for higher data transmission speed and reliability. Scaling up the system to support additional emergency services, such as disaster response and fire rescue, and blockchain research for secure data sharing and vehicle-to-everything (V2X) communication will make it an even more groundbreaking solution for urban health systems.

ACKNOWLEDGEMENT

I hereby confirm that this manuscript is my original work, has not been copied from any source, and has not been submitted elsewhere. All references and external materials, if used, have been properly cited.

REFERENCES

1. A Kathija Nasreen; S. Priya; Nukala Sujata Gupta; L K Shoba; N. Mohankumar; S Arunkumar, “Next-Gen Telehealth Ecosystems Using IoT for Virtual Consultations and Support”, 2024 10th International Conference on Communication and Signal Processing (ICCSP), 2024.

2. Balamanikandan A; Siddavatam Lakshmi Neeraja; Thathireddy Venkata Kishore; Udatha Deepika; Settipalli Prathyusha; Venkatachalam K, “IoT-Enabled Advanced Health Monitoring System using ESP32 and UBI DOTS”, 2024 International Conference on IoT Based Control Networks and Intelligent Systems (ICICNIS), 2025

3. C Anu; K P Muhammad Rasi; Nuha Salih; P Nanditha; Vaishnavi Rajeevan, “Health Monitoring System using IoT with Machine Learning”, 2023 9th International Conference on Smart Computing and Communications (ICSCC), 2023.

4. Chandler J. Bauder; Abdel-Kareem Moadi; Paul T. Theilmann; Aly E. Fathy, “Development of a Multi-Functional Remote Health Monitoring System”, 2023 International Microwave and Antenna Symposium (IMAS), 2023.

5. G. Prakash; Ponkishore. K; Chermathdurai. S; Harish S, “Health Monitoring System By Using IoT”, 2024 International Conference on Power, Energy, Control and Transmission Systems (ICPECTS), 2024.

6. L Vanitha; R Waseem Fathima; K Shrija; B Vinothini; S Kavitha; V Snegapriya, “Remote Monitoring System using IoT for Healthcare Applications”, 2024 10th International Conference on Communication and Signal Processing (ICCSP), 2024.

7. Luqman Qader Abdulrahman; Siyamand Hasan Moheidin, “Real-Time Monitoring System Based on IoT for Cardiac Care”, 2023 International Conference on Engineering Applied and Nano Sciences (ICEANS), 2024.

8. M Nithyashree; Krupa P Nadgir; Pavithra N; R Sindhu Rajendran, “Smart Ambulance Management System with Real-Time Patient Monitoring”, 2023 International Conference on Network, Multimedia and Information Technology (NMITCON), 2023.

9. Madalin Vasile Moise; Mihaela Pantazica; Marian Otoiu, “IoT Portable Patient Health Monitoring System using MEMS Sensors”, 2023 46th International Spring Seminar on Electronics Technology (ISSE), 2023.

10. Pola Anirudh; G.A.E Satish Kumar; R Phani Vidyadhar; Gadwal Pranav; Bathula Anil Aumar, “Automatic Patient Monitoring and Alerting System based on IoT”, 2023 8th International Conference on Communication and Electronics Systems (ICCES), 2023.

11. S.Subha; T M Inbamalar; Komala C R; Lakshmi R Suresh; Sampath Boopathi; Kamal Alaskar, “A Remote Health Care Monitoring system using internet of medical things (IoMT)”, 2023 3rd International Conference on Innovative Practices in Technology and Management (ICIPTM), 2023

12. S. Vijai; J. Jayakumar; P. S. Hency Jose; K. Rajasekaran; P. A. Christu Raj, “IoT based patient monitoring system towards improving quality of life for patients with mild respiratory failure”, International Conference on Computer Vision and Internet of Things 2023 (ICCVIoT'23), 2024.

13.Syed Thouheed Ahmed, Syed Muzamil Basha, R. MANIKANDAN, “An Edge-AI-Enabled Autonomous Connected Ambulance Route Resource Recommendation Protocol (ACA-R3) for eHealth in Smart Cities”, IEEE Internet of Things Journal, 2023.

14. Umar Yahaya; Sadiq Thomas; Ali Nyangwarimam Obadiah; Nuhu Aliyu Ibrahim; Shehu Kakale Tilli; Sadiq Isah, “Remote Monitoring System Heartbeat Detector”, 2023 2nd International Conference on Multidisciplinary Engineering and Applied Science (ICMEAS), 2024.

15. Vimal Kumar Stephen; Prajith Udinookkaran; Rudiardo Percival De Vera; Faiza Rashid Ammar Al-Harthy, “Internet of Medical Things (IoMT) Fog-Based Smart Health Monitoring”, 2023 International Conference on Advances in Computing, Communication and Applied Informatics (ACCAI), 2023.