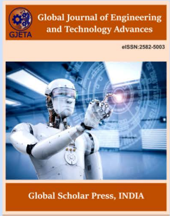
Global Journal of Engineering and Technology Advances

eISSN: 2582-5003

Cross Ref DOI: 10.30574/gjeta

Journal homepage: https://gjeta.com/



(Review Article)

A mobile application to aid emergency response through multi-stakeholders' collaboration

Godson S. Olusanya *, Monday O. Eze and Charles Okunbor

Department of Computer Science, Babcock University, Ilishan Remo, Ogun State, Nigeria.

Global Journal of Engineering and Technology Advances, 2023, 17(01), 001–008

Publication history: Received on 20 August 2023; revised on 28 September 2023; accepted on 01 October 2023

Article DOI: https://doi.org/10.30574/gjeta.2023.17.1.0200

Abstract

The impact of timely response to road emergencies cannot be overemphasized. Responding quickly to road emergencies makes it possible for emergency responders to save lives and properties. It is believed that one-minute improvement in response time can result in six percent (6%) increase in the lives saved. Emergency responders depend on the road networks that other road users also depend upon for their day-to-day activities. All stakeholders (emergency responders inclusive) must therefore, cooperatively and collaboratively use the road networks to, particularly, allow responders have priority access on the roads. This article thus, suggests the use of a mobile application to include the various stakeholders in emergency response operation cycle, ranging from reporting and notification to awareness creation and information dissemination and, all the other related activities.

Keywords: Smart emergency response; Smart transportation; Response time; Stakeholders; ERMS; Mobile Application

1. Introduction

Road emergencies are no longer new to us, they occur frequently and are capable of taking the lives of individuals who are victims. These emergencies, which could result in injuries and death, are seen as a major challenge and threat to human lives [1]. According to the statistics taken by World Health Organization (WHO) in 2018, a little short of 1.5million people die and the recorded injuries are pegged at 50million, yearly [2]. Some of these deaths could have been avoided if there was a reduction in the time of response.

Timing therefore, becomes crucial and cannot be toiled with, because, the time of response after an emergency, plays a significant role in saving a life [1,2,3]. A victim of a road accident, for instance, is likely going to be saved if emergency response arrives within the shortest possible time required to stabilize the victim.

If timing is of the essence in emergency response, it, therefore, becomes necessary to ensure that victims of road emergencies receive emergency response within the shortest possible time. However, ensuring that emergency response is carried out without delay comes with contention with traffic conditions on the roads [2,4,5,6,7].

The contentions with the traffic conditions are a function of the road users/commuters and the emergency responders jostling for the limited existing road networks (especially urban roads). These road users continuously populate the cities and there is no prediction of a reduction, any time soon. Instead of a reduction in the number of commuters on the roads, projections that have been made indicate a rise in the road users [5,7,8]. The United Nations' (UN) projection indicates that by 2030, the population in the urban areas would have increased to 4.9billion [9].

* Corresponding author: Godson S. Olusanya

This, therefore means that, the emergency responders are at the mercy of the current traffic condition at the time of any operation (emergency response). This is so because, the traffic condition is determined by the volume of vehicles and commuters plying the roads.

Invariably, it has become important to seek improved methods, particularly through the use of Information Communication Technology (ICT), to control traffic or, at least, manipulate traffic flow in such a way as to grant priority access to emergency responders [5].

Several researches targeted at manipulating traffic to grant priority access to emergency responders exist in literature. They include; Dynamic Light Control System, Smart Road Surveillance System, the Shortest Path Selection System, Lane Clearance or Reservation System, and the Mode of Operation Selection System [4,10,11,12,13,14].

However, a major stakeholder, which is categorized as road users (or general commuter), has not been given proper consideration in the attempt of these researches to improve response to road emergencies. Since emergency responders and other road users rely on the same road network to move around and go about their day-to-day activities, then, these road users cannot be ignored if any attempt is to be made at lessening the time taken for emergency response.

There is, therefore, a need for emergency response operatives, road users, traffic control operatives and, other stakeholders involved, to work cooperatively to ensure that priority access is granted to emergency responders on the roads.

This research article is structured as follows: section 1 is an introduction to the research article, section 2 gives an overview of related works in literature, section 3 discusses how stakeholders can aid the improvement of response time and, the article is concluded in section 4.

2. Literature Review

The continuous influx of people into the urban areas puts pressure on the existing infrastructure and makes it difficult to meet up with the demands placed on it [5,9]. Proactive measures are therefore, encouraged in attempting to satisfy the demands of the ever-increasing population [7,9,15]. Adopting proactive measures include the use of ICT-driven methodologies, like Internet of Things (IoT), mobile applications, among others, in the delivery of effective and efficient services in order to satisfy the residents [9,16,17].

Emergency response is a service, in the city, that is both important and critical. These characteristics of it are tied to its propensity to save lives and properties. Any form of carelessness, oversight or neglect in the delivery of this service, can result in an irreparable loss of lives and properties [14,18,19,20,21].

Since emergency response is critical and cannot be toyed with and, dependence on traditional methods cannot grant efficiency and timely delivery, it has therefore, become inherent to look to smarter strategies (ICT-based solutions, particularly) for efficient service delivery [7,8,17,22,23,24,25].

2.1. Existing Systems that Aid the Improvement of Emergency Response Time

Emergency response time improvement lies around controlling and manipulating traffic to ensure that emergency responders do not have any form of inhibition during movement. The following technologies, as identified in literature, are geared towards this goal.

- **Dynamic Light Control System:** This system involves changing traffic lights based on inputs from the environment. It is unlike the traditional one which depends on time limiters. This system, therefore, gathers information regarding the traffic situation such as; the volume of vehicles on the roads and emergency occurrences, to determine control [13,26].
- **Fastest Route Selection System:** To ensure getting to the location of the incident in the shortest possible time, systems such as this are designed to determine the fastest route to be taken between the take-off location and the destination (incidence location). Using suitable algorithms, this system selects a route that will lead emergency responders to the location of response within the shortest possible time [19,26].
- **Mode of Operation Selection System:** This type of system combines different approaches in ensuring that emergency response officials are granted priority access on the roads; thereby, working as a form of hybrid system. The system determines the mode of operation based on the severity of emergency. The mode of

operation includes; traffic light manipulation, speed limit change, lane clearance, permission to use reserved lanes, and movement re-routing for other road users [4].

2.2. Related Works of Researchers

Deqi and his colleagues simulated a framework, which is a conceptual design of an information system that handles emergency response by; monitoring traffic to detect accidents, notifying responders upon detection, identifying paths to be taken and initiating dispatch, and keeping records of response outcomes [27].

Djahel alongside some researchers designed the prototype of an adaptive traffic control system that is capable of selecting from a list of response options based on the severity of the emergency [4]. These response options are to aid the movement of emergency responders and ensure that they have priority access on the roads. They also avoid the disruption of normal traffic for the passage of non-critical emergencies.

Khalil, Javid and Nasir proposed a system that automatically detects auto crashes via sensors attached to the vehicles and sends notification to responders to avoid delay [28].

Dar, working with some researchers, leveraged on fog computing in proposing a system that can detect emergencies and send notifications for quick ambulance dispatch [18]. The system upon detecting an emergency, sends a trigger for notification to be made. The notification information, which includes the location of the event occurrence, is sent to the nearest hospital for an ambulance to be dispatched.

Particle Swarm Optimization (PSO) algorithm was used by Amer and his colleagues to design a system which determines the shortest path to be taken by emergency responders, in real-time. The system relies on the information it receives from road sensors [10].

Mohammad with his colleagues worked on an automated system that is capable of detecting varying emergencies and dispatching emergency responders to the location after the genuineness of the emergency has been confirmed [29].

Almuraykhi and Akhlaq [26] designed a Smart Traffic Light System (STLS) to aid the movement of emergency responders by determining the fastest route to be taken when information about the emergency location is inputted. It also tracks the movement of responders and manipulates the traffic light to accommodate the expected priority movement of the responders.

Based on the severity of an emergency, the fuzzy inference system proposed by Kumar, Rahman and Dhakad [13] is capable of manipulating traffic light to ensure that emergency responders are given the needed priority access commensurable to the severity of emergency.

A web-based system was designed by Omotosho and some collaborating researchers. The system uses Ant Colony Optimization algorithm to determine the shortest path to be taken by emergency responders [30].

2.3. Missing Link in Existing Research Works

Various research works of researchers, some of which have been identified in this article, are geared towards improving the response time of emergency responders. These works have been able to influence the major factor which contributes to the response time of the emergency responders.

The major factor, being traffic condition on the roads, wields a strong force on the time taken to respond to emergencies. It, therefore, becomes laudable when anything is done to improve the time of emergency response. The outcome of the works of these researchers on controlling and manipulating traffic and, suggesting routes to be taken, results in emergency responders being granted priority access on the roads and subsequently, reducing the time taken for their response.

However, the outcome of these researches, particularly the ones identified in this article, has failed to actively include major stakeholders in the emergency response operation. If emergency response operatives depend strongly on the roads they share with other road users, then, they cannot overlook the impact of these other road users.

These road users would always be on the roads and are usually oblivious of the operations of the emergency responders except in some cases when they come in contact with the incident or are brought to awareness through an audible sign coming from the sirens mounted on the emergency vehicles.

When road users are not notified of the operations of the emergency responders on the roads, they are not likely going to clear the roads ahead of the arrival of the responders nor are they going to consider re-routing their journeys to ease movement on the route taken by responders. The attempt of road users to clear the road when the emergency responders are barely a few meters away from them, will, at best, further increase the response time. For instance, there would not be ease in clearing the road for the passage of an emergency vehicle when they are all (emergency responders and other road users) held up in the same traffic.

If, therefore, the time taken for emergency response is to be greatly reduced, there is the need to consider these stakeholders and include them collaboratively and cooperatively to experience a smoother passage on the roads.

3. Response Time Improvement with Stakeholders' Cooperation

Any project that wants to end up in success and benefit all concerned, must significantly include every stakeholder, because, a project is seen as the cooperation of stakeholders in the pursuit of a goal [31]. Emergency response, as a project must therefore, seek the cooperation and collaboration of all stakeholders to be successful at the goal of saving lives and properties.

The findings of Sharma and Sebastian [32] indicate a six (6) percent increase in the number of lives saved when there is one (1) minute reduction in the time taken to respond to an emergency.

Leveraging on the works of the researchers, which can help control and manipulate traffic, provides some form of improvement in the response time of responders, however, if any further reduction in time taken to respond to emergency can be achieved, that would be laudable; after all, nothing is too much a cost in saving lives and properties.

Since emergency responders and all road users which include; motorists, passers-by, traffic controllers, passengers, among others, depend on the same available road networks to transport themselves from location to location then, they must collaboratively and cooperatively use the roads to ensure that there is no jeopardy in the goal of saving lives and properties during emergency response.

It is, therefore, expected that an innovative way (particularly, ICT-driven) is sought out, to link all the concerned stakeholders (other road users, particularly) in emergency response operation with the emergency responders and ensure that they work cooperatively in clearing the roads to grant priority access to responders.

3.1. Proposed Operational Mode of Emergency Response

Emergency response has delay inherent in it when road users, who are a major stakeholder in the process, are unaware of the operation carried out by emergency response operatives. It has, therefore, become important to take seriously, the impact the road users can have on the condition of the traffic on the roads. Consequently, a mode of operation, that will link and leverage the contributions of all concerned stakeholders in the process is suggested to contribute to improving the response time of emergency responders.

The proposition in this article is, therefore, that of an Emergency Response Management System (ERMS) that can link three (3) categories of stakeholders; the emergency responders, traffic control officers and other road users (like motorists and passers-by). Apart from the server-side of the system, the proposition is a mobile application that will put the mobility of the categories of the users into consideration.

The emergency responders' category will have initiators and responders with access to the backend (server-side) and the frontend (client-side). The traffic control officers' category will include those that are saddled with the responsibility of directing traffic while the last category, which is the road users' category, will include passers-by, motorists, passengers, cyclists and other similar users.

When category one (emergency responders) receives a notification of an emergency, which could be sent by Category two (traffic control officers) or Category three (road users), it will initiate a response operation via the proposed ERMS. The initiation process includes; a selection of response route, generation and forwarding of traffic clearance procedure to traffic control officers and sending of push notifications to road users to aid them in re-routing and guide their travel plans.

The response route will be the shortest path between the location of the emergency responders (those closest to the incidence location) and the location of the incidence. The traffic clearance procedure, which will be sent to the traffic control officers, will include the mode of operation which is being adopted so the officers can be guided on what lane to clear or what route to re-direct.

Push notifications, on the other hand, is to be sent to all other road users to ensure that those not yet on the response route can re-route their movements and those on the response route can take the next exit road from the route to ensure a clear path for the emergency responders.

It is, however, necessary to say that, not all emergency cases will require the measures described above. Therefore, there will be a determination of the mode of operation based on the severity of the emergency that would have been determined from the emergency notification.

Category two (traffic control officers) upon receiving a notification, on the traffic clearance procedure, is expected to direct or re-direct traffic accordingly to accommodate the movement of the emergency responders.

Category three (road users) are to re-route their movements based on notifications received via the ERMS or by adhering to the direction of the traffic control officers. They are also expected to send notifications of emergencies using the same platform whenever they become privy to them. Notwithstanding, all users of the system will be able to send notifications of emergencies with the needed information required for response.

An overview of the ERMS operational mode is described in Figure.1 while Figure.2 gives a sample of interfaces of the mobile application.

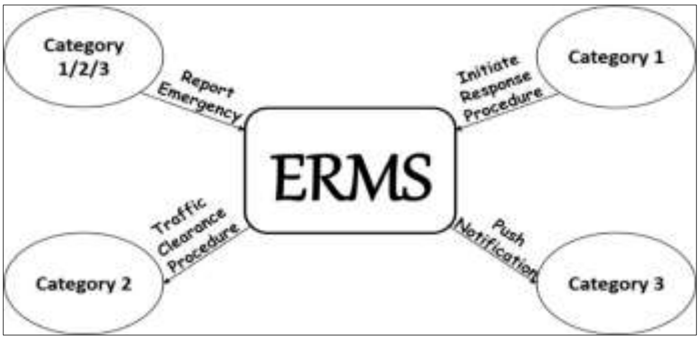


Figure 1 ERMS Operational Mode

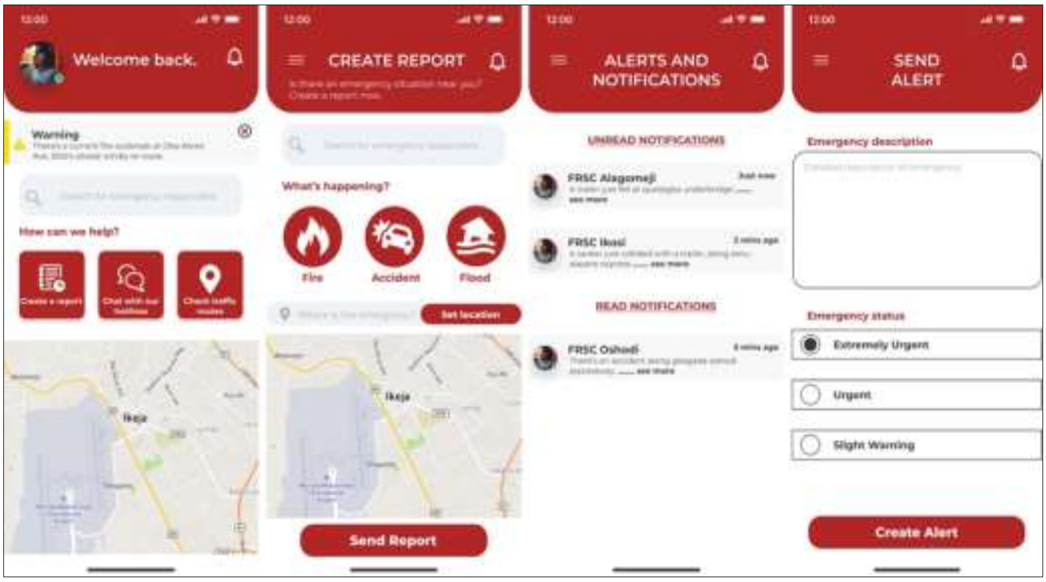


Figure 2 Sample Interfaces of the Mobile Application

3.2. System Work Flow

The whole process commences when there is an identification and a reporting of an emergency situation. The reporting is made via the ERMS to the emergency responders who in turn, initiate a response.

The ERMS upon receiving an initiation of emergency response operation from the emergency responders, will send a traffic clearance procedure to the traffic control officers to guide traffic direction and push notification to road users for movement planning and re-routing.

Figure 3 gives a diagrammatic description of the work flow

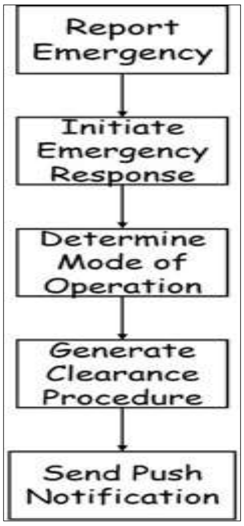


Figure 3 System Work Flow

4. Conclusion

Emergency response operation, being a project that must rely on stakeholders to achieve its goal, can no longer focus on the emergency responders alone while neglecting other important stakeholders, particularly the road users.

Since the emergency responders and the other road users have the road network, as a common resource in the pursuit of their daily goals then, cooperation in the use of this common resource cannot be overlooked.

The emergency responders must, therefore, be innovative and quick to adopt proactive measures which include collaborating with all the necessary stakeholders to ensure that they have easy passage on the roads in their attempt at responding to emergencies to save lives and properties.

Innovation and proactive measures call for ICT driven initiatives which will bring to the frontline, the adoption and dependence on existing technologies that can aid the operations of the emergency responders.

Emergency response operations cannot henceforth, really on the methods that exclude some stakeholders (road users, particularly) if emergency response time is to be improved upon.

Compliance with ethical standards

Acknowledgments

The authors acknowledge Global Journal of Engineering and Technology Advances (GJETA) for consideration of this article for publication. They also acknowledge themselves for their time, contributions and successful collaboration.

Disclosure of conflict of interest

The authors do not have any conflict of interest in the writing of this article.

References

[1] Dar BK, Shah MA, Islam SU, Maple C, Mussadiq S, Khan S. Delay-aware accident detection and response system using fog computing. IEEE Access. 2019; 7, 70975-70985.

[2] Bhatti F, Shah MA, Maple C, Islam SU. A novel internet of things-enabled accident detection and reporting system for smart city environments. Sensor. 2019; 19(2071), 1-29.

[3] Boukerche A, Coutinho RWL. Smart disaster detection and response system for smart cities. IEEE Symposium on Computers and Communications (ISCC), 2018; 01102-01107.

[4] Djahel S, Smith N, Wang S, Murphy J. Reducing emergency services response time in smart cities: An advanced adaptive and fuzzy approach. IEEE. 2015.

[5] Olusanya GS, Eze MO, Ebiesuwa O, Okunbor C. Smart transportation system for solving urban traffic congestion. Review of Computer Engineering Studies. 2020; 7(3), 55-59.

[6] Talari S, Shafie-Khah M, Siano P, Loia V, Tommasetti A, Catalao JPS. A review of smart cities based on the internet of things concept. Energies. 2017; 10(421), 1-23.

[7] Nigam N, Singh DP, Choudhary J. A Review of Different Components of the Intelligent Traffic Management System (ITMS). Symmetry. 2023; 15(583), 1-40.

[8] Azgomi HF, Jamshidi M. A brief survey on smart community and smart transportation. 30th International Conference on Tools with Artificial Intelligence, IEEE. 2018; 932-939.

[9] Oladimeji D, Gupta K, Kose NA, Gundogan K, Ge L, Liang F. Smart Transportation: An Overview of Technologies and Applications. Sensors. 2023; 23 (3880), 1-32.

[10] Amer HM, Al-Kashoash HAA, Kemp A, Mihaylova L, Mayfield M. Coalition game for emergency vehicles re-routing in smart cities. 10th Sensor Array and Multichannel Signal Processing Workshop (SAM), 2018; 306-310.

[11] Bhogaraju SD, Korupalli VRK. Design of smart roads – A vision on Indian smart infrastructure development. 12th International Conference on Communication Systems and Networks (COMSNETS). 2020; 773-778.

[12] Guillen-Perez A, Cano M-D. Intelligent IoT systems for traffic management: A practical application. IET Intelligent Transport System. 2021; 15, 273-285.

[13] Kumar N, Rahman SS, Dhakad N. Fuzzy inference enabled deep reinforcement learning-based traffic light control for intelligent transportation system. IEEE Transactions on Intelligent Transportation Systems. 2020; 1-10.

[14] Nellore K, Hancke GP. Traffic management for emergency vehicle priority based on visual sensing. Sensors. 2016; 16, 1892, 1-22.

[15] Lenz B, Heinrichs D. What can we learn from smart urban mobility technologies? Pervasive Computing, IEEE. 2017; 84-86.

[16] Montori F, Bedogni L, Bononi L. A collaborative Internet of things architecture for smart cities and environmental Monitoring. IEEE Internet of Things Journal. 2017; 1-14.

[17] Olusanya GS, Okunbor C, Avwokuruaye O. Internet of Things (IOT) as the future of networked devices: An overview. Global Journal of Engineering and Technology Advances. 2021; 9(3), 31-37.

[18] Dar BK, Shah MA, Shahid H, Fizzah F, Amjad Z. An architecture for fog computing enabled emergency response and disaster management system (ERDMS). Proceedings of the 24th International Conference on Automation & Computing, UK. 2018.

[19] Katre PR, Thakare AD. Design of quick response system for road network in emergency services. IEEE. 2017; 332-335.

[20] Kodali RK, Mahesh KS. Smart emergency response system. Proc. of the 2017 IEEE Region 10 Conference (TENCON), Malaysia, November. 2017; 712-717.

[21] Pecar M, Papa G. Transportation problems and their potential solutions in smart cities. IEEE. 2017; 195-199.

[22] Ahmed F. Implementation of smart cities under IoT & big data analytics. International Journal of Computer Science and Network Security, 7(10). 2017; 153-158.

[23] Anthopoulos L, Attour A. Smart transportation applications' business models: A comparison. Proceedings and Companion Submissions of the 2018 Web Conference Companion, April 23-27, Lyon, France. 2018.

[24] Romano M, Onorati T, Aedo I, Diaz P. Designing mobile applications for emergency response: Citizens acting as human sensors. Sensor. 2016; 16(406), 1-17.

[25] Saarika PS, Sandhya K, Sudha T. Smart transportation system using IoT. International Conference on Smart Technology for Smart Nation, IEEE. 2017; 1104-1107.

[26] Almuraykhi KM, Akhlaq M. STLS: Smart traffic lights system for emergency response vehicles. IEEE. 2019.

[27] Deqi H, Xiumin C, Zhe M. A simulation framework for emergency response of highway traffic accident. International Workshop on Information and Electronics Engineering (IWIEE). 2012; 29, 1075-1080.

[28] Khalil U, Javid T, Nasir A. Automatic road accident detection techniques: A brief survey. IEEE. 2017.

[29] Mohammad N, Muhammad S, Bashar A, Khan MA. Formal analysis of human-assisted smart city emergency services. IEEE Access. 2019; 7, 60376-60388.

[30] Omotosho OJ, Okonji C, Ogbonna AC, Adesina S. A prototype web-based emergency response system that incorporates the findings from the shortest route techniques for path optimization. International Journal of Innovative Research in Computer Science & Technology (IJIRCST). 2020; 8(2), 29-36.

[31] Liang X, Yu T, Guo L. Understanding stakeholders' influence on project success with a new SNA method: A case study of the green retrofit in China. Sustainability. 2017; 9(1927), 1-19.

[32] Sharma S, Sebastian S. IoT based car accident detection and notification algorithm for general road accidents. International Journal of Electrical and Computer Engineering (IJECE). 2019; 9(5), 4020-4026.