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Dual-Activation Emergency Situation Notification System: A Feature Driven Development Approach

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ABSTRACT

Emergencies can unpredictably arise, posing severe threats to individuals' lives. Swift and effective communication plays a crucial role in promptly relaying vital information to relevant response agencies and loved ones, aiming to minimize or eliminate the impact of such disasters. Existing systems often require manual triggering of distress signals through button presses or image captures. However, these methods can be ineffective, particularly when victims are under the surveillance of wrongdoers, rendering them unable to discreetly use their devices. To address this issue, this study introduces the Dual-Activation Emergency Situation Notification System (DA-ESNS) model, which ensures that potential wrongdoers remain unaware of the user's attempt to seek help by employing an efficient communication and alerting system during emergencies. Through a review of previous models, the DA-ESNS model was developed to address identified gaps. The Feature Driven Development software development process model was selected due to its agile and incremental nature, enabling focused development and integration of the notification feature. ReactJS and NodeJS were utilized for frontend and backend development, respectively. The integration of Twilio API and Geolocation API facilitated SMS notifications and precise location sharing with emergency response teams and predefined contacts. The DA-ESNS model automatically relays distress signals by persistently listening for predefined keywords or manually triggered by clicking on corresponding emergency cards, notifying both the emergency response team and the victim's family members. The model was implemented across various mobile platforms, providing a centralized and interactive interface. By offering quick notifications and offline accessibility, the DA-ESNS model streamlines the emergency alert process, significantly improving the effectiveness of emergency response teams in reducing the impact of crises through rapid reaction times. As a result, the DA-ESNS model emerges as a valuable and effective tool in emergency management.

1. INTRODUCTION

The advancement of computer and communication technologies has revolutionized the ease and speed of communication, enabling individuals to connect with others at the click of a button. However, emergencies and panic-inducing situations are inevitable and often unforeseen, with varying degrees of severity, including life-threatening circumstances. To effectively handle such emergencies, countries have established specialized response teams like the police authorities, fire departments, and ambulance services. These response teams are typically accessible through emergency phone numbers, such as 911 in the United States, 112 in Nigeria, and 999 in the United Kingdom [1].

Traditionally, individuals in emergency situations would call the appropriate response team to report the incident, but due to the caller's panicked state, accurate information and effective communication can be challenging. This can result in delayed or inadequate response from the emergency services. Additionally, false alarms, including misdials, hoax calls, and non-emergency calls, can burden the response teams and waste valuable resources. For example, in New York City, it was found that approximately 10 million calls received annually were accidental, false, or hoaxes, resulting in significant amounts of "wasted work" [1].

Moreover, in some countries, citizens may lack trust in the emergency call centers, leading to reluctance in using the designated emergency numbers. Surveys conducted in Nigeria revealed that a significant percentage of respondents did not trust the operators of the 112-emergency number, were unaware of its existence, or believed it to be inoperable [2]. Instead, people often prefer to call their family or neighbors in emergency situations, indicating the need for a communication system that allows victims to reach out to trusted individuals. Smartphones, which have become increasingly prevalent with approximately 5.4 billion unique mobile subscribers, provide a potential platform for such emergency communication [3].

To overcome the limitations of traditional emergency notification techniques and address the challenges of poor network connectivity, researchers have developed devices to aid victims in emergency situations [4-6]. However, these devices often require constant user feedback, which may not be feasible in scenarios such as kidnapping or armed robbery. Additionally, some of these devices are gender-specific, excluding male users, and accidental triggers can lead to false alarms. Furthermore, these devices are separate from the user's

regular mobile device, requiring constant carrying.

To ensure effective emergency notifications and overcome these challenges, a reliable mechanism is needed to alert response teams. This paper proposes the Hybrid Emergency Services Notification System (DA-ESNS) model, which aims to improve upon traditional emergency notification techniques and existing emergency systems. The DA-ESNS model is designed to cater to various emergency scenarios, including situations where victims are unable to physically interact with their devices and where network availability is limited. It provides solutions to ensure notifications can be sent and received in challenging circumstances. Additionally, the model considers scenarios where victims, in sound mental states, can report emergencies through the application, thereby notifying the appropriate response teams.

The primary objective of this research is to develop the DA-ESNS model, which incorporates both automatic and manual notification mechanisms. This hybrid approach aims to optimize the effectiveness of emergency notifications and minimize response times in critical situations. The practicality and functionality of the model will be evaluated through implementation.

2. LITERATURE REVIEW

2.1 Review of related works

Much research on emergency notification has been conducted to ascertain the effectiveness of communication and the benefits of incorporating the swift provision of rescue services to affected victims. Many studies also discuss the effectiveness and integration of communication in an emergency. Jadhav et al. [7] presents an emergency management system that allows for ad-hoc communication between the victim and the emergency service providers through the click of a button during disaster times using the smartphone over Wi-Fi, integrating GPS location tracking. The system comprises three modules: Client Application, Rescue Application, and Server which is implemented as a web-based Java Application. A Disaster Alert and Notification system was proposed by Sarah et al. [8] that helps register family members or multiple receivers to send notifications for help, by sending the current position obtained by GPS and including the shortest path of the safe zone on the map of the application, it was only to run on android devices. Although a very thoughtful idea, the downside was it was more useful if the disaster-prone area had been detected or stored beforehand by the disaster management server and not fully reliable for real-time-based disasters. Ali and Muslim [9] developed a system to detect falls, car accidents, and heart rate failure using a smartphone and smartwatch. The use of a smartwatch or smartphone helped in providing distinct separable signal variation due to the large number of hardware sensors from the smartwatch or smartphone accelerators and sensors to recognize emergency cases like heart rate failure, falls, and car accident, then sends videos, locations, heart rate to emergency contact to provide help. Khan et al. [10] implemented an Accident Detection and Smart Rescue System using Android Smartphone with Real-time Location Tracking which uses the onboard sensors of a typical smartphone for detecting accidents and reporting to the nearest available emergency response team. The system consists of an integration of existing systems such as SOSafe for the emergency victims, SOSafe Go for the emergency responders, and Firebase for cloud storage, messaging, and authentication. The system also integrates real-time location tracking of an accident situation to reduce the response time and increase the chances of survival. Vaidya et al. [11] proposed an Android application for human safety called Suraksha. The goal of this research was to create a security-enhancing application for users. While signing up for the application, the user is prompted to save the emergency contact information. In the event of an emergency, the pre-loaded message and the user's GPS location are transmitted to the selected contacts after a button has been clicked. Deshpande et al. [12] developed a Crisis Management Notification System that introduces an Android-based mobile application designed to track emergencies, with a specific focus on women. The system's primary objective is to deliver emergency services to registered users. By simply clicking a single emergency button, the smartphone captures images or objects in the user's vicinity. This action initiates the emergency assistance process, which promptly sends an alert or message to the administrator. The administrator verifies the authenticity of the alarm to ensure it is not a false alarm and promptly dispatches an ambulance to assist the victim as soon as possible. Alternatively, the system can share the victim's location with their relatives for further assistance. Although this concept appears promising for crisis management, it has certain limitations. Firstly, the system only notifies ambulance services and fails to alert other response teams, which means it may not be suitable for emergencies such as fires where specialized assistance is required. Moreover, the system's exclusive design for women restricts its utilization by individuals of other genders. Furthermore, it is not suitable for life-threatening emergencies where the victim may be unable to physically operate or handle a phone. The use of an emergency mobile application for women was proposed by Kobalan and Hamzah [13] which was referred to as the Women Safeguard Wing Mobile application. This application seeks to help women during emergencies by creating awareness through the click of a button. Users trigger the emergency button which automatically sends a pre-programmed message with the user’s GPS location as well as a photo displaying the current situation via SMS to predefined emergency contacts. This system also consists of other functions such as locate me function, check-in function, post-emergency function, status function, and so on. This system also has a social network function that allows users to post emergency statuses on Facebook. However, this system lacks the function of notifications being sent to appropriate emergency response teams to increase the chances of survival, the use of pre-programmed messages may restrict better understanding of the current emergency at hand, the manual trigger made by the user can be ineffective in cases where the victim is held, hostage. Heng [14] created an Android-based Emergency Services System that utilizes location tracking as its primary feature. The system incorporates an authentication pin to ensure secure user operations and protect against unauthorized access and malicious attacks. It involves a mobile application designed for tracking users' locations during emergencies. By leveraging GPS services, the system accurately monitors the users' whereabouts. Additionally, it includes a whistling feature that users can utilize when they find themselves in perilous circumstances. To enhance security and deter malicious users, the system also incorporates identity authentication functions to verify users' identities.

However, these research efforts and their effectiveness encounter certain limitations. The emergency response team is required to accept the distress call from the victim to view the current emergency [10]. This can lead to significant time delays if the response team accepts the request after a considerable period from the initial occurrence of the emergency, or even unintentionally rejects the request. Such delays can be detrimental to the victim's well-being and survival chances. Additionally, the "Offline" mode feature [10] can hinder the reception of notifications when the response team is not connected to the system, potentially reducing the chances of timely assistance for the victim.

The system relies on the victim's self-consciousness to manually trigger a distress signal by clicking a button [11]. This approach fails to address scenarios where the victim experiences a sudden loss of consciousness or is unable to physically activate the distress signal. As a result, the chances of receiving timely rescue intervention from the selected contacts in critical situations may be significantly reduced.

The Alarm Whistle feature introduced by Heng [14] is an innovative and clever concept. However, it can have unintended consequences in certain instances of kidnapping or robbery emergencies, as it may alert criminals to the victim's attempt to seek help from people or response teams. Additionally, the requirement for the user to log in every time a distress message is sent to verify their identity can be time-consuming and burdensome for the user.

After reviewing various research works, effective communication has been recognized as a crucial factor in emergencies. Unlike these related works, the proposed research aims to minimize direct communication between the user and the system during emergencies. This is achieved by utilizing keyword recognition through the user's microphone, which consistently listens in the background. This approach ensures that potential wrongdoers remain unaware of the user's action to seek assistance. Furthermore, the system incorporates the option of manually triggering an alert by clicking on emergency cards within the user's dashboard. This dual approach, combining keyword recognition and manual activation, distinguishes the proposed research and enhances the user's safety and confidence in emergency situations. To address this, the proposed research aims to implement a hybridized emergency notification system that can alert both relatives and service providers during emergencies, either automatically or manually. In the automatic notification method, the system enables the victim to utter a predefined keyword (e.g., 'help') within the proposed application. After a three-second delay, this triggers an automatic alert to the respective relatives, notifying them of the emergency. Alternatively, the manual notification method involves the victim logging into the system and clicking on available emergency cards. This action then triggers notifications to individual service providers who can offer assistance. By incorporating both automatic and manual notification mechanisms, this research seeks to enhance the effectiveness of emergency notifications and improve response time in critical situations.

2.2 Review of related models

2.2.1 Smart emergency notification system (SENS) model

In a study carried out by Yıldız and Yiltan [15], a model called SENS (Smart Emergency Notification System) was proposed. This model aimed to automatically identify emergency cases based on images captured by smartphones and sent to response teams, such as the police, fire services, and ambulance management, through the internet. The SENS model comprised three modules: SENSdroid (a mobile application), WebSENS (a web application), and NotiSENS (a PHP-based software agent).

SENSdroid, the mobile application, allowed users to capture images using their smartphones. These images, along with GPS location, date, and time data, were sent to the NotiSENS module. NotiSENS processed the received image and then notified the appropriate emergency coordination center, triggering necessary actions.

While the SENS model presented an innovative approach to emergency notification based on image analysis, its practicality could be limited in certain scenarios. For instance, if a victim is unable to physically use their phone during a robbery or if they are under surveillance by perpetrators, they may not be able to capture and send images via SENSdroid, reducing the effectiveness of the system in such situations.

Overall, the SENS model demonstrated the potential of utilizing smartphone images for automatic emergency identification and notification. However, its applicability may be diminished in specific circumstances where victims are unable to utilize their phones. Figure 1 shows the SENS model.

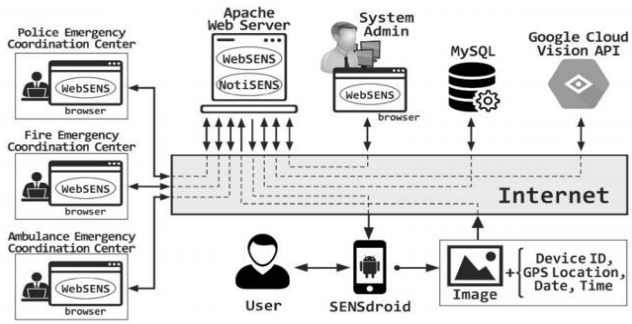


Figure 1. SENS system model [15]

2.2.2 digiRESCUE system model

In a study conducted by Kommey et al. [16], a smart personal emergency rescue system called digiRESCUE was developed. This system aimed to assist individuals in dangerous situations by providing a means to send SOS messages and alert selected contacts. The digiRESCUE system consisted of two main components: Hardware and mobile software application.

The hardware component of digiRESCUE consisted of a button embedded with a chip. When the button was pressed, it activated the associated software. The software, running on a mobile device, allowed users to record or write SOS messages and store contacts to be alerted in case of an emergency. The messages were stored in an SD Card within the software, and the chip facilitated the transmission of the emergency alert through Bluetooth connectivity.

While digiRESCUE provided a means for signaling nearby security and authorities, it relied on manual triggering through the press of a button. This required the victim to be conscious and aware of the emergency, which may not always be the case in sudden or unconscious situations. This limitation reduces the effectiveness of the system in ensuring prompt rescue or survival of the victim.

Additionally, digiRESCUE's reliance on specialized hardware could make it unaffordable for some individuals,

limiting its accessibility. Moreover, the system primarily sends messages to family and friends, which may not always be the most suitable respondents in every emergency scenario that requires specialized intervention. Overall, while digiRESCUE presented a novel approach to personal emergency rescue, it had limitations in terms of manual triggering, affordability, and reliance on non-specialized respondents. Figure 2 shows the digiRESCUE model.

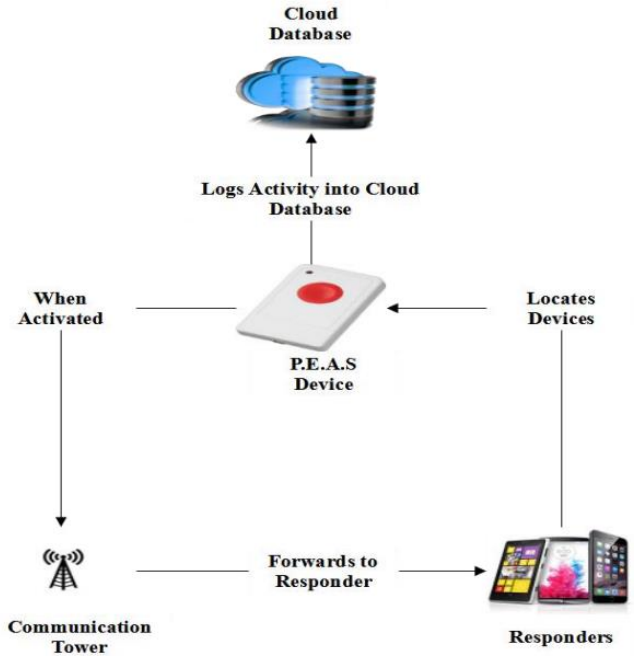


Figure 2. digiRESCUE system model [16]

2.3 Common themes in related works

The literature reviewed in section 2.2 exhibits similar trends, shared terminology, and varying levels of effectiveness, some of which will be detailed. These works are designed to notify specific recipients, including relatives and emergency services, during critical situations. These alerts are typically initiated through manual actions like button presses or image capture. For instance, Yıldız and Yiltan [15] employ images and GPS location as data to be sent to rescuers. However, this approach may be less effective in scenarios where victims face restricted access or encounter poor network connectivity. To address this limitation, this research focuses on reducing user interaction by using voice commands like shouting the keyword "help." This enables distress signals in any situation. The proposed approach aims for enhanced effectiveness through automated alerts by monitoring voice and keywords. This consideration is particularly important in cases where victims face limitations. Additionally, the system incorporates the manual trigger option, similar to other related works, through the click of an emergency card.

3. METHODOLOGY

The DA-ESNS model was developed by incorporating insights from extensive research, analyzing existing research works and models, and identifying gaps. These gaps were carefully synthesized and taken into account during the design process of the DA-ESNS model. Limitations, areas for improvement, and unexplored aspects within the area of emergency notification were identified to understand the strengths and weaknesses of previous models and approaches. Also, the synthesis of the identified gaps involved extracting common themes, patterns, and shortcomings from the existing models to gain a comprehensive understanding of the research landscape and to identify key areas where the DA-ESNS model could make a significant contribution in filling those gaps. The extensive research and synthesis conducted before and during the design of the DA-ESNS model helped to ensure that the model was informed by the existing knowledge base, addressed the identified gaps, and contributed to the advancement of emergency notification systems. The DA-ESNS model comprises various interconnected components, including users, platforms, a registration module, an SMS module, a notification module, a verification module, IndexedDB, a network module, the Twilio API, the Geolocation API, and a MongoDB database. Figure 3 illustrates the interactions among these components, demonstrating how they work together to create a coherent system.

In implementing the DA-ESNS model, the Feature Driven Development (FDD) software development process model was adopted. FDD is an incremental and agile approach that focuses on developing specific features of the product in a systematic and planned manner. The FDD methodology involves five activities with the first being the development of an overall model as shown in Figure 3 and the other four involving building, planning, and designing the features. This model highlights the different components in the system and their interactions with each other, it also helped in categorizing the different existing features in the system which aided our development process. The major feature focused on during development was the notification feature to ensure seamless communication between the users and the emergency service providers.

ReactJS, an open-source, cross-platform JavaScript framework, was utilized for building user interfaces due to its component-based architecture, larger community ecosystem compared to other frameworks, efficient Virtual DOM rendering for faster updates which in turn enhances easier development and support. Material UI was integrated with ReactJS with advantages such as providing robust set of predefined components, ensuring consistent community and visually appealing interfaces in order to enhance the visual aesthetics of the front end. MongoDB, an open-source, document-oriented database program, was chosen for data storage due to its effective accommodation for changing requirements through scalability, support for unstructured data with its flexible schema and diverse data types management. The Twilio API was employed to enable the transmission of SMS notifications to emergency response teams and predefined contacts, leveraging Twilio's advantages of global coverage, developer-friendly integration, and seamless scalability, which set it apart as a robust solution for ensuring swift and reliable communication during critical situations. Figma, a free design tool, facilitated collaboration among designers, aiding in the creation of application screens, and its cloud-based nature offers the advantage of real-time concurrent editing, making it stand out compared to other tools, ensuring seamless teamwork and efficient design iteration.

By leveraging the FDD model and incorporating these methodologies, the development team aimed to ensure an iterative and efficient process for designing and implementing the DA-ESNS model.

3.1 Research design

3.1.1 Data collection

The following data will be collected through the DA-ESNS model:

(1) **GPS Location Data:** The DA-ESNS model will collect and analyze the GPS location data of emergency incidents to understand the distribution of emergencies across different areas.

(2) **SMS Notification Logs:** From the SMS notifications sent to respective emergency response teams and predefined contacts, SMS data will be logged and analyzed to assess the efficiency of the system's communication and response time.

(3) **System Logs:** The system activity logs which includes error messages and exceptions will be collected and analyzed to identify and resolve issues which might not be obvious to the users of the system.

3.1.2 Data privacy

In protecting user data throughout the data collection and analysis process within the DA-ESNS model, the following measures were put in place:

(1) Encryption: Strong encryption techniques were applied to all sensitive data, ensuring that information was securely encrypted during both transmission and storage. Additionally, HTTPS communication protocols were utilized to guarantee secure data transfer between the client and the server.

(2) Access Control: Robust access controls were implemented, granting varying degrees of permissions based on user roles. This approach prevented unauthorized access to both transmitted and stored data within the database, ensuring that only authorized personnel could access sensitive information.

3.1.3 Evaluation metrics

The effectiveness of the DA-ESNS model was tested using the following parameters:

(1) Response Time: This measures the time taken for the DA-ESNS model to detect and relay emergency alerts to the respective response teams and predefined contacts.

(2) Offline Capability: This tests the system's ability to function in offline mode, to ascertain that it can store and forward emergency alerts when internet connectivity is restored.

(3) Accessibility: This tests the accessibility of the DA-ESNS model on different platforms, including mobile devices (Android and iOS) and web browsers.

4. RESULTS

The results and findings of this study are organized into two sections to provide solutions to the objectives of this research.

4.1 DA-ESNS model

The DA-ESNS model, based on the SENS model mentioned earlier, serves as the foundation for developing the emergency notification application. The system involves three key user roles: the client (victims), the service providers (police authorities, fire service providers, medical service providers), and the administrator responsible for adding details of new emergency service providers. The application is developed using the Progressive Web Application (PWA) platform, which allows users to access it through a web browser and store it on their home screen like a native mobile application. The application is comprised of various modules, including the registration module, notification module, messaging module, and more.

Two external APIs are utilized in the project. The Twilio API is used to send emergency messages to predefined contacts and emergency response teams through a Twilio trial number. The Geolocation API is utilized for location tracking. These platforms and APIs work together to create the workflow of the application. When a distress message is triggered, the Twilio API sends a message that generates a push notification containing the distress message and the victim's current location. This notification is then sent to the appropriate response providers who take the necessary actions. The history of the emergency action is stored in the database via an internet connection.

In situations where there is no internet connection or the user is offline, the request is cached in the browser's IndexedDB. Once a slight network connection is established, the distress message is sent accordingly.

The model in Figure 3 constitutes the following key elements:

(1) Users: The user roles within the DA-ESNS consist of clients (victims), emergency service providers (such as firefighters, ambulance personnel, and police), and administrators. Each user role has specific functionalities and access levels within the system. Clients are the individuals who may need to trigger emergency alerts or seek assistance. Emergency service providers are the professionals responsible for responding to emergencies. Administrators have privileged access and are responsible for managing and maintaining the DA-ESNS.

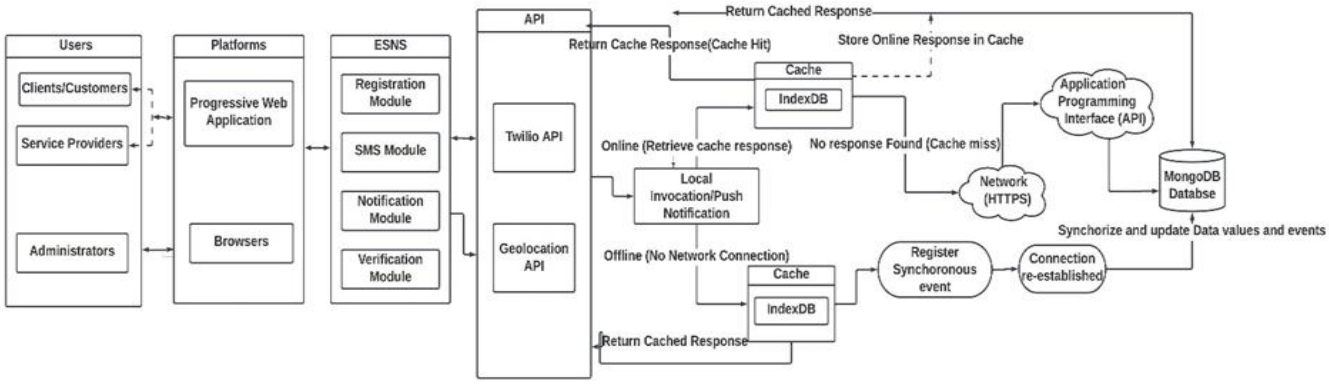


Figure 3. DA-ESNS model

(2) Platforms: The DA-ESNS is accessible through various platforms, primarily mobile devices with different sizes and form factors. Users can access the system using web browsers on their devices or by clicking on the installed application after the initial visit. The supported platforms include Android-based devices and iOS-based devices, allowing users on both operating systems to utilize the DA-ESNS seamlessly.

(3) Hybrid Enhanced Situation Notification System (DA-ESNS): This is the core system that offers a range of functionalities based on the user's role. It comprises several modules that work together to ensure efficient emergency communication. These modules include:

Registration Module: This module handles the registration process for users, allowing them to create accounts and provide the necessary details for accessing the system.

SMS Module: The SMS module facilitates the sending and receiving of text messages, enabling communication between the system and predefined contacts, such as emergency response teams or designated individuals.

Notification Module: The notification module is responsible for generating and sending timely alerts and notifications to the appropriate recipients, including emergency response teams, predefined contacts, and system administrators based on the push notifications or local invocation from the IndexedDB.

Verification Module: The verification module ensures the authenticity and validity of user information and actions within the system. It may involve processes like email verification or two-factor authentication to enhance security and prevent misuse.

These modules collectively form the DA-ESNS, working in conjunction to enable effective communication, alerting, and verification processes during emergencies.

(4) IndexedDB: IndexedDB is a JavaScript-based, object-oriented, transactional database system specifically designed for storing structured data, including files, on the client side. It provides a low-level API that allows for efficient storage and retrieval of data objects, making use of indexed keys to enable high-performance searching. One of the key advantages of IndexedDB is its support for asynchronous operations. This means that tasks performed using IndexedDB are executed in the background, allowing other operations within the application to continue without being blocked. This asynchronous behavior ensures a smooth and responsive user experience. In the context of the DA-ESNS, IndexedDB serves as the local storage solution. It enables efficient management and retrieval of data on the client side. This is particularly beneficial for the DA-ESNS, as it requires persistent storage capabilities to store and retrieve important information even when offline or in low-connectivity situations.

(5) Network (HTTPS): In the DA-ESNS model, the network component refers to the communication between the system and the internet using the Hypertext Transfer Protocol Secure (HTTPS). HTTPS ensures secure and encrypted data transmission over the network. Service workers, which are a crucial part of the DA-ESNS model, specifically operate with the HTTPS protocol. This is done to ensure the integrity and confidentiality of the data being transmitted between the client-side application and the server. By utilizing HTTPS, the DA-ESNS model can provide a secure and protected communication channel, safeguarding sensitive user information and maintaining the privacy of data transmitted over the network.

(6) Application Programming Interface (API): Within the DA-ESNS model, this component encompasses the integration of the Twilio API and the Geolocation API. The Twilio API is responsible for facilitating the sending of SMS messages to both the emergency response teams and the predefined contacts. The Twilio API incorporates functionalities such as messaging, voice, video, authentication, and contact center capabilities. It stands out for its smooth integration, flexible communication services, and reliable scalability. Its robust security features, coupled with extensive developer support, position the Twilio API as the superior choice among alternatives. On the other hand, the Geolocation API is employed for location tracking and is selected due to its user-friendly nature, compatibility with diverse devices, and streamlined integration with applications necessitating geolocation services, making it a preferred option.

By utilizing the Twilio API, the DA-ESNS model can efficiently deliver SMS notifications to the designated recipients, ensuring timely communication during emergencies. This functionality allows for quick alerting of emergency response teams and predefined contacts, enabling them to take appropriate actions.

The Geolocation API is part of this component, which enables the system to retrieve the precise location of the emergency incident. The Geolocation API provides access to the device's location information, allowing the DA-ESNS model to include the actual incident location in the SMS notifications sent to the relevant parties.

(7) Database (MongoDB): The database component in the DA-ESNS model refers to MongoDB, a NoSQL database. It serves as the storage system for all the data within the DA-ESNS, organizing it into documents. MongoDB enables efficient querying and synchronization of data with the application.

One key feature of MongoDB is its ability to provide customizable identity-based security access controls. This ensures that data writes and reads are securely managed, allowing for fine-grained control over who can access and modify the stored information.

MongoDB plays a role in ensuring data integrity by receiving sanitized data passed from the APIs. This helps to prevent any malicious or invalid data from being stored, ensuring the reliability and consistency of the DA-ESNS data.

The DA-ESNS model comprises vital elements, including three user roles: victims, emergency service providers, and administrators. The model is user-friendly, accessible through web browsers or home screens as a mobile app. External APIs, Twilio and Geolocation, aid in sending emergency messages and tracking locations. Twilio sends alerts to contacts and response teams with messages and locations after an is triggered through the use of “help” keyword or the manual clicking of an emergency card on the user’s dashboard. The model’s workflow saves emergency history in the database. If offline, messages are saved and sent when there is an internet connection.

4.2 DA-ESNS implementation

This section pertains to the application development process and the obtained outcomes, encompassing elements such as the development interfaces, SMS responses, and more. Within the user module of DA-ESNS, some excerpts of the system include:

4.2.1 User login and dashboard interface

The login interface serves as the entry point for users with existing accounts to access the application. Users are required to provide their email and password, which enables the system to store their states. Figure 4 showcases the mobile view of the login interface.

Once users successfully log in, they are re-directed to the dashboard interface as shown in Figure 5. This interface serves as the central hub for all signed-in users. It consists of several tabs:

(1) Dashboard Page: This page displays a list of emergency services provided by the system. Users can easily trigger an emergency by clicking on the corresponding emergency card, as shown in Figure 5.

(2) Emergency History: This tab presents a log of previous emergency requests made by the users, along with relevant details.

(3) First Aid Tips: This page offers various first aid information for different emergencies. It aims to provide users with guidance on handling emergencies before the arrival of the emergency response team.

(4) Profile Page: This tab allows users to view and manage their personal details and account settings.

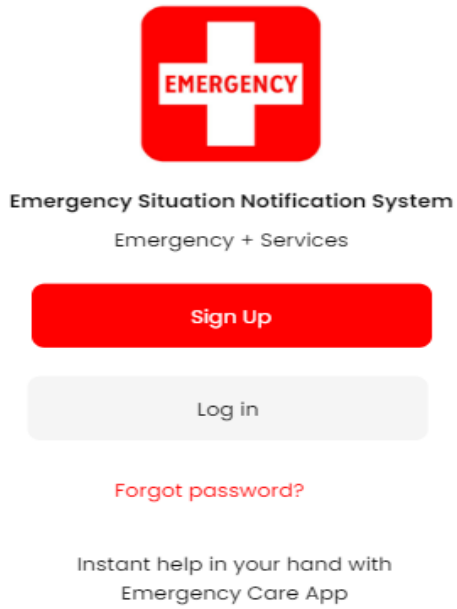


Figure 4. Login page

4.2.2 User emergency notification interface

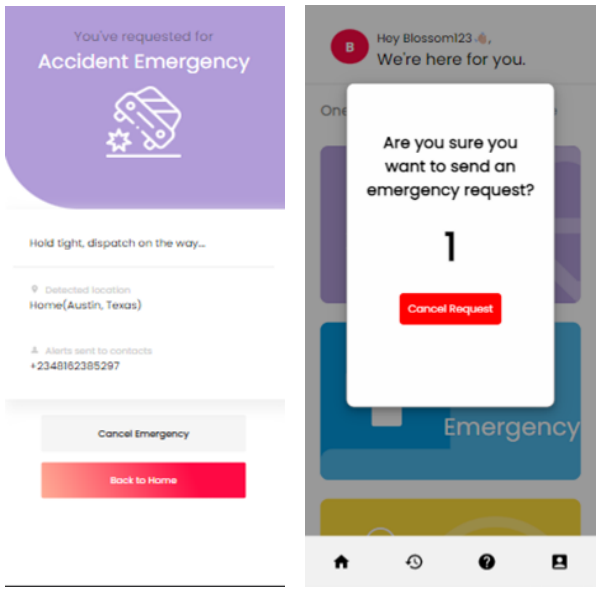
The system developed in this case has a dual form of activation, catering to both manual and automated requests for emergency response. Figure 6(a) depicts the manual trigger for help, which occurs when a user clicks on a card. This interface displays the emergency request details, including the location and the emergency service provider. In the case of automated notification to the response team, the user simply needs to utter the predefined keyword or include it in a statement. Upon doing so, a popup appears, showing a countdown timer of 3 seconds (adjustable by the administrator).

This countdown period allows the user to cancel the emergency request in case the keyword was mentioned by mistake, thus reducing false alarms. Once the 3-second countdown elapses, the emergency alert is sent to the predefined contacts of the user. Figure 6(b) showcases the interface of the automatic emergency notification popup.

Figure 5. User dashboard page

4.2.3 User first aid and emergency history page

The first aid interface is designed to provide users with videos demonstrating various hazards or attacks and the appropriate methods of handling them. It offers tips on different first aid emergencies and guides on administering adequate care. Figure 7 displays the interface for accessing first aid tips. On the other hand, Figure 8 exhibits the emergency history interface. This interface presents a comprehensive list of all manual emergencies previously sent by a particular user. Each entry in the list includes details such as the type of emergency, the date and time when the emergency alert was sent, and the color associated with the emergency type. This interface enables users to review their past emergency incidents and track the information related to each event.



(a) (b)

Figure 6. (a) Manual trigger page; (b)Interface of the automatic emergency notification

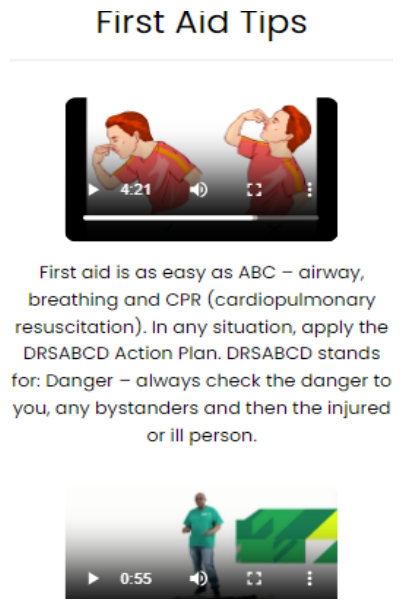


Figure 7. First aid activity page

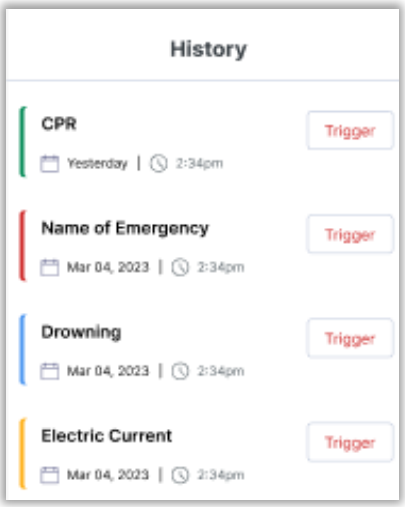


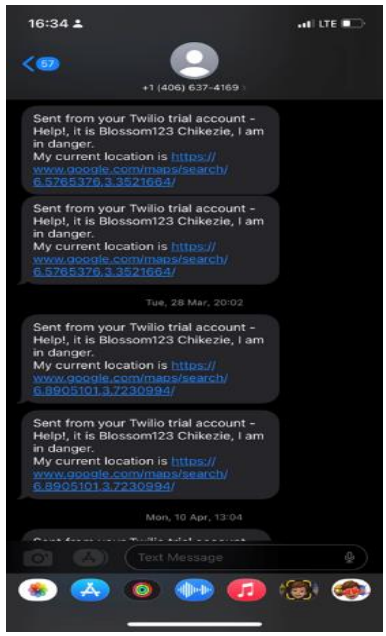
Figure 8. Emergency history page

4.2.4 SMS Response for predefined contacts and response providers

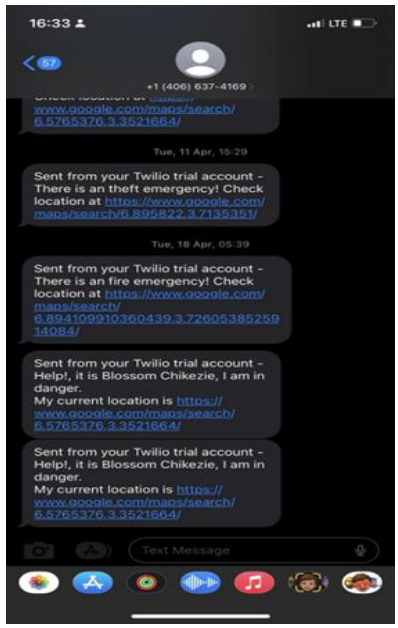
Figure 9(a) displays the message received by the predefined contacts and respective agencies after the victim mentions the predefined keyword, which is automatically detected by the system. This message serves as an alert for an emergency. Figure 9(b), on the other hand, showcases the message received by the respective response team specifically for a fire-related incident. This message is triggered when the user clicks on the fire card on the dashboard interface, indicating the need for immediate response and assistance from the appropriate response team.

Both figures highlight the communication aspect of the system, ensuring that the relevant contacts and response teams are promptly notified about the specific emergency to take appropriate action.

Once logged into the system's dashboard, users (victims) possess several capabilities. They have the option to activate emergency alerts by clicking on designated cards, thereby notifying the appropriate emergency teams about ongoing issues. Additionally, users can review their historical emergency incidents and access guidance on administering initial aid.



(a)



(b)

Figure 9. (a) Sample message received by the predefined contacts; (b) Sample message received by the respective response team

4.3 Usability and user experience

The DA-ESNS application's design prioritizes ease of use for users with minimal tech experience. The design process incorporated several key considerations:

(1) **User-Friendly Navigation:** The system's dashboard offers a user-friendly navigation experience for logged-in users (victims). By clicking on easily identifiable emergency cards, users can swiftly alert the relevant emergency teams about any ongoing issues. Furthermore, they can conveniently access a record of their past emergency incidents and readily find guidance on providing immediate first aid assistance.

(2) **Clear and Readable:** Text and icons were designed to be clear and easily readable by users of the system.

(3) **Feedback for Actions:** Users receives immediate feedback for every action taken through relevant alerts.
(4) **Error Handling:** Clear error messages were incorporated to guide users whenever an issue arises.
(5) **Streamlined Data Input:** The process of notifying the emergency team through the use of the 'help' keyword and manual clicks of the emergency cards minimizes the need for extensive data input.

These design features collectively ensure that users, regardless of their technological background, can confidently interact with the application. Additionally, the system effectively manages false alarms by incorporating a three-second delay between the initiation of a distress call and the transmission of the alert to the relevant response agencies. This interval allows for the cancellation of signals sent unintentionally.

5. CONCLUSIONS

This research study has investigated the consequences of mishandled emergencies, which can result in severe outcomes and even death for victims. It has also discussed in different literature works ways that have been imbibed to reduce and curb the occurrence of emergencies in society. As a response to this issue, this paper focuses on the implementation of automated and manual emergency triggers through the shout or inclusion of the key word "help" in a sentence as well as the manual click of the emergency cards on the user's dashboard on the system. The system aims to enhance emergency alertness and response by delivering timely and accurate notifications to predefined contacts and emergency responders, depending on the situation. It comprises a web-based dashboard for emergency response teams and a progressive web application (PWA) for users. The DA-ESNS utilizes various channels, including SMS messages to predefined contacts and emergency notifications to responders.

In conclusion, the system addresses crucial factors such as security, efficiency, and mode of control, thereby simplifying the emergency alert process through swift notifications and offline accessibility provided by PWAs and service workers. This ensures the system is accessible to diverse users, including mobile (Android and iOS) and web users. The swift and automated alert system has the potential to greatly expedite response times during emergencies, potentially saving lives by facilitating prompt medical interventions and reducing the severity of injuries. Moreover, the immediate alerts sent to response teams can improve evacuation planning and coordination among responders, which in turn can mitigate the overall impact of disasters. By providing an accessible tool for public reporting of emergencies, the DA-ESNS model contributes to heightened public safety, enabling community members to take quick actions and collectively create a safer environment. Moreso, the system positively impacts public health by enabling rapid response, providing education, and facilitating data-driven decision-making. It also enhances emergency management practices by improving coordination, resource allocation, and overall preparedness during emergency situations.

Although challenges such as increased power consumption due to continuous keyword monitoring exist, future works can further minimize this challenge in several ways such as ensuring code efficiency and less consumption of device resources in implemented algorithms, offering the option to enable or disable monitoring when not required. Though, the advantages of implementing such a system outweigh this drawback, making it a valuable addition to emergency response infrastructure. It is also crucial to indicate that the system designed does not provide solutions to current emergencies but rather serves as an aid or enhancement to the operation by the response agencies.

Recommendations for improvement include enhancing network speed to expedite database requests and information retrieval, incorporating mobile technologies to further make the system a mobile application and increase user's access and interaction with the system, customizing key words or sentences for the users of the system so as to aid their usage. Additionally, efforts to minimize power consumption on mobile devices caused by persistent keyword monitoring would significantly enhance the system's efficiency.

To guarantee the system's sustainability, adaptability, and continuous improvement, there are plans for comprehensive user testing involving a diverse range of potential users. This approach aims to unearth any usability concerns and gather vital feedback, thereby refining the system to meet the needs of a broader user spectrum. Additionally, as the user base expands, strategies will be devised to optimize database performance, ensuring seamless application responsiveness even amidst higher user volumes. The exploration of emerging technologies will be a priority, aimed at elevating user experiences, bolstering security protocols, and streamlining communication processes. Collaboration with additional emergency response agencies is also on the agenda, expanding the system's capacity to handle a wider array of emergency scenarios. These forward-looking plans underscore the commitment to ensuring the DA-ESNS model's effectiveness and continuous evolution.

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