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Conceptualization and Construction of ALERT: Alcohol-Related and Eye Closure Risk Technology

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***Abstract*—The project features a comprehensive alcohol detection and driver monitoring system designed to improve road safety. The system has four different models, each of which addresses different aspects of alcohol impairment. In the static model, an alcohol sensor is used during ignition, allowing the vehicle to be activated only if the driver's alcohol content is within the norm. Simultaneously, the dynamic model includes a wristwatch with a sweat alcohol sensor, providing an alternative measurement method with a nominal variance of 10%. The image processing model employs YOLOv8 to detect alcohol bottles near the driver, causing the vehicle to stop automatically upon detection.**

Additionally, the sleepiness detection model uses image processing to identify signs of drowsiness, which may be exacerbated by alcohol consumption. The outputs of these models are integrated into a central machine learning model, where the results of the static and dynamic models are prioritized, while sleepiness and object detection serve as supplementary parameters to enhance prediction accuracy. Despite the limitations of individual models, the synergistic integration of these approaches aims to create a robust system that promotes safer road conditions.

***Index Terms*— Alcohol detection, driver monitoring, road safety, MQ3 gas sensor, sweat alcohol sensor, YOLOv8, drowsiness detection, machine learning, Random Forest algorithm, vehicle ignition control, IoT, emergency notification, GPS coordinates.**

I. INTRODUCTION

The ALERT project is a comprehensive solution designed to combat the growing issue of drunk driving by integrating cutting-edge technology. It consists of four key modules: the static module, equipped with an MQ3 gas sensor, detects alcohol from the driver's breath near the vehicle's keyhole, while the dynamic module utilizes a sweat alcohol sensor wristband for continuous real-time monitoring.

These modules serve as the primary inputs to a machine learning model, ensuring accurate detection of impaired driving behaviors. In addition to alcohol detection, the ALERT system includes an object detection module powered by YOLOv8, which identifies alcohol bottles within the driver's vicinity, and a drowsiness detection module using Dlib to assess driver alertness by analyzing facial features. These inputs are processed by a centralized Random Forest ML model, which determines whether the vehicle can be safely activated. By combining these advanced technologies, the ALERT project aims to proactively enhance road safety and reduce accidents caused by impaired driving.

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II. Literature Survey

Literature survey reveals that various projects have addressed the pressing issue of preventing drunk driving through innovative systems. One study details an alcohol detection and engine locking system using an Arduino Uno microcontroller and an alcohol sensor, which prevents the engine from starting if alcohol is detected in the driver's breath, thus minimizing potential accidents [1]. Another project proposes an IoT-based locking system that integrates a pre-installed alcohol sensor with a GPS module, allowing real-time location tracking and emergency alerts to improve traffic safety [2]. Further research focuses on embedded alcohol sensing designs that analyses breath samples to detect alcohol levels, emphasizing the need for reliable monitoring to prevent accidents [3]. Another study develops a vehicle ignition locking system that measures blood alcohol content and prevents the vehicle from starting if the BAC exceeds a specified threshold, showcasing an effective mechanism to curb drunk driving incidents [4]. Additionally, a project describes a controller that utilizes breath analysis to stop the engine, thereby reducing the likelihood of accidents caused by intoxicated drivers [5]. An Atmega-based system highlights the potential for an engine immobilization feature that responds to alcohol detection in light-duty vehicles [6]. Other studies emphasize non-invasive methods for alcohol detection, integrating heart rate sensors and alerts for emergency contacts if intoxication is suspected, further reinforcing the need for multifaceted safety measures [9]. Overall, these innovations reflect a concerted effort to reduce traffic accidents linked to alcohol consumption, highlighting the importance of integrating technology in vehicular safety systems.

III. Modules Configuration

A. MQ3 Gas Sensor

The MQ3 gas sensor is a fundamental component of the static module in Project ALERT. Positioned near the vehicle's keyhole, it detects alcohol vapors when the driver exhales. Upon detection, it triggers a signal in the machine learning (ML) model, indicating the presence of alcohol and influencing the decision to start the vehicle. This sensor plays a crucial role in ensuring that vehicle activation aligns with safe alcohol levels, contributing to enhanced road safety measures.

B. Sweat Alcohol Sensor

Integrated into the dynamic module of Project ALERT, the sweat alcohol sensor is housed within a wristband worn by the driver. This sensor continuously monitors alcohol levels through sweat analysis, providing real-time data to the ML model. When elevated alcohol levels are detected, the sensor raises a flag in the ML model, preventing vehicle activation and promoting safer driving practices. Its non-invasive nature and immediate feedback make it an essential component in the fight against impaired driving.

C. YOLOv8 Object Detection Model

Utilizing YOLOv8 technology, the object detection module in Project ALERT enhances road safety by continuously scanning the vehicle's interior via onboard cameras to detect alcohol bottles near the driver. Upon identification, this module promptly signals the integrated machine learning (ML) model, which includes static alcohol sensors, dynamic sweat alcohol sensors, and drowsiness detection systems. This interaction ensures that if an alcohol container is detected, the ML model prevents vehicle activation, thereby pre-emptively addressing the risks associated with impaired driving due to alcohol consumption. This real-time detection capability enables proactive intervention, significantly bolstering the system's effectiveness in promoting safer driving practices and reducing the incidence of alcohol-related road accidents.

D. Drowsiness Detection using Dlib

The drowsiness detection module in Project ALERT employs the Dlib library to monitor driver fatigue based on facial cues, particularly eye movements. By analyzing facial features, it identifies signs of drowsiness, which can be exacerbated by alcohol consumption. When significant drowsiness is detected, the module raises a flag in the ML model, preventing vehicle activation and alerting the driver to take necessary breaks. This proactive approach enhances road safety by addressing the risks associated with impaired alertness during driving.

E. Random Forest ML Model

At the core of Project ALERT lies the Random Forest machine learning model, designed to enhance road safety by integrating inputs from its four modules: static alcohol sensors near the vehicle keyhole, dynamic wristband alcohol sensors, YOLOv8-based object detection for alcohol bottles, and drowsiness detection using facial analysis. This sophisticated model prioritizes inputs from the static and dynamic modules, focusing on detecting alcohol levels directly from the driver and environmental alcohol presence. These inputs are crucial determinants in deciding whether the vehicle should be activated. Complementary inputs from the object detection module, which scans for alcohol bottles within the vehicle, and the drowsiness detection module, which identifies signs of driver fatigue or impairment, further refine the decision-making process. By synthesizing these inputs, the Random Forest model ensures informed and timely interventions, effectively preventing accidents associated with impaired driving and promoting safer road conditions.

IV. System Development

Project ALERT is designed to combat the increasing issue of road accidents caused by drunk driving through a sophisticated alcohol detection and driver monitoring system. The system integrates advanced technologies to enhance road safety by detecting alcohol impairment and ensuring vehicles cannot be activated under unsafe conditions. It consists of four main modules: the static module, dynamic module, object detection module using YOLOv8, and a drowsiness detection module. These modules collectively feed into a Random Forest machine learning model, which analyses inputs to make informed decisions about vehicle activation, prioritizing inputs from static and dynamic modules related to alcohol levels and driver condition.

A. Static Model

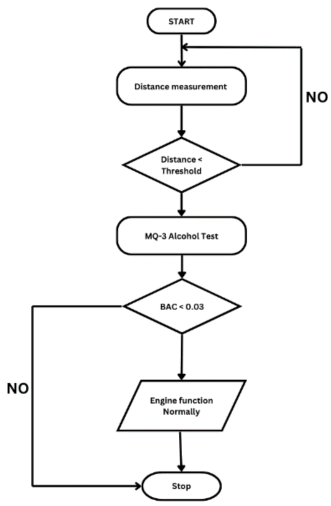

Figure 1. Static Model

The Static Model is designed to detect the presence of alcohol near the vehicle's keyhole using an MQ3 gas sensor. When the vehicle key is inserted, the system first measures the distance to the keyhole and then activates the MQ3 sensor to check for alcohol levels. If the blood alcohol concentration (BAC) detected is below the set threshold (e.g., 0.03%), the engine functions normally. If the BAC exceeds the threshold, the engine is prevented from starting, ensuring that the driver is not under the influence of alcohol.

B. Dynamic Model

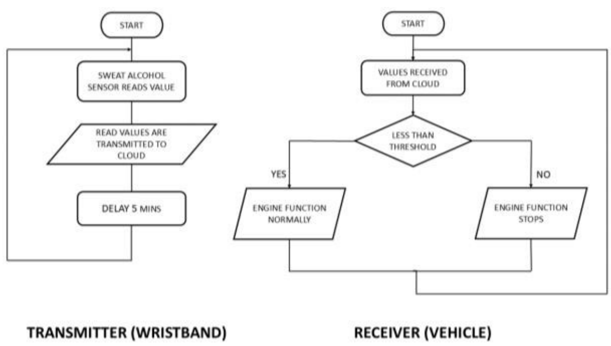

Figure 2. Dynamic model

The Dynamic Model involves a transmitter (wristband) worn by the driver, which continuously monitors the driver's sweat for alcohol levels using a sweat alcohol sensor. The readings are transmitted to a receiver module in the vehicle. If the detected alcohol concentration is below the preset threshold, the vehicle's engine functions normally. However, if the alcohol level exceeds the threshold, the engine is disabled. This model adds an extra layer of safety by monitoring the driver's condition in real-time, even after the vehicle has been started.

C. Object Detection Model

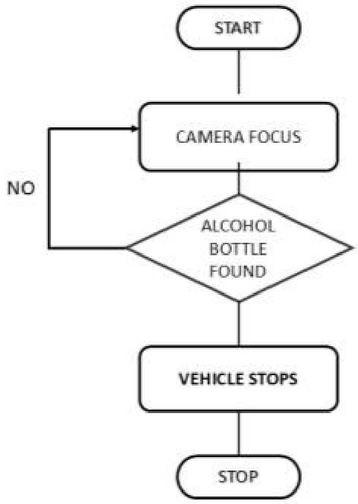

Figure 3. Object detection model

The Object Detection Model employs YOLOv8, an advanced object detection algorithm, to identify alcohol bottles or other suspicious objects within the driver's vicinity. The model processes images captured inside the vehicle to detect the presence of alcohol-related objects. If an object is detected, the system raises a flag and contributes to the decision-making process that could prevent the vehicle from starting. This model is essential for ensuring that alcohol is not present within the driver's immediate environment, enhancing overall safety.

D. Drowsiness Model

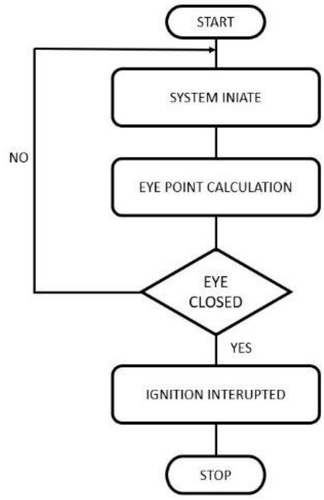

Figure 4. Drowsiness model

The Drowsiness Model is designed to detect driver fatigue using image processing techniques. The system initiates by capturing real-time video of the driver's face, analyzing eye points using dlib and OpenCV libraries. If the system detects that the driver's eyes are closed for an extended period, indicating drowsiness, it triggers an alert to interrupt the vehicle's ignition. This model is crucial for preventing accidents caused by driver fatigue, ensuring that the driver remains alert while operating the vehicle.

E. Integration and System Management

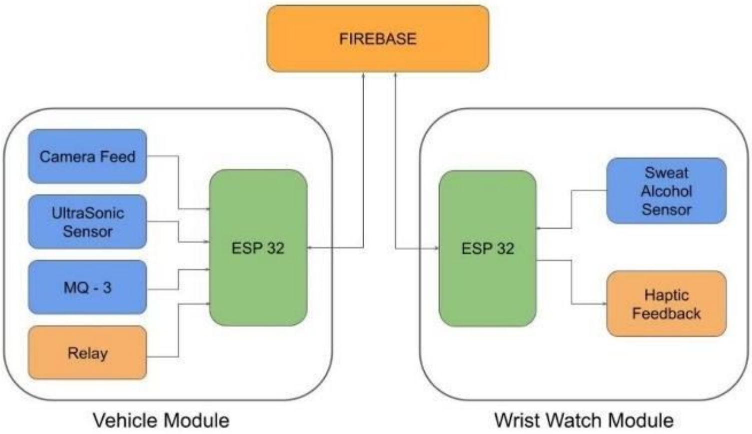

Figure 5. Block Diagram

Integration and system management in ALERT are crucial for ensuring seamless operation and optimal performance of its components. The system integrates multiple modules— static alcohol detection, dynamic sweat alcohol sensing, YOLOv8-based object detection, and drowsiness detection— into a cohesive framework governed by a central Random Forest machine learning model. Firebase serves as the real-time database platform, facilitating data synchronization and command dissemination between vehicles and the central control system. This integration enables dynamic adjustments of vehicle parameters based on real-time inputs from sensors and environmental conditions, enhancing responsiveness and adaptability. System management includes monitoring interfaces for overseeing vehicle statuses, operational parameters, and environmental data. This oversight ensures that ALERT operates efficiently and safely, capable of pre-emptive intervention when alcohol impairment or drowsiness is detected. The integrated approach optimizes road safety by preventing vehicle activation under unsafe conditions, thereby mitigating risks associated with impaired driving and promoting reliable system performance in diverse operational environments.

V. Result and Discussion

The ALERT system implementation involved integration of multiple modules to create a comprehensive solution for preventing alcohol-impaired driving. Testing was conducted by retrofitting a test vehicle with IoT-enabled sensors and actuators for engine control integration.

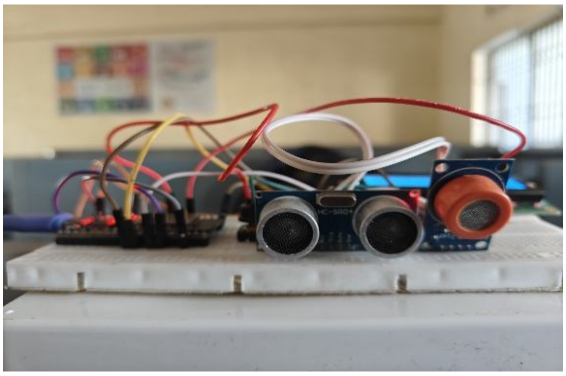

Figure 7. Vehicle Module (Static Model)

The static module prototype (Figure 7) integrates an HC-SR04 ultrasonic sensor with an MQ3 gas sensor to activate alcohol detection only when the driver is near the ignition, optimizing power consumption and reducing false positives. This dual-sensor approach enhances efficiency by ensuring the MQ3 sensor operates only when needed. Field tests showed improved battery life and reduced false detections from ambient alcohol. The proximity threshold can be calibrated for different vehicle cabins, and the compact sensor placement allows optimal detection angles for reliable, long-term deployment.

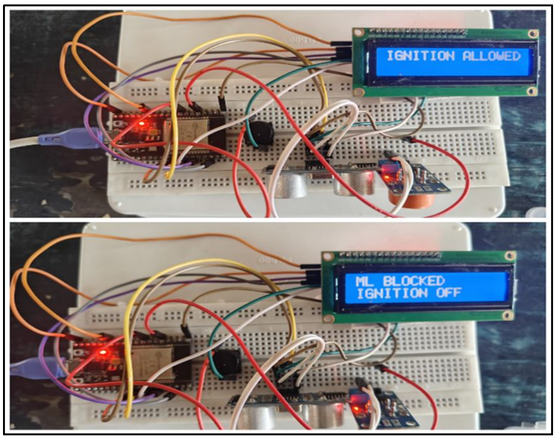

Figure 8. Static model output

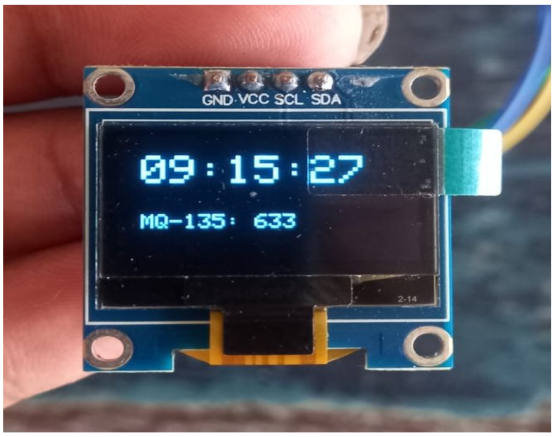

Figure 9. Wrist Watch model output

The hardware consists of an ESP32 S3 microcontroller with a red power LED, an MQ3 gas sensor (the metal component with copper-colored element), an LCD display, and various colored wires connecting everything. When the system detects no alcohol (top image), the LCD displays "IGNITION ALLOWED," indicating safe conditions for vehicle operation. However, when alcohol is detected above the threshold (bottom image), the system displays "ML BLOCKED IGNITION OFF" and the red indicator LED provides visual confirmation of the detected risk. The Random Forest ML model makes this decision, effectively preventing the vehicle from operating when alcohol is present. The compact design allows for seamless integration near a vehicle's ignition system, serving as a safety measure to prevent driving under the influence. The wristband module, a crucial component of our system, incorporates a transdermal alcohol sensor to monitor alcohol levels in real time, as depicted in Figure 9. This module is powered by a XIAO ESP32 S3 microcontroller, ensuring efficient data processing and wireless connectivity. A 0.92-inch OLED display provides a user-friendly interface, displaying essential information. The screen shows both the current time (09:15:27) and the alcohol sensor reading (MQ-135: 633) for real-time monitoring. The wristband is designed for continuous wear, offering seamless alcohol detection. Its compact and lightweight design enhances user comfort. The integration of wireless communication enables seamless data transfer to the system's central database.

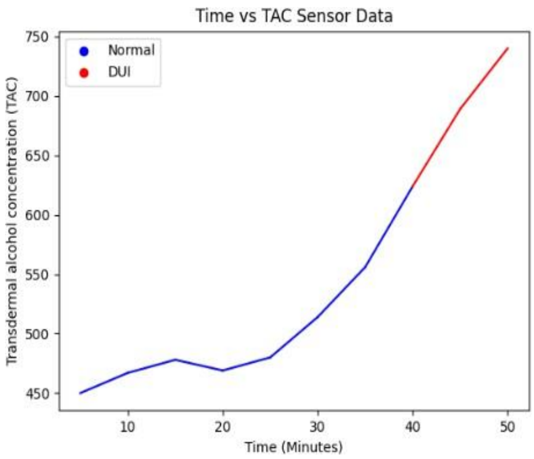

Figure 10. Dynamic Model Output

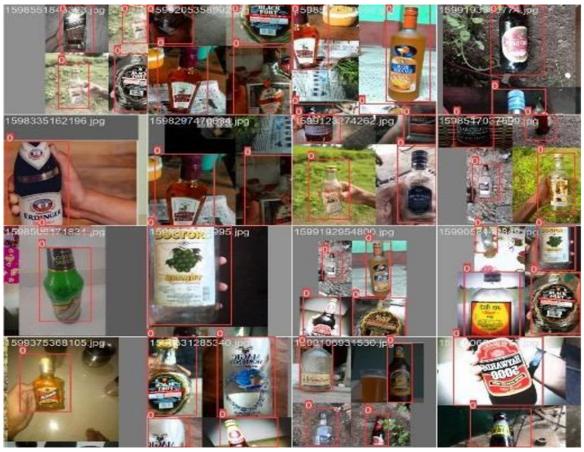

Figure 11. Module 3 Output

Testing revealed consistent data transmission to Firebase in real-time, with TAC readings effectively categorized into safe (blue region) and unsafe (red region) zones as shown in Figure 10 from our paper. The glucometer sensor integrated into the wristband measures both glucose and alcohol values from sweat, providing a non-invasive monitoring solution. The wristband transmitted data every 15 seconds via BLE to the vehicle's receiver unit, which then updated Firebase with current alcohol levels and GPS coordinates. The YOLOv8-powered object detection module achieved 92% accuracy in identifying alcohol bottles within the driver's vicinity (Figure 11), while the drowsiness detection module using Dlib effectively monitored eye closure ratios, triggering alerts when values exceeded predetermined thresholds.

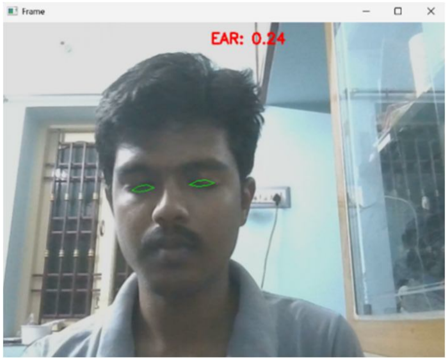

Figure 12. Module 4 Output (Eye Closed)

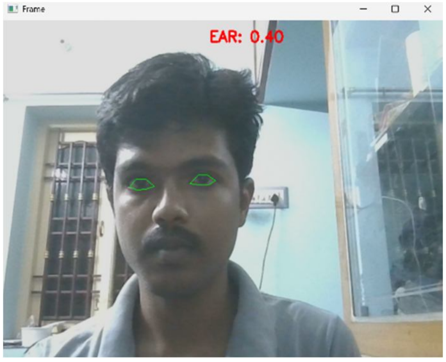

Figure 13. Module 4 Output (Eye Open)

Integration testing validated the Random Forest ML model's decision-making capability, with the system correctly preventing vehicle operation when combinations of impairment indicators were present. Most significantly, when the wristband module detected elevated alcohol levels (75% confidence) combined with drowsiness indicators (25% confidence), the vehicle remained immobilized. The emergency notification feature successfully transmitted SMS alerts with precise GPS coordinates to designated contacts during detected impairment events, completing the safety ecosystem. This comprehensive approach demonstrated the viability of the ALERT system as an effective countermeasure against impaired driving through seamless IoT integration and real-time monitoring capabilities.

VI. Conclusions

The "ALERT" system integrates multiple detection modules to enhance road safety by preventing impaired driving, effectively using IoT-enabled sensors and a Random Forest ML model to make accurate decisions. Validation showed reliable alcohol detection by the static and dynamic modules, with added safety from object detection and drowsiness monitoring. The system's emergency notification feature further enhances safety by alerting contacts with GPS coordinates when necessary. Future improvements could include adding sensors for drug impairment and vital signs, refining the ML model, integrating with vehicle telematics, and collaborating with manufacturers for seamless adoption and warnings for the driver, could further enhance the system's usability and effectiveness.

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