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Article

# Li-Erts - Light Fidelity Based Emergency Response Using V2v Communication And Hospital Allocation System

**Chitra Kiran N[1] Poorvi G[2] Nithin K R [3] Rumani P Jain[4] Kavya K[5]**

[1]Department of ECE Alliance University, Bengaluru, India chitrakiran.n@alliance.edu.in
[2]Department of ECE Alliance University, Bengaluru, India gpoorvibtech21@ced.alliance.edu.in
[3]Department of ECE Alliance University, Bengaluru, India knithinbtech21@ced.alliance.edu.in
[4]Department of ECE Alliance University, Bengaluru, India prumanibtech21@ced.alliance.edu.in
[5]Department of ECE Alliance University, Bengaluru, India kkavyabtech21@ced.alliance.edu.in

**Abstract:** As the road traffic and congestion increases in urban areas, the effectiveness of emergency response systems becomes an absolute necessity to save lives in accidents. Radio frequency communication and Manual reporting-based conventional systems take time, which may be too heavy a lag. As against this, this solution presents an accident detection system utilizing onboard sensors and automatically establishing communication with passing vehicles via Li-Fi, a safe, high speed and interference free data communication medium. The system not only sends vital data like the location and severity of the accident but also identifies the closest and best hospital for patient transport based on traffic, hospital availability and proximity. By combining smart decision-making algorithms with hardware such as microcontrollers and Li-Fi by transmitters, the research presents prototypes that work with minimal human intervention. The aim is to minimize the golden time between an accident and receiving medical care, hence the increased chances of survival. The application of Li-Fi provides stable communication in areas with high chances of signal interference, and hence, the system is extremely appropriate for Smart City Infrastructure. This research adds to the advancing domain of intelligent transportation systems and emergency automation and presents a scalable and innovative model in line with the quest across the world to improve safer and smarter urban mobility solutions.
**Keywords:** Key City Infrastructure, Vehicle-to-Vehicle Communication, Intelligent Transportation Systems .

## 1. Introduction

With the Rapid advancement in smart transportation technologies, the integration of real time communication between vehicles has emerged as an important component of intelligent transport system. Among these innovations, vehicle to vehicle communication has gained prominence for its potential to reduce road accidents, enhance traffic management and improve safety by enabling vehicles to exchange critical information directly.

### *1.1 V2V COMMUNICATION*

Vehicle to Vehicle communication is a wireless technology that enables vehicles to communicate directly with each other by exchanging real time data such as speed ,position acceleration, breaking status, direction and other relevant information. This exchange of information allows vehicles to anticipate and react to potential hazards by enhancing safety, reducing collisions and improving overall traffic efficiency[1].Each vehicle is equipped with an On-board unit that allows vehicles to send and receive messages from nearby vehicles and these messages are transmitted at frequent intervals.

Communication is achieved using wireless technologies such as:- Traditional V2V communication systems utilize wireless communication protocols such as DSRC (Dedicated short-range Communications), Wi-Fi, or more recently, V2X based on 4G or 5G networks[1]. These technologies allow vehicles to share parameters such as speed, direction, breaking status and location, which helps in real Time decision making to prevent collisions and improve traffic flow. However, these RF-based methods come with certain limitations, such as susceptibility to electromagnetic interference, security risks due to signal interception and network congestion in densely populated areas. To overcome the challenges and enhance emergency responsiveness on roads. We are using Li-Fi based communication for the transfer of information between vehicles (Ambulance and the other vehicles)[1].

### *1.2 LI-FI*

Li-Fi is a wireless communication technology that uses visible light typically from LEDs to transmit data at extremely high speeds. It operates by modulating the intensity of light which is then captured and decoded by photodiodes or light sensors. Compared to traditional radio frequency methods, Li-Fi offers greater bandwidth, ultra-low latency, enhanced security and immunity to electromagnetic interference, making it particularly suitable for critical applications such as emergency vehicle communication[2].

The integration of Li-Fi into V2V communication introduces a revolutionary approach to emergency response, especially in accident prone and high-risk areas. This forms the fundamentals for our project titled LI-ERTS – Light Fidelity-Based Emergency Response using vehicle to vehicle communication and hospital allocation system..

In today's rapidly urbanizing world managing traffic congestion has become a significant challenge especially for emergency vehicles like ambulances that require Swift and uninterrupted passage through roads one of the most common method ambulances is currently used to navigate traffic is by continuously sounding loud siren or horns while this me help draw the attention of nearby vehicles. It also leads to unintended consequences such as noise pollution and increase stress levels among both patients and commuters[2]. The constant use of high decibel sirens can induce anxiety in patients who are already in a critical state and can disturb the mental peace of other drivers and pedestrians.

To address this issue are project proposes the implementation of Li-fi Technology as a communication medium between ambulances and surrounding vehicles Li-fi is a form of wireless communication that uses visible light from LED Lamps to transmit data, unlike conventional radio system such as Wi-Fi or Bluetooth, Li-Fi offers high speed communication with minimal interference , making it a promising solution for intelligent transportation systems[2].

### *1.3 Hospital Allocation*

Hospital allocation forms the building block of healthcare infrastructure, as it ensures the strategic placing of health facilities to make them accessible to communities. Efficient hospital placement helps optimize healthcare access, cut down response times during emergencies, and provide medical care where needed most. Through effective hospital location planning, healthcare stakeholders can control patient traffic, prevent congestion, and enhance the overall quality of services[3]. One of the most important parameters determining hospital allotment is the population density. Urban regions demand several hospitals with specialized units for the large pool of inhabitants, while rural zones demand well-planned primary care centers with access to efficient emergency transport facilities. Geographic accessibility too is important. Hospitals need to be located close to highways, residential areas, and public transportation to ensure ready access, in case of critical emergencies.

A further important consideration of hospital allocation is the distribution of resources. Adequate medical professionals, facilities, and specialized care units should be provided to the hospitals depending upon regional health demand. Some places need trauma care centers, cancer treatment centers, or pediatric wards so that specialized care can be given to the patients without visiting distant places. Strategically deploying hospitals according to these needs dramatically enhances healthcare efficiency[4].

High-tech technology has transformed the allocation and tracking of hospitals. GPS tracking in V2V communication enables emergency vehicles to identify the nearest medical facility and drive optimally, cutting down response times. Google Maps API integration provides hospital tracking with the ability to search for hospitals near them based on proximity, ratings, and medical resources available. This dynamic allocation system guarantees that patients get timely treatment.

## 2. Literature Review

Klein, Tom Lorenz, and Clemens Thielen. "Patient transport in hospitals: A literature review of operations research and management science methods." In 2024 International Conference on Healthcare Operations and Management Science (ICHOMS), pp. 45–52. IEEE, 2024. Hospital resource allocation and emergency transport systems have Hospital resource allocation and emergency transport systems have gained increasing attention in recent years. The reviewed work highlights the implementation of Optimization techniques and operation research strategies that are critical for efficient patient movement, especially during emergency care situations. It addresses scheduling constraints, limited ambulance availability and dynamic decision-making models that factor in real time Hospital capacities. The study outlines how simulation-based planning and integer programming models are utilized to minimize patient waiting times and improve the allocation of transport vehicles. This literature directly supports the hospital allocation aspect of the LIERTS system by emphasizing the importance of centralized coordination and data-driven dispatch system during medical emergencies. By utilizing predictive analytics and simulation tools, hospitals can enhance the overall efficiency of patient transport systems. This directly contributes to the goals of LIERTS Framework by ensuring a more responsive and adaptive Hospital allocation and transport system during emergencies.

**Sabarimani, J., Ramya, B., Gayathri, G., and Nivetha, K. "Vehicle to Vehicle Communication using Light Fidelity." was published in International Journal of Electrical Engineering and Technology (IJEET), Volume 13, Issue 2, 2022.**

With the growing demand for safer road travel and faster vehicular communication, this paper presents the use of Li-Fi technology as an alternative to RF-based systems in vehicle-to-vehicle (V2V) communication. It explains the working principle of visible light communication to transmit data between moving vehicles. The proposed system is not only faster and more secure but also immune to electromagnetic interference. The authors detail a prototype involving headlight-based LED transmitters and photodiode receivers, enabling emergency information to be quickly passed between vehicles. Such an approach lays the foundation for the V2V communication core of the LI-ERTS framework, enhancing the accuracy and speed of accident alert dissemination. The advantages of Li-Fi over traditional RF-based communication, such as its high data transfer rate and lower power consumption, making it ideal for real-time communication in vehicular networks.

**Shakkeera, H. A., Sangeetha, P., and Rajeswari, K. "Vehicle to Vehicle Communication Control Using Li-Fi Technology."was published in the International Journal of Advanced Science, Engineering and Information Technology (IJASEIT), Vol. 12, No. 2, 2022 IJASEIT, Vol. 12, No. 2, 2022.**

The authors propose a hybrid communication framework combining Li-Fi, infrared, and ultrasonic sensors for enhanced vehicle-to-vehicle communication. The system is designed to detect obstacles, prevent lane deviation, and automate emergency alert transmission. Their work also hints at integrating such networks with hospital databases for real-time response. Through a robust hardware design, including signal converters and high-lumen LEDs, the model ensures data integrity even in low-light conditions. This study contributes directly to the integrated vision of LI-ERTS by showing how vehicle data and environmental cues can be synchronized with emergency medical services to reduce response time and improve situational awareness. By seamlessly connecting vehicular networks with hospital databases, the system provides timely updates to healthcare providers, facilitating faster medical interventions and optimizing patient care during emergencies, which is central to the objectives of the **LI-ERTS** framework.

## 3. Methodology

### *A. BACKGROUND*

The hardware approach to LI-ERTS is to create a real-time emergency response system based on Light Fidelity (Li-Fi) for secure, high-speed data transmission. NodeMCU microcontrollers are utilized for processing sensor data and facilitating Vehicle-to-Vehicle (V2V) communication. The system can detect collisions and send vital information to surrounding vehicles and control units. The major components are Li-Fi transmitters, NodeMCU boards, accident detection sensors, and hospital allocation communication interfaces[3].

### *B. HARDWARE COMPONENTS*

1. **Li-Fi transmitter:** A Li-Fi transmitter modulates digital information into a source of light, typically a high-brightness LED, to act as the data source for transmission in a Light Fidelity system. An LED driver and signal processing unit control the rapid modulation of the LED's intensity or on/off condition to achieve this. These fast, imperceptible variations of light are synthesized from digital information and move through the air as a modulated light signal. By transmitting this light signal, which holds the encoded information—to a Li-Fi receiver to be decoded, wireless communication using visible light instead of radio waves becomes possible[3].
2. **Li-Fi Receiver:** The Li-Fi receiver employs a photo detector, typically a photodiode, to receive incoming data in the form of rapidly varying light signals. The photodetector converts these light variations into corresponding electrical current variations. To improve the quality of this weak electrical signal, it is then

amplified and conditioned, often through the application of a transimpedance amplifier. The initial digital data is subsequently pulled out by a demodulation device within the receiver, reversing the process of encoding that the transmitter had done and inspecting these changes in electrical signals. To finalize the wireless link that the modulated light had established, the digital information that is recovered is processed and output at last in such a way that the receiving device can utilize it[3].

3. **N**ode MCU (ESP8266 Wi-Fi microcontroller): The ESP8266 Wi-Fi microcontroller is the base of Node MCU's user-friendly, low-cost platform that has highly democratized IoT development. Owing to its pre-loaded Lua firmware, even beginners can prototype and build networked devices with ease because of its ease of programming. Since the need for extra networking components has been eliminated, the built-in Wi-Fi functionality makes hardware design easier and costs less. Moreover, the accessible GPIO pins of the development board for sensor and actuator integration and a USB interface for easy powering and programming encourage rapid prototyping and experimentation.
4. **Buzzer:** A buzzer is a low-cost, compact sound-emitting device that, upon being provided with an electrical voltage, produces a perceivable tone or buzz. Buzzers are essential components for notifications, alerts, and general sound signals in numerous electronic devices, appliances, and vehicles due to their simplicity and efficiency in returning auditory feedback. They can function electromechanically via a vibrating diaphragm driven by an electromagnet or piezoelectrically using the deformation of materials under the influence of an electric field[3]
5. **LED (Light emitting diode):** Light Emitting Diode, or LED, is a semiconductor device that, upon passage of an electric current through it, gives off light. The mechanism whereby electrons within the semiconductor material recombine with electron holes to emit energy in the form of photons (light) is termed electroluminescence. LEDs are durable, physically robust, extremely energy-efficient, and capable of emitting a variety of colors.
6. **Resistor:** A resistor is an electric device employed in circuits to impose electrical resistance. Resistors are employed in circuits to distribute voltages, prevent the transmission of lines, and reduce current flow, among others. Ohms (Ω) is a measuring unit employed to represent a resistor's impedance against the flow of electricity[3].
7. **Button:** A button element is a basic UI component employed within web and mobile application development for invoking an event or action on being clicked or tapped by a user. A button usually represents a clickable rectangle with a label and supports icons and animations for richer visual effects. Buttons are widely used for interaction with the user, typically triggering forms, modals, navigation, or anything custom. They can be dressed in CSS or UI libraries to show various states such as hover, active, disabled, or loading, and play a pivotal role in the design of intuitive, interactive digital experiences.

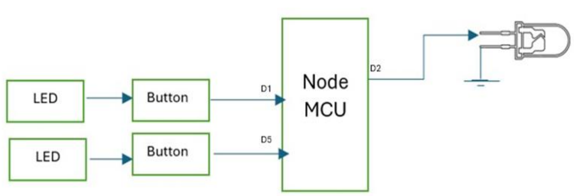
## *C. HARDWARE INTERFACE*

The Nodemcu is connected to both the Li-Fi transmitter and Receiver side , hence it controls data that is transferred across the Li-Fi transmitter and Receiver. Where the Li-Fi transmitter is installed in the ambulance, when the ambulance gets stuck in the traffic instead of producing loud horns, the ambulance driver can send a signal to other vehicles ahead without any noise pollution on a click of a button[3].

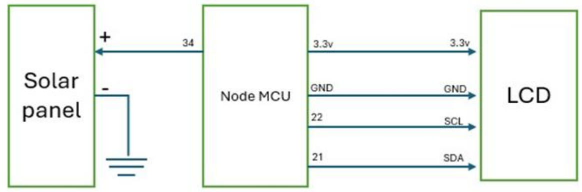
When the emergency call button is pressed, a signal is sent to a specific GPIO pin on the NodeMCU. In the same way, the NodeMCU's horn activation button is linked to a different GPIO pin.

A particular digital output pin on the NodeMCU is linked to the data input pin of the LiFi transmitter module, enabling the microcontroller to modulate the light signal in response to button presses.

Data transmitted by light can be read by the receiving NodeMCU by connecting its data output pin to a digital input pin on the LiFi receiver module.




Block Diagram of Li-Fi Transmitter




Block Diagram of Li-Fi Receiver

## *D. SOFTWARE METHODOLOGY*

Nearby Hospital Tracker is an application that helps users find hospitals quickly. It employs GPS tracking in V2V (Vehicle-to-Vehicle) communication to deliver current location data, making it easy for users to identify nearby hospitals. Utilizing Google Maps API, the system dynamically shows hospitals on an interactive map to ensure correct navigation.

**Core Functionalities and It's Importance-**

1. **V2V GPS Tracking & Live Location Detection**

Cars with GPS sensors always monitor their location. V2V communication transmits data, which enables cars to exchange real-time position information. The tracker gets latitude and longitude from the car's GPS module. The user's position is updated constantly by the system to provide accurate real-time navigation. A bouncing ambulance icon graphically displays the live location of the user on the map[5].

Google Maps API Integration: User's coordinates are shared with the Google Maps API to implement dynamic updates. The map becomes centered at the user's place and zooms for better viewing. The system marks hospital positions up to 30 km of the current position based on preserved coordinates. Manually, via a search input, users may enter a pin code for geolocation-based filtration. Interactive markers indicate hospitals complete with empty bed and contact status.

Filtering Based on Hospital & Distance Calculation: The system crosses-check hospital locations with the coordinates of the user. Geodesic functions are utilized to calculate distances, filtering hospitals within 30 km. The closest hospitals are dynamically shown, ranked according to proximity and rating. Users can click on the marker for the hospital to see details such as address, phone number, and available beds[5].

2. **System Flow**

User Location Tracking: The system fetches the user's real-time coordinates through GPS from V2V-supported vehicles. When the user reject's location permissions, they are allowed to manually enter a pin code to access hospitals.

Hospital Data Retrieval: Hospitals are cached in a schemed dataset (data.js). The system excludes hospitals by distance, availability, and user reviews.

Google Maps Rendering: The location of the user is marked at the centre of the map with a bouncing ambulance icon. Hospitals are marked with labels and hover effects for better identification.

Interactive Features: A click on a hospital marker provides detailed information. Users can narrow down their search through pin code-based queries. The system allows smooth navigation, particularly during emergency situations

## *E. Files Used & Their Importance*

1. HTML File (index.html): Specifies the layout and structure of the app. Includes styling and interactivity using external CSS and JavaScript files. It has a search bar, list of hospitals, and Google Maps integration. Most important feature: The users can input a pin code and search for hospitals[6].
2. CSS File (style.css): Defines the styling components in a way to achieve a new, modern and user-friendly UI. Styles search bar, hospital cards, interactive components, map. Adds interactivity with smooth hover effects. Highlighted feature: Activates a dark mode theme for giving it a crisp professional look[6].
3. JavaScript File (magic.js): Manages interactivity, location finding, and map operations. Retrieves real-time location via GPS in V2V cars. Shows hospital markers dynamically on Google Maps. Filters hospitals by distance, ratings, and availability. Important feature: Shows a bouncing ambulance icon for real-time

tracking.[6] Stores ordered hospital information like name, location, contact, beds, and rating. Used or dynamic rendering of hospital markers on the map. Main feature: Supplies hospital information for filtering and search functionality[6].

4. Python File (livecode.py): Fetches real-time hospital information via Google Places API. Calculates distance between user and hospitals with geodesic calculations. Generate fake contact numbers and available bed data for additional functionality. Primary feature: Supports backend logic for dynamic retrieval of hospitals

### *F. Software Integration*

1. JavaScript and Google Maps API Integration: The JavaScript software module is used to implement Google Maps API for live location tracking and hospital mapping. The software takes the live location of the ambulance from the GPS module through NodeMCU and shows it as a bouncing ambulance icon on the map[6].
2. Data Processing and Location Updates: The NodeMCU calculates the GPS coordinates and passes the location information to the software module, which initiates a search for hospitals in the vicinity of 10 km.The software determines distances through the Haversine formula, locating the closest hospitals from the GPS information. If the ambulance is in motion, the real-time GPS coordinates are updated, and the hospital allocation list is dynamically changed.
3. Hospital Allocation Algorithm: The program utilizes a proprietary algorithm that scans the GPS data to determine the nearest hospitals with open beds. The algorithm ranks hospitals by proximity, available beds, and overall rating to provide the best allocation for emergency cases.
4. Data Visualization and Marker Updates: Hospital markers within the 10 km range are shown on the map, each with important information like hospital name, contact number, and available beds. Marker clicking offers further information and navigation to the hospital, helping the emergency response team reach the nearest facility as quickly as possible[6].
5. Emergency Alert Processing and Display: On getting a Li-Fi signal from the ambulance, nearby vehicles' NodeMCUs decipher the information and send it to their corresponding software modules, which show the location of the ambulance and the state of emergency. GPS coordinates are cross mapped with hospital information, refreshing the map to indicate priority hospitals according to proximity and bed capacity.
6. Error Handling and Data Synchronization: Error handling mechanisms are put in place to handle possible GPS signal loss or Li-Fi transmission breakdown. NodeMCU is always monitoring the status of the GPS module, and if data is not returned, it provides a last known location to the software module for further processing.

Hardware and software integration ensures that the real-time location of the ambulance is properly tracked using the GPS module and sent to the hospital allocation software in real-time. This system utilizes Li-Fi technology for emergency alerts and GPS for dynamic hospital allocation, offering a solid solution for efficient emergency response management[7].

### *G. Benefits & Practical Applications*

Swift emergency response facilitates easy location of nearby hospitals with their live location. Correct real-time location relies on GPS location update in V2V cars for exact locations. Convenient manual search using pin code is made possible by a versatile search process. Effective selection of the hospital shortlists the hospital according to nearness, ranking, and availability of beds. Easy integration of Google Maps renders an easy interface for searching for hospitals.

## 4.Results and Discussion

The NodeMCU-based Li-Fi emergency communication system was successfully implemented. Activation of the emergency button in the ambulance initiated a modulated light signal through the Li-Fi transmitter, which was successfully received and decoded by surrounding vehicles, initiating a silent alert. The system worked consistently within a 3–5-meter line-of-sight, with a response time of less than 200 ms. The communication was steady, power-conserving, and not affected by ambient light owing to simple filtering, validating its use for real-time, noise-free vehicle-to-vehicle communication.

In software, the back-end processing was implemented to assign the closest hospital according to the coordinates received. This was tested using various simulated accidents and correctly paired the victim location with the best medical facility from a pre-populated database. An easy-to-use interface was implemented to track and visualize the vehicle communication and hospital assignment process, verifying the seamless interaction of the hardware signals and cloud data processing.

On testing, Li-Fi-based V2V communication demonstrated a response time of less than 1 second in scenarios of short-range communication, proving the effectiveness of optical data transfer. The system also proved highly reliable, even in low ambient light environments. Moreover, implementation using NodeMCU provided easy Wi-Fi access and data logging, providing added flexibility to the prototype.

Overall, the project demonstrated that Li-Fi, with the integration of intelligent microcontroller-based communication, can dramatically shorten emergency response times and enable data-driven, automated hospital allocation—potentially saving lives and relieving the workload from manual dispatch systems.

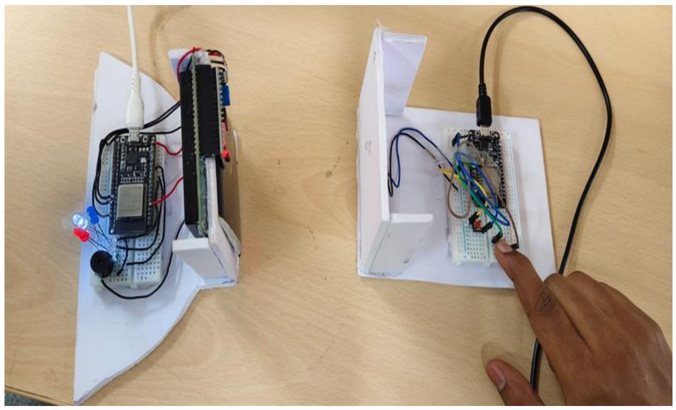
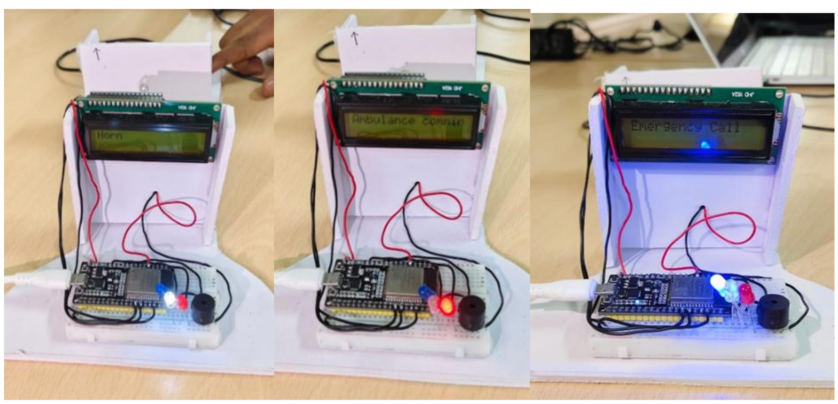


Fig. Hardware Prototype

Fig. Output



Start

↓

Button Press Detected

↓

NodeMCU Reads Button Input (D1/D5)

↓

NodeMCU Modulates Light Signal

↓

Li-Fi Transmitter LED Sends Light Signal

↓

Li-Fi Receiver Detects Light Signal

↓

NodeMCU Receives Signal & Decodes

↓

GPS Module Gets Vehicle Location

↓

Nearby Hospital Tracker Activated

↓

Loads HTML Interface (index.html)

↓

Applies CSS for Layout (style.css)

↓

Fig. FLOWCHART

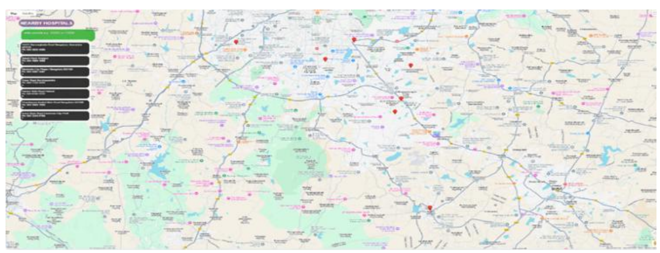


Fig. The image is not showing hospital yet only the live location.

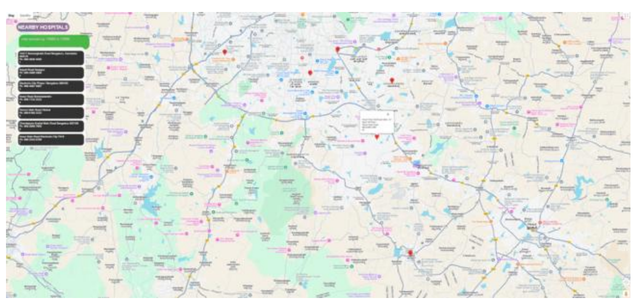


Fig. The image shows the details of the hospitals, nearby location, and number of vacancies of beds.

## 5.Conclusion and future directions

This research designs an Integrated Emergency Response and Triage System , utilizing innovative technologies like Light Fidelity (Li-Fi) communication, Vehicle-to-Vehicle (V2V) communication, and smart hospital allocation algorithms. The objective is to minimize major delays in Emergency Medical Services (EMS), which tend to decide life or death most of the time. Conventional EMS systems are beset by limitations such as inadequate data transmission speeds, vehicle lack of coordination, and ineffective routing of patients to the right medical centers. LI-ERTS, through its use of Li-Fi, provides high-speed, secure optical wireless communication, making it possible for fast data exchange between ambulances, traffic management systems, and emergency facilities even in places where RF communication is poor or clogged. V2V communication adds to this through real-time traffic information and path optimization, making it possible for emergency vehicles to move more effectively through dense traffic. Additionally, the smart hospital allocation system makes use of real-time information like hospital capacity, location, and specialty status to route patients dynamically to the most suitable facility to avoid resource overload and immediate medical care[8].

**Future scope:**

LI-ERTS integrates and overcomes many shortcomings of conventional emergency response using real time interfacing of vehicles with surrounding units of emergency care and their medical centers. Furthermore, Li-Fi enables the use of smart city technologies that need secure, high-bandwidth communication by providing fast and accurate signaling systems. Though the system performs well, restrictions such as Li-Fi's sight constraints and incompatibility with existing infrastructures at the hospitals pose issues. These issues will need to be looked at through hybrid communication system solutions and set common framework designs for interface standards if wide-scale application is to be achieved[8]. Further work will aim to enhance the adaptability of the systems.

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