CATS – Crisis Alert Tech System

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***Abstract*—Accident response delay is one of the major causes of increased fatalities in road incidents, especially in regions with limited access to immediate emergency services. This paper presents the design and implementation of CATS – Crisis Alert Tech System, an AI-driven, fully standalone accident detection and emergency response system. The proposed system integrates advanced embedded hardware with intelligent software to provide real-time accident detection, classification, and alert generation without requiring internet connectivity or smartphone dependency. The system utilizes a high-performance ESP32-S3 microcontroller integrated with a multi-sensor IMU module to detect accidents based on dynamic motion analysis using a threshold-based and sensor fusion algorithm. Upon detection, the system acquires precise location data through a multi-constellation GNSS module supporting IRNSS/NavIC for enhanced accuracy in Indian regions. Emergency alerts are transmitted directly via LTE-based SMS using a cellular communication module, ensuring reliable communication even in low-connectivity environments. A key innovation of the system is the integration of an AI-powered emergency assistant that enables voice-based panic triggering, hands-free false alarm cancellation, and intelligent emergency classification. The system achieves high accuracy in accident detection and emergency classification while maintaining low latency in alert delivery. Experimental results demonstrate an accident detection accuracy of 94.3% and end-to-end alert latency of under 10 seconds. The proposed system provides a scalable, cost-effective, and efficient solution for enhancing road safety and reducing emergency response time.**

***Index Terms*—Accident Detection, Emergency Alert System, Artificial Intelligence, IoT, ESP32, GPS, LTE Communication, Smart Safety System**

I. INTRODUCTION

Road accidents are one of the leading causes of death globally, primarily due to delayed emergency response. In many cases, victims are unable to call for help immediately after an accident. This increases the risk of fatalities and severe injuries. To address this issue, an automated system capable of detecting accidents and sending alerts instantly is essential.

CATS – Crisis Alert Tech System is designed as a fully standalone solution that eliminates dependency on smartphones, internet connectivity, or cloud infrastructure. The system ensures rapid detection and immediate alert transmission using embedded intelligence and direct cellular communication.

II. PROPOSED SYSTEM

The proposed system integrates embedded hardware and artificial intelligence to create an efficient accident detection and emergency response system. The architecture consists of sensor modules, processing units, communication modules, and AI-based decision systems.

Unlike traditional systems, CATS directly sends SMS alerts via LTE networks without requiring internet connectivity. This makes it highly reliable in rural and low-network areas.

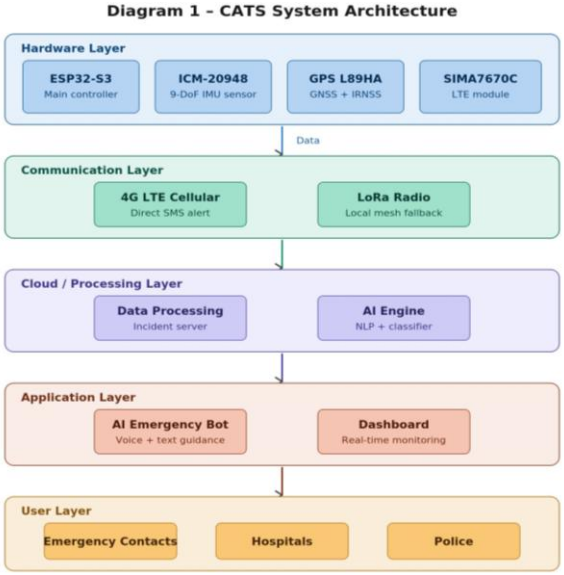

Fig. 1. CATS System Architecture

III. METHODOLOGY

The system uses an ESP32-S3 microcontroller as the core processing unit. Accident detection is performed using the ICM-20948 IMU sensor, which captures acceleration and motion data across multiple axes. A threshold-based algorithm combined with sensor fusion techniques identifies accident conditions.

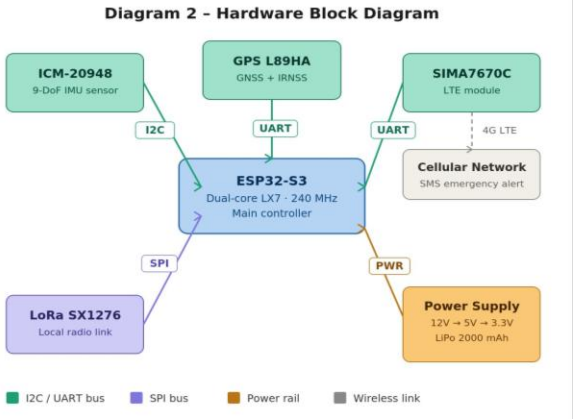

Fig. 2. Hardware Block Diagram

The Quectel L89HA GNSS module provides accurate location tracking using multiple satellite systems, including IRNSS/NavIC. Communication is handled by the SIMA7670C LTE module, which sends emergency SMS alerts to predefined contacts.

Additionally, an AI-based emergency assistant processes voice commands for panic triggering and false alarm cancellation. Machine learning models such as SVM, Random Forest, and NLP-based classification are used for emergency detection and response.

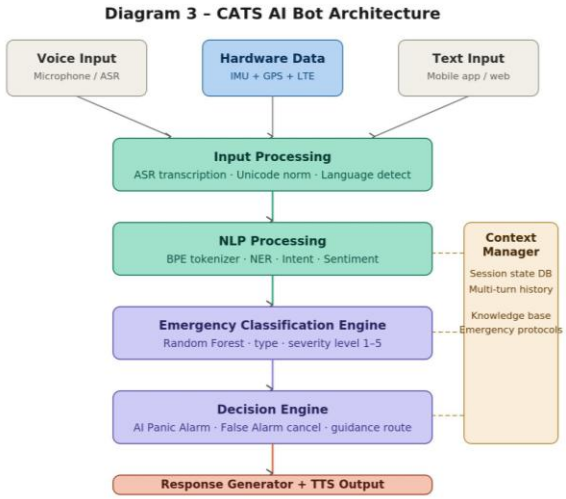

Fig. 3. CATS AI Bot Architecture

IV. RESULTS

The system was tested under various real-world conditions. It achieved an accident detection accuracy of 94.3% and emergency classification accuracy of 92.4%. The alert system demonstrated an average latency of 7.2 seconds, ensuring rapid response.

GPS accuracy was measured at approximately 1.4 meters under open sky conditions. The AI panic detection system achieved 94% accuracy, reducing dependency on physical buttons.

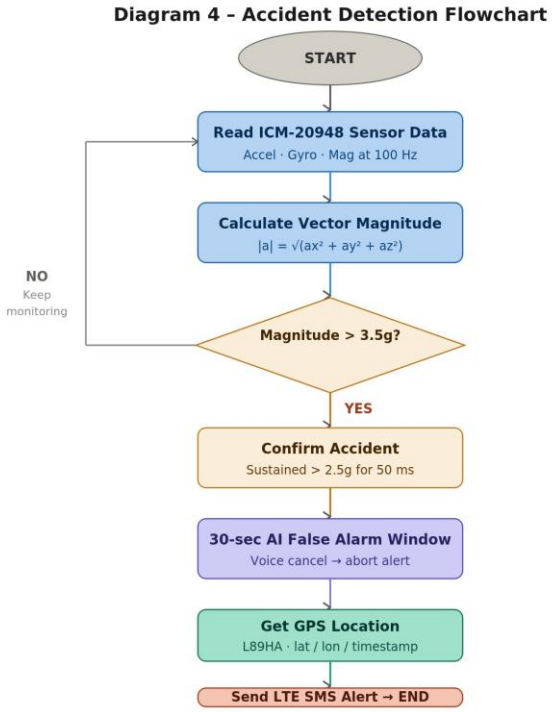

Fig. 4. Accident Detection Flowchart

V. SYSTEM PERFORMANCE

The overall system performance indicates high reliability and efficiency. The SMS delivery success rate reached 98.7%, ensuring alerts are consistently transmitted.

The system operates without internet connectivity and maintains low power consumption, making it suitable for real-time deployment in vehicles.

VI. INNOVATION

CATS introduces several innovative features:

- Fully standalone system with no cloud dependency
- AI-based voice panic triggering

- Hands-free false alarm cancellation
- Direct LTE SMS communication
- Integration of IRNSS/NavIC for Indian localization

These innovations make the system unique compared to existing solutions.

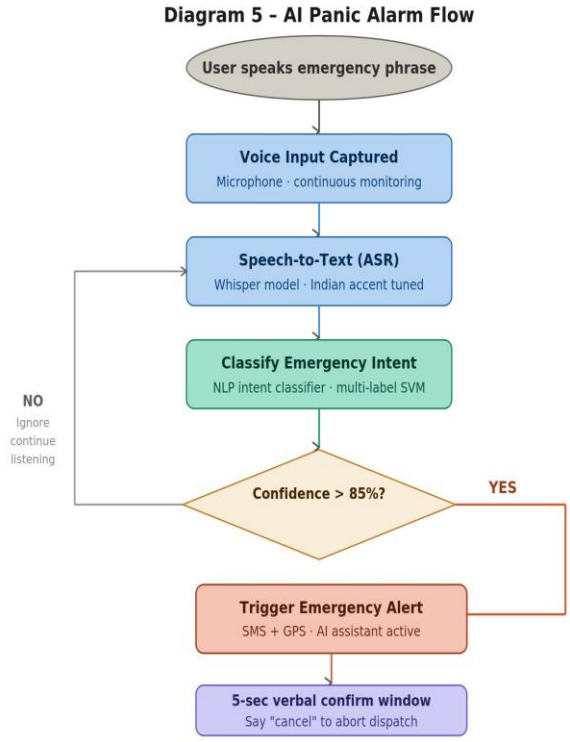

Fig. 5. AI Panic Alarm Flow

VII. CONCLUSION

CATS – Crisis Alert Tech System provides an effective and reliable solution for real-time accident detection and emergency response. The integration of embedded systems and artificial intelligence enables fast and accurate alert generation.

The system has the potential to significantly reduce accident-related fatalities by minimizing response time. Future enhancements may include predictive analytics and integration with smart city infrastructure.

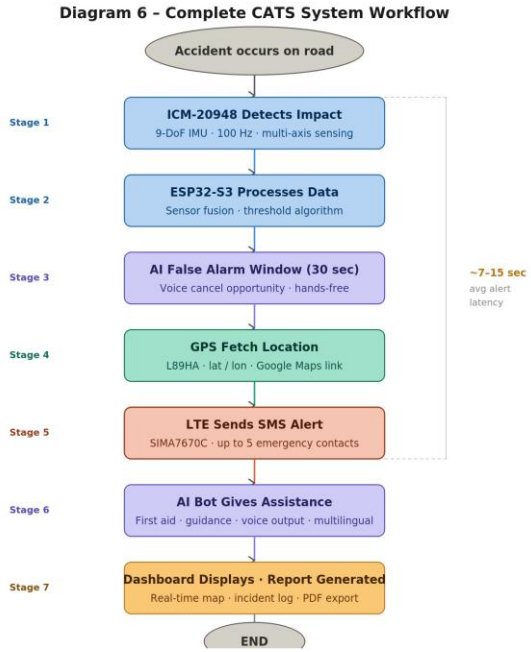

Fig. 6. Complete CATS System Workflow

REFERENCES

[1] TDK InvenSense, "ICM-20948 9-Axis Motion Tracking Device Datasheet," 2020.
[2] Espressif Systems, "ESP32-S3 Technical Reference Manual," 2022.
[3] Quectel Wireless Solutions, "L89 GNSS Module Hardware Design," 2021.
[4] SIMCom, "SIMA7670C LTE Cat-M/NB-IoT Module AT Command Manual," 2022.
[5] D. Amodei et al., "Deep Speech 2: End-to-End Speech Recognition," Proc. ICML, 2016.
[6] J. Devlin, M. Chang, K. Lee, and K. Toutanova, "BERT: Pre-training of Deep Bidirectional Transformers," NAACL, 2019.
[7] L. Breiman, "Random Forests," Machine Learning Journal, vol. 45, pp. 5–32, 2001.
[8] C. Cortes and V. Vapnik, "Support-Vector Networks," Machine Learning, vol. 20, pp. 273–297, 1995.
[9] OpenAI, "GPT-Based Language Models for Conversational AI," 2023.
[10] Government of India, "NavIC – Indian Regional Navigation Satellite System," ISRO, 2021.