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An Intelligent Driver Safety System Using Raspberry Pi for Drowsiness and Alcohol Detection

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***Abstract*—In the world, Road traffic accidents caused due to driver fatigue and alcohol intoxication continue to be a major concern that results in significant loss. The increased alcohol intake by people, which negatively impacts judgment, coordination, and vehicle control, while fatigue of the driver is known to increase the reaction time. This paper presents the design and implementation of a low-cost intelligent driver safety system using a Raspberry Pi edge computing platform. The proposed system integrates vision-based drowsiness detection, alcohol detection, and driving behaviour monitoring to identify unsafe driving conditions in real time. The eye closure behaviour is analysed through the Eye Aspect Ratio (EAR) derived from facial landmarks. The alcohol presence is detected through an MQ-3 alcohol sensor. Once the alcohol level is found to be greater than a predetermined threshold level, the vehicle's ignition is prevented through a relay. Experimental results show that the system is able to detect the driver's unsafe behaviour with a reduced latency period.**

***Index Terms*—Driver Monitoring System, Internet of Things (IoT), Raspberry Pi, Computer Vision, Drowsiness Detection, Alcohol Detection, Edge Computing, Intelligent Transportation Systems**

I. INTRODUCTION

Road accidents that happen because people are tired, drunk or driving badly are still a cause of death on the roads around the world. Driver fatigue makes people less alert and slower to react while drinking alcohol affects their judgment and ability to drive safely which increases the risk of accidents. Most safety features in cars focus on reducing injury after a crash than stopping bad driving from happening in the first place. New technology like computer vision and Internet of Things is helping to create systems that can watch drivers and see if they are tired or drunk. These systems can look at the drivers face. See if their eyes are closed how often they blink and the position of their head to figure out if they are tired or distracted. This might not work as well if the light is poor or if the camera is not positioned correctly. Other systems use sensors to detect alcohol, monitor how the car is moving, and identify its location, but they cannot understand what the driver is thinking. The Raspberry Pi allows for processing information in real time while the driver is in the car. This means the system can operate even with a weak internet connection. By combining systems that analyse the driver's face with sensors that detect various factors, we can create a better system to monitor drivers. This paper discusses a system that uses Internet of Things technology and a Raspberry Pi to keep drivers safe. The system examines what the driver is doing, checks for alcohol, monitors the car's movement, and assesses speed to determine if the driver is tired, intoxicated, or driving poorly. It also provides a score to indicate how well the driver is performing and what risks they face. Road accidents and driver safety remain a concern, and this system can help reduce accidents and enhance safety on the road

II. RESEARCH CONTRIBUTIONS

The primary contributions of this work are summarized as follows:

- Design and implementation of a low-cost multi-modal driver monitoring system using a Raspberry Pi edge computing platform.
- Integration of vision-based drowsiness detection and sensor-based alcohol and motion analysis using a unified sensor fusion framework.
- Introduction of a quantitative Driving Skill Score (DSS) model for comprehensive driver risk classification.

- Experimental comparison between vision-only, sensor only, and fusion-based approaches demonstrating improved detection accuracy.
- Real-time edge-based deployment ensuring low latency and independence from continuous internet connectivity

III. LITERATURE SURVEY

Driver monitoring systems have been studied a lot to reduce accidents caused by fatigue and drinking. Eriksson and Panagiotopoulos [6] showed one of the systems that use cameras to detect fatigue by tracking eye movements. This system. It only uses what the camera sees. Soukup ova and Cech [7] came up with a way to detect blinking in real time by looking at the face. This method is fast. Can be used on small devices but it does not look at other things the driver is doing. Islam [8]and others looked at ways to detect when drivers are sleepy Said that systems that use many types of data are more reliable. Some people have tried using sensors together to better understand how drivers behave. Sathyanarayana [9] and others used cameras and vehicle data to find driving patterns while Park and others [10] used a system that only looks at video to monitor drivers on small devices. However, most systems do not have a way to measure driving behaviour. Some driver monitoring systems use the internet and cloud platforms.[11] These systems can analyse data in one place They can be slow and need a good internet connection. The system we are talking about does things in time on a small device and uses a Driving Skill Score to judge drivers. This score looks at how the driver is doing and gives them a rating. The Driving Skill Score is a way to assess drivers and it is part of the proposed system. Driver monitoring systems like this one can help reduce accidents by keeping an eye on the driver and the road, at the time. The Driving Skill Score is a part of this system.

IV. PROPOSED SYSTEM

The system they are talking about is, for monitoring drivers. It is based on Internet of Things technology. It is really smart. This system runs on a Raspberry Pi computer. It works in real time. It uses computer vision and a lot of sensors to keep an eye on the driver's actions and the state of the car moving. The driver monitoring system checks the driver and the car all the time.

A. System Overview The system has four parts: a camera to watch the driver, sensors to watch what the driver is doing, a special computer to put all the information together, and a special internet connection to send alerts. A camera on the dashboard takes pictures of the drivers face so it can be looked at away. There are tools like an alcohol sensor, a motion sensor and a GPS that all work together to get information, about whether the driver has been drinking, how the vehicle is moving and how fast it is going. All of this information is looked at on a computer called a Raspberry Pi so it can happen quickly and work well.

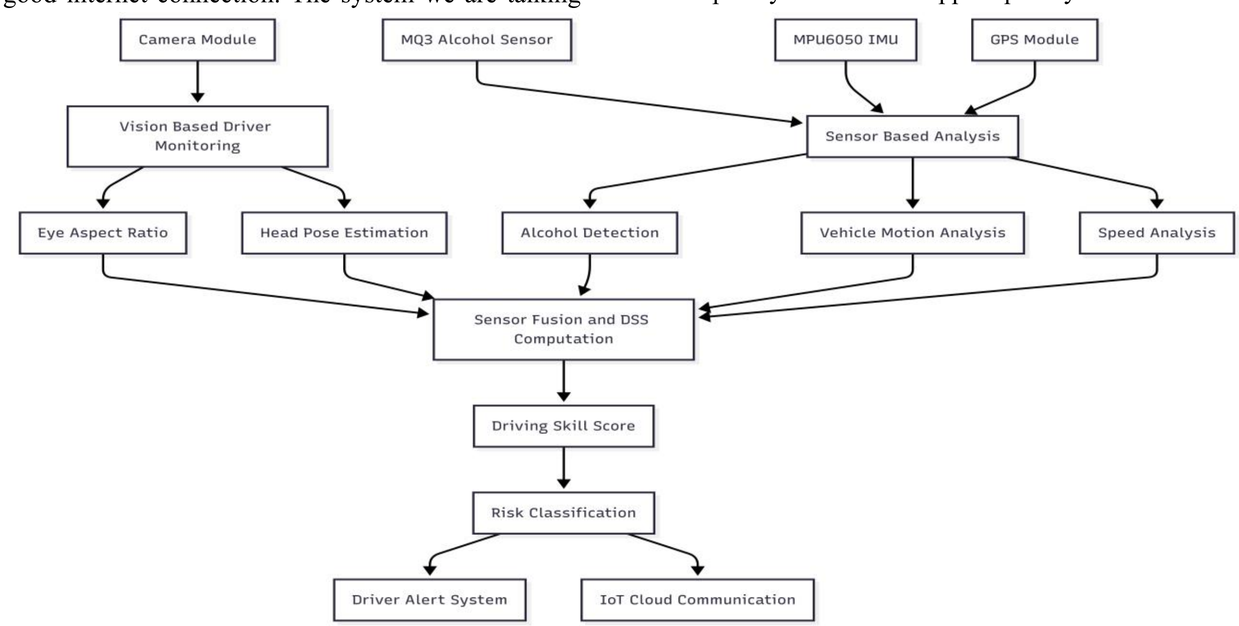

Fig. 1. Complete System Flowchart Diagram

B. Hardware Configuration

The system used a Raspberry Pi 4 Model B computer with 4GB of memory. It had a USB camera that could take 720p pictures. The camera took 22 pictures per second. The system also used an MQ-3 sensor to detect alcohol. This sensor worked with a converter to change its signals. The MPU6050 sensor gave information about movement and spinning. It updated this information 100 times per second. The GPS part of the system updated speed and location information, per second. The Raspberry Pi powered all parts. Used GPIO and I2C ways to connect them. The USB camera was used to get pictures of faces in time. The Raspberry Pi 4 Model B was the computer. The MQ-3 alcohol sensor detected alcohol. The MPU6050 sensor provided movement data. The GPS module provided location data.

C. Vision-Based Driver Monitoring

The vision module uses OpenCV and facial landmark detection to look at the way the drivers' eyes and head move. It calculates something called the Eye Aspect Ratio to see how long the drivers' eyes are closed and how often they blink. If the drivers' eyes are closed for a time and they do not blink very often the vision module uses this as a sign that the driver is getting sleepy [7]. The vision module also looks at the way the drivers head is moving to see if it is moving in a way, which can mean the driver is not paying attention to the road.

The vision module does all this to detect driver drowsiness. The Eye Aspect Ratio (EAR) is computed as:

$$EAR = \frac{\|p_2 - p_6\| + \|p_3 - p_5\|}{2\|p_1 - p_4\|} \qquad (1)$$

where p_1 to p_6 represent the coordinates of the eye landmarks. A sustained reduction in EAR below a predefined threshold indicates eye closure and potential drowsiness.

D. Sensor-Based Behaviour Analysis he MQ-3 alcohol sensor checks for alcohol, in a driver's breath. It indicates that the driver is intoxicated when it finds a lot of alcohol. The MPU6050 sensor monitors the vehicle's rotation and motion. It searches for strange movements, rapid acceleration, and braking. The vehicle's speed is provided by the GPS module. This enables us to determine whether the driver is driving erratically or at a high speed. The GPS module, MPU6050 sensor, and MQ-3 alcohol sensor all cooperate. They assist in determining whether a driver is intoxicated or operating a vehicle improperly. The MQ-3 alcohol sensor is crucial. It can identify vapors of alcohol. The driver is classified as intoxicated if sensor readings exceed a calibrated threshold. The MPU6050 IMU monitors acceleration and gyroscopic data. It detects braking, sudden acceleration and erratic vehicle movements. The GPS module provides speed information. This information is used to identify over-speeding and speed patterns.

E. Driving Skill Score

The Driving Skill Score is a way to measure how well someone drives by looking at what they do when they're behind the wheel. It takes into account things like how they move their eyes turn their head and if they have been drinking. It also looks at how the car's moving and how fast it is going. The DSS is computed as:

$$DSS = w_1E + w_2H + w_3A + w_4M + w_5S \qquad (2)$$

The Driving Skill Score is figured out using a formula that includes things like eye behaviour, head movement, alcohol detection, motion patterns from the car and speed behaviour from the GPS. The Driving Skill Score uses these things: eye behaviour, which's what the driver does with their eyes, head movement, which is how the driver turns their head, alcohol detection which is if the driver has been drinking, motion patterns from the car, which is how the car is moving and speed behaviour, from the GPS, which is how fast the car is going. The people who made the Driving Skill Score picked numbers to multiply each of these things so that they add up to a score. The Driving Skill Score is important because it helps us understand how skilled the driver is. The weights are picked in a way that

$$w_1 + w_2 + w_3 + w_4 + w_5 = 1$$

We want to make sure that each part of the test is equally important. The numbers we used were found by trying things and looking at what could go wrong and what is most important. We thought eye behaviour and alcohol detection were very important so we gave them weight. This is because we know from studies that these two things are closely related to the chance of an accident. We gave weight to how the car is moving and how fast it is going. Head movement is also important because it can tell us if the driver is distracted. The way we chose these numbers helps us get a safe evaluation of the driver. The numbers help us make sure we are looking at everything that's important, for the driver and the car and that we are paying attention to the things that could cause an accident. We are looking at the picture and making sure the driver is safe and the car is safe and that is what matters most. The driver and the car and eye behaviour and alcohol detection are all important. We need to look at all of these things to get a good evaluation.

F. Alert and IoT Communication

When the DSS falls below a safety threshold that we have already set the system turns on a buzzer and a vibration motor to warn the driver. The DSS values and the sensor data are sent to a platform. We use the internet to send this information. We use special ways, like MQTT or HTTP to do it. This helps us to keep an eye on things from away and to save the data for later use. The DSS values are very important so we make sure to send them to the cloud platform for monitoring and data logging of the DSS.

V. SYSTEM METHODOLOGY

The system they are talking about is going to do a lot of things. It is going to get data then it is going to clean up this data. After that it is going to find the important parts. The system is also going to look at how peoples' behaving and it is going to combine information from many sensors. Then it is going to make decisions. The Raspberry Pi is what they are using to do all of this. They want to keep an eye on the driver all the time so they are doing all of this with the system in time. The driver behaviour is what they are really interested, in monitoring.

Fig. 2. Process Flow of the System

A. Data Acquisition

Visual data is captured using a camera. Sensor data comes from the MQ-3 alcohol sensor, MPU6050 IMU and GPS module. We synchronize each data stream using timestamps. This helps us correlate and fuse the types of data accurately. The MQ-3 alcohol sensor, MPU6050 IMU and GPS module provide sensor data. The camera module provides data. We use timestamps to ensure that the visual data and sensor data are aligned properly. This alignment enables us to combine the data from the camera MQ-3 alcohol sensor, MPU6050 IMU and GPS module The data from the camera module and sensor data are correlated using timestamps. The sensor data includes inputs from the MQ-3 alcohol sensor, MPU6050 IMU and GPS module. The visual data, from the camera and sensor data are then fused together.

B. Preprocessing and Feature Extraction

Captured video frames are converted to grayscale. This helps to make the processing less complicated. Facial landmarks are detected using algorithms. The Eye Aspect Ratio (EAR) is calculated from these landmarks. It helps to check if a person's eyes are closing. Sensor data is cleaned using a low-pass filter. This removes noise, from the data. A threshold-based analysis is used to find motion patterns. This is done using data from the IMU sensor. It also helps to identify speed patterns. This is done using data from the GPS.

C. Behaviour Detection

The system can tell when a driver is getting sleepy because the EAR stays below a level for too long. If the drivers head is moving around in a way that is a sign that they are not paying attention to the road. The system figures out if someone is driving aggressively by looking at the information, from the IMU and GPS together. It can also tell if a driver has been drinking much because the MQ-3 sensor readings are higher than they should be.

D. Sensor Fusion and Decision Making

The things we learn from what we see and the information we get from sensors are combined using the Driving Skill Score model. We use the Driving Skill Score value we get to figure out if the driver is safe or not. The driver is put into one of these groups: moderate-risk or high-risk. We send out warnings when the Driving Skill Score shows that the driver is not driving safely.

VI. RESULTS

They created a system to monitor drivers and assess their driving skills using the Internet of Things. This system was installed on a Raspberry Pi 4. They tested it with five drivers in various scenarios. These included general driving, as well as situations where the driver was at risk, such as when they felt tired or distracted. They also assessed the system when drivers might have been impaired, like after drinking or when driving too fast. They evaluated how the system performed by examining several factors. They looked at its accuracy, precision, and ability to retain information. They also used a metric called the Driving Skill Score to measure the system's effectiveness. These assessments helped determine if the system was reliable in evaluating drivers' skills. The evaluation involved both the Internet of Things and the Driving Skill Score.

A. Driving Skill Score (DSS) Calculation

The Driving Skill Score (DSS) is computed using weighted sensor fusion as shown in Eq. (1):

$$DSS = w_1E + w_2H + w_3A + w_4M + w_5S \tag{3}$$

where:

E is for when our eyes close and how we blink,

H is for moving our head

A is about finding out if someone has been drinking alcohol. If the A number is high that means everything is okay no alcohol was found. If the A number is low that means alcohol was detected.

M is for the way we move like how we are going and if we are stopping or turning it is measured by a special device.

S for how fast we're going this information comes from the GPS.

The assigned weights satisfy $^{P}w_i = 1$ and are defined as: $w_1 = 0.30$, $w_2 = 0.20$, $w_3 = 0.25$, $w_4 = 0.15$, $w_5 = 0.10$

Based on the computed DSS value, the driver risk level is classified as shown in Table I.

Table I DSS range and driver risk level

DSS Range	Driver Status
80–100	Safe
50–79	Moderate Risk
<50	High Risk

B. Performance Metrics

The performance of the system is evaluated using standard classification metrics defined as follows:

$$\text{Accuracy} = \frac{TP+TN}{TP+TN+FP+FN} \times 100 \tag{4}$$

$$\text{Precision} = \frac{TP}{TP+FP} \times 100 \tag{5}$$

$$\text{Recall} = \frac{TP}{TP+FN} \times 100 \tag{6}$$

$$\text{F1-Score} = \frac{2 \cdot (\text{Precision} \cdot \text{Recall})}{\text{Precision} + \text{Recall}} \tag{7}$$

where TP, TN, FP, and FN represent true positives, true negatives, false positives, and false negatives, respectively.

C. Experimental Results

1) Real-Time Performance Evaluation: The Raspberry Pi 4 platform can process a video frame in 45 milliseconds. This means the Raspberry Pi 4 platform can do real-time performance at 22 frames per second. When the Raspberry Pi 4 platform gets data from sensors it does not take a lot of time to process it. The Raspberry Pi 4 platform does this because it uses filters and it only does things when the data reaches a certain point. The Raspberry Pi 4 platform does things faster, than other systems that need to send data to the cloud to work.

2) Detection Accuracy Comparison: Table II compares the performance of vision-only, sensor-only, and the proposed fusion-based DSS approach.

Table II Detection Accuracy Comparison

Method	Acc. (%)	Prec. (%)	Rec. (%)	F1 (%)
Vision Only	82.4	80.1	81.3	80.7
Sensor Only	75.6	74.2	73.8	74.0
Proposed Fusion (DSS)	92.3	91.4	90.8	91.1

3) Driving Skill Score Under Different Conditions: Table III presents the DSS values obtained for different driving conditions.

Table III Driving Skill Score By Driver Condition

Condition	E	H	A	M	S	DSS	Risk Level
Safe	90	85	95	88	90	88.6	Safe
Moderate Risk	65	60	50	55	65	63.2	Moderate Risk
High Risk	40	35	80	40	45	42.5	High Risk

VII. CONCLUSION AND FUTURE WORK

This examines a system intended to track drivers and evaluate their driving abilities. It makes use of a Raspberry Pi computer and has a number of sensors, including the GPS module, MPU6050 IMU, and MQ-3 alcohol sensor. These sensors assist in determining whether a driver is operating a vehicle dangerously, drunk, or sleepy. This system evaluates a driver's driving skills by using computer programs to analyse the data gathered by the sensors. To indicate whether a driver is safe or not, it offers a score known as the Driving Skill Score. This system worked well when we tested it. In 92This makes it ideal for applications such as helping trucking firms keep their drivers safe or preventing accidents from occurring. The Driving Skill Score system and the Raspberry Pi computer play important roles in driving safety. The IoT-based smart driver monitoring system performs well in its functions.

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