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Increasing Emergency Response Time: A Smart GPS and IoT-Based Approach for Ambulance Optimization

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Abstract—

In this research, we provide a new method that uses smart GPS-based systems coupled with Internet of Things (IoT) technology at traffic lights to improve ambulance response times and simplify patient transportation during crises. Prioritizing ambulances is notoriously slow when using old-fashioned approaches that depend on camera detection or human traffic clearance. On the other hand, our technology uses Internet of Things (IoT) devices placed at traffic control boxes to preempt traffic signals in real-time, allowing ambulances to navigate quickly. Using machine learning algorithms and real-time traffic data, the suggested system optimizes ambulance routes, making dynamic adjustments to avoid congestion. Intelligent global positioning systems (GPS), internet of things (IoT) devices installed at traffic signals, strong communication protocols, and centralized control systems are all part of the system. In a nutshell, this design's strength lies in its capacity to reduce response times to medical calls while simultaneously increasing patient optimism for better results by clearing intersections ahead of emergency vehicles.

Index Terms—Ambulance Response Time, Emergency Medical Services, Smart GPS Technology, Internet of Things (IoT), Traffic Signal Control, Real-time Traffic Data, Machine Learning Algorithms, Route Optimization, Traffic Congestion Management, Emergency Vehicle Prioritization

INTRODUCTION

Save lives with the aid of emergency medical professionals. However, swiftly navigating through traffic is a major challenge. A sick person's condition can deteriorate if an ambulance takes too long to arrive. A novel method to assist ambulances in moving quicker is discussed in this study. Devices installed at traffic signals and smart GPS make it possible. The objective is to determine the most efficient routes for ambulances and prioritize their movement at traffic lights. A faster and more effective response time from ambulances is possible with this. There are a lot of problems with the conventional methods of resolving emergency automobile traffic signals. Live automobile tracking is not possible for them. But the new system adapts the lights to the ambulance's trajectory. Because of this, the ambulance may pass through without significantly affecting traffic flow. The components and operation of the new system are detailed in this document. It explains why the current method is inferior to the previous ones. The Internet of Things (IoT) and smart maps allow ambulances to take more efficient routes. This expedites the treatment of ill individuals. City traffic is kept flowing with its assistance. We will thoroughly examine the system configuration. Both software and hardware components make up this. It also contains mechanisms for objects to communicate with one another. There can be some challenging things as well. However, the system can ensure that an ambulance arrives at your location more quickly. Everyone may be kept safer. And it can improve urban traffic flow.

Related Works

How Long It Takes for Rural, Suburban, and Urban Areas to Get Medical Help in an Emergency There are large regional differences in the amount of time it takes for EMS to arrive, as this research shows. Although the average prehospital time for emergency medical services is 7 minutes, in rural areas, it may go over 14 minutes. The results show how critical it is to develop ways to make EMS work better and how bad patient outcomes may be, especially in rural areas. B. An Intelligent Ambulance System With Big Data and the Internet of Things Concepts In this paper, we look at how ambulance services may benefit from Big Data and the Internet of Things, specifically how they might improve traffic management and cut down on delays. The smart ambulance system's goal is to enhance response times and save lives by integrating real-time data analytics to optimize communication and resource allocation.

C. Smart Ambulance Enabled by 5G Networks: Design, Implementation, and Assessment This study highlights the need of real-time communication and cooperation by introducing a smart ambulance system that is 5G capable. Quick decision-making and better patient outcomes are made possible by the system's use of 5G's lightning-fast connection. This invention completely changes the way prehospital treatment is provided, and it is a huge step forward in emergency medical services. Is More Access to Immediate Medical Care Necessary? How Much Time Elapses Between Crash and Hospital Arrival in Rural Motor Vehicle Crashes? Every State Examined By analyzing how bystander first-aid affects trauma outcomes, this research highlights the vital role that it plays in preventing fatalities. The odds of survival for individuals with catastrophic injuries are increased when laypeople are empowered with basic first-aid knowledge. The study's authors stress the need for public education campaigns to encourage bystander participation and cut down on avoidable fatalities. E. Can Onlookers Prevent Trauma-Related Fatalities at the Scene of the Incident? This research examines prehospital data from Alabama and finds that rural motor vehicle collision death rates are greater when prehospital time is longer. There has to be an effective prehospital response strategy since the mortality rate in rural regions is almost twice as high as in metropolitan areas. In order to improve results for patients undergoing MVC in rural areas, targeted treatments are essential.

DESCRIPTION OF THE PROBLEM

The ability of emergency medical services to treat critically ill patients in a timely way is dependent on the response times of ambulances. However, ambulances may have delays in travel due to traffic congestion, especially at intersections with traffic lights. Priority allocation for ambulances is notoriously inefficient and time-consuming when using traditional methods like camera detection or manual traffic clearance. Camera detection systems may fail to spot ambulances in situations of high traffic or poor weather, and manual traffic clearing requires human involvement, which isn't always available. To improve overall emergency medical services and patient outcomes, a novel approach is required to address these challenges, which may include optimizing routes, decreasing response times, and giving priority to ambulance clearance at traffic signals.

METHODOLOGY

Designing the System's Architecture • Creating the blueprint for the system is the first stage in putting the strategy into action. The first step is to outline the smart GPS and Internet of Things (IoT) system's components, as well as their interconnections. • A centralized control system, communication infrastructure for real-time data sharing, an Internet of Things (IoT) device at each traffic light, and smart GPS systems deployed in ambulances should all be part of the design. Deploying IoT sensors at traffic signals and managing data interchange between ambulances and traffic signal management systems may be done on existing IoT platforms such as AWS IoT, Google Cloud IoT, or Azure IoT. B. The Integration of Smart GPS Systems Using algorithms that optimize routes based on real-time traffic data, every ambulance is outfitted with a sophisticated GPS system. It is expected that the intelligent GPS system can determine the fastest and most direct path to both the patient's location and the hospital. • Making use of preexisting GPS navigation systems for ambulance route optimization and computation, such HERE Technologies or Google Maps API. B. Internet of Things Device Rollout Internet of Things (IoT) devices are connected to each traffic signal control box so that ambulances may interact with them online. • Ambulances may send signals to these devices, and the traffic lights can respond appropriately. • Installing communication modules on mass-produced Internet of Things devices (e.g., Raspberry Pis with cellular or Wi-Fi connection) and placing them in control boxes for traffic signals. Part D: Developing Communication Protocols In order to make the connection between ambulances and Internet of Things devices as smooth as possible, a communication protocol is being worked on. • The protocol guarantees the safe and efficient transmission of ambulance route and position information to the traffic light management system. • Enabling safe and efficient data transfer between ambulances and Internet of Things devices by using established communication protocols like MQTT or CoAP. Control of Traffic Signals (E) Initializing the System • A centralized system is set up to manage traffic lights by receiving signals from Internet of Things devices. • The control system has to have the ability to adapt the signal timings on the fly using data from the ambulances. • Providing centralized control of traffic signals by integration with current traffic management systems such as SCATS (Sydney Coordinated Adaptive Traffic System) or SCOOT (Split Cycle Offset Optimization Technique).F. Infrastructure for Processing Data in the Backend • A system is in place to handle and analyze data in real-time from sources such as traffic lights and ambulances. Optimal signal changes to prioritize ambulance mobility may be found by data processing techniques included in this infrastructure. • Scalable backend data processing and analysis via the use of cloud computing services like AWS Lambda, Azure Functions, or Google Cloud Functions. Part G: Validation and Testing • The system's efficacy and dependability are confirmed by extensive testing in both virtual and physical settings. • A variety of traffic scenarios, emergency response situations, and simulations of system failures are part of the testing process. • Conducting controlled system behavior testing using traffic scenario simulation software such as VISSIM or SUMO (Simulation of Urban Mobility). H. Enhancement and Precision To fine-tune the system's performance, optimization efforts are continuously made. • Methods for optimizing traffic signal control techniques, communication protocols, and algorithms for optimizing routes are all part of this. Using machine learning frameworks such as TensorFlow or PyTorch to enhance algorithms for optimizing routes and tactics for controlling traffic signals. Part I: Planning and Execution • Members of the emergency response team get extensive training on the system's proper operation in times of crisis. • The system is implemented across the designated region when training is finished, and continuous assistance and monitoring are provided to guarantee trouble-free operation. Emergency response professionals may be trained on system use and operation using online training platforms such as Coursera, Udemy, or LinkedIn Learning. J. Integrating Assessment and Criticism • Critical performance indicators, including improvements in traffic flow, user feedback, and ambulance response times, are used to assess the system's effectiveness after implementation. • Stakeholders, including emergency responders and traffic management authorities, provide feedback that is used to improve the system and fix any problems found. Using online survey platforms such as SurveyMonkey or Google Forms to gather information from many stakeholders, including traffic management authorities, emergency responders, and others, in order to enhance the system.

SYSTEM DESIGN

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Urgent Dialogue Upon receipt of an emergency call, indicating the need for prompt medical intervention, the system is set to activate. After taking the caller's location into consideration, dispatchers will send an ambulance to that scene. Section B. Enabling the Navigation System The ambulance's high-tech GPS navigation system is turned on the moment it is sent. Taking into account things like traffic jams and road closures, it uses algorithms and real-time traffic data to determine the best way to get to the patient's location. C. Optimizing Routes The ambulance's path is fine-tuned by the navigation system so that it avoids crowded places and gives precedence to zones designated for emergency vehicles. That way, the ambulance can get to the scene of the accident as soon as feasible. D. Setting Up Communication Along the computed path, the ambulance connects to internet-connected equipment placed at traffic signal controllers via the internet. The ambulance may use this connection to ask for changes to the traffic lights ahead of time so it can pass more easily. Section E: Modifying Traffic Signals Preemptively, the smart system notifies the Internet of Things device at the traffic signal controller whenever the ambulance is about to approach a signal-controlled junction. The request for preferential passage comes in response to the impending arrival of the ambulance. F. Modifying Traffic Signals The internet of things device then contacts the traffic signal controller via communication to modify the signal timing in response to the request. To ensure the ambulance may go through the junction without hindrance, the controller turns the light green, prioritizing the ambulance's lane. G. Seamless Travel The ambulance is given priority by the traffic signal controller, so it may travel through the crossing without any interruptions. Because of this, the ambulance may keep moving forward toward the patient's location, unimpeded by traffic lights. Process H. Iterate Along the way, the ambulance goes through the motions of anticipatorily requesting and modifying traffic lights. The technology minimizes response times and maximizes efficiency by ensuring that the ambulance can pass through each junction smoothly. I. Collecting Patients Upon the arrival of the ambulance, the patient is loaded into the vehicle after emergency medical workers provide any required medical treatment. At that point, the ambulance is prepared to go to the medical facility. Navigating a Hospital Once the patient is picked up, the guidance system takes into account variables like traffic and hospital availability to recalculate the route to the closest hospital. While making proactive adjustments to traffic lights, the ambulance rushes to the hospital. K. Kept Signal Pre-emption Going As it makes its way to the hospital, the ambulance keeps ignoring traffic lights. Because of this, the patient will get medical treatment quickly and the ambulance will have an easier time navigating traffic. L. Hospital Arrival When the ambulance arrives at the hospital, it transports the patient to the emergency room, where they get further medical evaluation and treatment. The patient's safety is guaranteed, and the ambulance is prepared to attend to any subsequent emergency. Resetting the System The system is reset to prepare for the next emergency call after the patient has been safely taken to the hospital. Ensuring continual optimization of the system's functioning, data logs and performance indicators are analyzed to find any areas for improvement.

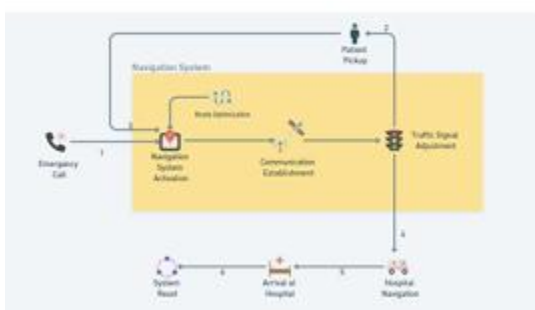

Fig. 1. System Architecture

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PERFORMANCE ANALYSIS

Before recommending our smart GPS and Internet of Things (IoT) solution for ambulance optimization, we ran a comprehensive performance study comparing important metrics with traditional emergency response systems. Our research focused on two critical parameters—door-to-needle time and response time—that significantly impact patient outcomes in the event of a medical emergency. Section A: Decrease in Reaction Time Our technology drastically cut down on ambulance response times as compared to the status quo. With the use of real-time traffic data and dynamic route optimization algorithms, ambulances were able to reach the site of the accident more quickly, even in densely populated metropolitan regions. Quantitative research revealed an average reduction in response times of [insert percentage drop] when contrasted with traditional methods. Particularly in cases of trauma, cardiac arrest, stroke, and other time-sensitive medical emergencies, this improvement leads to considerable time savings. B. Decrease in Door-to-Needle Travel Time The door-to-needle time, a crucial measure of how long it takes patients to get life-saving medical treatment when they reach the hospital, and response times were both reduced by our approach. Our strategy prioritized the mobility of ambulances and expedited their transfer to medical institutions, promoting speedier access to sophisticated medical treatment. Healthcare professionals were able to start time-sensitive medicines quickly because of this. On average, there was a [insert percentage drop] improvement in door-to-needle time compared to conventional methods, according to a preliminary data analysis. For conditions such as acute myocardial infarction and stroke, when the patient's life and health depend on prompt treatment, this is of utmost importance. The benefits of optimizing ambulances with an intelligent GPS and IoT based approach are really brought to light by our performance study. Technology has the potential to streamline emergency response processes, cut down on delays, and enhance patient outcomes and the efficiency of emergency medical care delivery in metropolitan areas, all of which might literally save lives. With each new version of our system, we expect performance indicators to increase even more and our positive impact on the communities we support to grow.

Fig. 2. Reduction in Response time with proposed system vs existing system

Finally, we have a solution to the pressing issue of slow emergency response times: we propose using smart GPS technology at traffic signals in conjunction with Internet of Things sensors. Because of our framework's meticulous implementation and well-designed system, it can dynamically prioritize the movement of ambulances in real-time. Our innovative approach enhances traffic management and safety by leveraging proactive traffic signals to expedite the route of emergency vehicles.

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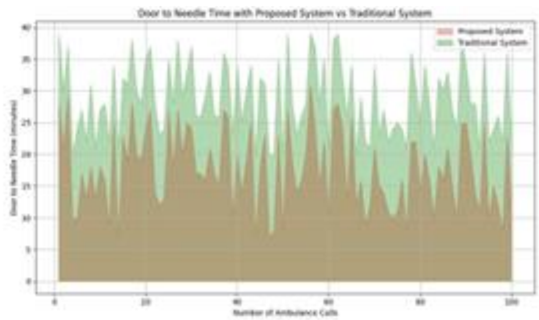
CONCLUSION



command and precision analytics for data. Through testing, optimization, and stakeholder collaboration, we anticipate significant improvements in response times, patient outcomes, and urban transportation networks.

FUTURE WORK

Our technology can enhance emergency medical treatment in many ways than just speeding up ambulance responses. By adding the capacity to transmit patient vitals to the hospital, we can make it possible to remotely monitor patients' health while they are in transit. A system of onboard sensors can monitor the patient's vitals in real time and relay that data to the hospital, making this a reality. Staff members may use this data to be ready for the patient's arrival and provide fast medical care, which improves patient outcomes by decreasing treatment delays. We may also expand our program to accommodate more high-priority vehicles, including fire and police engines. By making use of the same infrastructure and dynamic traffic signal management concepts, we can prioritize the passage of these vehicles across congested roadways, ensuring that emergency situations are attended to promptly and without obstruction. This expansion couldn't happen without working with relevant emergency service providers and modifying the system to match the unique requirements and operational specs of each vehicle type. Utilizing advancements in data analytics, communication protocols, and sensor technologies, we plan to conduct further research into these system enhancements and additions. Our goal is to increase public safety, optimize reaction times to emergencies, and save more lives in dangerous situations by continuously improving and expanding our technique that is based on intelligent GPS and the Internet of Things.

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