AI-POWERED ER TRANSPORTATION OPTIMIZATION SYSTEM WITH REAL-TIME BED AVAILABILITY MONITORING

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Apr. 9, 2024

Abstract

Timely access to emergency medical services is crucial for saving lives, particularly in cases of life-threatening conditions. However, the current process of finding available hospital beds with the available treatment is often disorganized. This research paper presents an innovative solution that uses artificial intelligence (AI) to address this problem. The proposed system utilizes AI-powered bed occupancy detection and real-time hospital bed availability tracking to streamline the communication between ambulances and hospitals that will reduce response times and improve patient outcomes. The paper discusses the technical implementation, as well as the ethical considerations surrounding cybersecurity and data privacy. The results demonstrate the potential of this AI-driven approach to save lives, optimize resource utilization, and reduce the environmental impact of emergency medical services.

Introduction

Delays in accessing emergency medical care can have dire consequences, leading to increased death rates. A study conducted in Malaysia concerning ST-elevation myocardial infarction (STEMI) patients revealed that 36% of 222 patients arrived late (>3h)[2]. One of the key challenges faced by emergency

medical services (EMS) providers is the difficulty in efficiently locating the nearest hospital with an available bed, especially in crowded urban areas. Currently, the process of finding an available bed often involves a series of inquiries to multiple hospitals or the use of outdated databases, which can cause significant delays in patient transport and treatment. The goal of this research project is to develop an AI-powered system that can streamline the communication between ambulances and hospitals, enabling faster identification of the closest available emergency room (ER) bed and optimized routing for ambulances. By using advanced technologies, such as object detection and image classification software and mobile applications, the proposed solution aims to address the communication gaps and inefficiencies that hinder the effective delivery of emergency medical care.

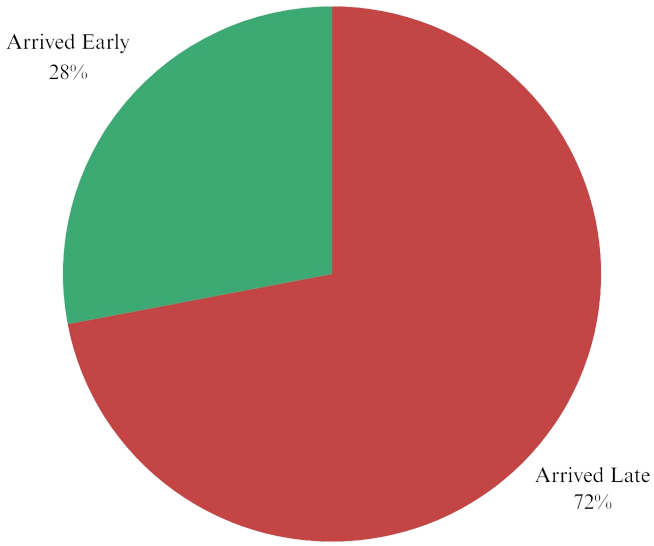

Figure 1: percentage of 539 ischemic stroke patients arriving before and after 4.5h of stroke onset in Seoul, South Korea.[1]

Methodology

A. Hardware & Software

The proposed system consists of three main components: AI-based bed vacany detection, real-time hospital bed availability tracking, and intelligent routing algorithms.

1. AI-based Bed Occupancy Detection:
    - The system utilizes custom-designed 3D-printed boxes, each equipped with a Raspberry pi 4 module and a built-in camera.
    - These boxes are placed over each ER bed, allowing the integrated camera to capture images of the bed's occupancy status.
    - Using a Convolutional Neural Network (CNN) in MobileNet with Teachable Machine to create image classification models with Tensorflow Lite object detection software to detect whether the bed is occupied or vacant.
2. Real-time Hospital Bed Availability Tracking:
    - The bed vacany information from the boxes is transmitted to a central application.
3. Intelligent Routing Algorithms:
    - The application leverages google’s maps api to analyze factors such as traffic conditions, road closures, and the proximity of hospitals with available beds.

- Based on this analysis, the system provides EMTs with the optimal route to the nearest hospital with an available ER bed, considering factors like travel time and emergency severity.

Figure 2: Steps of application use.

B. Cyber awareness

Cybersecurity and Ethical Considerations Ensuring the security and privacy of the data collected and processed by the system is of utmost importance. The following cybersecurity measures are implemented:

- SSL/TLS encryption for secure communication between the client and the server.

- Use of a proxy or Content Delivery Network (CDN) to enhance traffic security.
- Robust input validation to mitigate common application vulnerabilities, such as SQL injection and cross-site scripting (XSS).
- Secure password handling, including the use of bcrypt hashing, to protect sensitive information.

Results

Regarding ethical considerations, the system is designed to prioritize patient care and safety, without discriminating based on factors such as religion, gender, or race. The AI algorithms focus solely on optimizing resource allocation and response times to improve patient outcomes.

The implementation of this AI-driven emergency bed availability and ambulance routing system has the potential to deliver several key benefits:

1. Reduced response times and improved patient outcomes:
    - By quickly identifying the nearest hospital with an available ER bed, the system can significantly reduce the time it takes for patients to receive essential medical care, potentially saving lives.
    - The intelligent routing algorithms can help ambulances reach their destination more efficiently, further optimizing the overall response time.

2. Enhanced resource utilization and cost savings:
    - With faster turnaround times, the system can increase the availability of ambulances, reducing the need for additional resources and resulting in cost savings for emergency medical services.
    - Reduced fuel consumption and maintenance costs due to more efficient ambulance routing can also contribute to overall cost savings and environmental benefits.
3. Scalability and adaptability:
    - The modular design of the system, with its bed occupancy detection and centralized application, allows for easy scalability and integration with additional hospitals and emergency medical facilities.
    - The AI-driven algorithms can continuously learn and adapt to changing conditions, such as traffic patterns and hospital bed availability, to maintain optimal performance over time.

Discussion

A. Future work & application

Our project costs approximately $80 and its potential for scalability and integration into broader services underscores its market appeal. Future plans such as in-app ambulance summoning, severity-based medical condition classification, and connecting EMS protocols with the hospital's capabilities.

B. Conclusion

This research paper presents an innovative AI-driven solution to address the challenges faced by emergency medical services in locating available hospital beds and optimizing ambulance routing. By leveraging advanced technologies, such as object detection, image classification models, and intelligent algorithms, the proposed system has the potential to save lives, improve resource utilization, and enhance the overall efficiency of emergency medical care. The implementation of robust cybersecurity measures and the consideration of ethical principles ensure the system's integrity and societal impact. As the demand for timely and effective emergency medical services continues to grow, this AI-powered approach offers a promising way to transform the way ambulances communicate with hospitals and deliver critical care to those in need.

References

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