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A Unified Smart Solution for Child Security and Parental Insights

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Abstract: *Child safety has become a major priority in today's rapidly evolving, technology-oriented society, where parents often find it difficult to maintain constant awareness of their children's activities and overall well-being. Conventional monitoring approaches are proving inadequate in settings marked by frequent mobility, unpredictable health conditions, and rising environmental risks. To overcome these limitations, this paper presents an Internet of Things (IoT)-enabled child monitoring and protection framework that delivers dependable real-time location tracking, continuous health observation, and intelligent emergency response capabilities. Implemented using embedded C, the system incorporates essential hardware components, including GPS for accurate positioning, temperature and heart-rate sensors for vital health monitoring, GSM for instant communication, and an ESP32-CAM module for real-time visual feedback. The device continuously evaluates the child's condition and automatically transmits SMS-based and app-based alerts to parents or guardians whenever abnormal health parameters, unusual movement patterns, emergency-button triggers, or geo-fence violations are detected. Advanced functionalities such as live video streaming, a panic-alert feature, energy-efficient operation, and secure data handling further enhance system reliability and timely intervention. Through the integration of IoT sensing and proactive alert mechanisms, the proposed solution aims to reinforce parental oversight, minimize emergency response time, and promote a safer and more supportive environment for children in contemporary living conditions*

Keywords: Child Safety, Internet of Things (IoT), GPS Tracking, Heartbeat Monitoring, Geo-fencing, ESP32-CAM, Real-time Alerts, Emergency Response

I. INTRODUCTION

Child safety has emerged as a critical global issue as modern living continues to shift toward increased mobility, widespread urbanization, and growing technological reliance. Parents and caregivers frequently encounter difficulties in maintaining continuous oversight of their children, particularly in environments where risks associated with health, movement, and personal security can arise unexpectedly. In many situations, children may encounter unsafe surroundings, sudden health complications, or emotionally challenging incidents without immediate notice from guardians. Conventional supervision strategies— such as occasional communication or depending on nearby individuals—prove inadequate in circumstances that demand rapid action and accurate situational awareness.

Advances in the Internet of Things (IoT), embedded technologies, and wireless communication have opened new possibilities for addressing these concerns through intelligent, real-time monitoring systems. IoT-enabled solutions can consistently capture, process, and transmit data from wearable sensors, allowing remote tracking of vital health indicators, mobility patterns, and environmental conditions. These systems function as digital extensions of parental supervision, offering continuous visibility even when direct presence is not possible. Furthermore, IoT-based monitoring enables early identification of abnormal health signals, unsafe movements, or sudden behavioral changes, thereby minimizing delays in response.

In response to these challenges, this study introduces a smart IoT-based child monitoring and protection system that integrates location tracking, physiological sensing, emergency alerting, and live video monitoring into a compact wearable device. The system incorporates GPS for precise location identification, temperature and heartbeat sensors for health evaluation, GSM modules for real-time SMS notifications, and an ESP32-CAM for live visual updates. Additional capabilities include geo-fencing, a panic alert mechanism, and automated detection of irregular conditions.

II. LITERATURE REVIEW

[1] Vishnupriya et al. provide an extensive review of IoT-driven child safety solutions that incorporate wearable sensors, GPS modules, and GSM communication to enable continuous monitoring and rapid emergency notifications. Prior studies demonstrate the use of panic switches, RFID-based identification, GPS tracking, and multi-sensor health assessment for detecting unusual conditions and improving child security. Several researchers also underscore the importance of wearable platforms capable of measuring vital parameters such as body temperature, heart rate, and stress levels to anticipate potential emergencies. Additional works investigate behavior-monitoring systems and automated alert frameworks that minimize reliance on manual intervention, thereby increasing reliability for children. Collectively, the reviewed literature highlights the demand for an integrated, sensor- rich, IoT-enabled wearable architecture, which the proposed system enhances by incorporating context- aware behavioral response capabilities.

[2] Dusi Durga Prasad underscores the significance of assistive smart home technologies that enable elderly and differently-abled users to operate household appliances through intuitive voice-based interfaces. Noruwana demonstrates that speech-driven IoT systems enhance user comfort, improve automation performance, and adapt effectively to varying environmental contexts. Shawon shows that Bluetooth-enabled voice automation built using Arduino offers high accuracy, low implementation cost, and improved usability for individuals with limited physical mobility. Sanyaolu further reports that Arduino–Bluetooth solutions are simple to install, affordable, and suitable for controlling basic household devices. Collectively, these studies provide a reliable foundation for low-cost, voice-activated smart home architectures, reinforcing the feasibility of Bluetooth-based systems that enhance convenience and accessibility.

[3] Wu and Jiang designed a school-bus monitoring framework that integrates GPS with biometric verification to improve student safety and provide real-time location visibility for parents and school authorities. Another study introduced a wrist-watch–based child tracking device that issues alerts whenever predefined safety zones are violated. A separate two- module child monitoring architecture equipped with GPS, a camera, and wireless transceivers was proposed to maintain continuous communication between the parent and child units.

Android-based tracking applications have also been investigated, enabling guardians to define secure regions and receive notifications when these limits are exceeded. IoT-enabled bus-tracking platforms utilizing GPS and cloud services further demonstrate the practicality of real-time location analytics. However, several IoT child- tracking devices rely primarily on smartphones or single-sensor inputs, often resulting in inaccurate notifications and reduced system reliability. Many emergency-oriented wearables require manual activation, making them less suitable for young children. Although SMS-based and Bluetooth-enabled child safety systems have been explored, their dependence on unstable communication links restricts both accuracy and dependable operation.

[4] Arivarasan et al. provide an overview of various IoT-based infant monitoring solutions that integrate sound, temperature, humidity sensors, and GSM communication to detect crying, discomfort, and abnormal environmental conditions. Earlier studies focus on cradle automation, motion sensing, and alert generation using microcontrollers such as Arduino and Raspberry Pi, enabling parents to receive real-time notifications. Several works also emphasize the importance of incorporating video surveillance, as many existing models lack camera functionality and rely solely on text-based warnings. Other researchers explore advanced sensing techniques including heart-rate tracking, sleep–wake pattern detection, and machine-learning-driven cry interpretation to enhance infant protection. Collectively, the literature highlights the growing need for a unified IoT framework that combines multimodal sensing, remote supervision, and automated response mechanisms—an objective further strengthened by the proposed infant monitoring architecture.

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[5] P. K. P and collaborators survey a range of child-safety monitoring solutions that employ wearable IoT devices incorporating GPS, GSM, and health-sensing modules to support parents with real-time supervision. Earlier studies discuss activity- monitoring wristbands, machine-learning regression models for predicting behavioral patterns, and multi-sensor wearables capable of tracking temperature, humidity, motion, and heart rate to generate prompt alerts. Additional works highlight SMS-enabled communication frameworks that deliver continuous updates to caregivers, including location information and emergency SOS notifications. Further research showcases GPS–GSM tracking units that offer more reliable, long-distance monitoring than traditional Bluetooth- or Wi-Fi-based systems. Collectively, existing literature identifies the need for improved sensing accuracy, fewer false notifications, and adaptive monitoring mechanisms—gaps addressed by the proposed smart alerting device through integrated object-detection capabilities and proximity-based warning features.

[6] Kadhiresh S and co-authors review a variety of IoT-driven child safety systems that predominantly utilize GPS, GSM, temperature sensors, heart-rate monitors, and motion detectors to facilitate continuous supervision. Earlier studies emphasize wearable wristbands and smart devices designed to record vital parameters, deliver SMS notifications, and support remote parental oversight. Several works also discuss camera-enabled monitoring and emergency alert mechanisms that transmit real-time location and health information during critical situations. Additional research introduces advanced sensing modules, including sleep- quality assessment, respiratory-rate tracking, and tactile detection, to enhance the precision of risk identification. Collectively, the surveyed literature highlights the demand for a more cohesive IoT ecosystem featuring automated alerts and real-time analytical capabilities—an objective reinforced by the proposed child activity monitoring solution.

[7] Chowdhury et al. emphasize the importance of a GSM-enabled, multi-sensor wearable framework for achieving dependable child monitoring. Dorsemaine et al. define IoT as an interconnected sensing ecosystem capable of supporting intelligent safety applications. Silva discusses the role of wireless sensor networks in providing stable communication channels for embedded systems. Haghi et al. review medical IoT wearables and demonstrate enhanced accuracy through multi- sensor physiological monitoring. Research by Datar and Bhagwat identifies the limitations of Wi-Fi and Bluetooth, noting reduced reliability for continuous tracking scenarios. Braam et al. introduce a Bluetooth-based wristband; however, its short communication range limits its suitability for emergency response. Prince highlights the usefulness of SMS-driven microcontroller platforms for remote monitoring in safety applications. Moodbidri and Shahnasser further validate GSM- supported child safety wearables, emphasizing the significance of multi-sensor data transmission in reliable monitoring solutions.

[8] Farooq et al. review IoT-based women's safety systems and emphasize the rising global concern of harassment and assault. Existing solutions commonly use GPS–GSM modules, voice commands, or fingerprint triggers, but many rely heavily on manual activation. Wearable devices— such as smart rings, jackets, and shoes—integrate sensors like accelerometers, pulse-rate, temperature, and vibration sensors, though performance is often limited by single-sensor dependence and unstable communication. Some works apply machine learning models, including logistic regression and hidden Markov models, to detect threat patterns, yet accuracy remains inconsistent. Comparative studies also identify issues related to cost, battery life, and network dependence. Overall, the literature indicates progress but highlights the need for automated, multi-sensor, and more reliable IoT architectures for women's safety.

[9] Masud et al. review existing IoT-based child safety systems that primarily use RFID, microcontrollers, GPS tracking, and basic alert mechanisms but lack full remote monitoring. Prior studies describe wearable devices offering SMS alerts, location tracking, and simple health measurements such as temperature and heart rate. Other works present snapshot-enabled modules and Bluetooth/GPS security systems, though these typically support only limited safety functions. As shown in the comparison table (page 2), most systems do not include features such as real-time weather data, oxygen-level sensing, or camera-based location imaging. Overall, the literature identifies gaps in feature integration and system effectiveness, which the proposed IoT monitoring solution addresses through multi-sensor fusion, cloud support, and a user-friendly mobile application.

[10] Thamaraimanalan et al. survey earlier child-safety solutions focused on geofencing, IoT-based tracking, and GSM alerts that notify parents when predefined boundaries are crossed. Prior works discuss wearable devices equipped with sensors, motion detection, and emergency SMS capabilities, including Raspberry Pi–based systems and mobile apps for

real-time image capture (page 2). Additional studies examine mobile safety applications, movement- recognition methods, and geofencing models used in logistics, disaster response, and healthcare. The review notes that many existing systems lack integrated multi-sensor health monitoring and reliable emergency communication. Overall, the literature highlights the need for combined GPS, GSM, and IoT features—a gap addressed by the proposed child- safety device through geofencing, panic-alert support, and continuous sensor-based monitoring.

[11] Shameema Latheef R and Sumimol L review IoT-based child monitoring systems featuring GPS–GSM tracking, SMS alerts, and wearable devices with basic safety sensors. The related works (pages 2–3) describe panic-button systems, school-route monitoring apps, and Bluetooth–GPS trackers, noting that most rely on alerts rather than real-time behavioral assessment. Prior research also covers mobile safety tools and IoT wearables used in women's security, health monitoring, and activity recognition, showing wide applicability but limited child-centered integration. Many existing devices offer notification-only functions without immediate situational alarms, reducing emergency responsiveness. Overall, the literature highlights the need for affordable, multi-module IoT solutions with instant alarms and precise location tracking—capabilities provided by the proposed Bluetooth–GPS wearable smart gadget.

[12] Jintanachaiwat et al. (2024) and Swaroop et al. review IoT-based girl-child safety systems that use GPS, GSM, and wearable sensors for real-time monitoring, as noted in the introductory and related- work sections (pages 1–2). Prior studies describe shock-generating wearables, pressure-sensor alarms, temperature-based devices, and multi-sensor IoT gadgets for detecting harassment or abnormal conditions. Other works incorporate skin-resistance sensors, panic-button mechanisms, and cloud platforms like ThingSpeak for alerting and data visualization. However, many existing solutions depend on manual triggers or limited sensing, lacking automated intelligence for emergency detection—a limitation highlighted in the discussion. Overall, the literature identifies the need for intelligent classification and automated alert systems, which the proposed GPS-IoT and fuzzy- classifier models aim to fulfill.

[13] Moodbidri and Shahnasser review child-safety wearables that mainly use Wi-Fi and Bluetooth for parent–child communication, highlighting their limited range and reliability (page 1). Prior studies include multi-sensor wristbands like Vital Band, baby-monitoring devices such as Mimo and Sproutling, and Bluetooth alert wearables, which monitor activity and environment but fail over long distances. Existing solutions also feature location tracking, environmental sensing, and emergency alerts, yet most rely on smartphone connectivity, reducing practical effectiveness. The review emphasizes the need for robust communication, with GSM-based systems mitigating connectivity issues. Overall, the literature identifies gaps in long-range, low-dependency child monitoring, addressed by the proposed SMS-driven wearable offering GSM- enabled location, temperature, UV sensing, and distress alerts.

[14] Benisha et al. review child-safety technologies integrating IoT, GPS, GSM, and wearable sensors for real-time monitoring (page 2). Prior studies include Bluetooth- and Wi-Fi-based wearables tracking temperature, UV exposure, and SOS alerts, but these are limited by range and smartphone dependency. The literature also covers emergency-response systems, child-tracking apps, and multi- sensor IoT devices, many of which require manual activation or lack automated health monitoring.

Several works highlight wearables for location tracking and alerting but note shortcomings in communication reliability and intelligent sensing. Overall, the review underscores the need for an integrated, autonomous wearable with GSM alerts and multi-sensor health monitoring, as implemented in the proposed child-safety device.

[15] Srinivasan et al. review child-safety systems using threshold-based alerts, manual panic buttons, and basic IoT communication like Wi-Fi, Bluetooth, and GSM (pages 1–2). Prior studies include wearables tracking heart rate, temperature, and location, but many face unreliable connectivity, limited sensing, and high false-alarm rates from fixed thresholds. The literature also notes devices lacking emotional-state detection, missing distress events with normal vitals. Existing systems often omit intelligent classification, relying on simple comparisons that reduce accuracy. Overall, these works highlight the need for autonomous, machine- learning-based child safety solutions, addressed by the proposed system using Decision Tree classification on BVP, GSR, and temperature data for intelligent distress detection.

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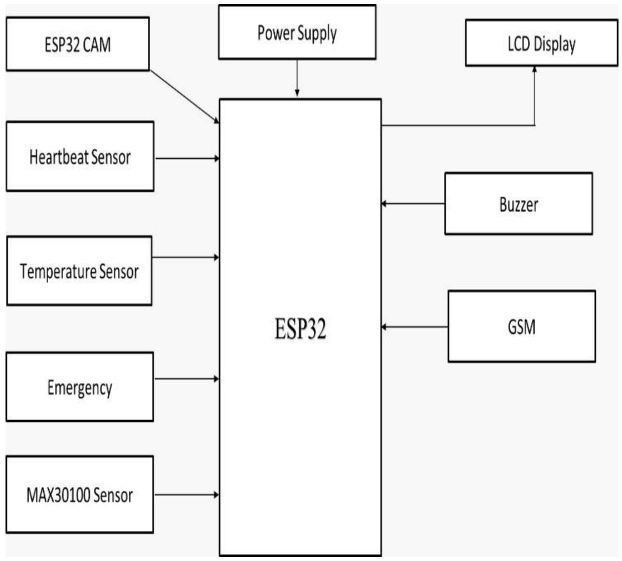
III. SYSTEM ARCHITECTURE



IV. LITERATURE SUMMARY

Sl. No	Citation	Year	Methodology/Algorithms used	Findings
1	Contextualized Advanced Wearable Technology for Child Safety.	2025	Arduino Mega, Sensors (SpO2, GSR, Temp), MQTT, GSM/GPS, IoT Alert System	Pros: Auto alert without manual trigger, wearable (bangle/ring), real- time health + location data. Cons: Depends on power/internet; no ML used.
2	Bluetooth-based Voice-Activated Smart Home System using Arduino Uno	2025	Voice commands processed via Android app sent via Bluetooth (HC-06) to Arduino Uno, Text-matching logic used	Pros: Low-cost, simple offline voice control, useful for elderly/disabled, no internet needed. Cons: Limited range, no command verification, minimal command support.
3	Improved Child Safety Using Edge- Fog-Cloud Enabled Smart IoT Wearable Device	2024	GPS, Heartbeat, Voice, Image sensing, Edge-Fog- Cloud alerts	Pros: Accurate, multi-sensor, real-time alerts Cons: Not yet implemented, complex system
4	IoT Based Infant Surveillance System	2024	NodeMCU with sensors (sound, temp, humidity, camera), Wi-Fi (ESP8266), cry detection algorithm, mobile app	Pros: Real-time alerts, cradle movement on cry, mobile monitoring, eco-friendly design. Cons: Wi-Fi dependent, crib-specific, may trigger false alarms.
5	Smart Device for Child Safety with Parental Alerts	2024	CNN + SSD for object detection, Ultrasonic sensor, NodeMCU, Buzzer	Pros: Real-time alerts, 88% accuracy, instant parental notification. Cons: Wi-Fi dependent, needs regular updates.
6.	Child Safety and Activity Monitoring System Using IoT	2023	GPS tracking, Heartbeat & temperature monitoring, Emergency video capture, IoT-	Pros: Real-time health and location data, auto alerts, Android app integration

			based real-time SMS alerts	Cons: Device not durable, lacks phone functions, needs hardware upgrade
7.	Multi-sensor Wearable for Child Safety	2023	Arduino UNO, GSM Module, DHT11, Heartbeat Sensor, GPS, SOS Light, Buzzer	Pros: Real-time SMS alerts, tracks health & location, low cost. Cons: Lacks camera, no mobile app SMS delays possible.
8.	The Role of IoT in Women's Safety: A Systematic Literature Review	2023	IoT-based devices using sensors (heartbeat, pulse, temp.), ML (Logistic Regression, HMM, Decision Tree), GPS, GSM, Raspberry Pi	Pros: Auto-alert via ML, covers major sensors and wearable, suggests robust IoT architecture. Cons: Needs better accuracy, often depends on internet, many devices need manual activation.
9.	Developing an IoT-based Child Safety and Monitoring System	2023	GPS tracking, Emergency alert, Camera capture, Health monitoring using sensors	Pros: Real-time tracking, health monitoring, SMS alert without GSM Cons: Needs internet, limited testing, no ML integration
10.	IoT based Safety Gadget for Child Monitoring and Notification	2023	Arduino UNO, GSM, GPS, Pulse Sensor, Temp/Humidity Sensor, MEMS Accelerometer, Mobile App, IoT	Pros: Real-time alerts, geofencing, app + SMS tracking. Cons: Network issues, no battery status, removal detection lacking.
11.	Wearable Smart Gadget for Child Monitoring based on IoT	2023	Uses Arduino (Nano & Mega), HC-05 Bluetooth, GPS, ESP-01 Wi-Fi modules. Master-slave model; buzzer triggered on disconnection	Pros: Real-time GPS tracking, buzzer alert system, wearable and child-friendly. Cons: Limited range (8m), no biometric sensors, Wi-Fi dependent.
12.	Girl Child Security System based on IoT Technology with GPS Tracker Comparing with Fuzzy Classifier Based Safety Device	2022	GPS Tracking Algorithm, IoT-based Real-time Monitoring via Thingspeak, Fuzzy Classifier Algorithm for abnormal activity detection	Pros: Real-time location tracking, better performance of IoT-based system over fuzzy logic, faster alert system, wearable device concept Cons: Accuracy of fuzzy system is low, continuous internet and power required, affected by climate, not very suitable for very young children
13.	Child Safety Wearable Device	2022	SMS-command control, GPS tracking, Temperature & UV sensing, SOS signal, Buzzer alert	Pros: Works without internet, easy SMS-based control, alerts nearby people Cons: Can't handle multiple commands, no app, bulky design
14.	Design of Wearable Device for Child Safety	2021	Heartbeat detection algorithm, GPS tracking, MEMS accelerometer alerting, IoT-based real- time monitoring, GSM-based SMS alerting	Pros: Real-time monitoring, no manual operation needed, alerts parents/police via SMS, tracks health & location Cons: Depends on network and GPS availability, no video/image capture, wearable not compact
15.	Intelligent Child Safety	2020	Decision Tree Classifier	Pros: Detects distress automatically

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	System using ML in IoT Devices		algorithm on Raspberry Pi; inputs: BVP, GSR, skin temp; Arduino for sensors, GSM & GPS	using vitals, 96% accuracy, real-time SMS

V. CONCLUSION

IoT-Based Child Safety and Health Monitoring System was successfully developed and implemented to provide real-time monitoring of a child's vital signs and ensure immediate response during emergencies. The system integrates multiple sensors, including the MAX30100 for SpO_2 and pulse measurement, as well as temperature and heartbeat sensors, connected through an ESP32-CAM microcontroller with GSM communication. Through continuous sensing and data processing, the ESP32 efficiently analyzed physiological parameters to detect abnormalities such as elevated temperature, irregular heartbeat, or low oxygen saturation. In emergency situations, the system automatically activated a buzzer and sent SMS alerts to parents or guardians for prompt action. The GSM module facilitated long-range communication, while the LCD interface provided local display and monitoring options. The results confirm that the prototype functions as a reliable, low- cost, and portable solution for real-time child monitoring. Its modular architecture and multi- sensor design make it adaptable for broader health tracking and safety applications. Overall, the system effectively achieves its objectives of improving child safety, enhancing parental awareness, and ensuring prompt emergency response through an intelligent integration of IoT and embedded system technologies.

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