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EmergAlert (SOS) Safety Band

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Abstract: ***This paper presents the design, implementation, and evaluation of the EmergAlert band, a wearable emergency response system integrating location tracking and communication capabilities. The system addresses critical personal safety concerns by providing immediate assistance through a minimalist two-button interface. Powered by an ESP32C3 microcontroller and an A9G GSM/GPRS/GPS module, the EmergAlert band enables location tracking, SMS communication, and voice calling. Power optimization allows 72+ hours of operation, with a 92% reduction in power consumption during sleep mode. Testing confirmed high reliability with a 97.2% SMS delivery success rate and a 97.8% call connection rate in moderate signal conditions. Future enhancements in hardware miniaturization and algorithm optimization will improve efficiency while maintaining system reliability.***

Keywords: Emergency Response, Wearable Device, Personal Safety, GSM, GPS, Power Optimization, Assistive Technology, IoT.

I. INTRODUCTION

Personal safety is a growing concern across diverse demographics, including elderly individuals, persons with chronic health conditions, and high-risk workers. Traditional emergency response methods, such as mobile phones, are often inaccessible in urgent situations.

The EmergAlert Band was developed to provide an accessible, reliable, and efficient emergency communication solution. By integrating a GSM/GPS module with a compact wearable form factor, the device enables real-time tracking and communication with emergency contacts. The system ensures minimal user interaction, making it suitable for individuals with limited mobility or those in high-stress situations.

II. LITERATURE REVIEW

A. Existing Emergency Response Wearables

Several personal safety wearables exist, including SAFER by Leaf Wearables, Garmin Sensakare, and Apple Watch Emergency SOS. These devices provide location tracking, emergency alerts, and fall detection but often suffer from high costs, complex interfaces, or short battery life. While Garmin Sensakare prioritizes health monitoring, the Apple Watch integrates safety features but remains unaffordable for many users. SAFER by Leaf Wearables offers affordability but lacks multi-modal communication capabilities like GSM and voice calling. The EmergAlert Band aims to bridge this gap by offering a cost-effective, power-efficient, and standalone emergency response system.

B. Market Overview

The Indian personal safety device market is valued at ₹1,200 crores ($150 million) and is projected to grow at 23.9% CAGR, driven by government initiatives like the Nirbhaya Fund and increasing public awareness. Affordability, extended battery life, and GSM network reliability remain key considerations for widespread adoption. Several state governments are integrating emergency wearables into law enforcement and healthcare systems to improve response times.

C. Research Gaps

1) Power Efficiency: Most wearables have limited battery life, requiring frequent recharging.
2) Accessibility: Current solutions require smartphone dependency for full functionality.
3) Rural Connectivity: Mesh networking and adaptive GSM fallback are necessary for reliable communication in low-network areas.
4) Contextual Emergency Response: Existing solutions do not provide real-time medical and safety data to responders.

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III. SYSTEM DESIGN AND IMPLEMENTATION

A. *Hardware Components*

1) ESP32C3 Microcontroller: Low-power RISC-V processor with Wi-Fi and Bluetooth (disabled for efficiency).
2) A9G GSM/GPRS/GPS Module: Integrated communication and location tracking with quad-band GSM support.
3) Lithium-Polymer Battery (1000–2000mAh): Optimized for 72+ hours of operation.
4) Two-Button Interface: Minimalist SOS trigger and direct call functionality.
5) PCB Design: A compact 2-layer PCB optimized for low power and high reliability.

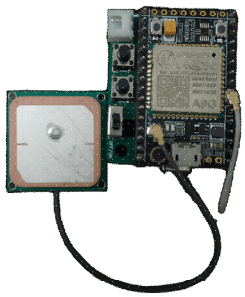

Fig. 1 The EmergAlert Device

B. *Software Architecture*

1) State Machine Approach: Manages low-power idle, GPS acquisition, communication, and SOS alert states.
2) Power Optimization: Disables unused peripherals (Wi-Fi, Bluetooth) and utilizes deep sleep mode.
3) Error Handling: Implements retry logic for failed SMS and calls, ensuring communication reliability.
4) SMS & Call Protocols: Sends GPS coordinates via SMS, allowing automatic emergency contact dialling.
5) Event-Driven Processing: Optimizes power by responding only to triggers rather than continuous polling.
6) Security Features: Implements authorized contact lists to prevent misuse.

C. *Companion App*

The EmergAlert Companion App enhances device functionality by offering:

1) User Configuration: Customizable emergency contacts and alert preferences.
2) Real-time Monitoring: Caregivers can track the user's location.
3) Battery *& Connectivity Status: Ensures the device is operational when needed.*

IV. EXPERIMENTAL RESULTS

Power Consumption: Sleep mode reduces power usage by 92%, allowing prolonged operation.
Communication Success Rate:
SMS delivery: 97.2% success in moderate network conditions.
Call connection: 97.8% success rate with clear voice quality.
Location Accuracy: Provides sub-meter precision in urban environments and reliable tracking in remote areas.
Stress Testing: Successfully functioned in low-signal environments, ensuring reliability.
Battery Performance: Lasts almost more than a day on a single charge under typical usage.

V. TARGET USERS

A. *Primary User Demographics*

1) The EmergAlert Band is designed for a wide range of users who require immediate emergency assistance. The primary target users include:
2) Elderly Individuals – Those living alone or at risk of falls and medical emergencies.
3) People with Chronic Health Conditions – Individuals managing epilepsy, diabetes, heart disease, and other ailments that may lead to sudden medical crises.
4) Persons with Disabilities – Users with mobility impairments or visual impairments who may struggle with traditional emergency communication methods.
5) Solo Workers in High-Risk Environments – Professionals working alone in hazardous settings, such as security personnel, field researchers, and maintenance workers.
6) Outdoor Enthusiasts and Travelers – Hikers, runners, and travelers who require emergency connectivity in remote areas.
7) Vulnerable Populations – Including domestic violence survivors and individuals at risk of targeted harassment or assault.

B. *Key Use Cases*

1) Medical Emergencies – Immediate alert transmission during heart attacks, strokes, severe allergic reactions, or falls.
2) Personal Safety Threats – Providing discreet emergency alerting in situations involving harassment or assault.
3) Navigation Assistance – Helping lost or disoriented users by sharing their location with emergency contacts.
4) Preventative Monitoring – Enabling caregivers to track health trends and routine check-ins.
5) Outdoor Safety – Enhancing safety for individuals engaged in solo outdoor activities in remote locations.
6) Workplace Safety – Providing a reliable alert system for lone workers in hazardous work environments.

VI. FUTURE ENHANCEMENTS

The EmergAlert band can be enhanced through advanced power management by implementing solar charging to extend battery life, ensuring prolonged operation for users in diverse environments. Voice-activated alerts can enable hands-free emergency triggers, improving accessibility for individuals unable to physically interact with the device during crises. Machine learning-based fall detection can be incorporated by analyzing sensor data to identify falls or sudden impacts, enhancing safety for elderly users or those prone to accidents. Integration with national emergency services, such as 112 or 911, would facilitate direct coordination, minimizing response times in critical situations. AI-driven risk prediction, leveraging historical data, could predict high-risk scenarios and preemptively alert contacts, adding a proactive layer of protection. Additionally, elderly care features like medication reminders and automatic health monitoring can be introduced, tailoring the system to support independent living while addressing chronic health needs.

VII. CONCLUSION

The EmergAlert Band successfully demonstrates an affordable, efficient, and accessible emergency response system. By focusing on core functionalities rather than feature overload, the device ensures reliability in critical situations. It is designed to empower users with an intuitive, easy-to-use interface that enables them to seek assistance with minimal effort, particularly in high-stress scenarios.

Moving forward, enhancing AI-driven risk prediction, integrating health monitoring capabilities, and expanding emergency service partnerships will further strengthen the system's impact. The addition of machine learning-based fall detection and voice-activated alerts will enhance accessibility, making it more useful for individuals with limited mobility or cognitive impairments. Furthermore, the potential for solar charging and extended power management strategies can make the device even more self-sustainable, particularly in low-resource settings.

This research contributes to the growing field of assistive technology, providing a scalable, real-world safety solution that enhances personal security and emergency response efficiency. By continuing to refine and innovate upon this foundation, the EmergAlert Band has the potential to revolutionize emergency response for vulnerable populations worldwide, offering peace of mind to both users and their caregivers.

The EmergAlert Band successfully demonstrates an affordable, efficient, and accessible emergency response system. By focusing on core functionalities rather than feature overload, the device ensures reliability in critical situations.

Future work will enhance power efficiency, voice activation, and automated distress detection. This research contributes to the growing field of assistive technology, providing a scalable solution for personal safety worldwide.

VIII. ACKNOWLEDGMENT

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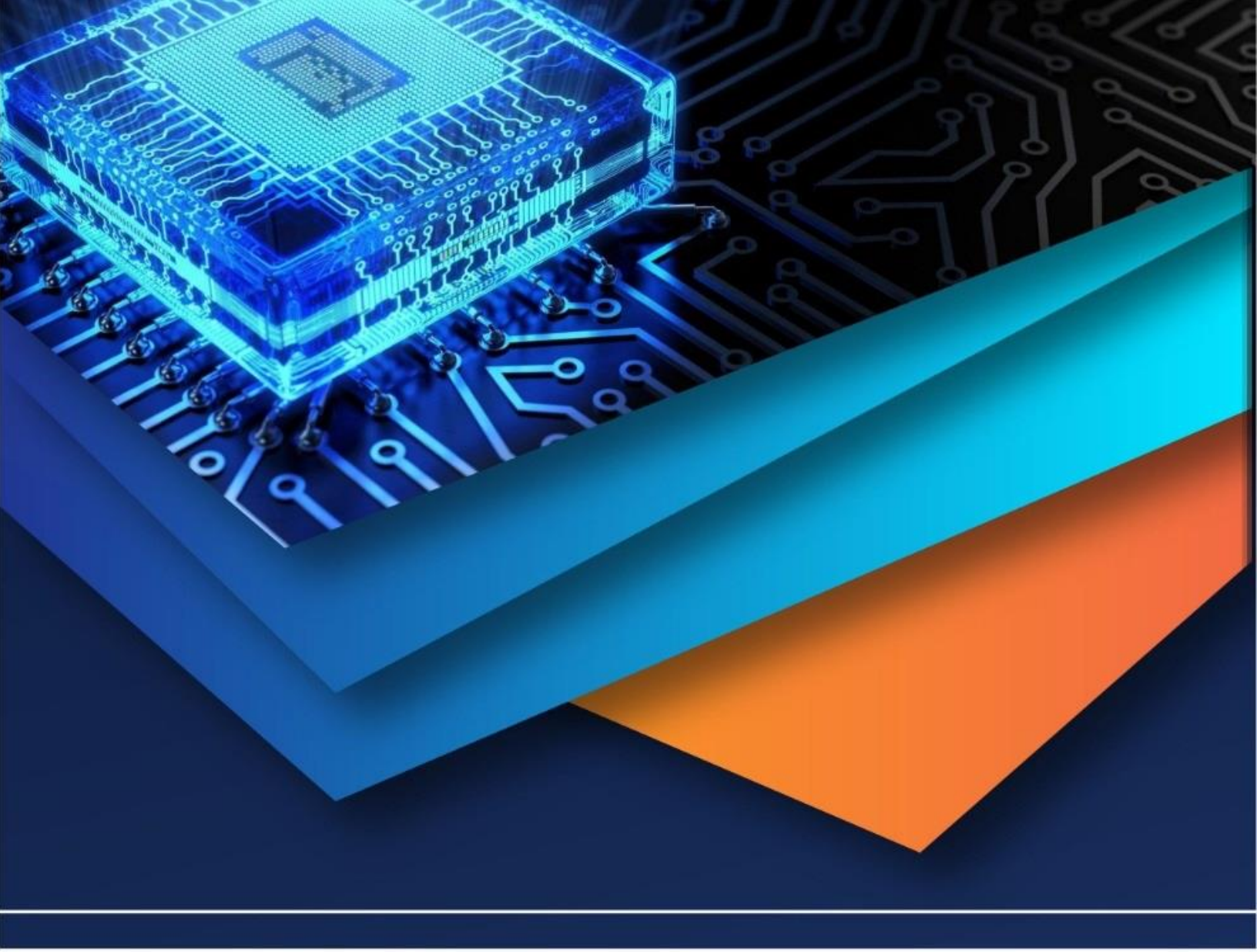

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