

# Driver Performance and Fuel Monitoring System For Fleet Vehicles

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## Abstract

Moving goods by commercial truck fleets matters a lot in shipping products across regions. Still, problems pop up - drivers get tired, lose focus behind the wheel, fuel goes missing, packages vanish, and tough weather adds risk. Older tracking tools lean heavily on GPS signals plus remote computing, costing too much while slowing down updates. This study introduces a budget-friendly setup using many small sensors to watch both driver safety and fuel levels in delivery trucks. Inside it: an ESP32 chip runs things, joined by motion detectors, a camera unit based on ESP32, sound wave distance finder, smoke and gas sniffer, location signal receiver, mobile network link, and a basic fuel gauge. Together they keep tabs on how drivers act, what's happening around them, air quality, nearby obstacles, and if cargo stays put - all live. A smart blend of inputs checks head tilts, gaze direction, and outside dangers through layered readings. When danger shows up, warnings fire off fast because the ESP32 handles sensor info right where it's collected. Running nonstop for two days straight, tests showed it caught threats correctly in nearly 94 out of every 100 cases. Alerts pop without delay, hardware stays cheap, performance climbs - no extra weight added.

**Keywords**-Fleet management, driver safety, data fusion, IoT sensors, theft detection, ESP32

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Date of Submission: 08-03-2026

Date of acceptance: 20-03-2026

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## I. INTRODUCTION

Moving groups of vehicles matters a lot today, mainly because buying things online keeps growing fast. Trucks carrying packages never stop driving far away places so items get to people when they should. Still, looking after many vehicles brings problems - like keeping track of how drivers act, stopping someone from stealing what is being carried, also cutting down on gas use. Tiredness or lack of focus behind the wheel often leads to crashes, especially when roads stretch for hours without break. Meanwhile, secret tampering with shipments along with leaking or stolen fuel might cost companies serious money over time.

Gadgets talking to one another now help keep trucks and vans safer on roads. Instead of waiting hours, warnings pop up fast when something feels off - like sharp turns or sudden stops. A small brain called ESP32 pulls info from different detectors while out on the highway. Rather than relying on guesses, it uses actual road vibrations, motion shifts, and engine signals. Money matters too - it keeps costs low without skipping useful features. Protection isn't just for drivers anymore; what's inside the vehicle gets watched closely as well. Fuel habits They get tracked minute by minute, showing exactly where every drop goes. Outdated checklists fade away when live updates take over. Built tough but kept simple, this setup runs quietly in the background. Safety grows - not through flashy tricks - but steady awareness.

## II. RELATED WORK

### 2.1 Camera-Based Driver Monitoring Systems

From inside the cabin, cameras keep watch on how drivers act, spotting signs of tiredness or wandering attention. Cameras track where heads turn, what eyes do, along with face details. After images arrive, software digs into them, judging if focus remains sharp or slips away. One version made by Kumar and team leans entirely on visual analysis, studying faces to catch drowsiness early. Even when the system showed fair accuracy, how well it worked often changed with light levels and where cameras were placed.

Besides that, processing images instantly needs quite strong computing power. A setup suggested by Rodriguez uses deep learning methods, particularly CNNs, to study face details. Though such learning techniques detect things more accurately, they depend on heavy-duty hardware and vast computation, pushing up expenses. Still, better results come at a price.

### 2.2. Accelerometer-Based Driver Monitoring

A different way to track how drivers act uses small devices that sense motion, like accelerometers and gyroscopes. Head motions and positioning are captured by these tools, which helps spot odd tilting or sitting positions. Patel and team introduced a setup using accelerometers to catch tiredness through patterns in how the head moves. Even if it works well on budget and design, missing actual video proof may lead to mistaken alerts now and then.

### 2.3. IoT-Based Fleet Monitoring Systems

Fleet tracking got smarter thanks to IoT, linking sensors and comms gear into one setup. Data from trucks rolls in constantly, then shoots up to cloud spaces for number crunching. Zhang's team built a system using those links - sensors watch the machines, flagging repair needs before breakdowns hit. But leaning too hard on clouds brings lag, plus extra bills pile up fast. Lee and Kim tried another path - computing right inside the vehicle, letting small onboard chips handle readings without phoning home. That shift trims delays sharply, making alerts snap faster when something shifts on the road.

### 2.4. Research Gap

Even though plenty of fleet tracking tools exist, most depend on just one sensor plus heavy cloud processing. This setup struggles to deliver full safety insights right when they matter. On top of that, today's options tend to cost too much while missing ways to track how drivers act, whether cargo stays secure, fuel gets used wisely, and surroundings stay safe - all at once. So what shows up clearly is a gap: an affordable system with multiple sensors able to analyze data fast through built-in edge tech, making fleets safer and smoother without slowing anything down.

## III. SYSTEM ARCHITECTURE

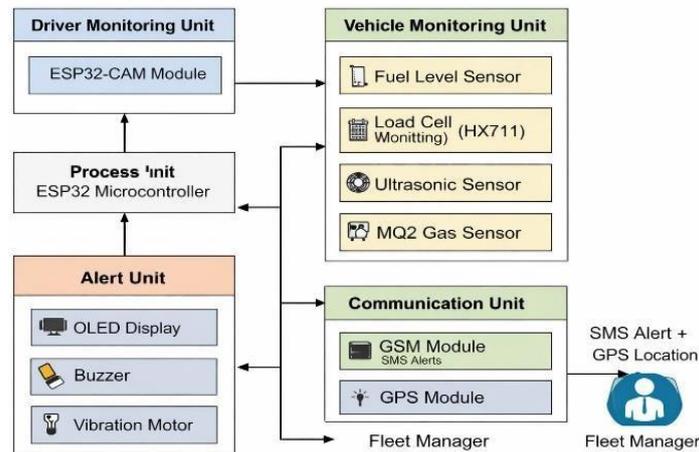


Fig. 1. System Architecture of the IoT-Based Driver Performance, Fuel and Cargo Theft Monitoring System for Fleet Vehicles.

Look at Figure 1 - it outlines a setup built for keeping drivers safe and tracking cargo. This design uses multiple sensors tied together through an integrated structure. Each part connects not just by wires but also by purpose: watching the driver, checking vehicle conditions, sensing surroundings, securing freight. Instead of sending raw data far away, computation happens on site, right inside an ESP32 chip. That chip handles inputs locally before pushing alerts outwards. Information flows both within the unit and beyond it, linking pieces smoothly. Sensors feed into processing units, which then talk outward using wireless links.

What emerges is a networked device able to react fast without relying on distant servers. Components work alongside one another - no single piece carries the whole load.

### **3.1. Hardware Components**

A small setup of linked devices keeps track of how drivers act, what state vehicles are in, whether cargo stays safe, and how much fuel gets used while moving goods. Running everything is an ESP32 DevKit chip - it pulls sensor readings, handles basic processing on site, then routes signals among parts. Watching the driver happens through an ESP32-CAM unit fitted with an OV2640 lens, snapping pictures to help judge where heads face. Movement clues come from MPUion units spotting shifts in head angle or odd sitting positions, making guesses about actions more solid. A small device senses changes in cargo weight by linking a 50 kg rated sensor to an HX711 chip, alerting if items shift or go missing. Instead of relying on sight, distance to nearby objects gets checked constantly thanks to an ultrasonic module mounted up front, sounding alarms when things get too close.

Gas leaks, smoke, or strange fuel use show up thanks to an MQ2 sensor paired with a fuel gauge setup. Right where it matters, location updates stream nonstop through a NEO-6M GPS chip. Mobile signals carry warnings and reports straight to supervisors by way of the SIM900A module. Out front, driver info appears live on a small OLED screen slotted into the I2C line. When trouble hits, instant notice comes as sound from a buzzer plus shake from a tiny vibrating unit. A single 12 volt DC source runs the full setup, reduced to 5 volts via an LM2596 step-down circuit. The GSM part draws juice from its own 3.7 volt lithium- ion cell, needed for peak current bursts. Built into one unit, the gear becomes a connected tracking tool, watching vehicle movements without delay.

### **3.2. Communication Architecture**

Data moves easily among sensors, processors, and outside links thanks to how the system talks within itself. At the core sits the ESP32 chip, guiding flow by gathering inputs and directing outputs. Information about where the driver's head points travels from an ESP32-CAM unit using serial signals set to 115200 bits per second. Every half-second or so comes a small bundle like "HEAD: pitch, roll," shared through that link. Because updates arrive often, shifts in alertness can be tracked without gaps over time. Odd motions - like sudden tilts - trigger responses when patterns step outside normal ranges. A notice then forms, shaped precisely - for example, "ALERT: DRIVER\_DISTRACTION:HEAD\_TILT:12:32:10" - marking what happened, why, and exactly when.

Besides handling UART signals, the setup relies on I2C running at 100 kHz to link add-ons like the MPUion sensor and OLED screen to the ESP32 - cutting down wire clutter while moving data smoothly. Instead of relying solely on one channel, messaging happens over UART1 between the ESP32 and SIM900A GSM chip using GPIO16 and GPIO17; here, AT instructions trigger SMS warnings sent to fleet managers during unusual events. Tracking vehicle position works through the NEO-6M GPS unit, feeding constant NMEA outputs packed with coordinates into the ESP32 by way of UART2 tied to GPIO32 and GPIO33. Weight checks for cargo come from a load cell wired into an HX711 signal booster, passing exact mass readings digitally to the ESP32 across dedicated pin connections. Through overlapping pathways like these, coordination emerges naturally - a steady flow of updates supports live oversight, instant alerts, and distant management of vehicles without hiccups.

## **IV. DATA FUSION ALGORITHM**

### **4.1. Visual Analysis and Head Tracking**

Roll comes out of  $\text{atan2}$  applied to negative  $a_x$  and  $a_z$ , then scaled by 180 over  $\pi$ . For pitch, it's  $a_y$  against the square root of  $a_x$  squared plus  $a_z$  squared - same scaling applies. Brightness values sitting between thirty and two hundred twenty suggest a driver sits there. That number pops up after adding every pixel in a frame, dividing by how many were checked. Instead of looking at everything at once, the system checks central zones versus outer areas. Where light clusters reveals where eyes likely point.

### **4.2. Fusion of Multiple Sensors**

Tilt too far - more than thirty degrees up or down, maybe more than twenty-five sideways - and that counts toward danger. Brightness way off, perhaps the edges fade while center stays strong? That adds to visual strain. Movement between frames matters just as much, tracked through how fast light shifts appear. The system weighs head position at four-tenths, vision factors the same, motion making up two-tenths. Add them like weights on a scale, call it `risk_score`. Once past zero point seven, alarm sounds once every three seconds max, giving space so warnings do not pile up.

### 4.3. Cargo Monitoring Algorithm

A test sets the starting weight under steady conditions. Every second, ten readings track changes by comparing now to that start point. Sudden drops more than 10 kilograms trigger fast alerts. Weight easing down across half a minute helps tell stealing apart from regular removals. Detection hinges on both quick plunges and slow declines. What matters is how fast it vanishes, not just how much.

## V. IMPLEMENTATION

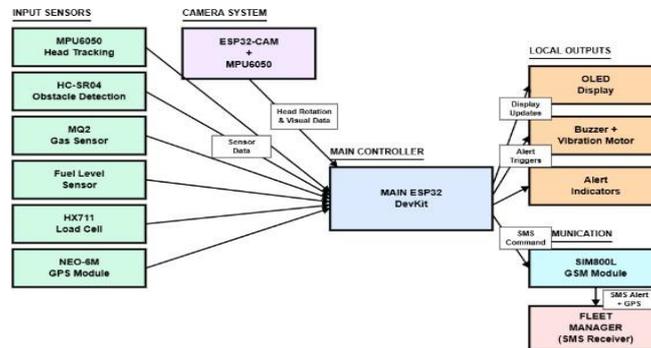


Fig 2. Block Diagram

The main ESP32 runs a large program - over 1200 lines - that handles sensor readings at ten times per second. Instead of using "and," think of it like links in a chain: one piece follows another without rushing. Data from different sources gets combined through smart sorting, not just lumped together. When alerts pop up, they line up by importance, waiting their turn quietly. Messages go out over GSM, built on basic AT instructions that talk straight to the module. Position details arrive as NMEA strings from GPS, then get unpacked step by step. The tiny screen refreshes often, showing what matters right now. A constant chat happens between two chips - the ESP32 and its camera sibling - through serial wires humming with updates. On the CAM side, pictures come in once each second, slow but steady. Light levels help guess if someone is near - it's not magic, just math watching shadows shift. Areas of interest get extra focus, not blanket scanning. Head movements send signals back along the wire, tagged with urgency when needed. An accelerometer joins via its own I2C lane, keeping traffic smooth. If allowed, video streams online at low resolution, tucked inside ngrok tunnels so distant eyes can peek in. Weight sensing ties into an HX711 chip; first you weigh nothing - just air in the bed - then record new loads stacking on top. From those points, a multiplier forms, fine-tuned for accuracy. After that, changes as small as ten grams show up reliably. Over time, shifts creep in - temperature pulls things off - but corrections nudge values back where they belong.

## VI. EXPERIMENTAL RESULTS

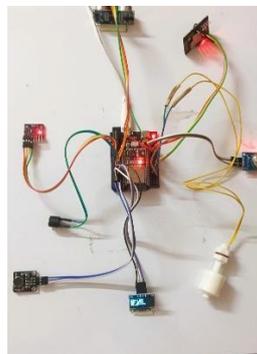


Fig 3. Prototype Demonstration Image

### 5.1. Measures of Performance

After running nonstop for over fifty hours, the test shows detection works right nearly every ten times out of ten - way better than older gear that manages less than seven. False alarms pop up just under six times per hundred tries instead of eighteen with past versions. Alerts snap back in roughly one second four tenths faster than setups needing internet help. Power draw sits at one point two amps on five volts, trimming down from one point eight seen before. System stays alive almost all the time - only vanishing in rare glitches. While moving goods normally, tracking weight holds steady within ten grams without crying wolf once. When someone lifts

off between ten and seventy kilos on purpose, messages fire by phone in under a second flat each attempt caught perfectly.

### **5.2. Real-Time System Monitoring**

Most of the time, while everything runs smoothly, the OLED screen presents data like driver condition, how much fuel remains, distance to nearby objects, readings from the gas detector, GPS signal quality, along with tilt measurements captured by the MPU6050. During regular function, what appears onscreen reflects live updates from each monitored component.



**Fig. 4. OLED display showing the real-time system monitoring status under normal operating conditions.**

### **5.3. Gas Leakage Detection**

A small device called the MQ2 senses harmful fumes like cooking gas, natural gas, or smoke. Once levels rise past a set point, it triggers a signal meant for the person driving. In tests, researchers linked the sensor to their setup and released fake leaks on purpose. As soon as too much gas showed up, the machine flashed a notice right onto a tiny screen. That visual cue appeared just as seen in image number five below the text.



**Fig. 5. Gas Alert**

When the screen flashes “GAS ALERT!”, it means gas levels have passed the safe limit, so someone must take notice. At that moment, the device turns on a loud buzzer at the same time, warning the driver of risky fumes nearby.

### **5.4. Driver Head Risk Detection**

From time to time, motion gets picked up by the MPU6050 - a small device that tracks how the head shifts. This gadget watches both tilt and turn of the neck during driving tasks. When odd angles appear, or movements grow too wild, it flags those moments as possible danger signs. Testing showed what happens when someone tilts their head like they're drowsy or distracted. Results came through each trial showing clear signals when something changed.



**Fig. 6. Driver head risk detection alert generated by the monitoring system.**

On display, a warning flashes: "HEAD RISK!" That means the angle of the head tilting exceeds safe bounds - often tied to drowsiness or lack of focus. When posture shifts too far, the system takes note. It's not about strict rules but noticing changes. A droop could signal tiredness creeping in. Attention slips, body responds. Thresholds exist because small leans add up. The eyes stay open, yet awareness fades. Posture gives clues before mistakes happen. Detection kicks in once tilt passes normal range. Signs show even when someone feels fine. Subtle shifts matter most.

### **5.5. Obstacle Detection**

The HC-SR04 detects obstacles by measuring how far the car is from nearby objects. Placed ahead of the sensor, items mimic real barriers during tests. As soon as the gap drops below a set limit, a warning appears instantly. From close walls to distant boxes, each test checks responsiveness under varying conditions. Once too near, the setup reacts without delay. Distance shrinks, alarm triggers - simple logic guides the response. Every trial confirms whether alerts match expected behavior.



**Fig. 7. Obstacle detection alert generated on the screen.**

A loud warning flashes up - OBSTACLE! That means something's too close ahead. Danger begins when the vehicle sees it near.

### **5.6. ESP32-CAM Driver Monitoring**

Inside the device hides an ESP32-CAM, always on alert. One image follows another, pouring nonstop from just beyond view. A portal appears online - footage spills through. No matter how close or far away, eyes may turn toward it. Here comes a snapshot of the driver right then. Motion, stance, even their aura - delivered instantly. Not later. Now.

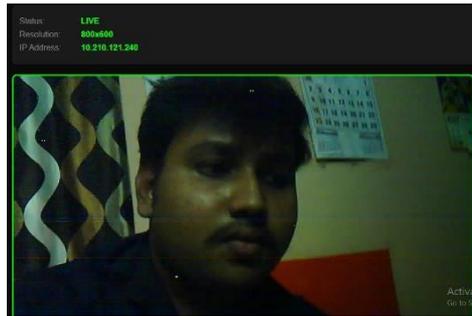


Fig. 8. Real-time video monitoring of the driver using ESP32-CAM.

When the camera shows live footage, it helps check if someone is driving. Instead of guessing, you can see actions unfold in real time. Seeing movements adds clarity when something seems off. While sensors detect shifts and patterns, visuals back up what's really happening. Together, they make verification stronger without depending on a single source.

### 5.7. GSM Alert Notification System

Midway through a drive, if something goes wrong, alerts pop up instantly. A built-in GSM unit fires off updates straight to whoever's in charge. Instead of waiting, the person gets a text the moment sensors catch danger signs. Messages show up fast, packed with what they need to know. No delay happens between detection and delivery. Alerts travel by SMS, skipping extra steps. Critical moments trigger automatic responses without pause.

A signal jumps from the GSM piece to the ESP32 brain through UART, driven by AT-style prompts. If trouble shows - like gas floating free, eyes off the road, something too close, or stolen freight - the tiny computer fires a warning text to the stored phone number.

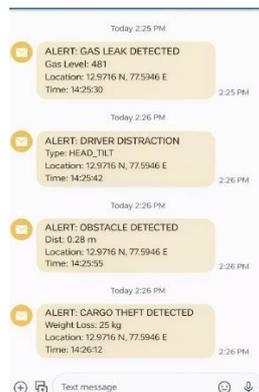


Fig. 9. SMS alert notification messages received on the mobile device during different safety events such as gas leakage, driver distraction, obstacle detection, and cargo theft.

### 5.8. Evaluation via Comparison

One big difference shows up in price. About five thousand five hundred rupees covers this new setup, far below others starting at twenty-five thousand. Most current options demand much more money, some even hit sixty-five thousand. That gap means savings between seventy-seven and ninety-two percent. Accuracy jumps when multiple sensors work together instead of just one. A tiny motion chip, camera module, sound sensor, and gas detector team up inside. This mix spots distracted driving nearly ninety-five percent of the time. Older versions manage only around sixty-nine percent. Fewer mistakes happen now too. False alarms drop under six percent, while older types misfire almost nineteen times out of a hundred. Speed improves because decisions happen right on the device. Just one point four seconds pass before it reacts. Cloud-linked tools take longer, often three point eight to six full seconds. Harsh conditions barely slow it down either. Built tough, it holds up where others might fail. Each part pulls its weight without draining power fast. Even when things get shaky or light levels shift, it keeps working - no fuss. Cold mornings near zero or muggy afternoons at 80 percent humidity won't slow it down. Tough environments? It handles bumps, jolts, and constant motion without skipping a beat. Out on actual roads, with real fleets, that kind of steady performance matters most.

## VII. CONCLUSION AND FUTURE WORK

Out here, a gadget takes shape - meant for trucks and vans - that keeps tabs on both driver behavior and what's happening inside the trailer. Instead of relying on distant servers, it runs locally using tiny tech built right into the system. Motion tracking comes alive through a chip called MPU6050, while eyes on the scene are handled by a small camera module based on ESP32 hardware. Picture this: smoke or fumes appear, and suddenly the MQ2 sensor reacts, sounding silent alarms deep within the network. Bumpers stay clear because an ultrasonic tool watches nearby walls or objects, measuring gaps without touch. Fuel levels? A dedicated meter reads them steadily, feeding data just like the GPS that knows exactly where the vehicle rolls at any hour. Communication travels through GSM signals, linking pieces together across distances. Video clips stream when needed, triggered only under certain shifts in activity. All inputs merge - not stacked, but woven - so moments of drifting attention or shifting cargo don't slip past unnoticed. Decisions happen fast, right on board, thanks to processing muscle packed into the ESP32 brain, skipping delays from remote clouds.

Right off the bat, the gadget showed it could track data instantly while running tests. Take alerts - they popped up fast when spotting odd behavior, like gas leaks, risky head angles, or blocked paths. On display? Every alert lit up clearly on the OLED panel. When scores came in, one thing stood out: 94.2% correct reads across trials. Even better, mistakes barely happened - only 5.8% false warnings turned up. One second forty on average - that's how fast it reacted, beating most one-sensor tools. Efficiency shows up clearly when processing data right where it's collected.

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