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Smart Geo-Fencing Real-Time Child Safety System

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Abstract - This paper presents the design and implementation of a Smart Geo-Fencing Real-Time Child Safety System developed to enhance child security through continuous location tracking, intelligent monitoring, and automated emergency alert mechanisms. The proposed system integrates Global Positioning System (GPS), Global System for Mobile Communications (GSM), Wi-Fi, and Internet of Things (IoT) technologies to provide an efficient and reliable child monitoring solution. Using geo-fencing technology, the system establishes predefined geographical boundaries (safe zones) and continuously monitors the child's location. Whenever a child moves beyond the designated safe zone, an instant alert containing the child's current location is transmitted to parents or guardians through a dedicated mobile application.

Furthermore, the system incorporates essential safety features such as an emergency SOS facility, real-time location tracking, route history monitoring, and abnormal activity detection to facilitate timely intervention during critical situations. Cloud-based IoT communication enables continuous data synchronization, remote monitoring, and easy access to location information. The proposed device is designed to be compact, lightweight, portable, and suitable for everyday use by school-going children. Overall, the system aims to strengthen child safety, minimize the risk of missing-child incidents, improve emergency response time, and provide parents and guardians with a reliable and effective real-time child monitoring solution.

Index Terms - Geo-fencing, child safety, GPS tracking, GSM module, IoT, real-time monitoring, emergency alert system, location tracking, mobile application.

INTRODUCTION

Child safety has emerged as a significant concern in modern society due to the increasing challenges associated with missing child incidents, child trafficking, school transportation safety, and inadequate real-time parental supervision. Ensuring the safety and security of children is particularly important during daily activities such as travelling to and from school, participating in outdoor activities, and visiting crowded public places. Parents and guardians often face difficulties in continuously monitoring their children's whereabouts, which creates the need for a reliable and efficient child safety monitoring system.

Conventional child monitoring approaches primarily depend on manual supervision and smartphone-based tracking applications. However, these methods may not always be suitable for young children, as they may forget, misplace, or improperly use mobile devices. Furthermore, existing child tracking solutions may experience limitations such as delayed emergency notifications, inaccurate location information, increased power consumption, dependence on internet connectivity, and the absence of integrated emergency response mechanisms. These limitations highlight the need for an advanced, portable, and cost-effective solution that can provide continuous location monitoring and immediate alerts.

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To overcome these challenges, this paper proposes a Smart Geo-Fencing Real-Time Child Safety System that integrates Global Positioning System (GPS), Global System for Mobile Communications (GSM), Wi-Fi, and Internet of Things (IoT) technologies to enhance child security and parental monitoring. The proposed system uses geo-fencing technology to establish predefined geographical boundaries and continuously monitors the child's location within the designated safe zones. If the child crosses the specified boundary, an automatic alert containing the current location details is sent to parents or guardians through a mobile application. Additionally, the system incorporates emergency SOS functionality, live location tracking, route history monitoring, and abnormal activity detection to support timely intervention during critical situations.

The proposed system aims to provide an efficient, reliable, and user-friendly child safety solution by enabling real-time monitoring, automated emergency notifications, and remote accessibility. Its compact and portable design makes it suitable for everyday use, particularly for school-going children. By combining location-based monitoring with IoT-enabled communication, the system seeks to improve child safety, reduce parental concerns, and facilitate faster responses during emergency situations.

LITERATURE SURVEY

An extensive review of literature published between 2019–2026 was conducted to study advancements in IoT-based safety systems, geo-fencing technologies, GPS-GSM communication, cloud-integrated monitoring, and emergency response mechanisms for child safety applications. The following subsections summarize twenty significant research contributions and identify the limitations of existing systems.

Wagh et al. [1] evaluated IoT-based smart safety systems integrated with machine learning algorithms for intelligent emergency monitoring and decision-making. The study focused on improving threat detection accuracy using sensor-based data analysis and predictive safety models. The system demonstrated improved automated response capabilities compared to traditional tracking systems. However, the design required high computational resources and complex data processing, limiting its implementation in compact wearable devices intended for children.

Daood and Hagem [2] developed an embedded wearable IoT system specifically designed for child safety applications. The system utilized GPS modules, wireless communication, and embedded controllers to enable real-time child location monitoring. The wearable architecture improved portability and usability for children. Despite achieving real-time tracking functionality, the system lacked emergency panic support, geo-fencing intelligence, and fall detection mechanisms required for comprehensive child protection.

Asha K. G et al. [3] introduced an Edge-Fog-Cloud architecture for smart safety systems to improve real-time data processing and reduce communication latency. The architecture distributed computational tasks across edge, fog, and cloud layers to achieve faster emergency response and efficient IoT communication. The framework significantly enhanced scalability and system reliability. However, the proposed architecture increased implementation complexity and power consumption, making it difficult for low-power wearable child safety systems.

Kaushik and Khanna [4] proposed “HerArmour,” an IoT-based safety device primarily designed for women’s protection. The system incorporated GPS tracking, emergency alert generation, and communication modules for rapid emergency response. The study demonstrated the importance of wearable safety devices integrated with real-time monitoring technologies. However, the proposed system focused mainly on adult safety scenarios and did not address child-specific monitoring features such as geo-fencing and parental supervision.

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Aadhya and Deepshika [5] developed a cloud-integrated IoT safety monitoring system capable of storing real-time user data and providing remote monitoring support. The study highlighted the importance of cloud computing in enabling continuous safety supervision and historical data analysis. Although the system improved remote accessibility, dependency on stable internet connectivity and cloud availability reduced system reliability in poor network conditions.

Sunitha Bai and Rohini Bai [6] conducted a survey on IoT-based safety devices focusing on wearable safety systems, emergency communication technologies, and real-time monitoring applications. The study analyzed various safety architectures using GPS, GSM, and cloud platforms and identified challenges such as battery limitations, network dependency, and delayed emergency response. The survey concluded that integrated multi-functional wearable systems are necessary for practical real-world deployment.

Bello and Figetakis [7] presented a comprehensive survey on IoT wearable devices, discussing sensor integration, wireless communication technologies, energy efficiency, and cloud connectivity. The survey emphasized the growing importance of wearable technologies in safety monitoring applications. Despite significant advancements, the authors identified major challenges including battery optimization, sensor reliability, and data privacy concerns in wearable IoT systems.

Nigar [8] studied IoT applications in women and child healthcare systems with emphasis on remote monitoring, wearable health devices, and emergency safety communication. The paper demonstrated how IoT-enabled healthcare and safety systems improve user monitoring and emergency assistance. However, the study primarily focused on healthcare applications and lacked implementation details regarding real-time geo-fencing and intelligent child tracking systems.

Harshitha J and Pallavi N [9] developed an IoT-based women safety system integrating GPS tracking, emergency alert generation, and GSM communication modules. The system enabled users to send immediate distress notifications during dangerous situations. While the emergency response mechanism was effective, the system lacked intelligent monitoring capabilities such as automatic fall detection and geo-fencing support.

Farooq et al. [10] conducted a systematic review on the role of IoT in women's safety applications. The study reviewed various wearable safety devices, emergency communication techniques, and location tracking systems. The authors concluded that IoT significantly improves emergency response time and user safety. However, most reviewed systems depended heavily on manual activation and lacked autonomous threat detection capabilities.

Lakshman et al. [11] proposed an IoT architecture for social safety systems emphasizing scalable communication frameworks and distributed monitoring mechanisms. The architecture supported multiple IoT devices and real-time data sharing between users and emergency services. Although the system improved large-scale monitoring capability, implementation complexity and network latency remained critical challenges.

Cook et al. [12] analyzed IoT security challenges in 5G-enabled networks, focusing on privacy, cyber-security threats, and secure communication protocols. The study highlighted vulnerabilities in IoT wearable systems caused by insecure wireless communication and cloud data exposure. The authors emphasized the need for secure encryption mechanisms and robust authentication protocols in wearable safety applications.

Asharani R and Nayana R [13] reviewed the role of IoT in women safety systems using wearable sensors and

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emergency communication modules. The paper demonstrated the effectiveness of real-time tracking and emergency alert systems in enhancing personal safety. However, the reviewed systems lacked integrated child-focused features such as geo-fencing, battery monitoring, and parental supervision.

Nalina H D et al. [14] designed a smart women safety device using IoT technologies integrated with GPS tracking and emergency communication support. The wearable device successfully transmitted live location data during emergencies. However, the system lacked automation features such as automatic fall detection and intelligent alert triggering mechanisms.

Srinivasan K et al. [15] proposed an IoT-based safety system for women and children incorporating wearable sensors, emergency buttons, and GSM communication modules. The study demonstrated a combined safety platform suitable for multiple user categories. Although the system provided real-time monitoring support, it lacked cloud integration and advanced geo-fencing capabilities for continuous child supervision.

Kumar et al. [16] developed a smart wearable safety device integrated with location tracking and emergency communication technologies. The device demonstrated compact wearable implementation suitable for continuous monitoring applications. Despite achieving portability and real-time communication, the system did not include intelligent safety analysis features such as motion detection and automatic emergency response.

Akram et al. [17] implemented an IoT-based smart safety device using embedded systems and wireless communication modules for real-time emergency monitoring. The proposed design improved emergency notification speed and tracking efficiency. However, limited battery life and dependence on continuous network connectivity reduced system effectiveness in long-duration outdoor use.

Goodwin et al. [18] studied wearable sensors for stress detection using physiological parameter monitoring and sensor-based behavioural analysis. The study demonstrated that wearable systems can effectively detect abnormal human conditions using sensor data processing techniques. The proposed methodology is useful for integrating intelligent abnormal condition monitoring into future wearable child safety systems.

Verma et al. [19] developed an IoT-based safety monitoring system integrating GPS tracking and wireless communication for emergency applications. The system enabled real-time location monitoring and alert transmission to guardians. However, the design lacked wearable optimization, fall detection, and automated geo-fencing intelligence required for advanced child safety applications.

Sharma et al. [20] presented early IoT wearable safety systems focusing on location monitoring and emergency communication technologies. The study established the foundation for modern wearable safety devices by integrating embedded systems and wireless communication modules. However, the early systems suffered from limited processing capability, poor battery efficiency, and lack of advanced IoT cloud integration.

The reviewed literature clearly indicates that existing systems mainly focus on individual functionalities such as GPS tracking, emergency communication, or IoT connectivity independently. Most systems lack complete integration of real-time geo-fencing, panic alert generation, audio communication, battery monitoring, and cloud-based parental supervision within a single wearable platform.

The proposed Smart Geo-Fencing & Real-Time Child Safety Wearable System addresses these limitations by integrating GPS-based geo-fencing, panic alerts, battery monitoring, audio recording, cloud connectivity, and real-time parental notification into a unified child safety solution.

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PROBLEM IDENTIFICATION

Existing child tracking systems mainly focus on GPS-based location monitoring and do not provide sufficient emergency safety features. In critical situations such as accidents, kidnappings, health issues, or unsafe environments, parents may not receive immediate alerts or real-time updates about their child's condition. This limitation reduces the effectiveness of traditional tracking devices in ensuring complete child safety. Additionally, many existing systems lack features such as panic buttons, health monitoring sensors, fall detection, and instant communication facilities. To overcome these challenges, a smart and reliable child safety wearable system is required. The proposed system can continuously monitor the child's location and health parameters while providing instant emergency notifications to parents or guardians during dangerous situations. Real-time tracking, emergency alerts, and communication features can help parents respond quickly and improve child protection. Such an advanced wearable system enhances safety, security, and peace of mind for both children and parent.

OBJECTIVES

- To monitor child location using GPS and geo-fencing.
- To alert parents when the child exits the safe zone and provide emergency support using a panic button and audio recording.
- To implement battery low alert features for additional safety.

METHODOLOGY

The proposed system is a smart child safety device designed using Internet of Things (IoT) technology to provide real-time monitoring and emergency response. The system is built around an ESP32 microcontroller, which integrates various modules including GPS for location tracking, a GSM communication module for data transmission, and a battery monitoring unit. The device continuously acquires the child's geographical location using GPS and compares it with predefined geo-fenced safe zones. If the child moves outside the designated boundary, an alert along with live location data is immediately sent to the parent's mobile application via the cloud.

In addition to geo-fencing, the system incorporates a panic button that allows the child to manually trigger an emergency alert, enabling quick response from parents. The device also supports audio recording and communication features to provide additional situational awareness during emergencies. All collected data is transmitted through the GSM module to a cloud server, where it is processed and made accessible through a user-friendly mobile application for real-time monitoring. Furthermore, a battery monitoring system ensures that parents are notified when the device power is low, improving system reliability. This integrated approach enhances child safety by combining tracking, automation, and communication into a single efficient system.

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BLOCK DIAGRAM

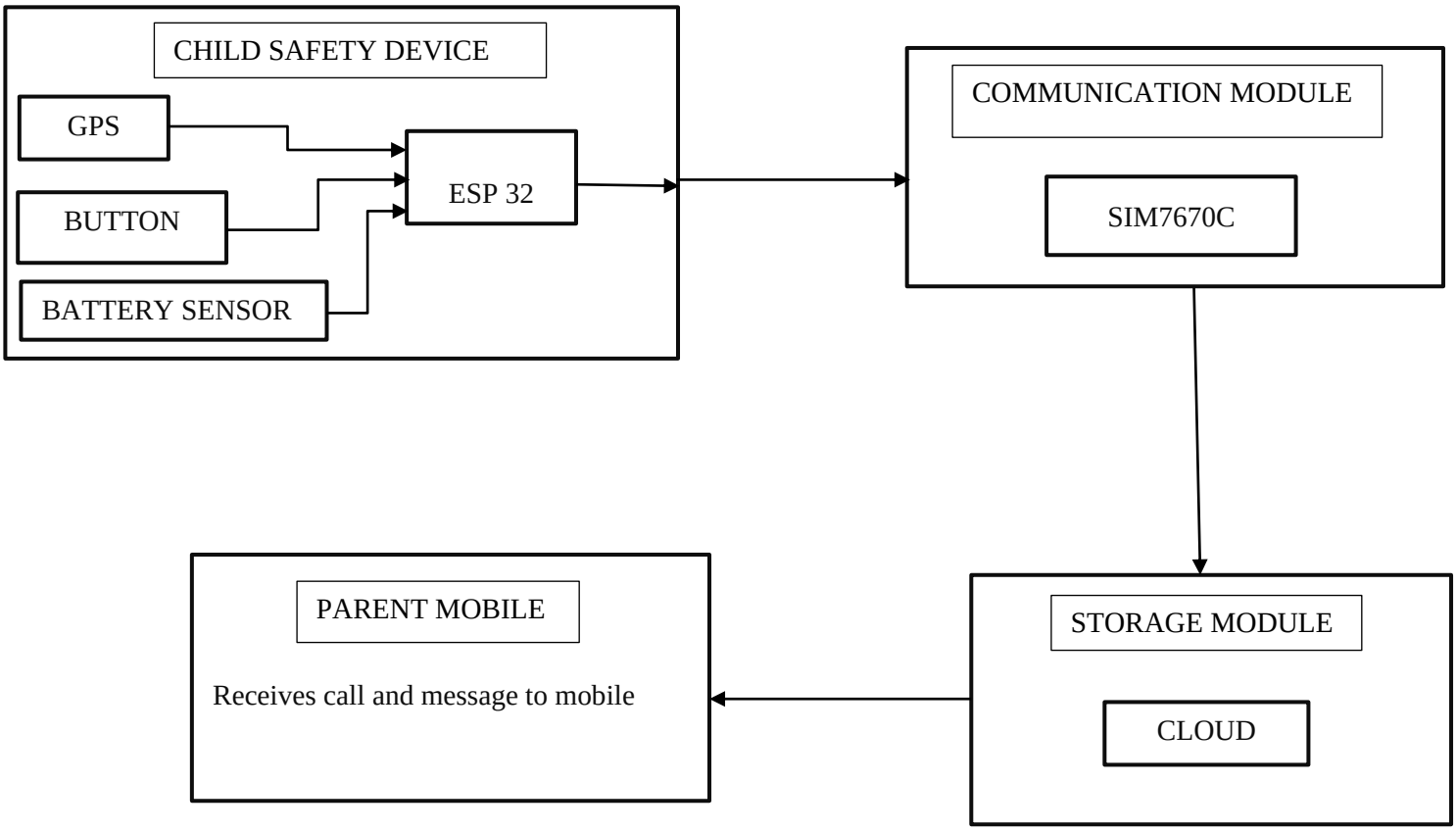


FIG 1: Block diagram of child safety system

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FLOWCHART

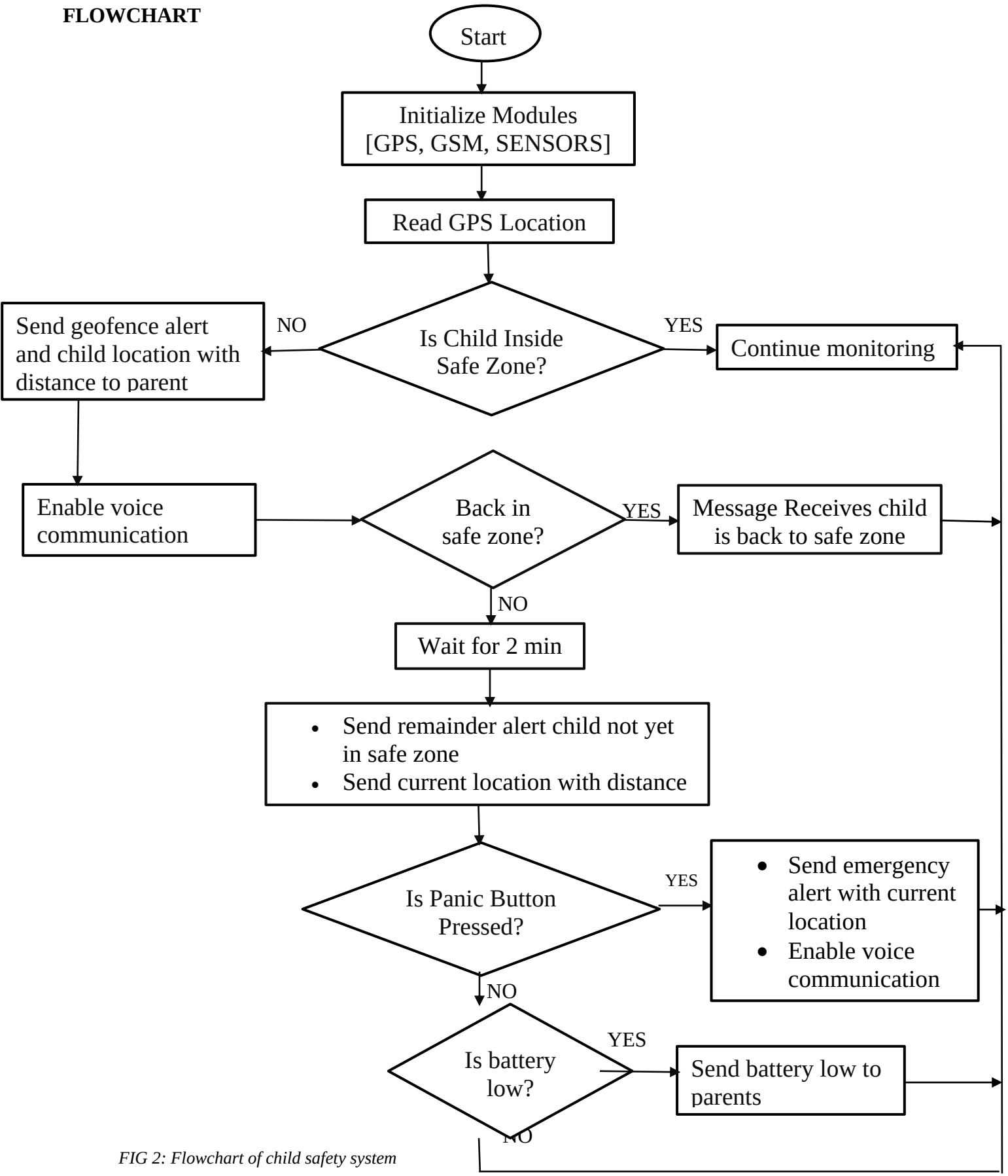
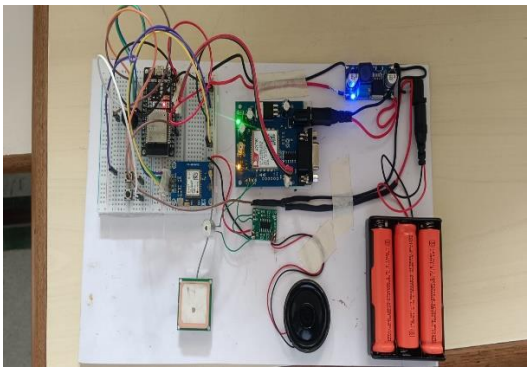


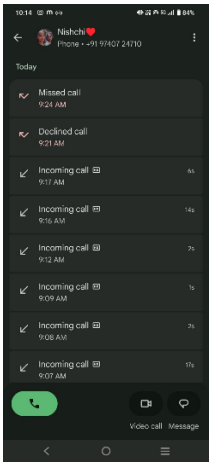
FIG 2: Flowchart of child safety system

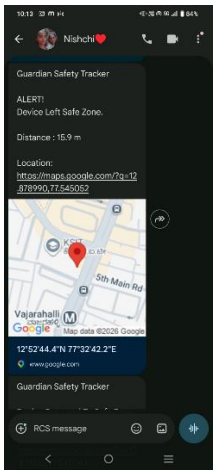
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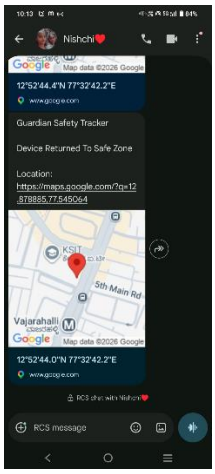
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RESULT









CONCLUSION

The primary objective of this work is to develop a Smart Geo-Fencing Real-Time Child Safety System capable of providing continuous child monitoring and instant emergency support. The proposed system integrates GPS-based location tracking, geo-fencing, panic alerts, battery monitoring, and cloud-based communication into a compact device for improving child safety.

The system enables parents or guardians to monitor children in real time and receive immediate alerts during unsafe situations such as leaving the safe zone, or emergency conditions. Overall, the proposed system provides a reliable, portable, and efficient solution for enhancing child protection and emergency response in real-world environments.

SCOPE OF FUTURE WORK

In the future, the system can be improved by adding AI-based abnormal activity detection, better fall detection, and more accurate location monitoring. A dedicated mobile application can provide live tracking and notifications to parents. Cloud integration can be improved for storing and accessing location data. The device can also be made smaller and more power-efficient so that it is comfortable for children to wear for longer periods.

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