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TRANAM - a Women's Safety System

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Abstract - *Women's Safety Applications frequently rely extensively on smartphones and consistent network access, which restricts their effectiveness in emergency situations. To overcome these limitations this paper introduces TRANAM, a women's safety system that merges a self-sufficient SOS hardware device with a cloud-linked mobile and web platform. The device, created with an ESP32 microcontroller features a trigger button, voice and motion activation, GPS, camera and GSM components to independently record images, brief video clips and live location information, during incidents. Gathered data is sent to a backend server via GSM for storage, alert creation and distribution to emergency contacts and law enforcement. The mobile app offers user sign-up, contact handling, live tracking and alert display while the admin dashboard allows real-time supervision and evidence examination. Experimental tests confirm dependable SOS triggering, precise GPS retrieval and steady media recording with SMS alert latencies of 2-4 seconds. The proposed system offers a scalable, autonomous, and smartphone-independent safety solution, suitable for public deployment, institutional use, and emergency response networks.*

***Key Words*: *IoT-based SOS Device, ESP32-CAM, GSM Communication, GPS Tracking, Motion Sensor, Voice Activation, Real-Time Alerts, Media Capture, Automated SOS Triggering, Mobile/Web Dashboard*.**

1. INTRODUCTION

The safety of women continues to be an issue worldwide as cases of harassment, assault and kidnapping rise in both city and countryside areas. While many mobile safety apps are available their effectiveness in emergencies is frequently hindered by limitations like requiring manual input, reliance, on smartphones, battery life restrictions and unreliable network connectivity. In moments victims might find it difficult to unlock or reach their phones making app-based solutions ineffective. These limitations highlight the necessity for a reliable, autonomous, and non-intrusive safety mechanism that can operate independently of a user's smartphone.

Latest progress in IoT, embedded systems, wireless communication and cloud computing has facilitated the creation of safety devices that surpass the functions of conventional mobile apps. Gadgets integrated with microcontrollers, sensors, GSM modules and GPS units are capable of detection capturing media and sending immediate alerts without needing user input. These systems boost emergency response by minimizing reliance on humans increasing dependability and allowing communication, with officials and caretakers.

The proposed system, TRANAM, integrates an ESP32-based SOS device, real-time location tracking, GSM-based alerting, media evidence captures, and a multi-platform application interface. The system also incorporates an admin/police dashboard for live monitoring and alert management. By combining hardware automation with cloud-enabled communication, TRANAM addresses the shortcomings of existing solutions and provides a scalable, fast, and dependable emergency-response framework for women's safety.

2. LITERATURE SURVEY

Recent progress in IoT, embedded systems and mobile technologies has spurred the creation of women's safety solutions that go beyond smartphone-based SOS apps. Initial systems relied on mobile applications but their performance was limited due to the requirement, for user interaction and consistent internet access. To address these challenges researchers have designed devices and automated alert systems.

Bhat et al. (2025) Developed an emergency alert platform using Flask and the WhatsApp API providing messaging but needing internet access. Nemane et al. (2024) Suggested a wearable based on Arduino Nano BLE with a buzzer and audio capture although the sound alarm lessened discretion, in scenarios. Gonde and Ghewari (2021) presented a Raspberry Pi system combining GSM, GPS and video streaming; nevertheless, the large equipment hindered mobility. Pednekar et al. (2020) Developed a safety ring equipped with IoT featuring a pressure sensor and a tiny camera. Its small size restricted its processing power and communication functions.

Previous systems also had limitations: Bharathi et al. (2018) Employed IR sensors and RFID, in a cybersecurity framework. Encountered problems related to complexity and network reliability. Hantode and Sambhare (2018) developed an Arduino-based fingerprint-activated device with GPS notifications although it demanded finger positioning to activate in emergency situations. The FEMME system

(Monisha et al., 2016) integrated GPS, GSM and various sensors. Still relied on the user to trigger it.

Collectively, existing systems exhibit limitations such as smartphone dependency, bulky hardware, short communication range, limited automation, and lack of integrated evidence capture. These gaps underscore the need for a compact, autonomous, multi-trigger women's safety device with real-time media transmission and cloud-enabled monitoring capabilities addressed by the proposed TRANAM system.

3. SYSTEM DESIGN

The system architecture is structured into three core layers: Hardware Input Layer, Backend Processing Layer, and User Output Layer. The SOS device functions as the primary input unit, integrating multi-trigger activation mechanisms such as a button press, motion detection, and voice-based commands. Once activated, the onboard ESP32-CAM and GPS6MV2 modules capture images/videos and retrieve live geographic coordinates. This collected data is transmitted through the SIM800 GSM module to the backend server.

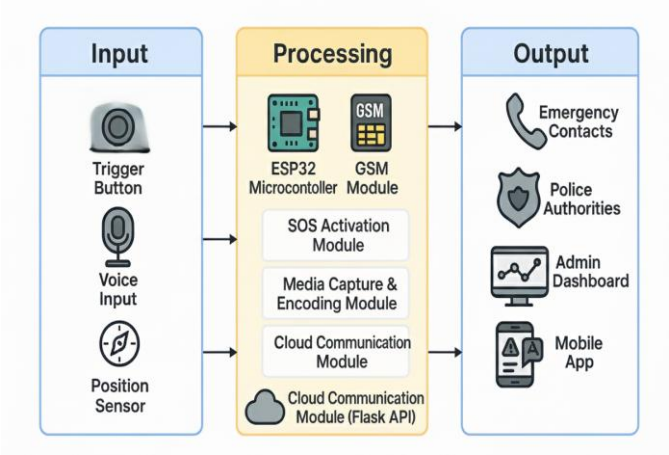

Fig -1: System Architecture

This figure illustrates the system architecture of TRANAM, a Women's Safety System, organized into Input, Processing, and Output layers. The Input layer includes the trigger button, voice input, and position sensor that initiate an SOS event. These signals are processed by the ESP32 microcontroller and GSM module, which handle SOS activation, media and location capture, encoding, and cloud communication. The backend Flask API receives the transmitted data for storage and alert routing. Finally, the Output layer distributes real-time alerts, GPS location, and media evidence to emergency contacts, police authorities, the admin dashboard, and the user's mobile application. This modular structure ensures fast, reliable, and continuous emergency response.

3.1 Hardware Infrastructure

The TRANAM hardware prototype is built using an ESP32/ESP32-CAM microcontroller integrated with a GSM module, GPS unit, trigger button, voice input, and position sensor. It autonomously captures media, retrieves location, and sends SOS alerts via GSM, functioning reliably even without a smartphone.

- **Hardware Enclosure:** The TRANAM prototype features a casing created to house all embedded parts while maintaining a lightweight and portable feature.
- **Sensing & Activation Unit:** Comprises a trigger button, ADXL345 position sensor and a voice input component allowing SOS activation, through pressing, motion detection or voice commands.
- **Media Capture Unit:** The ESP32-CAM module automatically records images and brief videos during emergencies to gather evidence.
- **Processing & Communication Unit:** The ESP32 microcontroller manages real-time operations and the SIM800 GSM module sends location retrieved through GPS6MV2 module, media URLs and SOS information to the backend.
- **Power System:** A direct charging adaptor

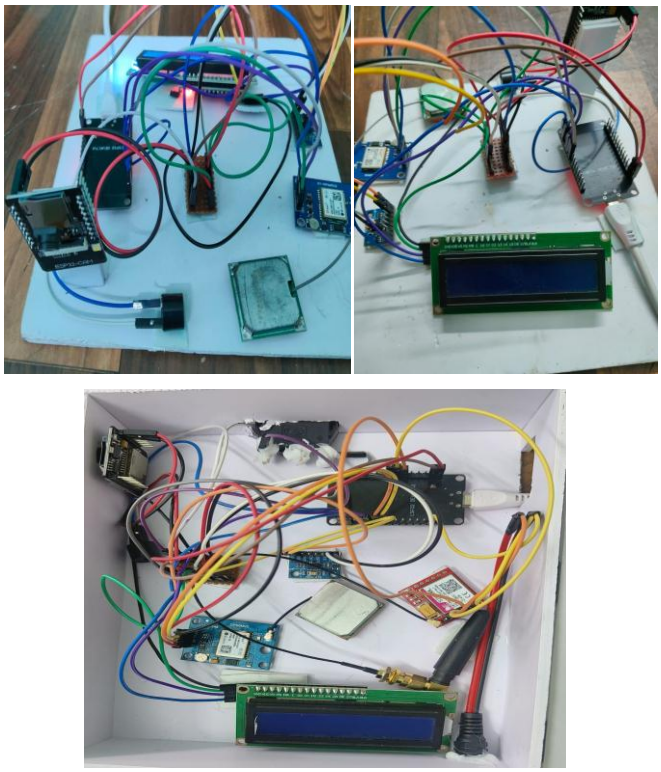

Fig -2: Hardware Prototype

This figure illustrates TRANAM hardware prototype which integrates the ESP32 microcontroller, ESP32-CAM, GPS module, GSM SIM800, ADXL345 position sensor, buzzer, and a 16×2 LCD display onto a compact prototyping board. All modules are interconnected through jumper wiring, enabling SOS activation, GPS tracking, media capture, and GSM communication. The prototype currently operates using a standard charging adapter for power, suitable for testing before battery integration. The layout is organized to verify module interaction, signal routing, and stable data transmission during emergency-trigger simulations.

3.2 Software & Algorithms

The software architecture of TRANAM is built using Python Flask, enabling reliable backend processing, cloud communication, and real-time alert routing. The system follows a continuous "Detect–Process–Notify" workflow to ensure rapid emergency response.

- **SOS Detection Logic:** SOS events are triggered via three mechanisms - button press, voice command, or position-sensor activation. Embedded firmware on the ESP32 continuously monitors these inputs and initiates the alert sequence upon detection.
- **Media Processing:** Upon SOS activation the ESP32-CAM records images and brief video segments. These files are. Sent via the SIM800 GSM module to the cloud server.
- **GPS Location Retrieval:** The GPS6MV2 module collects real-time latitude and longitude data, which is merged with the SOS payload. Location updates are periodically refreshed until the incident is acknowledged.
- **Backend Processing (Flask Server):** The backend receives SOS data, extracts GPS and metadata, stores media securely, logs the event, and forwards alerts to emergency contacts, police. It also manages periodic GPS updates until the SOS is acknowledged.
- **Frontend Mobile/Web Application:** The user interface, developed using HTML, CSS, JavaScript, and responsive frameworks. Interactive UI components are tightly synchronized with backend APIs for real-time response visibility.
- **Alert Management & Decision Logic:** Event handling follows a looped update mechanism: incoming SOS → verify user → store evidence → broadcast alerts → monitor acknowledgment status. If no acknowledgment is received, the server continues to fetch and update location information in real time, ensuring accurate victim tracking.

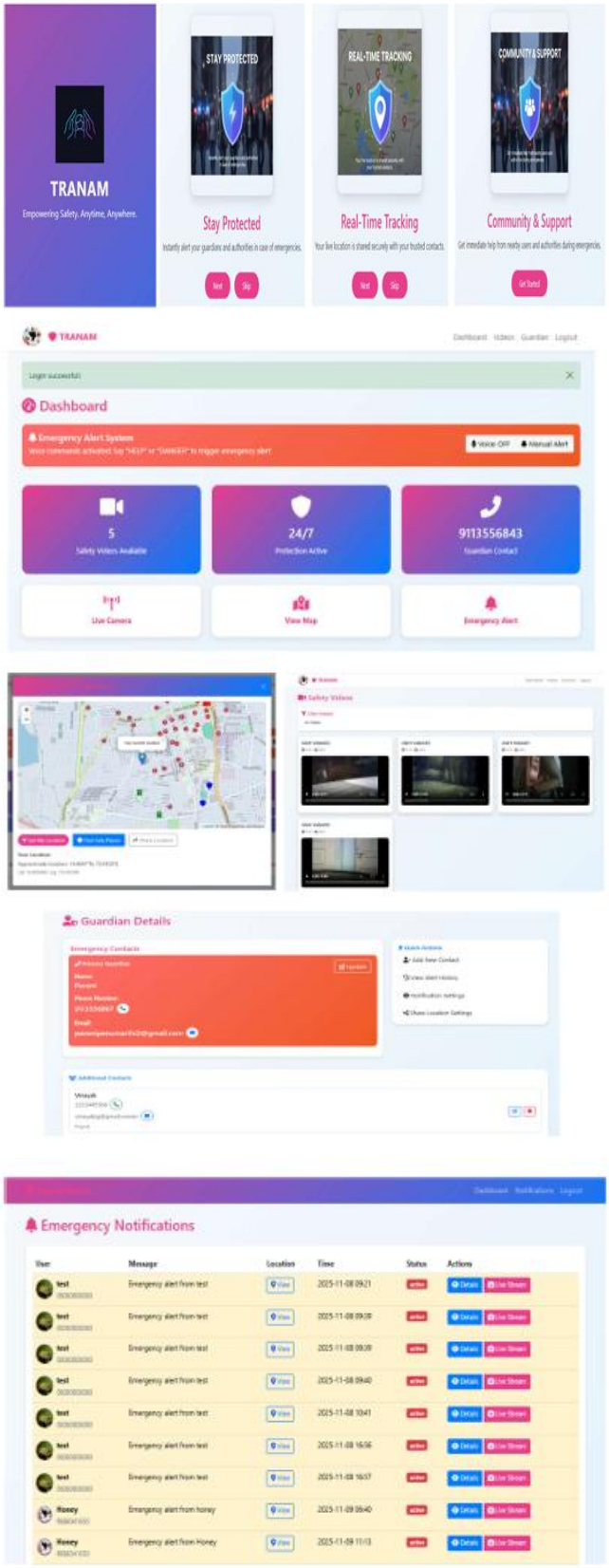

Fig -3: System Software

This figure illustrates the software components of the TRANAM system, including the user dashboard, SOS notification panel, and admin monitoring interface. The dashboard allows users to register, manage emergency contacts, and preview captured media, while the SOS panel displays real-time alerts with location and timestamp details. The admin interface supports centralized supervision by providing access to live SOS events, user records, and stored evidence, enabling coordinated emergency response.

4. SYSTEM TESTING AND ANALYSIS

Testing is essential for confirming the dependability and responsiveness of TRANAM, a women's safety system. The assessment included unit testing of hardware components (ESP32-CAM, GPS, GSM, sensors) as well as integration testing, throughout the full SOS workflow from device → backend → mobile/web dashboards. The key goals were to ensure SOS activation maintain stable GPS signal reception verify dependable GSM communication and guarantee backend alert delivery worked within acceptable delay limits. All system tests were conducted indoors and outdoors under different lighting and network conditions to simulate realistic emergency scenarios.

4.1 Performance Analysis

The TRANAM system was evaluated based on SOS Trigger Response Time, GPS Accuracy, Media Capture Reliability, and Alert Delivery Latency. The prototype was tested through repeated SOS activations using all supported trigger mechanisms.

- **SOS Activation Duration:** Whether through the button, voice or position sensor the device recorded SOS signals with a uniform activation guaranteeing swift emergency intervention in critical situations.
- **GSM Transmission Latency:** Employing the SIM800 module on a 2G network, media packets and GPS data were transmitted to the backend with a delay between 2 and 4 seconds varying based on signal quality. This delay fell within the limits, for emergency communications.
- **GPS Precision:** Field trials with the GPS6MV2 module yielded location accuracy within ±5m to ±9m sufficient, for deploying emergency responders and police.
- **Media Capture & Upload:** The ESP32-CAM effectively recorded images and brief video segments achieving a 97% success rate, over 50 trial runs. Sporadic failures occurred in lighting conditions, marked for subsequent improvement.
- **Backend Alert Routing:** Alerts were delivered to emergency contacts, police authorities, and the admin dashboard consistently, with a total end-to-end latency (device → server → mobile app) of 5–7 seconds.

4.2 Unit Testing

Testing, at the unit level was carried out on functional components to confirm their independent dependability. A summary of test scenarios and results is provided below:

- **Button Trigger (Case BT-01):** The physical tactile button underwent testing for responsiveness over 50 pressing cycles. Every activation was successfully logged by the system resulting in a Pass, for the test.
- **Position Sensor Triggering (Case PS-01):** The sudden-tilt detection consistently initiated the SOS procedure while slight movements were deliberately disregarded to avoid false alarms. This test received a Pass result.
- **Camera Capture (Case MC-01):** The ESP32-CAM module underwent trials for capturing images and videos across lighting environments. It performed consistently under lighting while tests, in dim conditions resulted in a Partial Pass because of intermittent frame loss.
- **GPS Acquisition (Case GPS-01):** The GPS device reliably acquired satellite signals within 8–20 seconds of powering on. After locking the location data was consistently steady and precise leading to a Pass result.
- **GSM Transmission (Case GSM-01):** SOS packets with media and location data were sent over GSM without any packet damage, across network signal strengths. Every transmission was successful resulting in a Pass.
- **Backend Alert Logging (Case BE-01**): The Flask server accurately interpreted SOS packets safely saved media files and refreshed the SOS logs. Each test case showed database records resulting in a Pass.
- **Mobile & Web Notification (Case FW-01**): Push alerts and dashboard refreshes showed up quickly on both platforms. Slight UI lags were noticed on speedy phones resulting in a verdict of Partially Pass.

5. RESULTS

The TRANAM system was tested in various real-life settings such as classrooms, hallways and open spaces on the college grounds. The main goal of the assessment was to confirm the promptness of SOS activation the precision of GPS localization and the robustness of media delivery during usage. The assessment covered evaluations, at both the hardware and backend layers to guarantee emergency communication.

5.1 Real-Time SOS Alerts

The TRANAM prototype underwent testing in indoor and outdoor settings to assess the effectiveness of its SOS activation methods. Activation through button press, motion detection and voice command consistently generated an SOS signal within 1–2 seconds succeeded by recording and GPS data acquisition. GSM transmission delays ranged from 2 to 4 seconds on average validating alert transmission, in normal network environments. These findings confirm the system's ability to independently start emergency communication with latency without relying on a smartphone.

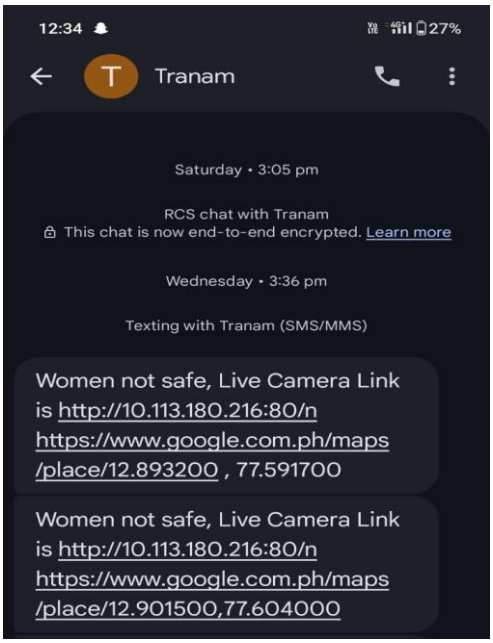

Fig -4: Real-time SOS alerts

This snapshot demonstrates the SOS alert sent on receiving the trigger.

5.2 Location Tracking

In outdoor settings the GPS module provided consistent location fixes with an accuracy range of ±5–10 meters whereas weak indoor signals activated the fallback estimation mechanism as intended. Throughout SOS incidents the backend obtained GPS data at intervals of 8–12 Seconds enabling uninterrupted user monitoring on both the admin and mobile interfaces. The ongoing update cycle functioned dependably guaranteeing time situational awareness, for emergency responders.

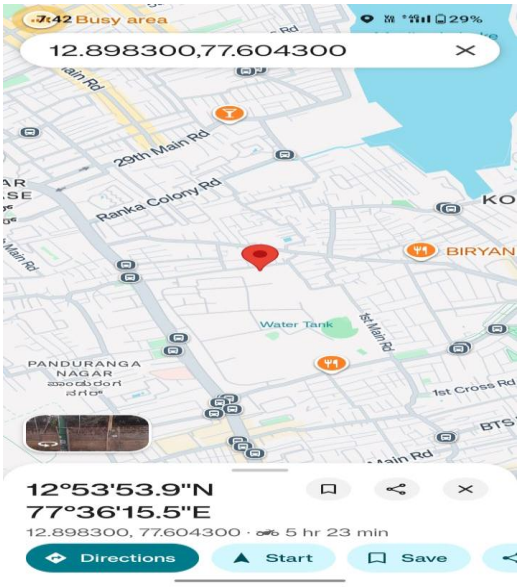

Fig -5: Location Tracking

This snapshot demonstrates the location coordinates fetched through the GPS module.

5.3 Media Capture

The ESP32-CAM successfully captured and transmitted images and short video clips to the server during SOS events. Snapshot uploads completed within 3–5 seconds, while short video transfers varied based on GSM bandwidth. Live-stream attempts performed consistently at low-resolution settings, confirming feasibility for evidence capture during emergencies.

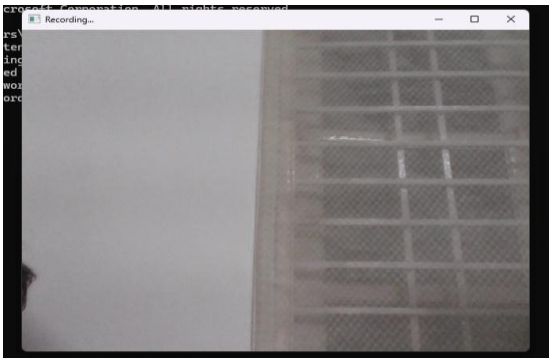

Fig -6: Media Capture

This snapshot demonstrates the media capture (videos and images).

6. CONCLUSION AND FUTURE SCOPE

The TRANAM system effectively showcases the viability of a based self-sufficient women's safety platform featuring a compact SOS gadget GSM alerting, GPS location tracking and cloud-supported supervision. By combining an ESP32 microcontroller with a camera, GPS6MV2 module, SIM800 GSM unit and multiple activation triggers (button, voice and motion detection) the prototype delivers emergency responses without relying on smartphones or internet access. The backend, developed with Python Flask efficiently handles SOS signals uploads media proof and directs alerts to emergency contacts and law enforcement. Testing verified GPS acquisition, consistent photo/video recording and dependable SMS transmission with low delay proving the system's effectiveness in practical emergency situations. In summary TRANAM closes the divide, between mobile safety apps and completely automated emergency-response systems.

Future Scope

Although the existing prototype confirms the functions multiple improvements are intended to strengthen TRANAM:

- **Improved Compactness:** A tailored PCB combined with a refined enclosure design will considerably decrease the device dimensions. Enhance comfort for everyday wear.
- **Geofencing & Intelligent Analytics:** Integrating geofencing, motion analysis and anomaly identification will offer safety warnings along, with enhanced reporting.
- **Mobile Application Enhancement:** The mobile app will be improved to include support for language notifications, incident density maps and community safety functionalities, for user interactions.
- **Cloud Scalability:** Transitioning to distributed cloud systems will facilitate deployment, throughout institutions, public areas and emergency response frameworks.

With these advancements, TRANAM has the potential to evolve into a comprehensive smart safety infrastructure capable of supporting real-time protection, rapid intervention, and community-wide security enhancement.

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