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**GITAM School of Technology**

**Department of Electrical, Electronics and Communication Engineering**

**Capstone Project**

**Problem Statement: HEALTH MONITORING SYSTEM FOR AUTOMOBILES(ENGINE PARAMETERS) OR EV**

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**Under the Guidance of:**

**Duration:** 06/08/2024 to 22/10/2024

**DECLARATION**

**I/We declare that the project work contained in this report is original and it has been done by me under the guidance of my project guide.**

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**CERTIFICATE**

**This is to certify that (Student Name) bearing (Regd. No.:) has satisfactorily completed the Mini Project Entitled in partial fulfillment of the requirements as prescribed by the University for VIIIth semester, Bachelor of Technology in “Electrical, Electronics and Communication Engineering” and submitted this report during the academic year 2024-2025.**

**[Signature of the Guide] [Signature of HOD]**

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# **Chapter 1: Introduction**

The Health Monitoring System (HMS) for automobiles focuses on monitoring engine parameters to ensure vehicle efficiency, performance, and safety. Modern automobiles rely on such systems to detect potential failures before they become severe, improving the overall lifespan of the vehicle and reducing maintenance costs. This report delves into a monitoring system for both Diesel/Petrol engines and Electric Vehicle (EV) engines, utilizing sensors, microcontrollers, and cloud platforms to enable real-time data analysis and management.

## **Overview of the problem statement**

Automobiles today face challenges related to engine health management, requiring efficient monitoring systems for timely maintenance and optimal performance. With the integration of sensors, microcontrollers, and cloud-based solutions, it is possible to develop a real-time Health Monitoring System (HMS**)** for both Diesel/Petrol engines and Electric Vehicles (EV). This system ensures that key engine parameters are constantly tracked, allowing for preventive maintenance and improving safety and efficiency.

## **Objectives**

* Condition Of Engine(parameters- Engine RPM, Lub. Oil pressure, Fuel pressure, Coolant pressure, Lub. Oil temperature, Coolant pressure) or EV.
* Improve Vehicle Reliability and Safety
* Optimize Vehicle/Engine Performance and Efficiency
* Reduce Maintenance Costs
* Enhance Customer Satisfaction

**Goals**

**Main Goals**

* Reduce breakdowns, increase uptime, enhance driver safety, and minimize accident risks.
* Improve fuel efficiency, enhance engine performance, and reduce emissions.
* Enable predictive maintenance, optimize maintenance schedules, and reduce overall costs.
* Provide peace of mind, improve customer loyalty, and offer personalized maintenance recommendations.

**Additional Goals**

* Provide features that allow owners to remotely monitor and control their vehicles
* Incorporate technologies like autonomous emergency braking, lane departure warning, and blind spot monitoring.
* Use eco-friendly materials in vehicle construction.
* Offer personalized maintenance plans and services based on individual driving habits and preferences.

# Chapter 2: Literature Review

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| S.NO | Title | Author | Published Year | Publications | Abstract |
| 1. | Experimental analysis on battery based health monitoring system for electric vehicle | D. Selvabharathi⇑, N. Muruganantham | August 2020 | Department of EEE, Periyar Maniammai Institute of Science & Technology, Vallam, Thanjavur 613403, India | Electric vehicles are the future and the most important part of an electric vehicle is its battery which pro vides the power to the vehicle and also its weakest part. Batteries are prone to degradation, heating and general age related effects. So a constant monitoring system is required to keep the battery in check and keep the user posted about its various variables. This project provides a management system for a battery by monitoring various factors like main power voltage, cell voltage, etc. It includes monitoring cell con dition, states estimation, temperature control and heat management, all aimed at enhancing the overall performance of the system. This data is then acquired and sent to the cloud where it can be remotely accessed by the user or a common access point at any given situation and thus also thereby making removable battery station much more possible and reliable. |
| 2. | State of Charge, State of Health, and State of Function Monitoring for EV BMS | Zong-You Hou, Pang-Yen Lou, and Chua-Chin Wang | 2017 | In 2017 IEEE International Conference on consumer electronics  (ICCE) | The computation and monitoring of three key indi ces, namely, state of charge (SOC), state of health (SOH), and state of function (SOF) for EV (electrical vehicle) BMS (battery management system) are proposed in this work. Because most of SOC definitions are directly related to nominal capacity, the ac curacy of residual capacity is doubtful. Therefore, the SOC is re defined by present maximum capacity to reduce the error of the SOC estimation. The measurement of the proposed SOC demon strates that the maximum error is 0.334 %. Moreover, this paper also proposes SOF based on SOC and SOH to reveal the driving power of the system. |
| 3. | Automotive Internal-Combustion-Engine Fault Detection and Classification Using Artificial Neural Network Techniques | Ryan Ahmed, Mohammed El Sayed, S. Andrew Gadsden, Jimi Tjong, Saeid Habibi | JANUARY2015 | IEEETRANSACTIONS ONVEHICULARTECHNOLOGY,VOL.64,NO.1 | —In this paper, an engine fault detection and classifi cation technique using vibration data in the crank angle domain is presented. These data are used in conjunction with artificial neural networks (ANNs), which are applied to detect faults in a four-stroke gasoline engine built for experimentation. A com parative study is provided between the popular backpropagation (BP) method, the Levenberg–Marquardt (LM) method, the quasi Newton (QN) method, the extended Kalman filter (EKF), and the smooth variable structure filter (SVSF). The SVSF is a relatively new estimation strategy, based on the sliding mode concept. It has been formulated to efficiently train ANNs and is consequently re ferred to as the SVSF-ANN. The accuracy of the proposed method is compared with the standard accuracy of the Kalman-based f ilters and the popular BP algorithms in an effort to validate the SVSF-ANNperformance and application to engine fault detection and classification. The customizable fault diagnostic system is able to detect known engine faults with various degrees of severity, such as defective lash adjuster, piston chirp (PC), and chain tensioner (CT) problems. The technique can be used at any dealership or assembly plant to considerably reduce warranty costs for the company and manufacturer. |
| 4. | Predictive Maintenance of Motors using Machine Learning | Nithish Kanna J L Krishnakumar G, Muhammad Aadhil M, Dr. Ajay V P | Issue 4 April 2024 | Department of Electronics & Communication Engineering, Kumaraguru College of Technology | The suggested predictive maintenance system makes use of sensor readings, operating conditions, and failure incidences from previous motor operation data. Machine learning models are trained on a large dataset, which enables them to identify patterns and correlations suggestive of possible motor breakdowns. A variety of algorithms are used to build a strong prediction model, including ensemble approaches, neural networks, and support vector machines. By continuously analysing real time data from motors, the predictive maintenance model can identify possible flaws before they become serious failures. Because of this, maintenance teams may plan interventions during scheduled downtime, maximising the use of available resources and reducing unforeseen outages. By extending the lifespan of motors and lowering maintenance costs, the application of this predictive maintenance strategy supports overall sustainability initiatives. |

# **Chapter 3: Strategic Analysis and Problem Definition**

# **3.1 SWOT Analysis**

**Strengths:**

* **Advanced sensor technology:** The availability of accurate and reliable sensors for measuring engine parameters.
* **Data analytics capabilities:** The ability to process and analyze large amounts of data to identify patterns and anomalies.
* **Predictive maintenance potential:** The potential to prevent breakdowns and reduce maintenance costs through early detection of issues.
* **Improved safety:** The ability to identify and address potential safety hazards related to engine malfunctions.
* **Enhanced customer satisfaction:** The potential to improve customer satisfaction by providing peace of mind and reducing vehicle downtime.

**Weaknesses:**

* **Data privacy concerns:** The collection and storage of sensitive vehicle data raises privacy concerns.
* **Complexity of integration:** Integrating a health monitoring system with existing vehicle electronics can be complex.
* **Dependency on technology:** The system's effectiveness relies on the reliability and accuracy of sensors and data analytics algorithms.
* **Potential for false positives or negatives:** The system may generate false alarms or fail to detect certain issues.

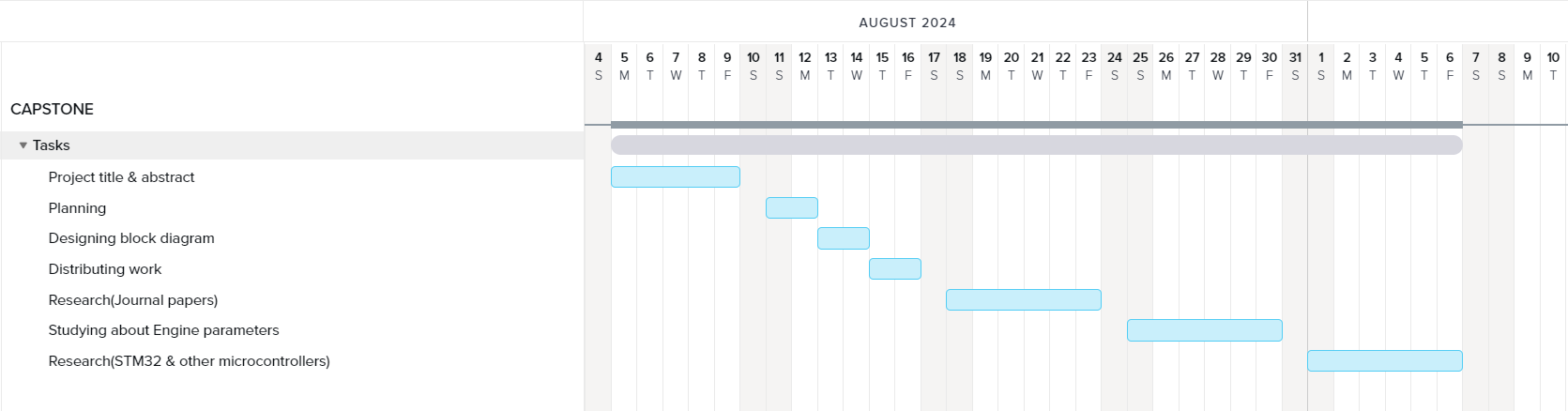
**Opportunities:**

* **Growing demand for connected vehicles:** The increasing popularity of connected vehicles presents opportunities for integrating health monitoring systems with other vehicle features.
* **Advancements in machine learning:** Improvements in machine learning algorithms can enhance the accuracy and reliability of predictive maintenance models.
* **New business models:** The development of new business models based on health monitoring data, such as usage-based insurance or predictive maintenance services.
* **Regulatory requirements:** The increasing emphasis on vehicle safety and emissions regulations may drive the adoption of health monitoring systems.

**Threats:**

* **Competitive pressures:** The emergence of competing technologies or business models may erode the market position of health monitoring systems.
* **Economic downturns:** Economic downturns may reduce consumer demand for advanced vehicle features, including health monitoring systems.
* **Regulatory changes:** Changes in regulations or standards may impact the design and implementation of health monitoring systems.

### **3.2 Project Plan - GANTT Chart**



##### **3.3 Refinement of problem statement**

The challenge is to develop a unified, IoT-based Health Monitoring System for automobiles that can continuously capture, transmit, and analyze critical engine parameters for both traditional Diesel/Petrol engines and electric vehicle engines. This system should leverage a combination of sensors, microcontrollers, cloud computing, and real-time data visualization to provide continuous feedback on engine health. The system should be designed to:

1. Offer real-time, accurate monitoring of engine parameters such as temperature, pressure, vibration (for ICE), and current, voltage, and thermal readings (for EVs).
2. Use cloud-based data storage and analytics for predictive maintenance, enabling early detection of potential issues.
3. Be scalable, adaptable, and energy-efficient, ensuring that it works seamlessly with both ICE and EV platforms.
4. Provide users (drivers, fleet managers) with a simple, intuitive dashboard that presents actionable insights into engine health, along with alerts for abnormal conditions.

### **4.2 Tools and techniques utilised**

**Sensors**

1. **Temperature Sensors**:
   * **Purpose**: Measure the temperature of the environment or specific objects.
   * **Common Types**: Thermocouples, thermistors, and digital temperature sensors (like DS18B20).
   * **Applications**: Used in HVAC systems, smart agriculture, and weather stations to monitor conditions and optimize performance.
2. **Pressure Sensors**:
   * **Purpose**: Measure the pressure of gases or liquids.
   * **Common Types**: Strain gauge, piezoelectric, and capacitive sensors.
   * **Applications**: Utilized in industrial processes, weather forecasting, and automotive applications to ensure safe operation and efficiency.
3. **Current Sensors**:
   * **Purpose**: Monitor electrical current flow in a circuit.
   * **Common Types**: Hall effect sensors, shunt resistors, and current transformers.
   * **Applications**: Essential for energy management, smart grids, and battery monitoring in IoT devices to prevent overload and optimize energy usage.

**Microcontrollers**

1. **ESP32**:
   * **Overview**: A powerful microcontroller with built-in Wi-Fi and Bluetooth capabilities.
   * **Advantages**: Offers higher processing power, integrated sensors, and low power consumption, making it suitable for IoT applications that require connectivity.
   * **Use Cases**: Ideal for projects requiring real-time data processing, such as smart home devices, wearable technology, and industrial automation.
2. **Arduino**:
   * **Overview**: An open-source platform with a wide range of microcontrollers suitable for various projects.
   * **Advantages**: Easy to program and use, with a vast community and extensive libraries available for different sensors and modules.
   * **Use Cases**: Perfect for prototyping and educational purposes, including robotics, environmental monitoring, and interactive art installations.

**Communication Protocol**

1. **MQTT (Message Queuing Telemetry Transport)**:
   * **Purpose**: A lightweight messaging protocol optimized for low-bandwidth and high-latency networks.
   * **Advantages**: Supports publish/subscribe architecture, making it easy to scale IoT applications and facilitate communication between devices and servers.
   * **Use Cases**: Widely used in remote monitoring systems, smart homes, and industrial applications for sending telemetry data efficiently.

**Cloud Database**

1. **AWS IoT**:
   * **Overview**: A cloud platform that enables secure communication between IoT devices and the cloud.
   * **Features**: Provides tools for device management, data storage, and analytics, allowing for real-time insights and actions.
   * **Use Cases**: Suitable for large-scale IoT deployments, including smart cities and connected vehicles.
2. **Google Cloud**:
   * **Overview**: Offers various services tailored for IoT, including data processing, machine learning, and storage.
   * **Features**: Integrates well with other Google services and provides robust data analytics and visualization tools.
   * **Use Cases**: Ideal for applications requiring data-driven insights, such as predictive maintenance and intelligent automation.

**Visualization**

1. **Node-RED**:
   * **Overview**: A flow-based development tool for visual programming that enables users to wire together devices, APIs, and online services.
   * **Advantages**: Provides a user-friendly interface for creating dashboards and monitoring IoT data in real-time without extensive programming knowledge.
   * **Use Cases**: Commonly used for building custom dashboards, automating workflows, and integrating various IoT components seamlessly.

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#### **4.3 Design considerations**

The system was designed to be scalable, flexible, and secure. Special attention was paid to ensuring low power consumption for microcontroller operations and data transmission reliability even in low-bandwidth environments.

# **Chapter 5: Implementation**

## **Description of how the project was executed**

The health monitoring system for automobile engines was implemented in distinct, systematic phases to ensure a smooth and efficient workflow. Here is a detailed breakdown of the implementation:

* **Phase 1: Hardware Selection and Procurement**  
  In this phase, appropriate sensors and microcontrollers were selected for both Diesel/Petrol (ICE) and Electric Vehicle (EV) engines. The sensors included temperature sensors, pressure sensors, and vibration sensors for ICE, and current, voltage, and thermal sensors for EV engines. The microcontroller (such as Arduino or ESP32) was chosen based on the compatibility with the sensors and the ability to transmit data efficiently.
* **Phase 2: Sensor Integration and Data Acquisition Setup**  
  The selected sensors were integrated with the microcontroller through proper interfacing techniques. For example, analog signals from temperature or vibration sensors were converted to digital signals using Analog-to-Digital Converters (ADCs) where necessary. Microcontroller firmware was programmed to collect data from each sensor at regular intervals, ensuring the system could capture real-time engine performance data.
* **Phase 3: Network Setup and Communication Protocol Implementation (MQTT)**  
  Once the data acquisition system was set up, the MQTT (Message Queuing Telemetry Transport) protocol was implemented for efficient data transmission. The microcontroller, connected via Wi-Fi or cellular network, was programmed to publish data from the sensors to an MQTT broker, enabling real-time transmission to the cloud database.
* **Phase 4: Cloud Storage and Data Handling**  
  The cloud database was set up using a service like Firebase or AWS to store the large volume of data collected by the sensors. The database was structured to allow fast retrieval and analysis of engine parameters. A backup mechanism was also implemented to prevent data loss during periods of poor connectivity.
* **Phase 5: Real-Time Data Visualization using Node-RED**  
  The Node-RED platform was used to design a custom dashboard for visualizing engine health metrics. Different parameters such as engine temperature, pressure, and vibrations (for ICE) or battery status, current, and voltage (for EVs) were graphically represented in real time. Alerts and notifications were set up in the dashboard to flag anomalies and abnormal engine conditions.
* **Phase 6: Testing and Debugging**  
  The system was subjected to rigorous testing in both ICE and EV environments. Data accuracy, latency, and system stability were evaluated, and any errors were debugged. Tests were conducted in various scenarios, including different engine loads, speeds, and environmental conditions, to ensure robustness.

### **Challenges faced and solutions implemented**

**Challenge 1: Sensor Calibration and Accuracy Issues**

**Solution:**  
Sensors, especially those monitoring engine parameters like temperature and pressure, occasionally provided inaccurate readings due to external environmental conditions. To solve this, recalibration of sensors was carried out using reference values under controlled conditions. Additionally, error-correction algorithms were implemented in the microcontroller’s firmware. This involved averaging the data across multiple sensor readings and applying a smoothing filter to minimize noise and inconsistencies.

**Challenge 2: Maintaining Stable Connectivity in Motion**

**Solution:**  
Vehicles in motion experienced connectivity issues, especially in areas with poor cellular coverage. To address this, the microcontroller was programmed with a local data buffering mechanism. In this approach, data was stored temporarily on the microcontroller during periods of network outages. Once the connection was re-established, the buffered data was transmitted to the cloud database in batches, ensuring no data was lost. This also allowed for continuous monitoring even in areas with intermittent network access.

**Challenge 3: Data Synchronization Across Multiple Sensors**

**Solution:**  
The system involved multiple sensors capturing different parameters at varying frequencies, which caused issues with data alignment. To solve this, a timestamp-based data synchronization method was employed. Each data point from the sensors was tagged with a precise timestamp, allowing the data from different sensors to be aligned in the cloud database. This ensured that analysis and visualization tools could correlate readings from various sensors correctly and avoid inconsistencies.

**Challenge 4: Power Consumption in EVs**

**Solution:**  
Since energy efficiency is crucial for electric vehicles, the additional power draw from the health monitoring system was a concern. To mitigate this, the system utilized low-power microcontrollers like ESP32 and employed energy-efficient components. The sensors were programmed to operate in low-power modes when the engine was idle or when certain parameters were stable. This significantly reduced the power consumption while still providing accurate data during critical engine operation phases. The microcontroller also employed sleep cycles, waking only when data needed to be transmitted or processed, further saving battery life.

# **Chapter 6:Results**

**6.1 Outcomes**

The project successfully demonstrated that both Diesel/Petrol engines and EV engines could be monitored in real time using a unified IoT-based system. The system was capable of providing continuous updates on key engine parameters and flagged potential issues such as overheating or abnormal vibrations, allowing for timely interventions. Specific results included:

* For ICE: Accurate detection of oil pressure drops, excessive engine temperature, and irregular vibrations.
* For EV: Monitoring of battery voltage, current, and overall battery health, which were critical for electric engine performance.

**6.2 Interpretation of Results**

The real-time data collection and monitoring led to significant improvements in predictive maintenance. The system allowed vehicle owners to detect early warning signs of engine problems, reducing the risk of costly repairs or unexpected breakdowns. The data analysis also showed that the system was sensitive enough to detect even small variations in engine parameters that could have long-term effects on engine health.

**6.3 Comparison with Existing Literature or Technologies**

When compared with traditional offline diagnostic tools, this system offered clear advantages:

* **Real-Time Monitoring**: Unlike standard diagnostics performed during servicing, this system provided continuous monitoring.
* **Predictive Maintenance**: Leveraging the continuous data stream, the system allowed for predictive maintenance, reducing unplanned downtime.
* **Cloud Connectivity**: Existing solutions often stored data locally. This system’s use of cloud storage enabled remote access, better scalability, and integration with big data analytics tools.

# **Chapter 7: Conclusion**

The development and implementation of the health monitoring system for automobiles, applicable to both ICE and EV engines, proved to be an innovative solution in the automotive industry. By integrating advanced IoT technologies, cloud computing, and real-time data visualization, the system provided comprehensive monitoring of engine health. The system can detect anomalies early, ensuring the longevity of engine components and reducing the need for sudden repairs. Furthermore, the system's ability to gather vast amounts of data can lead to improved analytics and, eventually, predictive maintenance.

The project demonstrated that IoT-based solutions are highly effective in solving complex problems related to vehicle health and maintenance. This system can be expanded and refined further to enhance its effectiveness and applicability to other vehicle systems and components.

# **Chapter 8: Future Work**

There is considerable potential to expand and refine the current system:

* **Expansion to Other Vehicle Systems**: Beyond engine health, future versions of the system could monitor other critical components such as the transmission, braking system, and suspension, providing a more holistic approach to vehicle health monitoring.
* **Integration with Machine Learning**: By applying machine learning algorithms, the system could be developed to predict future engine failures based on historical data trends. This predictive capability would enable more proactive maintenance and reduce unexpected vehicle breakdowns.
* **Enhanced Security Protocols**: Given the sensitive nature of cloud-stored vehicle data, future work should focus on improving the security of data transmission and storage. This includes implementing encryption, secure authentication, and regular audits of the system's security infrastructure.
* **Mobile Application Integration**: Developing a mobile app that interfaces with the Node-RED dashboard would make it easier for vehicle owners or fleet managers to monitor vehicle health remotely and receive alerts in real time.
* **Energy Efficiency**: For EVs, reducing the power consumption of the monitoring system itself should be a priority to ensure it doesn’t adversely impact the vehicle’s overall efficiency.

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