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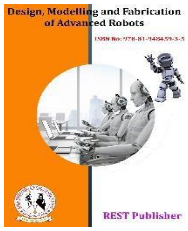

Development of Machine Monitoring System using IOT

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Abstract: *In modern industrial environments, real-time monitoring of machinery is essential to ensure safety, prevent breakdowns, and maintain optimal performance. This project proposes an Io T-based Machine Monitoring System integrating various sensors and actuators to automate and enhance the monitoring process. The system comprises a DHT11 temperature and humidity sensor, a vibration sensor, a gas sensor, a Peltier module, a motor, and an alarm buzzer, all controlled via a micro-controller connected to the Internet of Things (IoT) network. The DHT11 sensor continuously monitors the ambient temperature. When the temperature exceeds a defined threshold, the Peltier module activates in cooling mode; conversely, if the temperature falls below a lower threshold, the module operates in heating mode, maintaining optimal thermal conditions for machine operation. The vibration sensor detects abnormal vibrations, which may indicate mechanical faults. An increase in vibration levels triggers the system to reduce the motor speed, preventing further damage. Additionally, the gas sensor monitors for the presence of hazardous gases. If gas levels rise above safe limits, the alarm buzzer is activated to alert operators of potential danger. This integrated system enhances machine safety, reduces downtime, and provides a proactive approach to maintenance through real-time data acquisition and automated responses. The use of IoT enables remote monitoring and alerts, making the system scalable and adaptable for various industrial applications.*

1. INTRODUCTION

In modern industrial environments, the efficiency, reliability, and safety of machinery are critical for maintaining production quality and operational continuity. Traditionally, machine monitoring and maintenance activities have relied on periodic manual inspections and operator experience. However, such methods are often time-consuming, prone to human error, and incapable of detecting faults in real time. The emergence of the Internet of Things (IoT) has revolutionized industrial automation by enabling continuous, remote, and data-driven monitoring of machines.

A Machine Monitoring System using IoT integrates sensors, microcontrollers, and wireless communication technologies to collect and transmit real-time data from machines to a centralized monitoring platform. Parameters such as temperature, vibration, motor current, speed, and operating hours can be continuously tracked to assess machine health and performance. The system alerts operators whenever abnormal readings or fault conditions are detected, allowing for predictive maintenance and reducing unexpected downtime. By leveraging IoT platforms and cloud computing, this system enables data visualization, analytics, and remote control, supporting the principles of Industry 4.0 and smart manufacturing. The collected data not only improves maintenance efficiency but also helps optimize energy usage, enhance productivity, and extend machine lifespan through informed decision-making. The proposed IoT-based machine monitoring system thus provides an intelligent, scalable, and cost-effective solution for industrial automation. It bridges the gap between physical machinery and digital analytics, contributing to the transformation toward smart factories with higher reliability, reduced operational costs, and improved safety standards.

2. LITERATURE REVIEW

The integration of IoT into machine condition monitoring has evolved from simple remote telemetry to advanced, closed-loop predictive maintenance systems that combine sensing, edge processing, and cloud analytics. Modern systems continuously capture vibration, temperature, current, and acoustic signals and convert them into actionable maintenance decisions, reducing unplanned downtime and maintenance costs. Recent reviews and surveys document a rapid growth in IoT predictive-maintenance research and industry deployments from 2018 onward. Vibration measurement remains the principal non-invasive technique for detecting faults in rotating machinery (bearings, shafts, gears), often complemented by motor current signature analysis (MCSA), temperature, and acoustic emission sensors. Works emphasize careful sensor selection, proper mounting, and preprocessing (filtering, FFT, envelope analysis) to extract fault-indicative features. Several systematic reviews outline best practices for vibration sensing and feature extraction for reliable fault detection. System architectures vary from simple cloud-centric pipelines to hybrid edge–cloud designs. Edge computing (on-device or gateway) is increasingly favored to perform real-time signal processing and run light ML models, thereby reducing latency, bandwidth use, and false alarms before forwarding summarized insights to the cloud. Recent studies illustrate edge-AI frameworks and modular sensor platforms that improve responsiveness and scalability in industrial settings. The Machine learning (traditional classifiers, ensemble methods) and deep learning (CNNs, LSTMs) are widely applied for anomaly detection, fault classification, and remaining-useful-life (RUL) estimation. Publications show ensemble and hybrid models often outperform single techniques on streaming industrial data; however, they also note challenges such as limited labeled failure data and concept drift in non-stationary environments. Novel approaches combine unsupervised clustering for anomaly detection with supervised models when labeled examples become available. The Multiple industry case studies and prototypes demonstrate significant gains (reduced downtime, earlier detection of faults) when IoT monitoring and predictive algorithms are applied to motors, pumps, and rotating equipment. Implementations commonly use MQTT/HTTP for telemetry, cloud dashboards for visualization, and mobile/alerting integrations for maintenance teams. Real deployments emphasize engineering details — sensor placement, ruggedization, and integration with existing CMMS (computerized maintenance management systems). Based on the surveyed literature, promising directions include: lightweight edge algorithms for real-time anomaly filtering, hybrid feature representations that fuse vibration + current + temperature, data-efficient ML (few shot or transfer learning) for rare faults, and engineering solutions for sensor calibration and robust mounting. Your proposed system can contribute by demonstrating an end-to-end prototype that addresses one or more of these gaps with empirical evaluation on realistic operating data.

3. SYSTEM DESIGN

The Machine Monitoring System Using IoT is designed to continuously observe critical machine parameters and transmit real-time data to a centralized platform for analysis and decision-making. The system architecture consists of four main layers. Sensing Layer – collects real-time data from the machine. Control Layer – processes signals using a microcontroller. Communication Layer – transmits processed data to the IoT cloud. Application Layer – visualizes and analyzes machine performance on a user dashboard. The objective of this design is to create a low-cost, reliable, and scalable monitoring system that enables predictive maintenance and minimizes downtime in industrial operations. The hardware subsystem comprises multiple sensors interfaced with a microcontroller. Microcontroller (e.g., Arduino, ESP32, or NodeMCU): Acts as the system's central processing unit, acquiring sensor data and managing communication. Temperature Sensor (LM35 / DHT11): Monitors machine surface or ambient temperature to prevent overheating. Vibration Sensor (SW-420 or MPU6050): Detects abnormal vibration patterns indicating mechanical faults such as imbalance or bearing wear. Current Sensor (ACS712): Measures motor current to identify overloads or idle running conditions. Speed Sensor (IR sensor / Hall Effect Sensor): Tracks rotational speed of the machine shaft. Power Supply Module: Provides regulated 5V/3.3V DC to all components. Wireless Module (Wi-Fi / LoRa / GSM): Enables transmission of data to a cloud server or local gateway. Each sensor continuously transmits analog or digital signals to the microcontroller for preprocessing and conversion into readable machine parameters. The software design is divided into three functional blocks -Data Acquisition: The microcontroller reads sensor values at defined intervals. Data is converted using ADC (Analog-to-Digital Converter) and filtered to remove noise. Data Transmission: The processed values are sent to an IoT platform (such as Thing Speak, Blynk, or AWS IoT) through Wi-Fi or GSM using MQTT or HTTP protocols. Cloud Storage and Visualization: The IoT platform stores real-time and historical data. A web or mobile dashboard displays parameters such as temperature, vibration, and speed, along with time-stamped logs and alert notifications. System Workflow - Sensors continuously collect machine data. The microcontroller processes the readings and detects deviations beyond preset thresholds. Data is uploaded to the IoT cloud in real time. If any parameter crosses a danger limit, an automatic alert (SMS, email, or app notification) is generated for the maintenance team. Authorized users can remotely monitor the system and perform trend analysis to schedule maintenance before failure occurs.

4. CALCULATION

The Machine Monitoring System relies on sensor readings to evaluate the operational health of machines. The following calculations are commonly implemented. Temperature Monitoring. Machine overheating can cause damage or failure. The temperature sensor (LM35/DHT11) provides an analog voltage proportional to temperature.

Conversion Formula:

T(°C) = V_{out} \times 100
= sensor output voltage (in volts)
= Temperature in degree CCelsiu
Safety Threshold Example: T_{max} = 80°C
Vibration sensors (SW-420, MPU6050) detect abnormal oscillations in rotating machinery. RMS (Root Mean Square) value is commonly used to quantify vibration intensity.

Where:

= instantaneous vibration readings (m/s² or g)
4
= number of samples in measurement interval
Motor current indicates mechanical load and possible overload conditions. The ACS712 sensor outputs a voltage proportional to current:

Where:

= sensor output voltage
= quiescent voltage at zero current (usually 2.5 V for 5V sensors)
= sensor sensitivity in V/A (e.g., 185 mV/A)
Using a Hall Effect sensor or IR sensor, machine speed is calculated from pulse counts: Where:
= number of pulses detected in time (seconds)
= pulses per revolution of the sensor
= measurement interval (s)
Power usage of the monitored machine can be approximated as:

Where:

= supply voltage (V)
= measured current (A)
= power factor (assumed or measured, usually 0.8–1)
Monitoring power helps in detecting overload conditions and optimizing energy efficiency.

5. COMPONENTS

Microcontroller ESP32 / Nedelcu / Arduino Uno Data processing & IoT communication. Temperature Sensor LM35 / DHT11 Measures machine temperature. Vibration Sensor SW-420 / MPU6050 Detects abnormal vibrations. Current Sensor ACS712 Monitors motor current. Speed Sensor Hall Effect / IR Sensor Measures rotational speed (RPM). Communication Module Wi-Fi / LoRa / GSM Data transmission to IoT cloud. Power Supply Li-ion Battery / Adapter Provides stable voltage. IoT Platform Thing Speak / Blynk / AWS IoT Cloud storage, dashboards, alerts. Firmware & IDE Arduino IDE / platform IO Microcontroller programming.

6. BLOCK DIAGRAM

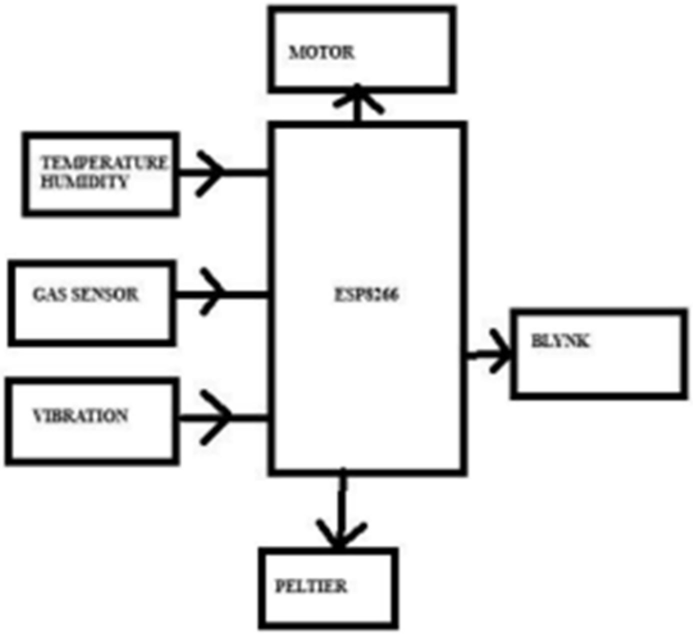

FIGURE 1.

7. CONCLUSION

The proposed Machine Monitoring System using IoT provides an effective solution for real-time monitoring, fault detection, and predictive maintenance in industrial machinery. By integrating temperature, vibration, current, and speed sensors with a microcontroller and cloud-based IoT platform, the system enables continuous data acquisition, analysis, and remote supervision. The system successfully demonstrates: Real-time monitoring of critical machine parameters to prevent unexpected breakdowns. Automated alert generation when sensor readings exceed predefined thresholds, allowing timely maintenance actions. Remote access and visualization via IoT dashboards, enhancing operational efficiency and decision making. Data logging for trend analysis, supporting predictive maintenance and energy optimization. The proposed solution is cost-effective, scalable, and adaptable to various industrial machines, contributing to the realization of smart factories and Industry 4.0 principles. Future work may focus on: Integrating advanced machine learning algorithms for predictive analytics. Enhancing edge computing capabilities to reduce latency and bandwidth usage. Expanding the system to a network of machines for centralized industrial monitoring.
In conclusion, this IoT-based machine monitoring system represents a significant step toward efficient, reliable, and intelligent industrial operations, reducing downtime, optimizing maintenance schedules, and improving overall productivity and safety.

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