

2205436 - Project Proposal

by Jade Williams

Submission date: 17-Oct-2025 09:48PM (UTC+0100)

Submission ID: 265649855

File name: 49685_Jade_Williams_2205436_-_Project_Proposal_689853_812114432.docx (69.13K)

Word count: 1688

Character count: 10625

Health Emergency Detection and Alert System for Drivers

Introduction

Road transport is fundamental to modern life, with vehicles of every type — including cars, vans, buses, and lorries — enabling the efficient movement of people, goods, and services across local, national, and international networks. However, the activity of driving, particularly over extended periods, presents significant health and safety challenges. Commercial drivers frequently experience long working hours, irregular rest breaks, limited access to medical support, and prolonged exposure to stress and fatigue. These conditions increase the risk of acute medical incidents such as cardiac arrest, stroke, heat exhaustion, and fatigue-induced drowsiness. When such emergencies occur on busy roads or at high speeds, the consequences can be severe, threatening the safety of the driver, passengers, and other road users, and often resulting in costly damage or loss.

Current vehicle management systems are primarily concerned with tracking, maintenance, compliance, and performance monitoring. While these technologies contribute to operational efficiency, they offer minimal consideration for the driver's physiological or mental wellbeing. Wearable health monitoring devices, such as smartwatches and fitness bands, provide some level of observation but are dependent on user cooperation and can be intrusive, uncomfortable, or impractical during prolonged driving. Additionally, most wearable systems operate independently of vehicle control or communication networks, making them unsuitable as an integrated safety measure.

Evidence consistently shows that health-related events play a major role in road safety. Fatigue alone is estimated to be a contributing factor in up to 20% of all road traffic accidents worldwide involving both private and commercial vehicles, with the estimate of 2% of all road accidents in Britain, according to the road safety charity Brake [1]. Although sudden medical emergencies occur less frequently, they can lead to immediate driver incapacitation, resulting in serious or fatal collisions. The risk is particularly high in rural or isolated areas, where delayed emergency response times can further worsen outcomes.

This project proposes the design and development of a Health Emergency Detection and Alert System applicable to all vehicle types. The system will continuously monitor physiological indicators such as heart rate, blood oxygen saturation, and temperature, alongside behavioural cues like eye closure, head position, and inactivity. In the event

of an emergency, it will trigger in-cabin warnings, transmit GPS coordinates via GSM or 4G networks to emergency services or nominated contacts, and, where possible, interface with the vehicle's systems to activate safety measures such as hazard lights or controlled deceleration.

By combining embedded sensors, camera-based monitoring, and onboard data processing using a low-power controller (for example, an ESP32 or Raspberry Pi), the system will operate unobtrusively and in real time. This multimodal and integrated approach aims to deliver a cost-effective, reliable, and non-intrusive solution that enhances road safety for all drivers, filling a critical gap in current vehicle safety technologies.

Literature Review

Physiological monitoring in vehicles has advanced significantly. Radomski et al. [2] developed a seat-integrated reflective photoplethysmography (PPG) sensor that measures heart rate through clothing with high accuracy (CCC = 0.976, MAE < 1 bpm). This unobtrusive design avoids compliance issues associated with wearables and is well suited for professional drivers as well as regular drivers, though sensitivity to motion artefacts remains a limitation. Their longitudinal testing under different road conditions demonstrates that such sensors can operate continuously over long journeys.

IoT-based systems provide low-cost approaches to driver monitoring. Kumar et al. [3] proposed a platform combining eye-blink detection, pulse sensors, and GPS, implemented on a NodeMCU with a web interface. Their system demonstrated feasibility for drowsiness detection and real-time alerting but was constrained by communication latency and limited robustness under dynamic driving conditions. Nevertheless, the integration of physiological sensing with location tracking highlights the potential of IoT frameworks for fleet-wide adoption for use in commercial vehicles.

Video-based systems extend driver monitoring by analysing facial features such as eyelid closure and yawning. Yang et al. [4] introduced video-based driver drowsiness detection, which optimises facial landmark usage and employs attention modules for higher reliability across lighting variations. Similarly, Wu et al. [5] combined facial localisation with lightweight operations to enable low-cost drowsiness detection. However, these approaches struggle with occlusions, night driving, and vibrations common in vehicles. Hybrid solutions that combine video with physiological data could mitigate these weaknesses and provide redundancy in challenging conditions.

Beyond fatigue, health emergencies such as stroke or cardiovascular distress require early detection. Hayashi et al. [6] proposed a multimodal monitoring system with verbal interaction, whereby uncertain detections prompt driver confirmation, reducing false

positives. This concept of confidence-based detection with driver feedback is promising for enhancing system trust and reliability.

Robust location and communication systems are equally vital. Belton et al. [7] demonstrated that assisted GPS (A-GPS) improves accuracy and acquisition under poor signal conditions, supporting faster and more reliable emergency response. Integration with GSM/4G ensures automatic communication with fleet managers and emergency services, which is particularly critical in remote highways or cross-border operations.

Driver comfort is an essential consideration, especially in commercial vehicles where long distance driving is common. Zeng et al. [8] have proposed a method of health monitoring using seatbelt embroidered metamaterials, providing continuous heart rate and respiration monitoring of the driver. The proposed project was tested in real-life driving scenarios to determine the accuracy of the product.

Radev et al. [9] proposed a system using sensing electrodes, providing a more reliable set of results than other existing systems. The proposed sensor array for this system requires the user to wear the sensors, making it unsuitable for vehicle integration. However, the system can be adapted to integrate into vehicles.

Taken together, the literature indicates that an effective driver monitoring system must integrate multiple modalities: physiological sensing for reliability, video or accelerometer-based behavioural detection for redundancy, and robust GPS/GSM for response. The gap lies in adapting and validating these technologies into one combined system to be fitted within vehicles.

Project Design

Objectives

The project aims to design a multimodal driver health monitoring system with the following objectives:

1. Monitor real-time physiological parameters (heart rate, SpO₂, body temperature).
2. Detect behavioural states indicating drowsiness or unconsciousness.
3. Provide in-cabin warnings and remote emergency alerts.
4. Enable optional integration with vehicle safety systems (e.g., hazard lights, controlled deceleration).

Hardware Architecture

- **Controller:** ESP32 or Raspberry Pi for sensor integration and processing.

- **Physiological sensors:** MAX30102 for heart rate and SpO₂ (mounted on steering wheel or seatbelt), MLX90614 for body temperature.
- **Motion sensors:** MPU6050 to detect head tilt, body posture, and driver unresponsiveness.
- **Video module (optional):** Camera with OpenCV to track eye-blink rate and facial landmarks.
- **GPS module:** Accurate positioning, supported by assisted GPS for reliability.
- **GSM module (SIM800L/4G modem):** For SMS or data-based alerts to fleet managers and emergency contacts.
- **Alert system:** In-cabin buzzer, LED indicators, and optional voice assistant.
- **Power supply:** 12V to 5V DC regulator connected to vehicle battery.

Software & Algorithms

- **Signal acquisition and filtering:** Physiological signals filtered for noise and motion artefacts.
- **Threshold detection:** HR < 40 bpm, SpO₂ < 85%, prolonged eye closure (>4s), or inactivity trigger alerts.
- **Confidence scoring:** Weighted scoring of multimodal inputs (physiological, behavioural, motion). If confidence is moderate, system can prompt driver verbally, following Hayashi et al. [6].
- **Emergency logic:** If thresholds are crossed, the system
 - (a) alerts the driver in-cabin,
 - (b) sends SMS/GPS coordinates to emergency services, and
 - (c) optionally interfaces with the vehicle's ECU to trigger hazard lights or speed limitation.

Example Scenarios

- **Cardiac event:** HR drops below 40 bpm → Immediate alert + location sent to emergency contact.
- **Unconsciousness:** No movement detected for 2 min → SOS message triggered.
- **Fatigue:** Eye closure detected >4s → Loud buzzer and voice alert.
- **Heatstroke risk:** Cabin temperature exceeds 40°C → Driver warned.

Innovations

- **Multimodal integration:** Combines physiological, behavioural, and environmental sensing for reliability.
- **Driver acceptance:** Sensors integrated into seatbelt/steering, minimising intrusiveness.

This design provides a comprehensive framework for real-world deployment, addressing limitations of prior single-modality systems.

Resources and Planning

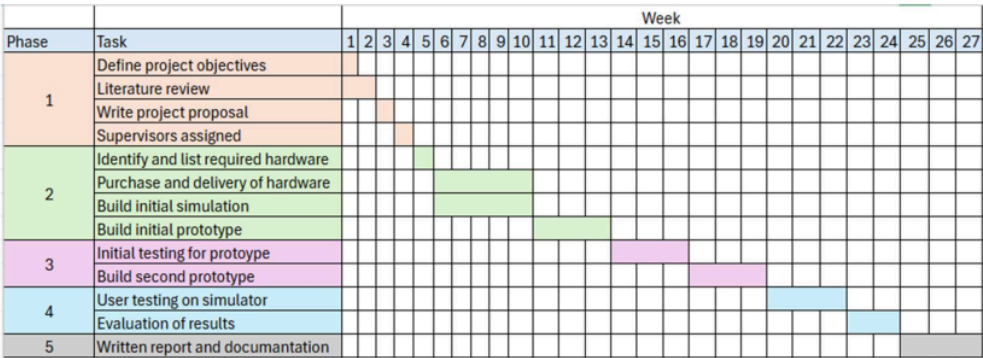
Resources

- **Hardware:** ESP32/Raspberry Pi, MAX30102, MLX90614, MPU6050, GPS, GSM module, buzzer, camera (optional).
- **Software:** Arduino IDE, Python (OpenCV).
- **Testing:** Driving simulator.

Project Plan

- Requirement analysis and literature synthesis (4 weeks).
- Hardware procurement and setup (9 weeks).
- System integration and software development (6 weeks).
- Laboratory testing with simulated emergencies (5 weeks).
- Evaluation and reporting (3 weeks).

Gantt Chart



Expected Outcomes

The project will deliver a prototype system capable of detecting driver emergencies in real time, demonstrated in simulated and real environments. It will show that multimodal monitoring combined with assisted GPS and GSM can provide rapid emergency alerts and potentially reduce accident risk.

References

- [1] "Brake - The Road Safety Charity," [Online]. Available: <https://www.brake.org.uk/get-involved/take-action/mybrake/knowledge-centre/driver-fatigue>. [Accessed 10 10 2025].
- [2] A. Radomski, M. Arai, K. Oshima, N. Oneda, A. Ueno and T. Daniel, "Reflective PPG Sensor Measures Heart Rate Through Clothing During Driving," *IEEE Sensors Journal*, vol. 25, no. 3, pp. 4157-4166, 2025.
- [3] K. Sambath Kumar, O. Gurrupu, J. Prabhakaran, C. Bhavani, D. Madhavi Latha and L. Kavya, "Real-Time Driver Drowsiness Detection System using IoT-based Physiological Monitoring and Web Interface," in *8th International Conference on Computing Methodologies and Communication*, Erode, 2025.
- [4] L. Yang, H. Yang, H. Wei, Z. Hu and C. Lv, "Video-Based Driver Drowsiness Detection With Optimised Utilization of Key Facial Features," *IEEE Transactions on Intelligent Transportation Systems*, vol. 25, no. 7, pp. 6938-6950, 2024.
- [5] Q. Wu, N. Li, L. Zhang and F. R. Yu, "Driver Drowsiness Detection Basen on Joint Human Face and Facial Landmark Localization With Cheap Operations," *IEEE Transactions on Intelligent Transportation Systems*, vol. 25, no. 12, pp. 19633-19645, 2024.
- [6] H. Hayashi, M. Kamezaki and S. Sugano, "Toward Health-Related Accident Prevention: Symptom Detection and Intervention Based on Driver Monitoring and Verbal Interaction," *IEEE Open Journal of Intelligent Transport Systems*, vol. 2, pp. 240-253, 2021.
- [7] D. Belton, T. Haddrell and C. De La Fuente, "Integrated Assisted GPS Solutions for Security Applications," in *The IEEE Seminar on Telemetry and Telematics*, London, 2005.
- [8] Q. Zeng, X. Tian, D. T. Nguyen, X. Yang, P. Chia and C. Wu, "Seatbelt-Embroidered Metamaterials for In-Vehicle Vital Sign Monitoring," in *2023 IEEE/MTT-S International Microwave Symposium*, San Diego, 2023.
- [9] H. Radev, G. Petrova and G. Spasov, "Driver physiological parameters monitoring-initial study in real-road driving," in *International Scientific Conference Electronics*, Sozopol, 2024.

2205436 - Project Proposal

GRADEMARK REPORT

FINAL GRADE

GENERAL COMMENTS

81 / 100

Project Proposal – ACCA6020 Independent Project

Student: Jade Williams

Intro / Aims & Objectives: 18/20

The introduction, aims and objectives are very well

Clear, but could be enhanced with brief objective (

Background to the Project / Literature Review : 17/

The background provides a strong overview of existing
addressing the limitation of present deployed single
analysis is desirable

Project Design : 24/30

The project design is briefly outlined, well structured

Resources / Planning :11/15

The Gantt chart is very satisfactory and suitable for
enhance better project evaluation.

More detailed and complete clearer milestones for

Document Presentation:11/15

The proposal is very well presented, well structured
presentation.

Neat presentation!

TOTAL:81/100

PAGE 1

PAGE 2

PAGE 3

PAGE 4

PAGE 5

PAGE 6