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Voice-Activated AI Safety Pendant for Women with Real-Time Location Sharing and Emergency Alert Transmission to Contacts via Mobile App

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Abstract- Women's safety continues to be a pressing concern globally, and timely access to help often determines the outcome of critical situations. With rapid advances in electronics and communication technology, there is growing potential to build practical tools that can offer support when it is needed most. This work presents a compact, AI-enabled wearable safety device developed specifically to assist women during emergencies. The device operates hands-free and relies on on-device voice recognition, implemented on an ESP32-S3 microcontroller trained using Edge Impulse. It uses Bluetooth Low Energy (BLE) to connect with a companion Android application. When the system recognizes the spoken keyword "Help! Help!" it functions entirely offline to activate the mobile app. The app then automatically fetches the user's GPS location and sends an SOS alert to selected emergency contacts. It also uses the Google Places API to identify nearby police stations for quicker support. To strengthen post-incident reporting, the wearable includes an AI-based motion and image-capture module that records relevant visual evidence through its built-in camera. The prototype is designed to be power-efficient, affordable, and mindful of user privacy, making it suitable for both rural and urban environments. Overall, the proposed system shows how edge AI and IoT connectivity can be combined to create a practical and reliable personal-safety solution.

Keywords – Women harassment, Wearable smart pendant, Emergency alert system, Critical situations, Voice-activated SOS, Automatic photo capture, GPS location tracking, IoT-based safety device, Bluetooth Low Energy (BLE), Edge AI processing, Real-time alerting.

I. INTRODUCTION

Women's safety continues to be a significant concern in daily life, especially in situations where immediate help is not accessible. Many incidents of harassment or assault occur suddenly, leaving the victim with no time or ability to unlock a phone, make a call, or manually activate an SOS application. In such critical situations, a hands-free and intelligent safety solution becomes essential.

Conventional mobile-based emergency systems often fail because they depend on manual user interaction. During real emergencies, users may be physically restricted, under threat, or too stressed to operate their smartphones. This gap creates the need for a compact, always available, and discreet wearable device that can automatically detect distress and trigger alerts without requiring physical access to the phone.

The Smart Pendant is designed to address this challenge through a combination of voice-activated SOS detection, BLE communication, real-time GPS location sharing, and automatic photo capture through the user's smartphone. When the pendant detects critical situations—such as repeated distress calls or sudden help commands—it instantly sends an emergency alert along with the user's live location. Simultaneously, the pendant triggers the smartphone camera to automatically capture photos of the surroundings, helping generate real-time evidence for quicker identification of threats.

The compact pendant form factor ensures that the device remains close to the user's chest, allowing rapid voice detection and discreet activation even under stressful conditions. The system is suitable for public places, workplaces, transportation, educational campuses, isolated areas, and emergency-prone environments, enabling rapid response and improving personal safety.

By integrating wearable technology, embedded AI, IoT connectivity, and real-time evidence generation, the proposed smart pendant offers a reliable and practical solution for improving women's safety in everyday scenarios.

II. LITERATURE REVIEW

To analyse existing women's safety systems and assess their effectiveness in emergency detection, response time, and user protection, the reviewed studies are classified into the following themes.

A. Delayed Emergency Response and Dependence on Manual Triggers

Despite the proliferation of women's safety devices and mobile applications, timely emergency response remains a critical challenge. A large proportion of existing systems rely on manual activation mechanisms such as panic buttons, smartphone interactions, or gesture-based triggers [3] – [6], [8], [15]. In real-world assault scenarios, victims may be immobilized, unconscious, panicked, or physically restrained, making manual triggering unreliable. Several studies report that systems fail to activate if the user is unable to press a button or access a smartphone during distress [3], [9], [17].

Additionally, dependence on smartphones for GPS acquisition, SMS transmission, or app-based alerts introduces further delays due to battery drain, background app restrictions, or network unavailability [6], [14], [21]. Even sensor-based automatic systems often suffer from false alarms or missed detections due to rigid threshold-based logic and limited contextual understanding [11], [17], [19]. These limitations highlight the need for hands-free, intelligent, and context-aware triggering mechanisms capable of operating reliably under real emergency conditions.

TABLE I. Key Factors Contributing to Delayed Emergency Response

Sr. No.	Segment	Driving Factor	Details
1	Technological	Manual trigger dependency	Panic buttons fail if the user is immobilized or unconscious
2	System Design	Smartphone reliance	App-based alerts depend on phone access, battery, and permissions
3	Algorithmic	Threshold-based sensing	Causes false alarms or missed detections in dynamic conditions

The factors summarized in Table I demonstrate that delayed emergency response in women's safety systems is primarily driven by manual activation dependency, smartphone-centric architectures, and simplistic sensing logic. Addressing these challenges requires intelligent, always-on detection mechanisms, such as voice-based or AI-assisted triggers, capable of functioning independently of continuous user interaction.

B. Connectivity Dependence and Usability Barriers

Most existing women's safety solutions rely heavily on continuous GSM, GPS, Wi-Fi, or cloud connectivity to transmit alerts, location data, and multimedia evidence [1], [2], [7], [11], [22]. While effective in urban environments, these systems exhibit reduced reliability in low-signal areas, indoors, or during network congestion. Several wearable and mobile-based solutions fail entirely when internet or GSM services are unavailable, limiting their usefulness in rural, remote, or emergency scenarios [3], [14], [24].

Usability challenges further hinder adoption. Bulky hardware designs, frequent charging requirements, and complex app interfaces reduce daily wearability and long-term user compliance [9], [10], [20]. Privacy concerns related to continuous monitoring, audio/video recording, and cloud data storage also discourage widespread acceptance, particularly among women concerned about data misuse [2], [5], [21]. These barriers indicate that connectivity- and usability-aware system design is essential for scalable deployment.

TABLE II. Drivers of Connectivity and Usability Barriers

Sr. No.	Segment	Driving Factor	Details
1	Infrastructure	Network dependency	GSM/GPS failures reduce system reliability
2	Design	Bulky wearable hardware	Limits comfort and daily usage
3	Privacy	Continuous monitoring	Raises data security and trust concerns

The factors in Table II highlight that excessive reliance on connectivity and poor usability design significantly constrain the real-world effectiveness of women's safety systems. Future solutions must emphasize edge intelligence, low-power operation, compact form factors, and privacy-preserving architectures to ensure sustained adoption.

C. Scalability, Reliability, and Real-World Deployment Challenges

Although many women's safety systems demonstrate promising results in controlled or prototype environments, scalability and real-world robustness remain major concerns. Systems dependent on city-wide BLE/iBeacon infrastructure or centralized cloud platforms face deployment complexity, calibration issues, and high maintenance costs when scaled to large populations [5]. Similarly, solutions integrating electric shock or tear gas mechanisms raise safety, ethical, and regulatory concerns that limit practical adoption [7], [10], [24].

Furthermore, many studies report limited field testing, often restricted to laboratory conditions or small user groups, without long-term evaluation under diverse environmental, social, and behavioral conditions [19], [20]. Battery limitations, sensor noise, and interoperability challenges across devices further reduce reliability during prolonged usage [13], [18]. These challenges underscore the necessity for lightweight, scalable, and extensively validated safety systems capable of operating consistently across varied real-world scenarios.

TABLE III. Key Scalability, Reliability, and Real-World Deployment Challenges

Sr. No.	Segment	Driving Factor	Details
1	Scalability	Infrastructure Dependence	Reliance on large-scale BLE/iBeacon or cloud infrastructure increases deployment complexity and cost when scaled to large populations
2	Reliability	Limited Real-World Validation	Most existing systems lack long-term field testing under diverse environmental and user conditions
3	Deployment	Safety and Regulatory Constraints	Use of electric shock or tear gas mechanisms raises ethical, safety, and regulatory concerns, limiting real-world adoption

D. Research Gap

A critical examination of existing women's safety systems reveals that, despite extensive research and multiple technological implementations, several fundamental gaps remain unresolved. Most currently proposed solutions depend predominantly on manual activation mechanisms, including panic buttons, smartphone gestures, or application-based triggers [3]–[6], [8], [15]. In real-world emergency situations, victims may be physically restrained, disoriented, or unconscious, making such manual interventions unreliable. Although certain systems incorporate physiological or motion sensors to automate alerts, they largely rely on predefined threshold-based logic, which is prone to false alarms or failure to detect genuine distress under dynamic environmental and behavioral conditions [11], [17], [19].

Another prominent research gap is the strong dependence on continuous GSM, GPS, internet, or cloud connectivity for system functionality [1], [2], [7], [14], [22]. Many reported devices and applications experience degraded performance or complete failure in indoor environments, low-network coverage areas, or during network outages. While offline capability is occasionally acknowledged, limited attention has been given to the development of edge-based intelligent systems capable of autonomous distress detection without persistent connectivity, restricting the reliability of existing solutions in practical scenarios.

Usability and wearability issues further limit large-scale adoption. Several wearable systems described in the literature involve bulky hardware, frequent battery charging, or complex user interfaces that reduce comfort and discourage continuous use [9], [10], [20]. Additionally, privacy and data security concerns arising from continuous location tracking, audio/video recording, and centralized data storage remain insufficiently addressed in many implementations [2], [5], [21]. These concerns pose significant challenges to user acceptance, particularly in long-term, real-world deployments.

Scalability and real-world validation also remain inadequately addressed. Some systems rely on specialized infrastructure such as BLE/iBeacon networks or smart city integration, increasing deployment complexity and cost [5]. Moreover, experimental evaluations are often limited to laboratory environments or small user groups, lacking comprehensive validation under diverse real-world conditions [19], [20].

III. CONCLUSION

This work presents an AI-enabled wearable safety system designed to provide autonomous and real-time emergency detection for women in vulnerable situations. By integrating an offline keyword-spotting model on the ESP32-S3 microcontroller, the system ensures continuous monitoring without dependence on network connectivity, thereby addressing a major limitation of existing mobile-based safety applications. The proposed BLE-based communication framework enables the seamless transmission of distress alerts to a paired smartphone, which automatically retrieves GPS coordinates and forwards an SOS message to predefined emergency contacts. Experimental evaluation demonstrates that the system achieves reliable keyword detection, low-latency alert transmission, and stable operation under varying environmental conditions.

The system effectively combines embedded intelligence, wireless communication, and mobile automation to create a proactive and hands-free safety mechanism. The hardware–software co-design ensures low power consumption and user comfort, making the solution practical for everyday use. While the current implementation focuses on wake-word detection and SMS-based emergency notifications, future extensions may include community-level mesh alerts, multi-sensor fusion, and integration with public safety networks to further enhance responsiveness and coverage. Overall, the proposed system represents a significant step toward leveraging edge AI and IoT technologies to improve personal safety and provide rapid assistance during critical events.

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