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IoT-based Real-Time Data Acquisition System for Non-Programmable Machines with Dashboard Visualization

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***Abstract*— The Internet of Things (IoT) has revolutionized the way we collect and analyse data in real-time by connecting physical devices and equipment to the internet. However, there are still challenges when it comes to extracting data from machines that cannot be programmed. This project proposes an IoT-based system designed to overcome this hurdle by collecting real-time data from such non-programmable machinery. The system is composed of three main components: a dashboard, IoT sensors, and the non-programmable devices themselves. The IoT sensors are attached to the non-programmable equipment and serve as data collectors. They transmit the gathered data to the cloud through a gateway. The dashboard is the visual representation of this data. It provides an intuitive user interface that displays the collected data in real-time. This allows users to monitor and evaluate the performance of the non-programmable equipment, identify any irregularities, and make necessary improvements. The proposed system has potential applications in various fields, including industrial automation, logistics, and supply chain management. By enabling real-time monitoring and performance assessment of non-programmable equipment, it can help businesses enhance their productivity, minimize downtime, and improve efficiency.**

***Index Terms*— Internet of Things, (IoT)Real-time data gathering, non-programmable machinery, Dashboard interface, IoT sensors**

I. Introduction

The transformative impact of the Internet of Things (IoT)on connectivity and real-time data analysis has been evident across various sectors such as manufacturing, shipping, and healthcare, aiming to enhance productivity, reduce costs, and improve operational efficiency. However, the challenge arises in gathering and analyzingdata from numerous non-programmable devices within these sectors due to their inherent lack of communicationand programming capabilities [1]. This project proposes an IoT-based system as a solution, designed to collect real-time data from non-programmable equipment and present it on a user-friendly dashboard. [2] Comprising IoT sensors attached to machines, these sensors capture information from various sources, including vibration, pressure, and temperature sensors. Through a gateway and communication protocols like MQTT, CoAP, or HTTP, the collected data is transmitted to the cloud, enabling efficient analysis on a cloud-based platform [3]. [4] The dashboard facilitates user configuration of alerts, notifications, and data visualization in tables, charts, and

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graphs, empowering organizations to detect issues early and take prompt corrective measures, thereby enhancing productivity. Applications for this system span industrialautomation, logistics, and supply chain management, offering businesses the means to streamline processes, reduce costs, and optimize overall effectiveness, exemplified by its ability to monitor and alert maintenance crews about temperature and pressure levels in a manufacturing facility, mitigating the risk of equipment failure [5].

With the use of cutting-edge technology, the suggested method will transform how companies monitor and maintain their equipment by giving them access to real- time location and motion sensor data. This data allows for proactive issue detection and personalized warnings by being effortlessly sent to the cloud, analyzed, and shown on an intuitive dashboard. By providing a thorough picture, enabling data-driven decision-making,and lowering maintenance costs through early issue identification, this technology improves operational efficiency. Because of its adaptability to manufacturing, logistics, and healthcare, it's the perfect instrument for maintaining competitiveness and optimizing operations.Businesses may increase productivity, obtain acompetitive advantage, and usher in a new era of productive operations by utilizing technology.

Installation of Sensors: IOT sensors will be attached to industrial machinery that is not programmable to collect data on a variety of aspects, such as the location, motion, and movement of the product that must be processed by the machine.

Data transmission methods include using a gateway andonline cloud-based servers like Tera Term, Firebase Server, and others, along with communication protocols.A cloud-based platform will receive the collected data. Information will be shown on a dashboard with an easy-to-use interface. There are other ways to display data on the dashboard, such as tables, charts, and graphs. Userscan also configure notifications and alerts for specific events or abnormalities.

II. RELATED WORK

Ayyaz, S et al., (2021) [6]. The research papers focus on different sectors of IoT implementation and data acquisition system thus it provides clear visualization the areas where the research is done and where and therefore the illustration of selected research paper is as follows.

Kato, M et al., (2022) [7]. The paper introduces a predictive maintenance system for manufacturing production lines using machine learning and IoT data. It aims to proactively identify potential equipment failures by analysing real-time sensor data. The system offers benefits such as reduced downtime, optimized production efficiency, and cost savings. Overall, it presents a valuable approach for improving maintenance operations in manufacturing settings.

Khanna, A. et al., (2023) [8]. The paper focuses on the development of a temperature analysis environment for cyber-physical systems on an IoT platform. Specifically, it investigates the dynamical properties of a machine tool spindle unit using carbon fibre reinforced plastics under temperature changes. The study aims to understand the effects of temperature on the spindle unit’s performance. The paper highlights the importance of temperature analysis in optimizing the design and operation of cyber- physical systems.

Kirmani, S. et al., (2023) [9]. The research emphasizes the importance of proactive measures to prevent machine failures and highlights the role of IoT in this context. By leveraging IoT technologies, such as sensor data and real-time monitoring, the paper proposes a system that can detect potential faults and breakdowns in machines, enabling timely maintenance actions. Overall, the study advocates for the implementation of IOT-based preventive maintenance strategies to enhance machine reliability and minimize downtime.

Kwizera, A. et al., (2021) [10]. The author in this paper provides a comprehensive survey on IoT-enabled smart grids, covering technologies, architectures, applications, and challenges. It explores the integration of IoT technologies in the power grid sector to enable more efficient and intelligent energy management. The survey highlights various IoT-based applications in smart grids, such as demand response, renewable energy integration, and grid monitoring. It also discusses the challenges associated with IoT implementation in smart grids, including security, privacy, and scalability.

The system aims to proactively monitor and analyse machine data in real-time to detect potential faults or malfunctions. By leveraging machine learning algorithms and IoT devices, the system can predict and prevent equipment failures, optimize maintenance schedules, and improve overall machine reliability. The paper highlights the advantages of this approach, including reduced downtime, enhanced operational efficiency, and cost savings. It showcases the potential of integrating machine learning and IoT in the field of machine. health monitoring.

III. SYSTEM ARCHITECTURE AND REQUIREMENTS

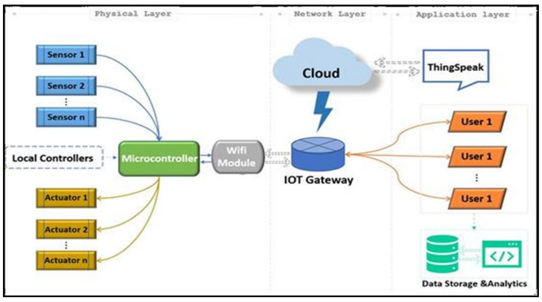


Fig 3.1: System Architecture

The architecture shown in Figure 3.1 is made up of non- programmable machines that are outfitted with a variety of sensors—such as vibration, pressure, and temperature sensors—to gather data in real time. An interface module attached to these sensors allows connection with the Internet of Things system. Data is gathered and preprocessed by an IoT gateway, which serves as a bridge to transfer it to the cloud based IoT platform. With a real- time dashboard for intuitive data visualization, the platform functions as a central hub for data storage, processing, and visualization. To get insights, such as failure prediction and pattern detection, data analytics approaches are used. The platform's user interface improves monitoring and decision-making capabilities by enabling interaction, configuration, and the reception of notifications for important events or anomalies in machine data.

System Requirements

Hardware:

1. IR Sensor
2. Node MCU Wi-Fi module
3. Arduino uno R3
4. Jumper wires
5. Power supply cable/ Batteries.

Software:

1. Arduino IDE
2. Tera Term

IV. METHODOLOGY

First, based on the system requirements, the architecture circuit is designed and implemented.

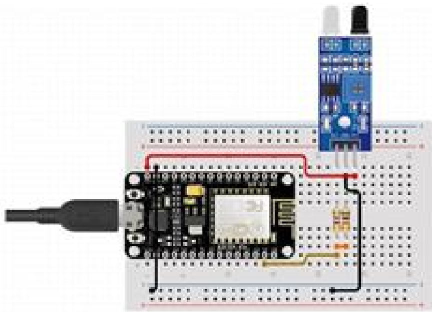


Fig 4.1: Circuit Diagram

The connection between an Infrared (IR) sensor and a Node Microcontroller Unit (MCU) is illustrated, emphasizing its role in data acquisition and processing. The IR sensor detects infrared radiation, measuring emitted heat and converting it for the Node MCU's understanding. The Node MCU, an ESP8266-based microcontroller, receives, processes, and acts upon the IR sensor's data. The specific pin connections between the two components are vital for seamless data transmission. This circuit forms the backbone of a system for real-time monitoring and analysis of infrared radiation, enhancing capabilities for applications like temperature monitoring and proximity detection. Its efficiency in facilitating communication between the IR sensor and Node MCU makes it a crucial component in systems relying on these technologies.

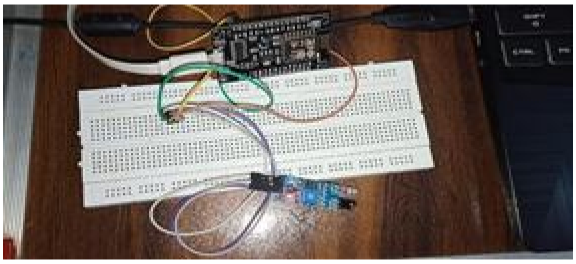


Fig 4.2 Above figure shows the implementation of the circuit diagram and connectivity.

Fig 4.3: Experimental Implementation

After a successful error-free code upload, the Wi Fi module established a connection to the Wi-Fi network using specified credentials. The system confirmed the successful connection, a crucial step for proper communication and functionality. The system was then mounted at the lathe machine's tool post after multiple location trials, selecting the tool post for optimal object detection. The setup's exact location on the lathe machineis shown in Fig 4.3, offering a visual representation for better understanding of the system's placement and operation.

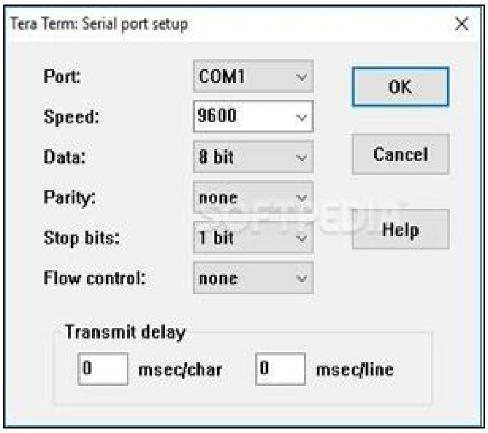
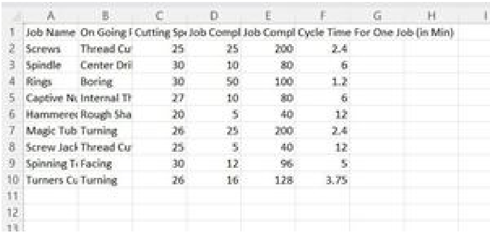


Fig 4.4: Terminal integration with sensors

The process begins with Tera Term, a terminal emulationprogram, establishing a connection to a device or system, allowing for command input and data retrieval. As the device outputs data, Tera Term displays it on the computer screen, and through its logging feature, the communication can be recorded into a text file. This logfile, containing relevant data, can then be processedusing external tools or scripts to a format suitable for Excel, such as CSV. Finally, the transformed data can beimported into Excel, leveraging its built-in functionalityfor importing from text files. While Tera Term facilitatescommunication and logging, the conversion and integration into Excel involves additional steps and tools to ensure a seamless workflow for data analysis and visualization. Refer Fig 4.5: for the data fetching into excel.



Job Name	On Going I	Cutting Sp	Job Compl	Job Compl	Cycle Time For One Job (in Min)
Screws	Thread Cu	25	25	200	2.4
Spindle	Center Dri	30	10	80	6
Rings	Boring	30	50	100	1.2
Captive N	Internal Th	27	10	80	6
Hammere	Rough Sha	20	5	40	12
Magic Tub	Turning	26	25	200	2.4
Screw Jack	Thread Cu	25	5	40	12
Spinning T	Facing	30	12	96	5
Turners Cu	Turning	26	16	128	3.75

Fig 4.5: Data fetched into excel

For the dashboard creation HTML, CSS and JavaScriptcoding is used in JavaScript from Chart.js graphs are taken and the integration of the excel to the graph is made.

V. Results And Discussion

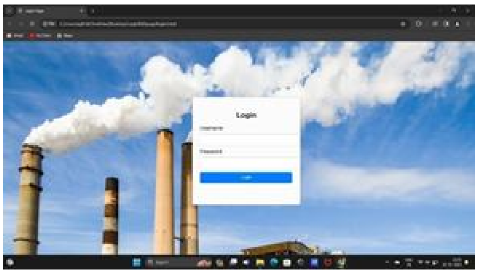


Fig 5.1: Login Interface

Crafted using HTML, CSS, and JS, the login page features secure authentication. Users must provide valid credentials to access the dashboard and visualizations, ensuring a protected and user-friendly experience

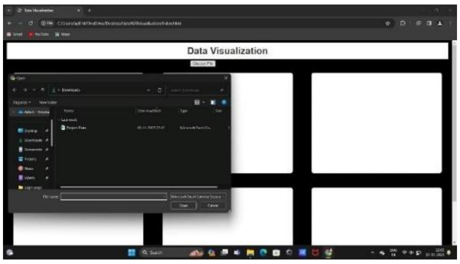


Fig 5.2: Dashboard Interface

This ensures that the data is readily available for monitoring and analysis, eliminating the need for manualdata retrieval. By utilizing the Tera Term platform, a user-friendly dashboard visualization is pro- vided. Select the excel sheet from the choose file menu in the top of the dashboard the file is imported (Fig 5.2).

Fig 5.3: Dashboard Visualization

From Fig 5.3 based on the excel sheet which we have attached the graphs are clearly seen in the dashboard where the user is easily able to see the number of productions done in particular day also it can be clearly seen where the process is running slow and where the machine failure occurs with this, we can track the record.

Based on the above dataset a model is predicted from various machine learning algorithms which are explained below. This includes dividing the data, specifying the features and target variables, importing the required libraries, building, training, and assessing the linear regression model. By using the trained model to forecast cycle times for each data point, adding these predictions to the Data Frame, computing the discrepancy between the anticipated and actual cycle times, and displaying a sorted Data Frame based on these differences, the secondportion expands on the analysis. The third portion is structured similarly to the first, but instead of using linearregression, it makes use of a gradient boosting regressionmodel. Like the second part, the fourth component makes predictions and analyzes data using the learned gradient boosting regressor model. Overall, this code demonstrates how to use gradient boosting andlinear regression models to forecast and analyze cycle durations.

VI. CONCLUSION

To conclude, the system that has been implemented, as illustrated in the circuit diagram (Fig 4.1) and its subsequent real-world application (Fig 4.2 and Fig 4.3), effectively combines an Infrared (IR) sensor with a Node Microcontroller Unit (MCU). This combination allows for the efficient real-time monitoring and analysis of infrared radiation. The successful integration of the Wi-Fi module and its network connectivity, as demonstrated in Fig 4.3, further emphasizes the system's robustness. The system's compatibility with Tera Term for data retrieval and its subsequent import into Excel, as shown in Fig 4.4 and Fig 4.5, exemplifies a streamlined workflow for data analysis.

Furthermore, the dashboard interface that has been developed (Fig 5.2 and Fig 5.3) offers a user-friendly platform for the monitoring and analysis of production data. It provides valuable insights into machine performance and potential areas for improvement. The login interface (Fig 5.1) ensures secure access to the dashboard, thereby enhancing the overall user experience.

In addition to the system's implementation, the machine learning model predictions, as discussed in the results and discussion section, employ linear regression and gradient boosting regression algorithms. These algorithms are used for forecasting and analysing cycle times in manufacturing tasks. This comprehensive approach facilitates the identification of patterns, detection of machine failures, and optimization of production processes.

In summary, the integrated system, in conjunction with machine learning predictions, offers a comprehensive solution for efficient industrial monitoring. It ensures data-driven decision-making and process optimization.

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