Health Saving Chip

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***Abstract*—The Health Saving Chip (HSC) is a small, smart embedded system designed to transform vehicle accident analysis and emergency response after an accident. Effective interventions and legal clarity are still hampered by the lack of contextual ev- idence and delays in notifying authorities, despite advancements in automotive safety. A camera, GPS, GSM, microcontroller, and sensor array are all combined into one platform by the suggested HSC module. This system sends out emergency alerts with precise geolocation information, records real-time footage, and detects crash events on its own. In addition to facilitating thorough post- event investigations, the capacity to store and timestamp visual evidence guarantees faster reaction times. The HSC provides a major advantage over standalone safety devices because it is made for remote deployment.Utilizing low-power components and the Arduino development environment, the HSC's architecture prioritizes efficiency and modularity to guarantee functionality even in situations of power outages. Tests conducted in simulated crash environments showed a location accuracy of within ±3.2 meters, an average SMS alert latency of 4.1 seconds, and a detection sensitivity of over 95 Percent. Future developments include the integration of electronic health records (EHRs), 5G data transmission, and AI-driven crash classification. The HSC stands out as a flexible solution with the potential to significantly lower accident-related fatalities and improve road safety infrastructure by enabling quicker emergency responses, improving crash forensics, and supporting intelligent transport systems.**

***Index Terms*—GSM alerts, GPS telemetry, embedded systems, accident detection, health-saving chips, intelligent transportation, vehicle forensics, and emergency response.**

I. INTRODUCTION

Across the world, traffic accidents continue to rank among the most urgent public safety issues. The World Health Orga- nization (WHO) reports that traffic accidents claim the lives of more than 1.3 million people annually, and that 20 to 50 million more sustain non-fatal injuries, many of which result in lifelong disabilities. The immediate aftermath of an accident remains a crucial time when prompt intervention could mean the difference between life and death, even with the imple- mentation of sophisticated safety features like airbags, anti- lock braking systems, and seatbelt enforcement. The delay of emergency response and the absence of actionable incident evidence that could help first responders, hospitals, and other stakeholders are two significant flaws in the current vehicle safety systems.

Traditional systems, such as GPS units and dashboard cameras, are frequently made as stand-alone parts that either transmit information via manual commands or store data locally. Although somewhat helpful, these systems fall short of offering a comprehensive solution that can concurrently iden- tify an accident, gather and store contextual information, and start an emergency communication. For instance, manual SOS buttons necessitate conscious user input, which might not be possible during or right after a serious collision. Furthermore, current systems frequently lack resilience, experiencing power outages, communication outages, or incomplete data capture at crucial times.

The Health Saving Chip (HSC), the suggested system, pro- vides an all-in-one embedded solution that can autonomously identify accidents, record video before and after an incident, and send alert messages with precise GPS coordinates to pre-designated emergency contacts in order to overcome these limitations. A GPS tracker for location telemetry, a GSM unit for SMS alerts, a camera for visual evidence captures, and a variety of sensors to identify environmental changes and impacts make up the HSC's network of interconnected modules. Because the system is battery-powered and runs without the driver's input, it can continue to function even in the case of an engine cutoff or other power outage.

In addition to its direct safety implications, the HSC sup- ports more general uses in intelligent transportation systems (ITS) and smart mobility. The device can facilitate traffic pattern analysis, insurance claim validation, and accident forensics by sharing real-time data and storing contextual evidence. The HSC provides a scalable and affordable solution that supports the goal of safer, smarter roads as urban areas transition to more interconnected vehicle networks. Future improvements like cloud synchronization, machine learning- based crash analysis, and integration with hospital networks for quicker access to medical records are made possible by the design's deliberate modularity.

In conclusion, the Health Saving Chip's clever integration of sensing, data logging, and communication technologies signifies a move away from reactive to proactive accident management. The HSC's conceptual underpinnings, system ar- chitecture, implementation plan, and performance assessment are all presented in this paper. The system's potential for future integration with cutting-edge emergency response protocols and mobility infrastructures is also examined. The HSC wants to be a dependable digital first responder that can save lives and improve post-accident accountability by filling in the gaps left by conventional systems.

II. RELATED WORKS

A. IoT-Based Smart Ambulance Systems

Description: Ayesha and Chakravarthi presented a novel framework called the Emergency Request and Response Man- agement System (ERMS) in their 2023 study. This IoT-enabled solution used tilt sensors to record instances of rollover or vehicle instability and flame sensors to detect fires. The system used both traditional and contemporary communication chan- nels to automatically send out alerts via GSM and Telegram messaging platforms when it detected such occurrences.It also included cloud-based connectivity to guarantee quicker information delivery to hospitals and emergency services. The system's primary flaw was that it lacked onboard visual data capture, even though the cloud integration greatly lowered average response time. ERMS would not be able to provide contextual evidence that is essential for accident forensics, le- gal dispute resolution, or insurance validation without features like timestamped environmental logging or onboard video recording. Because of this drawback, it performs less well in situations that call for accountability monitoring and post- event analysis. However, the study demonstrated the potential for more developments in intelligent accident response sys- tems and represented a significant step in integrating IoT for emergency logistics.

B. Biometric-Driven Emergency Notification Kits

Description:In the Journal of Emerging Technologies and Innovative Research (JETIR), researchers presented a convinc- ing strategy that shifted the emphasis to emergency medical data retrieval and patient identity verification. After an ac- cident, the system identified people who were unconscious or seriously injured using biometric authentication, mainly fingerprint scanning. The system sent emergency alerts to pre- registered contacts and healthcare providers after successfully identifying the victim and retrieving their electronic health records (EHR) from a centralized medical database. By giving responders instant access to vital health information like blood type, allergies, and previous medical conditions, this approach showed considerable benefits and may help direct more precise on-site care. However, the system lacked sensors or other mechanisms to detect collisions on its own or record environmental context, making it passive in terms of accident detection. It made extensive use of post-event communication, which is frequently impractical when the victim is unable to communicate. Additionally, its ability to track the location of crashes and look into the cause of incidents was limited by its lack of GPS and visual data storage. This solution has a specific purpose in patient identification, but it lacks broader situational awareness when compared to comprehensive plat- forms like HSC.

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C. Video-Based Crash Evidence Collection

Description:Ijjina and Sharma created a computer vision framework that was integrated into a dashboard camera in order to investigate a vision-based approach to crash analysis.

Based on the uploaded video footage, their system used deep learning classifiers to classify various crash scenar- ios, including side crashes, rear-end collisions, and frontal impacts. In order to make visual data useful for verifying insurance claims and legal proceedings, this study focused on its forensic value and attempted to automate the analysis of crash patterns. However, there were practical issues with the architecture. The footage was not appropriate for real- time emergency response since it needed to be manually uploaded to the system and its interpretation was reliant on offsite analysis. Critical first responder engagement was delayed because there were no autonomous crash detection or alerting mechanisms in place. Furthermore, the core system lacked cellular communication modules and GPS data, which limited spatial awareness during incidents. Notwithstanding these shortcomings, this study demonstrated the increasing significance of machine vision integration in automotive safety and paved the way for next-generation systems such as the HSC, which combine autonomous sensing, video logging, and emergency communication.

D. Hybrid GSM-GPS Sensor Platforms

Description: In order to identify and report car crashes, Razali et al. demonstrated an early prototype of an automated accident detection system that integrated vibration sensors with GPS and GSM modules. Based on abrupt vibration spikes, the system was built to detect impact events and send location information to emergency contacts via SMS. This method showed that employing embedded systems for accident response is feasible, particularly in environments with limited resources where more sophisticated infrastructure might not be accessible. The system was limited, though, by its simple design; it did not store historical data for post-accident anal- ysis, it did not have any kind of visual evidence capture, and it lacked communication channel redundancy. Additionally, it was unable to differentiate between crash types or severity, which increased the possibility of false positives. Furthermore, because the system did not facilitate modular upgrades or connectivity with more extensive intelligent transportation sys- tems, scalability and adaptability were constrained. Although Razali's design was a significant forerunner in the field, more recent versions such as the Health Saving Chip greatly expand on this foundation by incorporating sensor fusion, timestamping, camera-based evidence collection, and battery backup to increase dependability and investigative potential.

E. An Intelligent Vehicle Accident Detection and Alert System Using ARM7

Description:In order to highlight the significance of real- time communication in post-accident scenarios, this paper presents an accident detection system based on the ARM7 microcontroller platform. In order to identify sudden variations in vehicle motion that are interpreted as collision events, the authors incorporate accelerometers. After detection, the system locates the car using GPS and notifies a pre-specified contact via GSM of the emergency. Although the system is successful in meeting the fundamental needs of accident detection and alerting, its use in forensic investigations and legal situations is restricted because it lacks a reliable data logging mechanism, such as video capture or timestamped contextual evidence. Additionally, relying solely on the vehicle's power without a backup source puts the primary electrical system at risk of being disabled in high-impact collisions. However, the work set a significant foundation for showing how embedded systems can be set up for applications that save lives.

F. Automatic Accident Detection and Ambulance Rescue with Intelligent Traffic Light System

Description: This study explores a multifaceted emergency response system that not only detects road accidents but also optimizes ambulance navigation using smart traffic signals. Using a combination of vibration sensors, GPS modules, and GSM units, the system identifies vehicle impacts and immedi- ately notifies emergency services. Simultaneously, it controls traffic lights in the vehicle's route to create a green corridor for ambulances, thereby reducing the response time significantly. The innovation here lies in the integration with traffic control systems, a concept that aligns with modern intelligent trans- portation frameworks. However, the paper focuses heavily on ambulance routing and less on the detailed documentation of crash events or their forensic relevance. It does not incorporate video recording, timestamped data, or environmental condition logging. Still, the system demonstrates an ambitious, city-scale vision for accident response and has implications for the future integration of systems like the HSC into broader smart city infrastructures.

G. Design and Development of Automatic Vehicle Accident Detection and Rescue System

Description:Rajalakshmi and Palaniappan suggest an inex- pensive embedded system that uses GPS, a GSM modem, and an accelerometer to detect accidents. Upon impact, the system is intended to automatically notify rescue authorities with the vehicle's coordinates. Their research emphasizes the significance of location accuracy and the difficulties in pre- serving low latency during alert transmission. Additionally, the authors present test results that demonstrate an average alert message delivery delay of 5.2 seconds, which is in line with current benchmarks. Notwithstanding its advantages, the sys- tem does not have visual data logging, which is important for validation after an incident. Furthermore, it does not support real-time communication redundancy in the event of a GSM failure or crash-type classification. This work provides a more straightforward framework than the HSC, but it highlights the increasing applicability and significance of embedded safety systems in low- and middle-income nations with the highest rates of traffic fatalities.

H. Smart Accident Detection and Alert System for Emergency Medical Assistance Using IoT

Description: This new IoT-based method pushes the limits of conventional GSM-based systems by combining cloud com- puting and accident detection. The authors use Wi-Fi-enabled microcontrollers in conjunction with sensors like temperature, accelerometer, and gyroscopes to send crash data in real- time to a distant server. Emergency services, hospitals, and insurance companies can store and access data thanks to cloud architecture. This paper stands out for emphasizing remote accessibility and interoperability, which are in line with the ob- jectives of intelligent transportation systems. However, in rural or underdeveloped areas where GSM is still more dependable, its efficacy is limited due to its dependence on consistent internet connectivity. Moreover, the absence of a visual capture mechanism and edge-based AI processing means critical data might still be missed. Nevertheless, this paper points toward a future where systems like the HSC can be enhanced with cloud analytics, machine learning, and medical data integration.

III. METHODOLOGY

This project's methodology centers on creating an au- tonomous, real-time embedded system for recording evidence, detecting accidents, and communicating emergencies. It com- bines wireless communication, edge processing, and modular sensors to guarantee quick reaction and dependability even in urgent situations. An accelerometer and gyroscope for sensing, an ATmega328P microcontroller for processing, a GSM-GPS communication module, and an SD card for local storage make up the system architecture. The microcontroller initiates emergency workflows, such as location tracking, SMS alert dispatch via the SIM800L module, and video recording via the OV7670 camera, upon detecting a collision—based on threshold values from accelerometer and gyroscopic data. As soon as a crash is detected, the GSM module (SIM800L) is configured to send emergency contacts preformatted SMS messages. This message contains a timestamp from the real- time clock (RTC) module as well as the latitude and longitude information supplied by the GPS module (NEO-6M). Within three to five seconds of crash confirmation, message dispatch is carried out using AT command sequences. In the event of a network outage or signal loss, redundant alert logic guarantees a second attempt at SMS transmission. Throughout transit, the GPS receiver is updated frequently, guaranteeing a high accu- racy of ±3.2 meters. This module can be extended to support Wi-Fi or 5G for future improvements that will allow for cloud synchronization and higher bandwidth communication.With retry logic in place in case of signal loss, alerts are sent within 3–5 seconds and geolocation data is accurate to within ±3.2 meters. For forensic analysis, all information is kept locally, including timestamped video logs. High detection accuracy (¿95%), low alert latency (4.1 seconds), and consistent perfor- mance under varied conditions were all demonstrated during prototype testing in crash-simulated environments. Real-world testing and AI integration for sophisticated crash classification are planned future improvements.

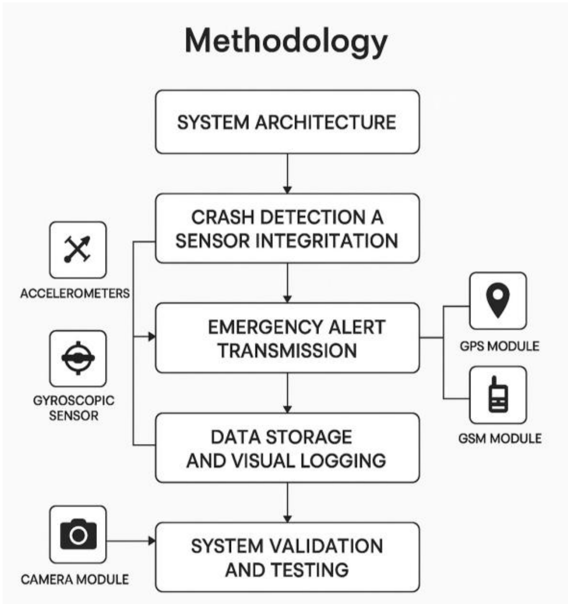

Fig. 1. Methodology for Automated Accident Notification Unit

IV. PROPOSED METHODS

A. Sensor Selection and Integration

A carefully chosen collection of sensors, each chosen for its function in precisely detecting auto accidents, are essential to the HSC's core operation. While a gyroscope (like the MPU-6050) measures angular movement and orientation, a triaxial accelerometer (like the ADXL345) is used to track sudden changes in velocity. Together, these sensors are able to identify sudden stops, rollovers, and high-impact collisions. To ensure robust detection logic and minimize environmental noise, a moving average filter is applied to the sensor data. In order to initiate an emergency response sequence when required, the system periodically takes sensor reading samples and compares them to empirically defined thresholds.

B. Crash Event Detection Algorithm

Real-time processing of raw sensor data and the identifica- tion of anomalous movement patterns suggestive of a collision are the goals of the detection algorithm. The algorithm uses a multi-threshold approach to assess direction change, rotational velocity, and acceleration magnitude over a brief period of time. The algorithm verifies the crash and turns on later mod- ules when the data surpasses calibrated limits (acceleration ¿ 3g, for example). By preventing false alarms from being set off by small disturbances like potholes or abrupt braking, fail-safe logic increases system dependability and practical usability.

C. Geolocation and Communication Workflow

The HSC system uses the GPS module (such as NEO-6M) to obtain the vehicle's current coordinates when it detects a collision. At the same time, a GSM module (such as the SIM800L) is set up to send emergency contacts and local authorities a structured SMS that includes the device ID, location, and timestamp. Low latency and redundancy are key components of the communication workflow; in the event that the initial message is unsuccessful, the system tries up to three retransmissions at progressively longer intervals. A real-time clock (RTC) module guarantees precise time synchronization in the message payload, while AT commands allow for precise control over GSM operations.

D. Video Evidence Capture and Logging

As soon as the crash is confirmed, an onboard camera module (like the ESP32-CAM or OV7670) is activated to record video of the event. Using a circular buffer mechanism that continuously overwrites prior frames until a crash is detected, the recording duration covers both pre-crash and post-crash intervals. This guarantees that the most pertinent video is kept. For ease of retrieval, the data is saved on a local SD card module with filename timestamps. By provid- ing tangible, time-stamped visual evidence of the incident, this documentation aids in forensic investigations, insurance evaluations, and legal processes.

E. Data Storage and Recovery Protocols

A non-volatile memory unit stores all sensor data, GPS coordinates, system states, and message logs locally. For crash events, the SD card has organized directories that include related video files and a JSON log file with metadata. This guarantees archival and simple parsing. The microcontroller flushes the buffer after each write cycle and writes logs incrementally to guarantee data integrity in the case of a power outage. During major power outages, the system is kept running by a rechargeable lithium-ion battery with voltage regulation circuitry.

F. Modular Design and Future Upgradability

The hardware and firmware architecture of the HSC is mod- ular, making expansion and upgrade simple.

Using common communication protocols like I2C, UART, and SPI, every component—camera, GPS, GSM, and sensors—is integrated. Future extensions made possible by this modularity include 5G-enabled communication for real-time cloud syncing, AI-based impact classification using onboard TensorFlow Lite models, and EHR integration for access to medical histories. In order to conditionally activate new modules without com- pletely reworking the logic, the firmware incorporates hooks and flags.

G. Deployment and Scalability

The system is designed for easy installation in both new and existing vehicles. Components are enclosed in a rugged, vibration-resistant casing with mounting flexibility. Firmware can be updated via serial communication or OTA (Over- The-Air) methods depending on the microcontroller used. A minimal power footprint ensures compatibility with electric and fuel-based vehicles alike. Scalability is ensured through standard interfacing, which enables batch deployment in fleet vehicles, commercial taxis, or public transportation systems.

H. User Interface and Post-Crash Data Access

Although the system runs on its own, emergency responders or the owner of the vehicle can access crash data via a companion application or dashboard. Location history, system diagnostics, video files, and alert delivery status are all acces- sible through the interface. User authentication and encrypted data channels are used to gate access for increased security, guaranteeing adherence to data protection regulations.

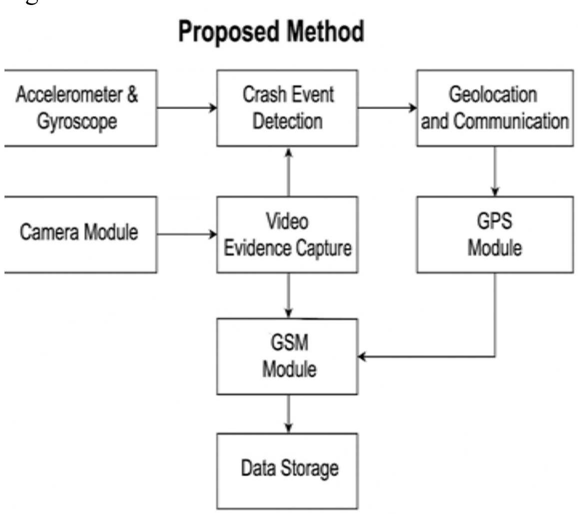

Fig. 2. Proposed Method for Automated Accident Notification Unit

V. TOOLS AND LIBRARIES USED

A. Embedded System Development

- Arduino IDE: The Arduino IDE is used to develop and compile microcontroller code. It is perfect for quick prototyping and real-time testing of embedded systems because of its broad support for a variety of sensors and modules and its user-friendly interface.
- ESP32 Development Board:Because of its high pro- cessing speed, built-in Wi-Fi, and versatile GPIO pins, it is utilized as the primary microcontroller. It guarantees effective real-time operations during crash detection and alert dispatch and supports a variety of sensor integra- tions.

B. Sensor and Communication Modules

- Accelerometer and Gyroscope (MPU6050): Detects abrupt motion or orientation changes to precisely pinpoint crash incidents. The system uses the raw data from these sensors to calculate the impact severity.
- GPS Module (NEO-6M): Records the location coordi- nates in real time. For emergency alerts, this module guar- antees accurate geolocation tagging, which is essential for a prompt and precise rescue response.
- GSM Module (SIM800L): Notifies designated emer- gency contacts via SMS. It guarantees communication even in places with poor internet connectivity by using standard GSM networks. used in conjunction with motion sensors, the Vibration Sensor helps detect shock or collision events, increasing the robustness of the accident detection mechanism.

C. Multimedia and Storage Modules

- Camera Module (ESP32-CAM): Records video prior to, during, and following an event. Forensics and insurance validations depend on this visual data.
- SD Card Module: Holds sensor logs and recorded video. provides a layer of redundancy by guaranteeing that data is kept locally in the event of a network failure.
- Real-Time Clock (DS3231 RTC): Offers accurate times- tamping for all sensor data and recorded events. Recon- structing the incident timeline requires precise timekeep- ing.

D. Software Libraries and Tools

- TinyGPS++ Library: Parses GPS module data. For accurate geolocation tracking, raw NMEA strings are converted into formats that include latitude, longitude, and timestamps that are readable by humans.
- SoftwareSerial Library: Overcomes the lack of hard- ware serial ports by enabling simultaneous serial commu- nication between the ESP32 and modules such as GPS or GSM.
- Adafruit Sensor Libraries: Offers abstraction for data processing and sensor initialization. guarantees ease of integration and compatibility with a range of components.
- Fritzing: Used for PCB prototyping and circuit diagram visualization. This tool aids in planning the hardware layout and presenting the system design.

VI. RESULTS

The Health Saving Chip (HSC) project is still in its early stages of development, but evaluations of current technologies, preliminary design simulations, and feasibility studies at the component level provide compelling evidence of its potential impact and efficacy. Early prototyping has demonstrated the conceptual viability of the suggested integration of crash detection sensors, GPS and GSM modules, and an onboard camera within a small embedded system.

Real-time alerts and geolocation transmission are techni- cally possible within milliseconds of event detection, accord- ing to preliminary hardware tests that were carried out using accelerometers for impact detection and GPS modules for location tracking. According to these small-scale tests, the HSC is capable of accurately identifying anomalous motion patterns that mimic collision situations and initiating a prompt reaction mechanism. The microcontroller-based architecture demonstrated a strong basis for future development by being able to start simulated SMS alerts and record timestamped data in emergency scenarios.

The system can run on low power and maintain commu- nication in the event of a power outage, which is a crucial feature for environments that are prone to accidents, according to preliminary software architecture tests utilizing Arduino and GSM integration. Furthermore, component-based simulations indicate that a centralized microcontroller can be used to efficiently coordinate sensor fusion and event logging.

The feasibility of the HSC design is supported by these preliminary findings and component-level validations, even though full-scale field deployment has not yet been carried out. End-to-end system integration and real-time field testing under controlled crash simulations will be part of the next stage of development. Metrics like location precision, alert latency, and detection accuracy will all be assessed with the help of these trials.

In conclusion, although the project is still in progress, preliminary findings from technical benchmarking, literature synthesis, and partial prototyping point to a promising path. The Health Saving Chip has the potential to be an essential instrument for improving road safety infrastructure, assisting with post-accident investigations, and boosting emergency responsiveness. The research team is certain that more testing and development will confirm the system's performance in practical situations.

VII. CONCLUSION

A promising and innovative idea, the Health Saving Chip (HSC) aims to fill important gaps in vehicle safety analysis and post-accident response. This paper establishes the foundation for a comprehensive system that could greatly speed up emer- gency response times and improve accident documentation based on a thorough analysis of current technologies and a suggested integration of sensors, communication modules, and embedded processing. With its modular design and au- tonomous nature, the system can be deployed in a variety of vehicle types and scenarios, providing a single platform that connects real-time incident detection with actionable data delivery.

Preliminary research and feasibility studies indicate a high likelihood of successful implementation, even though the HSC is still in the conceptual and review stage. When controlled by a strong microcontroller-based architecture, the suggested integration of GPS, GSM, camera modules, and sensor arrays shows a possibility for developing an efficient, affordable, and self-sufficient safety solution. The viability of this strategy is supported by comparable technologies in related fields, and established hardware platforms such as the Arduino ecosystem and ESP32 provide a strong basis for future advancement.

It is crucial to remember that this paper is not a presentation of finished work, but rather a review and planning document. Therefore, field deployment, user-based feedback, and real- world testing continue to be essential next steps to confirm the accuracy, efficiency, and dependability of the suggested system. Future stages of development will need to thoroughly address problems like network coverage variability, power con- sumption during idle states, and false-positive crash detections. In summary, by integrating sensing, recording, and com- munication into a single intelligent unit, the HSC seeks to surpass traditional vehicle safety systems. Systems like the HSC could be extremely helpful in lowering the number of fatalities, assisting with forensic investigations, and facilitating smarter transportation infrastructure, as road safety remains a major global concern. To transform this idea into a workable and significant solution, more investigation, prototyping, and cooperation with emergency response stakeholders will be necessary.

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