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Child Safety Device With GPS Tracking and Alert Messaging

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Abstract: *Designed to help prevent bullying, violence, and kidnapping. The device integrates various sensors and technologies, including GPS (Global Positioning System), GSM (Global System for Mobile) modules, and an alarm, to offer real-time tracking, emergency alert messaging, live streaming, and the ability to deter potential threats. Through a connected mobile app, the system also provides health monitoring and environmental awareness. The compact, discreet design allows it to be placed in commonly used child belongings, making it ideal for daily use. This approach provides a practical and reliable means of enhancing child safety and reducing the risks associated with kidnapping and child trafficking. The device activates in emergency situations with the press of a single button.*

Keywords: IoT, Child Safety, ESP32 Cam, GPS, GSM, Sensors, Mobile Communications, Smartphone

I. INTRODUCTION

The Internet of Things (IoT) is transforming how devices and systems interact by enabling seamless communication and data exchange through internet connectivity and physical sensors. In light of increasing child safety concerns, developing a technology-driven solution to monitor and protect children in emergencies is vital. The proposed system integrates IoT technology to provide smart monitoring and real-time assistance for parents.

At the core of this system is a Wi-Fi module that enables continuous data transmission and monitoring via a dedicated Android application. This app allows parents to access critical safety metrics and location tracking information stored on the cloud. Additionally, the system is equipped with GSM (Global System for Mobile Communication) and GPS (Global Positioning System) modules, ensuring precise location tracking and secure communication. By leveraging GPS coordinates, the system provides real-time location updates to parents, enhancing their ability to monitor their child's safety effectively.

Unlike conventional systems that rely on Wi-Fi or Bluetooth, which are often restricted by range and data transfer limitations, this solution incorporates SMS communication as a reliable backup method. SMS ensures a consistent connection between the safety device and the parent's mobile device, even in emergency scenarios where internet connectivity might be unstable.

The integration of cloud storage ensures that tracking data is securely saved and easily accessible through the Android app. This feature provides parents with peace of mind, knowing they can retrieve critical information anytime. The combination of Wi-Fi, GSM, GPS, and SMS technologies in this IoT-based safety system addresses the limitations of traditional systems, offering a robust and comprehensive solution for child safety.

By enabling real-time monitoring, location tracking, and secure communication, the system empowers parents to respond swiftly during emergencies, ensuring their child's safety and well-being. This innovative approach highlights the potential of IoT to enhance safety and connectivity in modern parenting.

II. LITERATURE SURVEY

1. Authors: M Nandini Priyanka, S Murugan, K. N. H. Srinivas, T. D. S. Sarveswararao, E. Kusuma Kumari
Title: Smart IoT Device for Child Safety and Tracking
Published in: 2019 IEEE

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This system utilizes the Link-It ONE board, programmed in embedded C and interfaced with temperature, heartbeat, touch sensors, and GPS, GSM, and digital camera modules. The innovative feature of this solution is its ability to automatically alert parents or caregivers by sending SMS notifications when the child requires immediate attention during emergencies.
Merits: This system includes parameters like touch, temperature, and heartbeat, which are analysed, and the results are plotted for these metrics.
Demerits: Implementing a comprehensive IoT solution that addresses all aspects of child safety remains a challenge.

2. Authors: Akash Moodbidri, Hamid Shahnasser
Title: Child Safety Tracking Device
Published in: 2020 IEEE
This device is designed to help parents easily locate their children. Currently, numerous solutions on the market offer tracking of children's daily activities and assist in finding their location via Wi-Fi and Bluetooth services on the device.
Merits: The advantage of this system is that it is compatible with any phone, regardless of price, and does not require advanced technical skills to operate.
Demerits: The device's battery has a short lifespan. A model with higher power efficiency is required to extend battery life.

3. Authors: Aditi Gupta, Vibhor Harit
Title: Child Safety & Tracking Management System by Using GPS
Published in: 2021 IEEE
This paper proposes a smartphone-based solution for child safety that allows parents to track their child's location. In emergencies, children can send an instant message and their current location through SMS.
Merits: Smartphones provide advanced features like GPS, SMS, and map integration, which enhance the tracking capabilities.
Demerits: This system does not have the capability to sense a child's emotional or behavioral state.

4. Authors: Dheeraj Sunehera, Pottabhatini Laxmi Priya Title: Children Location Monitoring on Google Maps Using GPS and GSM Published in: 2018 IEEE.This paper presents an Android-based solution for real-time child location tracking. Multiple devices can connect through internet channels to a primary monitoring device. This setup enables parents to track their children or even enhance personal safety for women by providing real-time location information via a GSM module and SMS.
Merits: Provides a real-time tracking system that can be accessed through an Android device and ad-hoc networks.
Demerits: This solution may have limited functionality in areas with weak internet connectivity, such as rural regions

III. PROPOSED SYSTEM

The proposed methodology for the "Child Safety Device" project involves using an ESP32 microcontroller, GPS module, GSM module, ESP32 cam module, a button, touch sensor, and power supply to create a portable safety solution for children. This device is designed to be compact and user-friendly, allowing quick and discreet emergency alerts to be sent to designated contacts in case of danger. The initial step in the methodology is to acquire essential components, such as the ESP32 microcontroller, GPS module, GSM module, button, touch sensor, relay module, temperature sensor, NodeMCU, and power supply, all of which are readily available online or at electronics stores.
The GPS module is connected to the ESP32 microcontroller through designated pins, enabling it to capture and relay the user's location coordinates. This data is processed by the ESP32, which calculates the user's current position and stores it in memory. The GSM module, connected similarly, establishes communication with saved contacts, allowing for location updates to be sent during emergencies. The module is configurable for updates via SMS or phone call, based on user preference.
The button, connected to the ESP32, serves as the activation trigger, allowing the user to discreetly request assistance. Upon pressing the button or engaging the touch sensor, the ESP32 microcontroller prompts the GSM module to send

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the current location to emergency contacts without drawing attention. The power supply can come from a battery or USB cable, with the battery being lightweight and compact for easy portability. For convenient access, the device can be attached to a keychain.

The device's software is developed using Arduino IDE, designed to manage essential functions, including GPS tracking, GSM communication, button activation, and live video streaming to a linked mobile device. The software interface is intended to be straightforward and accessible to users with minimal programming knowledge.

Once assembled, the device undergoes extensive testing to ensure operational accuracy. Tests should include both indoor and outdoor scenarios to verify range and connectivity, ensuring reliable communication with emergency contacts when needed. Overall, the proposed methodology aims to provide a practical and effective safety solution for children. By leveraging GPS and GSM technologies, the device allows for immediate emergency alerts, potentially reducing risks of violence, kidnapping, and harassment. This approach is designed for easy assembly and replication, encouraging widespread adoption of this safety tool

Hardware Requirements:

- ESP32 Microcontroller
- GSM SIM 800C Module
- GPS Neo 6M Module
- 16x4 LCD Display
- 7805 Voltage Regulator
- DS18B20 Temperature Sensor
- Push Button
- Buzzer
- LED
- Jumper Cables

Software Requirements:

- Arduino IDE for programming and managing device functions
- Android Studio for developing the mobile application interface

Languages Used:

- Embedded C for firmware and device control

IV. METHODOLOGY

- **Live Location Tracking**: The safety system incorporates a GPS module to determine and retrieve real-time location coordinates, which are processed by the microcontroller. Additionally, a GSM module enables the system to respond to location requests sent via SMS from the parent's phone. Parents can track the safety system's location using a dedicated app that collects and displays the current/live location data from an updated cloud server. The system connects to the cloud through Wi-Fi, allowing for regular or on-demand location updates to the cloud.
- **Panic Alert System:** The device includes a panic alert system activated by a button specifically for emergency situations. When this button is pressed, the device triggers multiple alerts, including SMS and phone calls to the parent's phone, which contain the current location coordinates and alert information. Additionally, the Wi-Fi module in the device sends an alert notification to the parent's app via the cloud. This feature is especially beneficial in school or public settings, offering a quick response option in panic situations.
- **GPS Module**: The GPS module is connected to the ESP32 microcontroller via designated pins, allowing it to retrieve the user's location coordinates. The ESP32 microcontroller processes and stores the current location data received from the GPS module in its memory for immediate or later transmission.

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- **Stay Connected Feature**: This feature ensures that the safety device and the parent's phone can communicate at any time, regardless of circumstances. Through the GSM module, the safety device can initiate or receive calls from the parent's phone. The device's display will show an active connection status for easy verification by the user.
- **Health Monitoring System:** The device includes a temperature sensor that continuously monitors health-related metrics. If any irregularities are detected in these parameters, the device sends an immediate alert to the parent's app via Wi-Fi. The app interface then displays this information, allowing parents to assess the child's health condition and take necessary action if required.

A. Software Requirements

The Arduino IDE is an open-source software tool used for writing code and uploading it to the device's board. It is compatible with Windows, Mac, Linux, and iOS platforms, offering a user-friendly interface for coding and uploading. Built on open-source technologies like Processing and Java, this software supports reliable interfacing with devices such as Arduino boards.

In this project, the GSM shield is chosen as the main connection method over Wi-Fi and Bluetooth to ensure robust connectivity with minimalconfiguration, enhancing system usability for a wide range of users.

The Android app for the parental device is developed using the Java programming language with the Android Software Development Kit (SDK). Java's versatility and compatibility with C make it suitable for developing efficient, interactive applications for Android devices. The parental app enables live tracking, alert notifications, and health monitoring, consolidating essential child safety features in a single accessible interface.

Case's

Case 1

When the button for sending SMS is triggered,A SMS is sent to the pre- registered mobile number in the device i.e parents' mobile number. This SMScontains a google map's link for the location of thedevice with a message "I need Help".

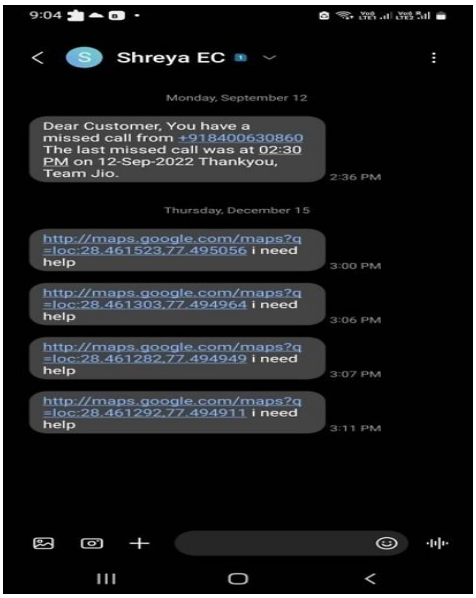

Fig.1

Case 2

When the button for making a call is triggereda call is sent to the pre-registered mobile no. in the device i.e the parent's mobile number. The parent can receive the call and hear what the child has to say. The microphone interfaced to the GSM modulefacilitates the transmission of voice of the child.

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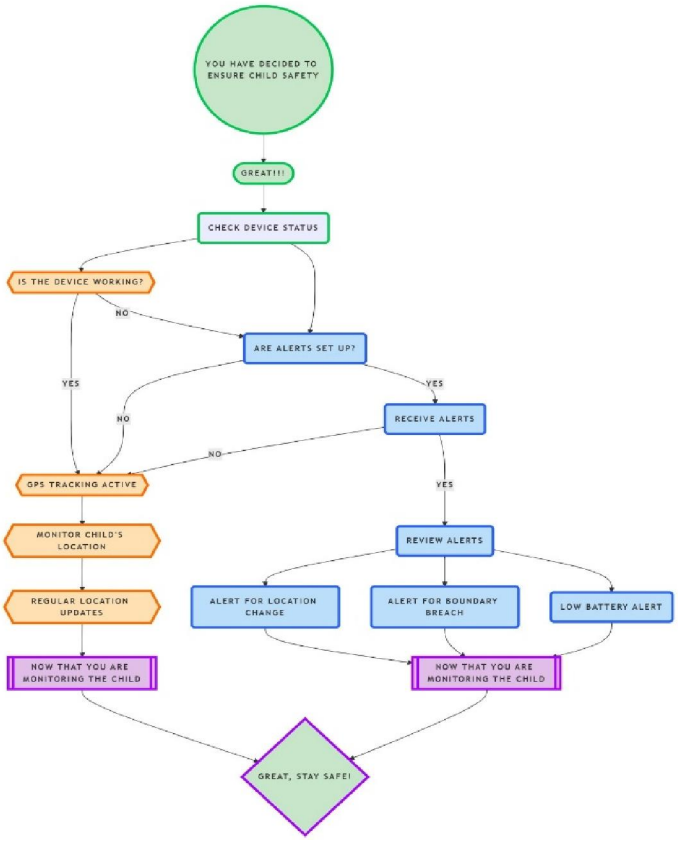
Fig.2

FLOWCHART



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V. CHALLENGES AND LIMITATION

Challenges

- **Accuracy of GPS Tracking**: GPS tracking may face inaccuracies in areas with poor satellite visibility, such as dense urban environments, forests, or tunnels. Obstacles like tall buildings or weather conditions (e.g., heavy rain or clouds) can disrupt GPS signals, leading to incorrect or delayed location updates. This can result in parents receiving inaccurate data, reducing their trust in the system. Developing a fallback mechanism, such as cell tower triangulation, may mitigate this issue but increases complexity. Ensuring precise location tracking under varying conditions remains a significant challenge.
- **Battery Consumption**: GPS tracking is known for consuming significant battery power on mobile devices, which can quickly drain the child's device. This is particularly problematic for children who might forget to charge their devices regularly. Optimizing the app to minimize battery usage without compromising functionality is a technical hurdle. Incorporating power-saving modes or adaptive tracking based on movement can help but may not completely eliminate the issue. Parents and children need to be mindful of keeping devices charged for the app to work effectively.
- **Connectivity Issues**: The app relies on stable internet or SMS connectivity to function. In areas with poor network coverage, such as rural regions or during emergencies, the app may fail to send real-time updates or alerts. This limitation can hinder the app's effectiveness during critical moments when immediate communication is essential. Offline functionality or hybrid solutions are challenging to implement but may be necessary to address this gap. Ensuring reliability in varying network conditions remains a critical concern.
- **Data Privacy and Security**: Collecting sensitive location data poses significant privacy and security risks, as this information could be exploited if hacked or leaked. Ensuring secure encryption and adhering to data protection regulations (like GDPR or COPPA) are mandatory to protect users. Mismanagement of data could result in legal liabilities or loss of user trust. Parents need reassurance that their child's information is handled securely. Building robust security protocols and maintaining transparency with users is essential but resource-intensive
- **Geofencing Accuracy**: Implementing geofencing features can be tricky, as the system needs to define accurate boundaries on a map. Inconsistent GPS data can lead to false alerts when a child is still within the designated area or fails to alert when the child exits the boundary. Setting appropriate sensitivity levels for geofencing is a technical challenge. Balancing between too many false alerts and missing critical events requires careful calibration. Regular testing and user feedback are necessary to fine-tune this feature.
- **Emergency Communication Delays**: SMS-based alerts or emergency calls may experience delays during network congestion, especially in high-traffic areas or during disasters. Parents may not receive critical alerts in real time, reducing the app's reliability in emergencies. Alternative methods, such as push notifications, may also face similar challenges in poor connectivity scenarios. Implementing a reliable fallback mechanism, while ideal, increases the app's complexity. Timely delivery of alerts is vital to the app's success.

Limitations

- **Dependence on Mobile Devices**: The app requires children to have functional mobile devices at all times, which may not always be practical. Devices can be misplaced, lost, or damaged, rendering the app useless. Additionally, some families may not have the resources to provide children with smartphones or tablets. The reliance on technology limits the app's accessibility for all users. Exploring hardware-independent solutions might address this limitation in the future.
- **Limited Functionality Without Internet**: Although SMS is a backup, many features like live tracking and map-based monitoring require an active internet connection. In regions with limited or no connectivity, the app's functionality becomes severely restricted. This limitation reduces its effectiveness in emergencies where parents need real-time updates. Offline modes or data synchronization mechanisms could help but are complex to implement. Ensuring usability in low-connectivity areas is a critical limitation.

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- **Parental Over-Reliance**: Parents might become overly dependent on the app for monitoring their child's safety, potentially neglecting other important safety measures. For example, teaching children how to handle emergencies or navigate their environment safely might take a backseat. This over-reliance could lead to vulnerabilities if the app fails or is unavailable. Encouraging parents to use the app as a supplementary tool rather than the sole safety measure is important. Balancing technology with traditional safety practices is key.
- **False Alerts**: Children might accidentally trigger the "Need Help" button or emergency call, leading to unnecessary panic for parents. Such false alarms can desensitize parents over time, making them less likely to respond promptly to genuine alerts. Designing the app to minimize accidental triggers, such as confirmation prompts, can help but may add complexity for children. Educating children on proper usage is critical to avoid misuse.

Scalability Challenges

- **Handling Increased User Base**: As the app gains popularity, it must accommodate a growing number of users, including families with multiple children. Scaling the backend infrastructure to handle higher volumes of data, real-time location tracking, and simultaneous SMS alerts becomes critical. This requires robust cloud servers and optimized app performance to ensure smooth operation without delays.
- **Adapting to Diverse Geographic Regions**: Different regions may have varying network conditions, regulatory requirements, and device usage patterns. For example, some areas might rely more on SMS than internet-based features due to limited connectivity. Adapting the app to work seamlessly across diverse environments while ensuring compliance with local privacy laws adds complexity.
- **Managing Data Storage and Retrieval**: Tracking the movement of multiple children over time generates significant amounts of location data. Storing this securely on the cloud while ensuring quick retrieval for parents presents a technical and cost-related challenge. Efficient data management systems and scalable cloud storage solutions are essential to prevent system slowdowns.
- **Balancing Costs with Growth**: Scaling up infrastructure for higher user demand or advanced features increases operational costs. For a pediatric app that may target cost-conscious families, keeping the app affordable while maintaining high-quality performance is a significant challenge. Offering a freemium model or partnering with organizations could help mitigate this.
- **Ensuring Multi-Device Compatibility**: Children and parents may use various devices (smartphones, tablets) with different operating systems and hardware capabilities. Ensuring compatibility across platforms like Android, iOS, and even older devices is crucial. As user diversity increases, maintaining consistent performance across all devices becomes increasingly challenging.

VI. CONCLUSION

The proposed mobile application for child safety provides an effective solution for parents to monitor their children's locations and ensure their safety. By relying solely on mobile and tablet devices, the app eliminates the need for additional hardware, making it accessible, cost-effective, and user-friendly. Key features such as GPS-based real-time tracking, geofencing alerts, emergency messaging, and direct communication empower parents to stay informed about their children's movements and respond promptly during emergencies

While the app offers significant advantages, challenges such as GPS accuracy, battery efficiency, connectivity issues, and scalability need to be addressed to ensure consistent performance. Future developments could focus on optimizing these areas, integrating predictive features, and enhancing user experience to meet diverse needs.

This app demonstrates the potential of leveraging mobile technology to address critical child safety concerns. With continuous improvement and a focus on user-centric design, it can become an indispensable tool for modern parenting, providing both security and peace of mind.

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VII. FUTURE ENHANCEMENTS

Predictive Analytics for Safety

- Implement machine learning algorithms to predict potential safety risks based on the child's location history and behavior patterns.
- For example, the app could alert parents if a child frequently deviates from their usual route or enters high-risk areas.

Offline Functionality

- Enable limited app features to work without an internet connection, such as storing location data locally and syncing it once connectivity is restored.
- This ensures the app remains useful in areas with poor network coverage.

Multi-Child Tracking Support

- Enhance the app to allow parents to track multiple children simultaneously on the same platform.
- Features like individual geofencing zones and alerts for each child can make the app more family-friendly.

Advanced Geofencing Features

- Introduce dynamic geofencing that adjusts based on real-time conditions, such as time of day or traffic patterns.
- Allow parents to customize multiple safe zones with unique alerts for each.

Voice Commands and AI Assistance

- Integrate voice command features to make the app more accessible for children, especially in emergencies.
- For example, a child could say "Help me" to send an emergency alert or make a call to their parents.

Real-Time Traffic and Weather Updates

- Add live traffic and weather data to enhance route safety.
- Alerts could warn parents if the child's route is affected by dangerous conditions like storms or accidents.
- This helps parents understand and improve their child's daily safety routine.

Integration with Wearable Accessories (Optional)

- While the app focuses on mobile devices, future versions could integrate with child-friendly wearable gadgets like smartwatches for added convenience.

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