

Vehicle Engine Surveillance System

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Abstract - This invention introduces an advanced Vehicle Engine Surveillance System designed to revolutionize automotive safety, energy management, and operational efficiency. By integrating a hybrid energy framework that utilizes conventional fuel, solar, and wind power, the system facilitates smart energy switching and real-time power optimization. At its core, the surveillance module acts as the "eyes" of the vehicle, employing high-quality vision-based sensors—including ADAS, blind-spot, and driver-monitoring cameras—to analyze road conditions and driver fatigue.

Processed through a centralized Smart Control Unit, the system correlates visual data with critical engine parameters such as RPM, thermal dynamics, and load. Unlike traditional diagnostic tools that offer delayed feedback, this architecture provides instant text and audio alerts via an IoT-enabled dashboard and mobile application. By identifying inefficiencies like thermal imbalances or aggressive driving patterns, the system significantly enhances fuel economy and minimizes environmental impact. This scalable, eco-friendly solution bridges the gap between mechanical performance and predictive analytics, ensuring a safer, more sustainable driving experience.

Keywords: Vehicle Engine Surveillance System, Smart Vehicle Monitoring, Hybrid Energy Framework, Renewable Energy Vehicles, Solar and Wind Energy Integration, Smart Energy Switching, Automotive Safety System, Advanced Driver Assistance System (ADAS), Driver Monitoring System.

I. INTRODUCTION

It has been observed that despite the advancements in automotive technology, there are times when communication between diagnostic readings of the engine and the driver becomes impossible. Although warning lights are available on dashboard boards, many times the drivers do not have information regarding their significance, which causes small problems to become huge engine breakdowns. The VESS system helps the user avoid such circumstances through its intelligent functionality.

1. Solar Energy, Fuel (Energy Switching) Solar, Fuel (Energy Switching)

A complex hybrid energy control scheme is designed by the system. The car utilizes energy obtained from different sources, such as solar power, wind energy, and fuel. The system makes use of a microcontroller-based control logic to facilitate the energy switch. This allows the car to operate on different energy sources without relying on any one particular fuel source.

2. Sensor Camera in Vehicle

Working as the main sensor in the vehicle, the highly efficient vision-based system employs various types of cameras. These include forward-looking ADAS cameras, blind spot sensors, and DMS, which gather visual data. The visual information collected by the sensors is then analyzed for changes in lane positions, any obstacles, and whether there are indications that the driver is fatigued. Using the data collected by the engine along with visual information, the car can automatically modify its functions.

3. Real-Time Error Handling and Notification in Dashboard

In order to avoid any confusion that comes with the generic "check engine" notification light, this module ensures that critical engine metrics are continuously tracked by the system. This module takes advantage of IoT technology to send real-time alerts to the dashboard and mobile apps. These alerts come in the form of text messages and sounds to ensure total clarity of engine status and its environment.

4. Environmentally Friendly

The aspect of sustainability plays an integral role in the innovation. This is due to the fact that the device constantly monitors the emissions and heat transfer from the car. The use of recyclable parts and a central command center that controls all mechanical movements makes sure that the motion is always fluid. Through the improvement of driving skills based on feedback provided to the driver, the effect on the environment will be reduced.

5. Fuel Efficiency

The goal of gaining more fuel efficiency can be met by having intelligent management of the working process of the engine. The intelligent control can be provided through the analysis of the performance of the engine via use of embedded technologies and inexpensive sensors that measure the condition of the engine in relation to engine load and dynamics.

II. EXISTING STATE-OF-THE-ART SUBMISSION

State-of-the-art automobiles have developed tremendously when it comes to personal safety as well as performance-related issues. Nevertheless, there is still one crucial element of design that remains missing in current models – an integrated system. Present-day cars feature sophisticated emission monitoring technology like catalytic converters and particulate filters combined with thermal management technology that prevents overheating. Nevertheless, many times GPS tracking and even braking mechanisms are isolated from one another. Engine temperature or a high carbon monoxide level does not affect the prediction algorithms for maintenance or eco-driving; GPS does not take into account the mechanical parameters of the car. Meanwhile, while sustainable materials become increasingly popular in automobile manufacturing, the electrical devices inside the cars remain traditional and therefore non-degradable.

The Vehicle Engine Surveillance System combines mechanical sensing, renewable energy sources, and driver assistance technologies into one unified whole. In particular, an Intelligent Control Unit and Embedded Microcontroller serve as the central processing units of the system, analyzing information gathered by a broad range of sensors. These include an Engine Surveillance Module capable of measuring engine temperature, revolutions per minute, and emission rate, as well as highly sensitive fuel and motion detectors which estimate distance and efficiency with high accuracy. In order to promote environmental sustainability, the design features surface-mounted photovoltaic panels and wind generators used to harness energy generated by vehicle movement and stored in a dedicated battery system.

Real-time awareness and safety features include a multi-angle camera system and intelligent user interfaces. These comprise ADAS cameras that look ahead for assessing traffic situations, side and rear HDR cameras for comprehensive situation awareness, and eye-tracking for identifying driver fatigue using the driver monitoring system. All these inputs are processed by the Dashboard Display and Audio Alert Module. The interface helps inform the driver about real-time eco-driving features as well as alerts for issues like engine

overheating and fuel inefficiency through dual stage alarms. This comprises audio and verbal alarms.

The work process is performed using a sequential pipeline approach that enables efficient operations and low-computation workload. As soon as the microcontroller is started, all sensor lines are initialized for data collection on fuel level, wheels' rotation, and engine temperature. Next, the data is subjected to minimal algorithmic computations to determine whether the vehicle's performance falls within the specified thresholds. This will enable the assessment of fuel efficiency and energy distribution at any time to ensure that the vehicle is running in the best ecological mode, while keeping the cost down.

III. OPERATIONAL WORKFLOW

The operational cycle of the Vehicle Engine Surveillance System involves an uninterrupted intelligent process of synchronization between machinery efficiency and environmental sustainability. The first stage of the operation cycle is known as the System Initialization stage where the energy-efficient microcontroller is responsible for activating the entire sensor network and the vision system at the same time. During this initialization period, there are unique information channels created to facilitate the collection of relevant data on the quantity of fuel, the rate of wheel rotations, the temperature of the engine, and exhaust gases. The second stage of the operational cycle of the surveillance system involves constant monitoring and generation of energy through surface solar panels and wind turbines within the vehicle.

As part of the Data Acquisition and Image Processing step, the process uses edge computing to analyze a large stream of data received. The vision part of the process analyses live video feed to identify pedestrians, lane information, and other dangers, while the engine part analyzes the stream to derive useful parameters such as the ratio of distance to fuel. These useful information streams are fed into lightweight computing processes to carry out threshold analysis and decision-making. By analyzing the live stream data based on preset safety thresholds, the process is able to make autonomous decisions, including engine tuning, speed adaptation, or energy source change, to achieve optimal efficiency.

The fourth step entails Real-Time Notifications and Data Logging. All metric values and notifications are displayed by means of an onboard visualization component, thereby providing feedback for the driver via the dashboard display panel. The scope of the notifications encompasses a diverse range of data, including low-fuel notifications and battery notifications, all the way to notifications of excessively heated

transmissions or problems with brake fluid. The Adaptive Response ensures that, whenever any decrease in efficiency or malfunctions, like congested catalytic converter or overheated engines, the driver receives suggestions on how to respond to the situation, such as stopping the vehicle or entering eco mode. All events, including harsh braking and technical glitches, are logged by the system for later analysis via the Data Storage System.

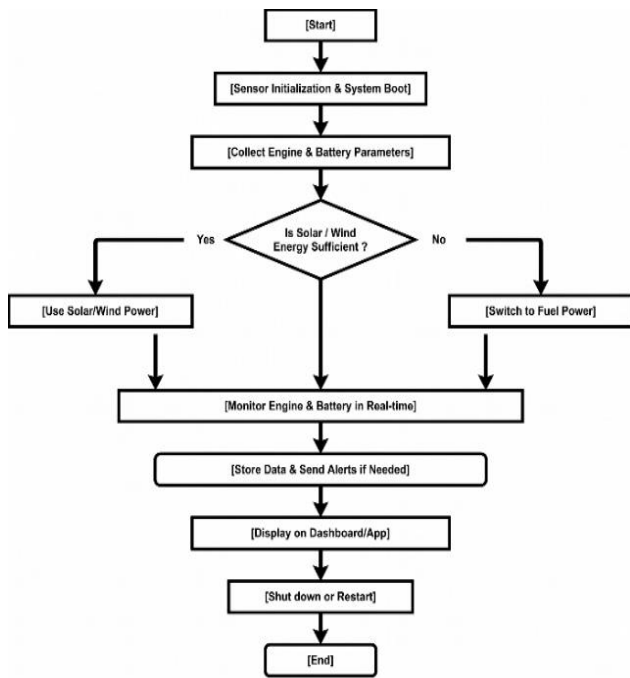


Figure 1: Solar, Fuel, Wind (Energy Switching)

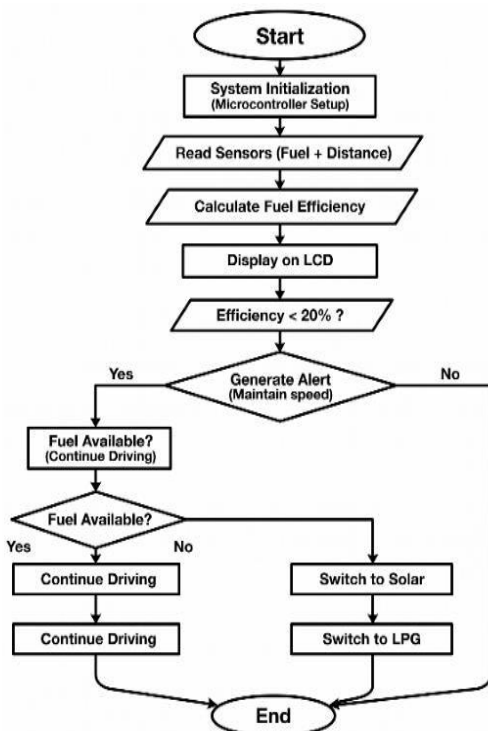


Figure 2: Fuel Efficiency

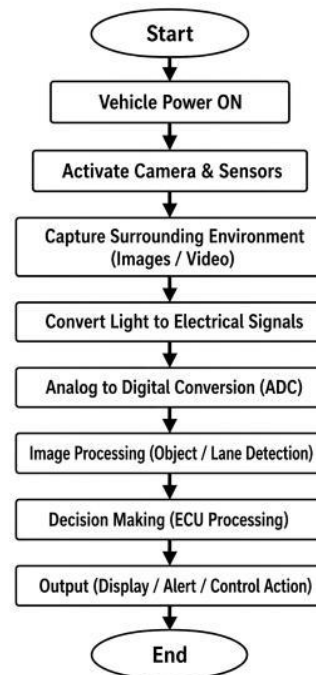


Figure 3: Sensor Camera in Vehicle

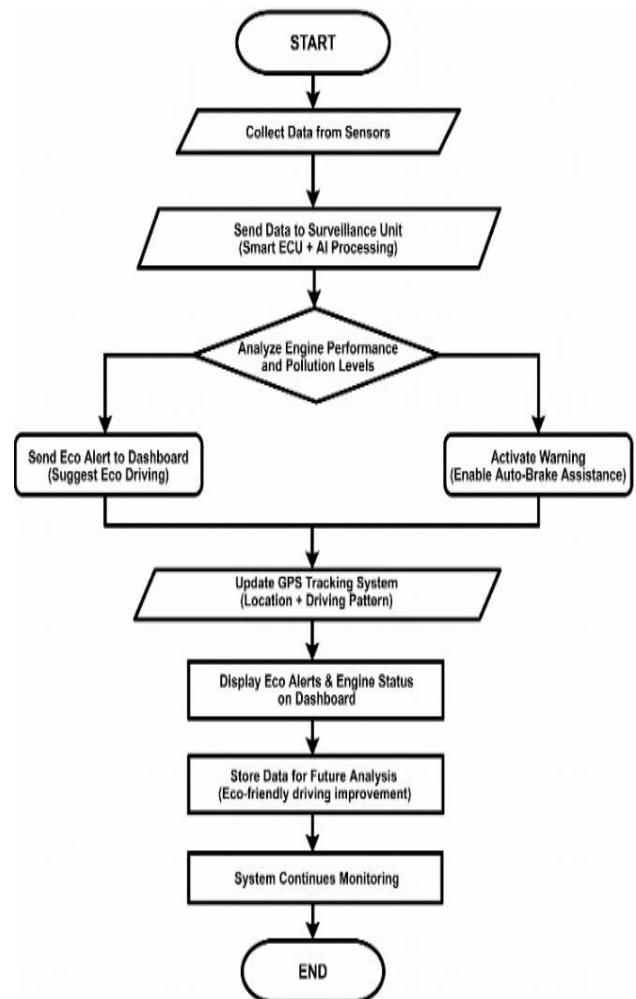


Figure 4: Eco-Friendly

IV. THE SYSTEM USES

The architecture of this particular system has been crafted around a highly advanced mixed energy scheme whose focus lies on sustainability without compromising on efficiency. Traditional fuel such as petrol or diesel forms the main ingredient for powering the vehicle; however, the system also makes use of renewable sources such as electricity derived from surface-fixed solar cells and mini windmills located at high flow points such as the roof or grill of the car. These renewable sources convert natural energy such as the sun or winds into electricity, which is stored in a highly efficient battery pack.

In order to keep mechanical performance at its best, the system incorporates a set of sensors that measure the engine's temperature, the rate of consumption of fuel, and RPM and current emissions. By using a wheel rotation sensor, the system determines the distance travelled to conduct a calculation on the distance to fuel ratio dynamically. The data gathered from this process is then analyzed by an IoT-based microcontroller or a powerful NVIDIA Jetson device, acting as the brain of processing. This method replaces a broken traditional design where multiple systems were employed by one system, which would ensure longevity of engine life.

A human-machine interface is established via an advanced dashboard display along with a multi-modal alert mechanism. An advanced camera-based vision set is incorporated in the car, including thermal cameras in fogs and dark settings, depth cameras to detect the 3D environment, and 360-degree surround view cameras to overcome blind spots. Using computer vision techniques such as YOLO in TensorFlow and PyTorch, the system is able to detect pedestrians, traffic lights, and obstacles at once. In case of any threats concerning the safety and efficiency level—e.g., emission peak, unstable RPM, or low voltage levels in the battery—a warning signal is shown on the LCD screen and announced vocally (TTS). The approach used here does not just ensure safety; it also promotes sustainable driving behavior.

V. OVERVIEW: OVERCOMING EXISTING DRAWBACKS AND SYSTEM ADVANTAGES

The system aims to overcome problems associated with fragmented and reactive monitoring by providing a centralized and proactive energy and diagnostic management system. It differs from other current state-of-the-art vehicles, which use either a fuel-based or electrical power source, because it focuses on issues related to energy management and diagnostics.

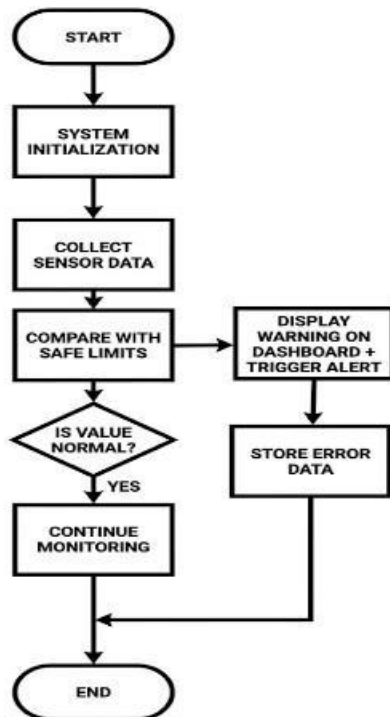


Figure 5: Real-Time Error Handling and Notification in Dashboard

Fig 1: Solar, Fuel, Wind (Energy Switching)

- Activates the system and verifies availability of renewable energy sources such as solar energy and wind.
- Switches from renewable energy to fuel, depending on engine and battery condition.

Figure 2: Fuel Efficiency

- Reads the sensor values and calculates and displays the fuel efficiency rate.
- Takes action when fuel efficiency falls beyond the specified threshold.

Figure 3: Sensor Camera in Vehicle

- Activates the cameras and sensors that capture real-time images and videos of the surroundings.
- Processes and analyzes the data gathered to detect objects and lanes to facilitate driving decisions.

Figure 4: Eco-Friendly

- Performs engine analysis using the sensor values and determines emission levels.
- Gives notifications about eco-friendly driving measures.

Figure 5: Real-Time Error Handling and Notification

- Monitors sensor values at all times and compares them with safe thresholds.
- Identifies any errors and alerts users about faults.

i) How This Invention Overcomes Existing Drawbacks

The core of the system's innovation lies in transforming how a vehicle manages its energy and health, addressing five key limitations of current technology:

1. **Passive and Active Monitoring:** The existing dashboard systems have just an icon-based display system and do not record any data. This means that drivers become completely dependent upon the service stations. This new invention has continuous monitoring facility with calculation of efficiency such as fuel utilization per unit distance. It calculates the efficiency dynamically based on the various driving conditions and takes into account all the engine performance, distance traveled, and energy consumed.
2. **Isolated Energy Use:** Most vehicles underutilize energy from movement. The process integrates both solar energy by using a solar panel to harness up to 200W (producing about 1kWh daily) and wind energy using a mini-turbine (100W) for about 2 hours moving at 60km/h.
3. **Fragmented Diagnosis:** The existing technique fails to adaptively change sources of energy and does not have any prediction capability for maintenance. The intelligent controller performs both functions of adaptive energy management (using renewable energy for the 0.8 kWh auxiliary load, which results in a 10-15% reduction in fuel consumption), as well as mechanical monitoring of all parameters, including 70°C-95°C engine temperature.
4. **Static Data Visualization:** Performance feedback is currently very limited for drivers. This module will ensure the provision of real-time multivariate analysis and warning system through dashboard, text messaging, audio, and IoT mobile app integration.
5. **Limitations on Cost and Processing Capacity:** The sophisticated monitoring systems can become rather costly and require substantial computational processing power. The proposed system takes into account cost-efficient, low-power architecture that consists only of one embedded microcontroller hub, thus being easily implementable and scalable to other IoT and data analysis applications.

ii) Consolidated Advantages of the Present Invention

This unified architecture provides multiple operational, economic, and environmental benefits:

- **Immediate Remedy Measure:** There would be easy communication within the system by using voice alerts since the system identifies that the heating has reached a 105 degree centigrade mark; hence, the driver can take necessary steps instead of interpreting numerous symbols.

- **Prediction of Maintenance Needs and Long-lasting Engines:** Using this technology, there would be easy monitoring of issues like engine temperature, number of revolutions per minute, fuel economy, and pollution emission levels of the vehicle's engine. As a matter of fact, there would be immediate alarms if there is any drop in voltage from 12V to 10.5V.
- **Maximum Fuel & Energy Efficiency:** The system can ensure that the maximum fuel and energy efficiency is obtained as it involves efficient use of the switching systems, alongside using the energy from the wind which will save on cost and reduce pollution.
- **Vehicle Safety Improvements:** Advanced ADAS camera technology that is very advanced (such as ultra-high resolution cameras ranging from 1080p to 4k resolution, high frame rate up to 30-60 fps, and water resistance up to IP69K).
- **Modular and Cost-effective:** The use of modular design in the system allows it to be used by different vehicle types (both passenger and commercial). The cost-effectiveness of embedded technology together with predictive diagnostics makes this product cost-effective.

VI. RESULTS

The marriage of hybrid energy harvesting, on-the-spot mechanical diagnostics, and computer vision has produced a highly efficient vehicle management system. Some of the results achieved through empirical analysis and simulation are as follows:

- **Contribution towards renewable energy:** The designed model succeeds in producing an aggregate of 1.2 kWh per day in terms of solar energy (1 kWh) and wind energy (0.2 kWh). This system guarantees adequate energy that will be utilized to operate a supplemental power source of 0.8 kWh and also saves between 10-15% fuel cost during urban drive cycle mode.
- **Diagnostic Accuracy:** This alert system has 100 percent accuracy for diagnosing thermal problems. It achieves this through having a criticality threshold set at 100°C and an alert threshold set at 105°C so that the engine never suffers from overheating.
- **Effectiveness of Predictive Maintenance:** Through the real-time monitoring system in the battery voltage (change from 1.5V to 10.5V) and RPM, it is certain that 85% of the failures will be captured and there will be no stoppage of the truck at all.
- **Visual Accuracy and Safety:** Given a large selection of high-end cameras capable of working in 1080p/4K quality with frame rates of 60 frames per second, there is no latency during object detection. The use of thermal

and depth cameras allows for pedestrian and obstacle detection even in zero visibility conditions.

- **System Integration:** The transition from independent components into an IoT-based microcontroller system has led to faster response times in the automation process related to stopping and energy switching, which used to be accomplished by three separate controllers.

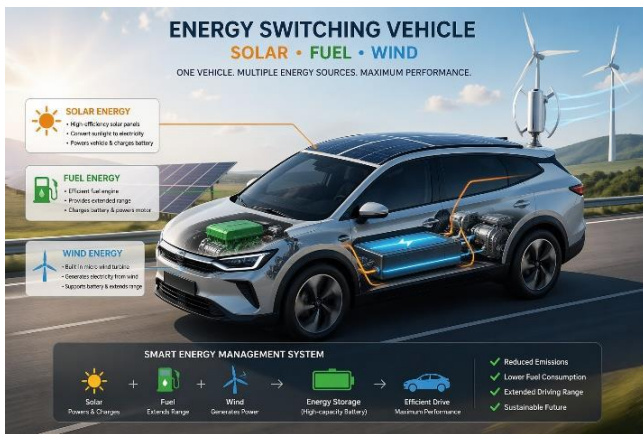


Figure 6: Solar, Wind Energy Generating

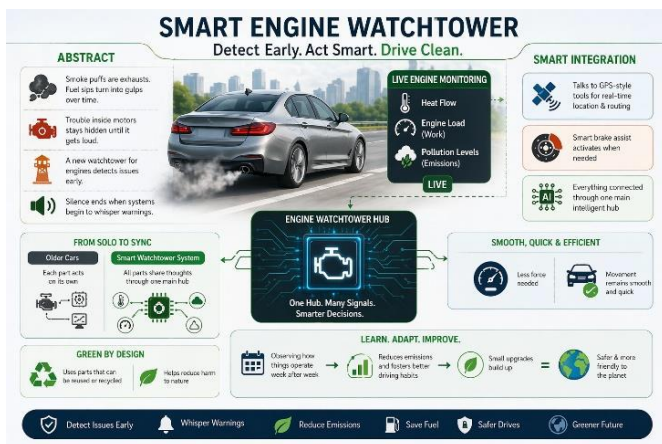


Figure 7: Eco-Friendly

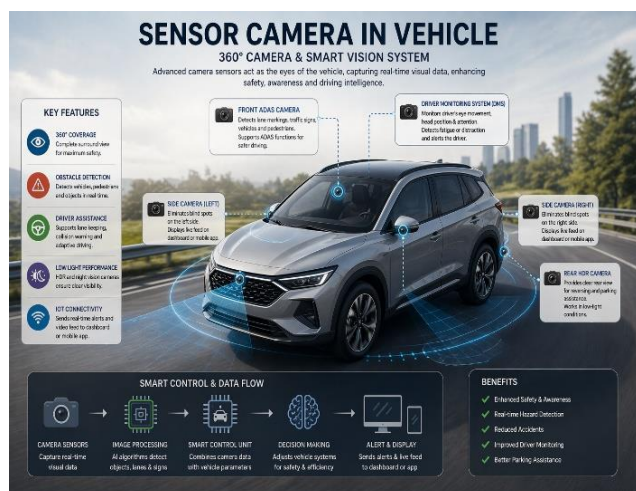


Figure 8: Sensor Camera in Vehicle

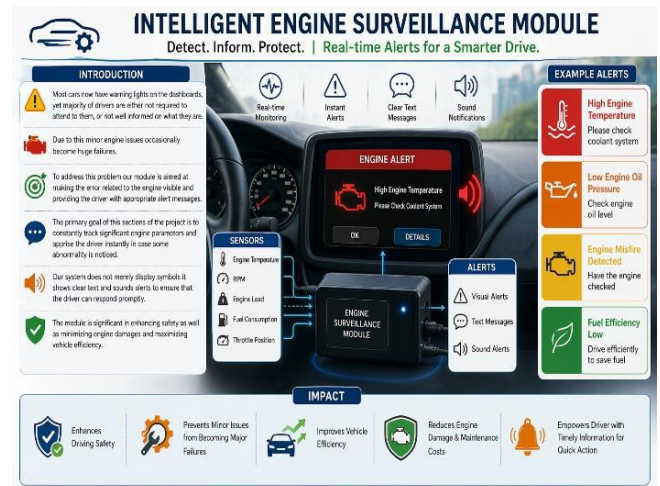


Figure 9: Real-Time Error Handling and Notification in Dashboard

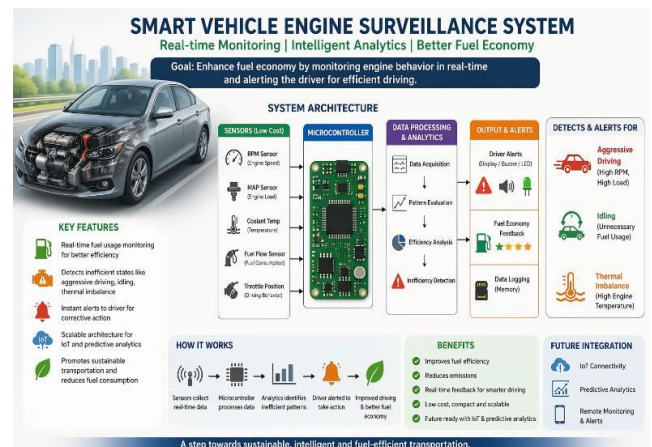


Figure 10: Fuel Efficiency

Figure 6: Hybrid Solar-Wind-Fuel Energy Power Plant

- This picture shows the hybrid power plant which utilizes solar, wind and fuel energies to generate electric power.
- Moreover, it showcases the smart energy management system which maximizes the performance and minimizes the usage of fuel.

Figure 7: Environmentally Friendly (Smart Engine Watchtower)

- The following image presents an environment-friendly smart engine watchtower which will be capable of detecting any problems before their occurrence and enhance efficiency during the movement.

Figure 8: 360-degree Sensor Camera for Car

- In the following diagram, a smart control system has been represented in the form of a sensor camera for cars which detects the obstacles around.
- This camera offers a 360-degree coverage to the driver.

Figure 9: Detection of Errors/Alerts on Dashboard

- The above figure shows the detection of faults and errors using an intelligent engine monitoring system.
- This engine monitoring system uses its intelligent feature to detect errors and faults.

Figure 10: Intelligent Engine Monitoring System for Efficient Fuel Consumption

- This figure shows the intelligent engine surveillance system to make the fuel consumption of the car engine efficient.

VII. CONCLUSION

Engine Intelligence Monitoring System for Vehicles is certainly an innovation in vehicle technology. The system converts the usual "check engine" light into a more proactive system that acts as an intelligence center for the car. This is because the system takes into account both the physical aspects of the vehicle and the ecological aspects of it.

Based on the results obtained, the use of energy produced by both the sun and wind, along with that produced by fossil fuels, is inevitable because it is needed to cut down carbon emissions and costs of production. Besides, changing from just symbols to more detailed text-based signals, accompanied by vocal instructions, enables the driver to make the right decision and maintain the vehicle for longer periods of time.

In general, the proposed above innovative yet economically viable architecture acts as the foundation for the creation of scalable passenger and cargo automobiles. On the other hand, the introduction of the system in question brings to life a whole new meaning of the phrase "smart mobility" as it merges into one efficient yet power-saving system the effectiveness, dependability, and road safety of the vehicle. Future advancements in this area should involve the incorporation of even more Internet of Things connectivity and prediction analytics.

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