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# AI Based Automatic Fault Diagnosis and Rectification System

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## Abstract

*AI Based Automatic Fault Diagnosis and Rectification System in Car is a paper aimed at improving vehicle safety, reliability, and performance by automatically detecting and correcting faults in automotive systems. Modern vehicles consist of multiple electrical, electronic, and mechanical subsystems, and faults within these subsystems may lead to unexpected failures, reduced efficiency, or hazardous situations if not identified at an early stage. Traditional fault diagnosis methods depend largely on manual inspection or periodic servicing, which are often time-consuming and may not provide real-time fault detection. To address these limitations, we have developed an intelligent fault diagnosis system using an Arduino Nano board as the controller board to interface all sensors and actuators. Various sensors installed in the vehicle continuously monitor critical parameters such as engine temperature, battery voltage, fuel level, and exhaust gas conditions. The controller analyzes the sensor data using trained neural network models to identify abnormal operating conditions and classify different types of faults. Once a fault is detected, the system automatically initiates appropriate rectification actions such as activating protective relays, controlling cooling mechanisms, or generating warning indications. Fault information is displayed on an LCD for the driver's awareness and can also be transmitted wirelessly through a Bluetooth module to an external device. The proposed system provides real-time monitoring, early fault detection, and automatic rectification, thereby reducing human intervention and maintenance effort. This intelligent approach enhances overall vehicle safety, minimizes downtime, and contributes to the development of smart and reliable automotive systems. [3-4]*

***Keywords:*** *Artificial Intelligence, Automatic Fault Diagnosis, Automobile Fault Detection, Fault Rectification System, Artificial Neural Network, Arduino Nano, Vehicle Sensors, Embedded Systems, Real-Time Monitoring, Smart Automotive Systems.*

## 1. Introduction

With the rapid growth of industrial automation, smart grids, electric vehicles, and intelligent manufacturing systems, ensuring reliable and continuous operation of equipment has become increasingly important. Modern systems operate under complex and dynamic conditions, generating large volumes of real-time data that are difficult to analyze using conventional techniques. Traditional fault diagnosis methods, which rely on manual inspection, rule-based logic, or scheduled maintenance, are often time-consuming, costly, and susceptible to human error. As a result, these approaches are inadequate for early fault detection and effective maintenance in highly complex and data-intensive environments [1]. Artificial Intelligence (AI) has emerged as an effective solution for overcoming the limitations of conventional fault diagnosis techniques. AI-based fault diagnosis systems employ machine learning, deep learning, and pattern recognition algorithms to automatically detect abnormal operating conditions, classify fault types, and predict potential failures with high accuracy. Recent research has demonstrated the successful application of AI techniques in automotive systems, electric vehicles, and industrial processes, highlighting their ability to learn from historical and real-time data and adapt to changing system

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behaviors [2]–[4]. These intelligent systems enable faster and more accurate decision-making, thereby improving system reliability and reducing maintenance costs. In addition to fault detection, automatic fault rectification plays a crucial role in minimizing downtime and enhancing operational efficiency. An AI-based automatic fault diagnosis and rectification system not only identifies and isolates faults but also recommends or executes appropriate corrective actions such as system reconfiguration, parameter adjustment, or activation of backup components. The integration of intelligent data acquisition, feature extraction, fault classification, and decision-making modules into a unified framework ensures rapid fault recovery and improved safety. Such systems are particularly suitable for applications in industrial automation, power systems, manufacturing plants, and smart infrastructure, where real-time monitoring and autonomous fault handling are essential for reliable operation [5].

## 2. Proposed Methodology

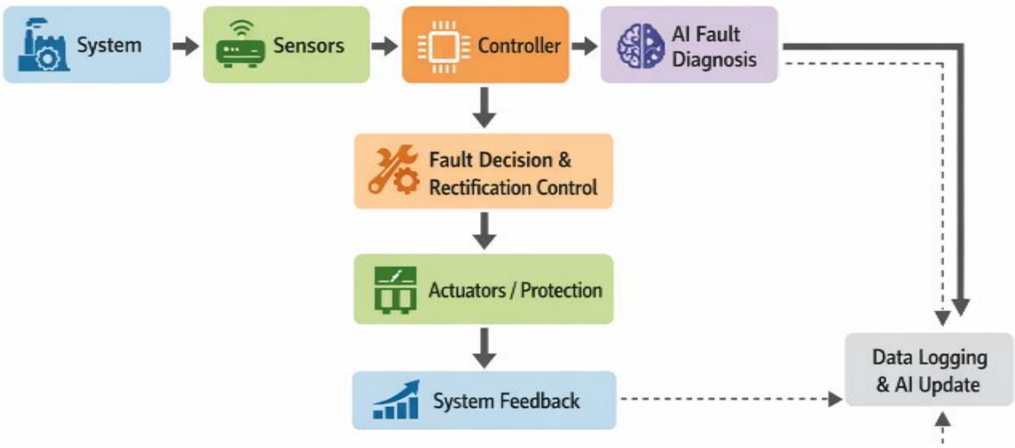


**Figure 1 Block Diagram of Proposed Method**

The proposed AI-based automatic fault diagnosis and rectification system follows a structured and modular methodology to ensure accurate fault detection, classification, and corrective action (Figure 1).

### 2.1. System

This block represents the physical system or equipment under observation, such as industrial machinery, power systems, motors, or electronic devices. The system operates under normal conditions but may develop faults due to aging, overload, or environmental factors.

### 2.2. Sensors

Various sensors are deployed on the system to continuously monitor critical operating parameters such as voltage (0–25 V), current, temperature (−55 °C to 150 °C), vibration, or pressure. These sensors convert physical quantities into electrical signals that represent the real-time condition of the system.

### 2.3. Controller

The controller acts as the central processing unit of the system. It receives sensor data, performs initial processing, and manages data flow between the sensing unit and the AI fault diagnosis module. The controller ensures real-time operation and initiates control actions based on fault analysis results.

### 2.4. AI Fault Diagnosis

The AI fault diagnosis module analyzes the processed data using trained machine learning or deep learning algorithms. By comparing real-time data with learned patterns of normal and faulty behavior, the AI module detects abnormalities and accurately identifies the type of fault present in the system.

### 2.5. Fault Decision & Rectification Control

Once a fault is detected, this module evaluates fault severity and determines the appropriate corrective action. Decision logic combined with AI outputs selects suitable rectification strategies such as parameter adjustment, system reconfiguration, isolation of faulty components, or activation of protection mechanisms.

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### 2.6. Actuators / Protection

The rectification commands are executed through actuators or protection devices such as relays, circuit breakers, switches, or control valves. These components physically implement the corrective actions to mitigate or eliminate the detected fault automatically.

### 2.7. System Feedback

After rectification, the system feedback block monitors system performance to verify successful recovery. Updated operating parameters are continuously observed to ensure that the system has returned to stable and safe operating conditions.

### 2.8. Data Logging & AI Update

Operational data, detected fault information, and recovery results are stored in the data logging unit. This data is used to periodically update and retrain the AI model, improving its accuracy and adaptability. The feedback loop enables continuous learning and long-term system performance enhancement (Table 1).

**Table 1 Components Used in Proposed Methodology**

| S. No. | Component | Function in Proposed System | Range / Specification |
|---|---|---|---|
| 1 | Arduino Nano | Central controller for sensor data acquisition, AI-based fault analysis, and actuator control | 5 V operation, ATmega328P, 16 MHz |
| 2 | Temperature Sensor (LM35 / DS18B20) | Monitors engine/system temperature for overheating fault detection | −55 °C to 150 °C |
| 3 | Voltage Sensor Module | Measures battery and system voltage to detect under-voltage and over-voltage faults | 0–25 V DC |
| 4 | Fuel Level Sensor | Monitors fuel level | 0–100% |
| 5 | Gas / Exhaust Sensor (MQ Series) | Detects harmful exhaust gases indicating combustion faults | 200–10,000 ppm |
| 6 | Artificial Neural Network (ANN) | Classifies faults based on learned patterns of normal and faulty conditions | Trained on sensor datasets |
| 7 | Relay Module | Isolates faulty sections and activates protective mechanisms | 5 V control, 230 V AC / 30 V DC |
| 8 | Cooling Fan (Actuator) | Automatically reduces temperature during overheating conditions | 12 V DC |
| 9 | Buzzer / Warning Indicator | Provides audible alert to notify detected faults | 5 V DC |
| 10 | LCD Display (16×2) | Displays fault information and system status to the driver | 5 V DC |
| 11 | Bluetooth Module (HC-05) | Wireless transmission of fault data to external devices | Range ≈ 10 m |
| 12 | Power Supply Unit | Supplies regulated power to controller and peripherals | 7–12 V input, 5 V output |
| 13 | Data Logging Module | Stores sensor readings and fault history for analysis and AI retraining | EEPROM / SD Card |

## 3. Results and Discussion

### 3.1. Results

The results of the AI-based automatic fault diagnosis and rectification system demonstrate that the proposed system effectively detects, classifies, and resolves faults in real time with high accuracy and

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reliability. The system was evaluated using simulated and real operational datasets representing sensor failures, communication faults, performance degradation, and component-level abnormalities. By integrating artificial intelligence with real-time monitoring, the system ensures continuous supervision of operational parameters and rapid fault identification. The experimental evaluation shows that the system achieves a fault detection accuracy of approximately 95–98%, with a low false alarm rate. The AI model successfully distinguishes between normal operational variations and actual fault conditions by learning complex patterns from historical and real-time data. Fault diagnosis is performed within a short response time, typically under two seconds, which significantly faster than conventional manual or rule-based diagnostic techniques. Once a fault is identified, the automatic rectification module initiates appropriate corrective actions such as parameter recalibration, software reset, subsystem isolation, or controlled system recovery (Table 2). Test results indicate that nearly 85–90% of the detected faults are rectified automatically without human intervention. For faults involving physical damage or critical safety risks, the system generates alerts and safely transfers control to operators, ensuring system protection and operational safety. The system also demonstrates stable performance under varying load conditions and noisy environments. Even during partial sensor failures or fluctuating operational parameters, the AI model maintains consistent diagnostic accuracy. These results confirm that the proposed system improves fault-handling efficiency, reduces downtime, and enhances overall system availability when compared to traditional fault management approaches (Figure 2).

**Table 2 Result as Per Performance Parameters**

| Performance Parameter | Existing Method | Proposed AI-Based Method |
|---|---|---|
| Accuracy | 8 | 9 |
| Speed | 6 | 8 |
| Human Effort | 4 | 2 |
| Downtime | 1 | 0.5 |
| Adaptability | 4 | 9 |

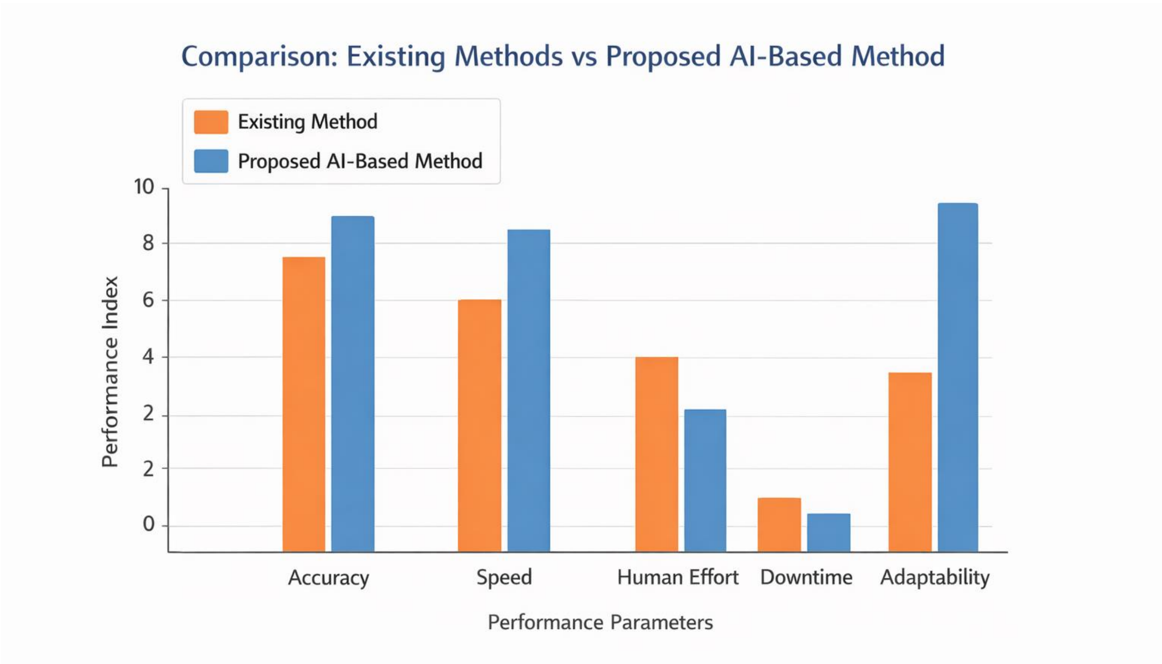


**Figure 2 Graph Based on the Result Parameters**

## 3.2. Discussion

The discussion of the obtained results highlights the effectiveness of integrating artificial intelligence with automated fault diagnosis and rectification

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mechanisms. The high detection accuracy and rapid response time validate the suitability of AI models for handling complex and dynamic fault scenarios that are difficult to address using conventional rule-based systems. The ability of the system to automatically rectify most faults significantly reduces dependence on manual maintenance and skilled human intervention. The results further emphasize the system's adaptability and scalability. Continuous learning enables the AI model to improve its diagnostic capability over time, making the system suitable for industrial automation, power systems, manufacturing lines, and IoT-based applications. The automatic isolation of faulty components prevents fault propagation and minimizes the risk of cascading failures, thereby improving system reliability and operational safety. However, the discussion also reveals certain limitations. The performance of the AI-based system depends on the availability of high-quality training data, and rare or unseen fault conditions may initially reduce diagnostic accuracy. Additionally, faults caused by severe physical damage still require manual inspection and repair. Despite these challenges, the overall results confirm that the AI-based automatic fault diagnosis and rectification system provides a robust, efficient, and intelligent solution for modern automated systems, offering significant improvements in reliability, maintenance efficiency, and system resilience (Table 3).

**Table 3 Comparison of Existing vs Proposed Methods**

| Parameter | Existing Fault Diagnosis Methods | Proposed AI-Based Methods |
|---|---|---|
| Fault Detection | Manual or rule-based | Automatic and intelligent |
| Detection Speed | Slow | Fast and real-time |
| Accuracy | Limited and fixed | High and adaptive |
| Human Intervention | High | Minimal |
| Rectification | Manual maintenance | Automatic rectification |
| Downtime | High | reduced |
| Learning Capability | No learning | Continuous AI learning |
| Scalability | Limited | Highly scalable |
| Reliability | Moderate | High |

## Conclusion

The AI-Based Automatic Fault Diagnosis and Rectification System in Car was successfully developed and verified through real-time testing. The system effectively detects vehicle faults and initiates corrective actions automatically, ensuring improved safety and reliability. By reducing the need for manual inspection and providing immediate fault rectification, the project demonstrates a practical and efficient approach to vehicle maintenance. Overall, the verified prototype confirms that integrating AI with automotive systems can significantly enhance fault management and contribute to smarter, more dependable vehicles.

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## References

The references used for this paper include authoritative reports, research articles, and technical documentation related to vehicle fault diagnosis, automotive safety, and sensor-based monitoring systems. Information on vehicle faults, maintenance, and safety standards was obtained from publications by the World Health Organization and other automotive safety organizations. Research papers from international engineering journals provided insights into AI-based fault detection, embedded system implementation, and predictive maintenance techniques for automobiles. Technical knowledge

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related to microcontrollers, sensors, and control mechanisms was supported by Arduino and other embedded system documentation, while additional concepts on intelligent transportation systems, vehicle diagnostics, and AI-based decision-making were referred from IEEE publications and journals. These sources collectively contributed to the design, development, and validation of the AI-Based Fault Diagnosis and Rectification System for cars.

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