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IOT Based Smart Industrial Fault Monitoring System Using Raspberry Pi

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***Abstract-** Internet of Things (IoT) is rapidly increasing technology. IOT is the network of physical objects or things embedded with electronic software, sensors, and network connectivity which enables these objects to collect and exchange data. IOT then deals with bringing control of physical devices over the internet. In this project, we are developing a system which will automatically monitor the industrial applications and generate Alerts/Alarms or make intelligent decisions using the concept of IoT. A number of sensors are deployed in our project to monitor industrial parameters like temperature, pressure, gas, etc. These parameters were carefully selected on the basis of the potential hazards they can cause to the normal working of the industry machine. The sensors used in our project are sensor Temperature DHT11, Gas sensor MQ9, Flame sensor LM393, Accelerometer ADxL335, Ultrasonic sensor HC-SR04, and PIR sensor.*

***Keywords** – Internet of Things (IoT), industrial safety, sensors, Raspberry Pi, fault monitoring, Wi-Fi module*

INTRODUCTION

Technology development is an unending process and hence it is necessary for us to be well equipped and aware of the new upgrades in the technology. These technological changes have thus brought ease in the daily human life. Automation has become the need of the day.
Today all the data, system is available on internet and the web technology is growing very fast. Embedded system with web technology provides remote management and controlling of embedded device via network interface Internet of Things (IoT) devices are controlled by web controller or E- controller which is a bunch of embedded system and software stack, Technology development is an unending process and hence it is necessary for us to be well equipped and aware of the new upgrades in the technology. These technological changes have thus brought ease in the daily human life. Automation has become the need of the day. Today all the data, system is available on internet and the web technology is growing very fast.

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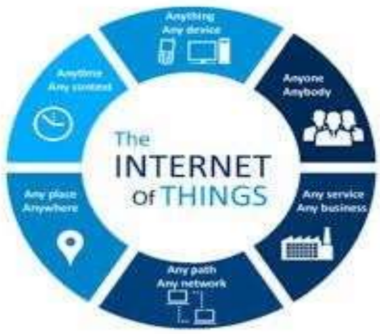

Figure 1. Internet of Thing

LITERATURE SURVEY

Previous studies have extensively explored various aspects of industrial safety and IoT integration. Research by Zheng et al. (2018) delves into smart manufacturing systems, emphasizing IoT's role in enhancing safety and efficiency. Similarly,Glória et al. (2017) discuss IoT gateway

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implementation for smart environments, providing insights into sensor integration and data management.

Other studies, such as Rigelsford (2003), focus on GSM network applications in remote monitoring, while Dinardo et al. (2018) examine machine condition monitoring in Industry 4.0 scenarios. These works underscore the importance of real-time data transmission and predictive maintenance facilitated by IoT technologies. Wang et al. (2018) demonstrated the use of wireless sensor networks for real-time fault detection in rotating machinery. Their work emphasized the need for low-power, robust sensor nodes to operate in harsh industrial environments. As per Singh and Roy (2019), integrating machine learning algorithms such as SVM and Random Forests has improved the fault detection accuracy by over 90%. However, their models were mostly tested in simulated environments. Research by Zhang et al. (2020) compared cloud-based analytics with edge computing. Edge computing was found to reduce latency and improve response time in critical fault detection, although it came at the cost of lower computational power. According to Khan and Patel (2021), security remains a major concern in IoT-based systems. They highlighted vulnerabilities in MQTT and CoAP protocols, commonly used for IoT communication Dr. Ananya Verma's 2022 review in *IEEE Transactions on Industrial Informatics* focused on the lack of standardized communication protocols and its impact on system scalability. She advocated for the use of OPC UA and TSN (Time Sensitive Networking) for real-time fault diagnosis. Federated learning (FL) allows distributed training of fault detection models without centralized data. Wu et al. (2023) integrated FL with blockchain to enhance data privacy and trust, demonstrating its effectiveness in heterogeneous industrial networks.

METHODOLOGY

Overview

The Raspberry Pi single board computer is used as the main device controller in the project. It is used to establish communication with the remote IOT server using the IOT protocols over the WiFi connection. are connected to these relays. And a four different sensors are also connected to Raspberry pi. The Raspberry Pi board communicates with the remote server based IOT platform by means of built-in WiFi. The control commands are provided by the user in the IOT platform.

The power supply on the circuit board provides 5VDC to the Raspberry Pi controller and the LCD.. The Raspberry Pi controller has built-in WiFi, USB, and A/V ports. The programming of the Raspberry Pi controller is done is Python scripting language. The Raspberry Pi controller runs the Raspbian OS which is a distribution of Linux OS. There are four relays connected to the output pins of the Raspberry Pi controller. Four different industrial devices These commands are then communicated to the Raspberry Pi controller over the WiFi using IOT protocols. According to these commands, the Raspberry Pi controller turns the relays on and off. An LCD is also connected to the Raspberry Pi controller which is used to display the device statuses as well as other messages.

Block Diagram

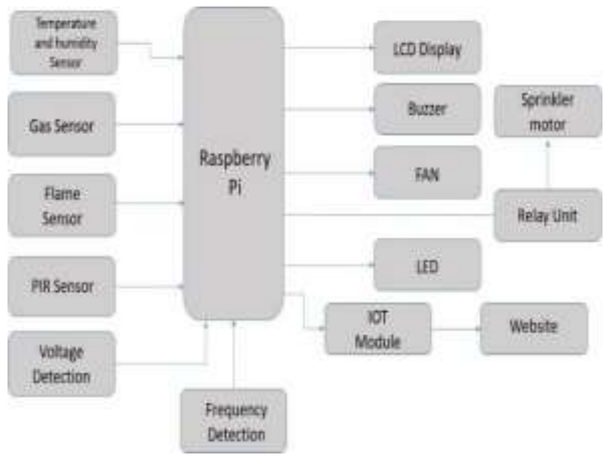

Figure3 Block Diagram

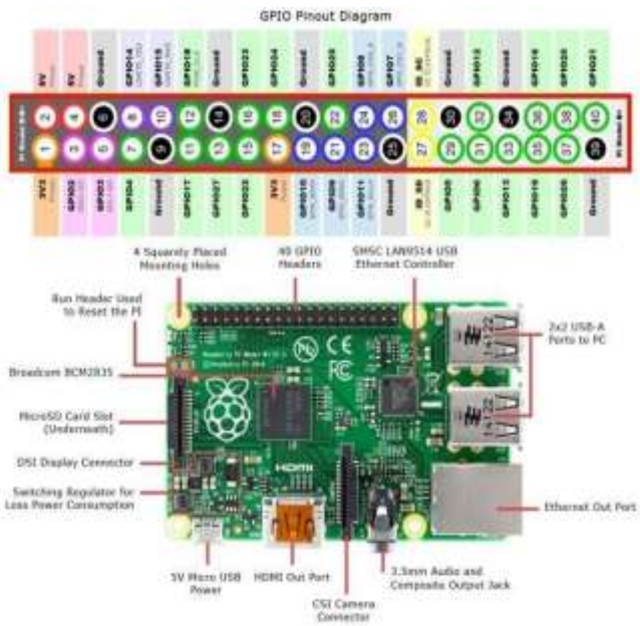

Figure 4 Raspberry Pi

The minimum power given to raspberry pi board is 5V,

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1A. USB ports are used to connect keyboard, mouse. Ethernet port is used for internet connection through LAN. HDMI port for monitor.SD card slot is used to handle memory of 16GB of capacity for operating system and programming files. We read the parameters from sensors and raspberry pi

Hardware Use:
Raspberry Pi, LCD Display, Wifi Module, Relay Temperature sensor, Humidity sensor, Gas sensor, Camera, Rectifier, Regulator, Resistors, Capacitors, Transistors, Power Supply, Cables and Connectors, Diodes, LED, Transformer/Adapter, Switch. IC, IC Sockets, Motor, Lamps. Some of Hardware descriptions are given below:
Raspberry Pi:

Raspberry Pi is a low cost, credit- card sized computer that plugs into a computer monitor or TV and uses a standard keyboard and mouse. It is a capable little device that enables people of all ages to explore computing and to learn how to program in languages like Scratch and Python. It is capable of doing everything you'd expect a desktop computer to do, from browsing the internet and playing high-definition video, to making spreadsheets, word-processing, and playing games. Raspberry Pi 4 is the latest iteration of the Raspberry Pi product family and it offers the fastest performance when compared with the previous generations.

3.3.3. Relay Module:

Even though the Relay Coil needs a small current in order to get energized, driving it directly from Raspberry Pi (for that matter, any Microcontroller like 8051 or Arduino) is not a good idea. A simple way is to drive the Relay Coil through a Transistor. The following image shows the connections required with respect to a Relay.

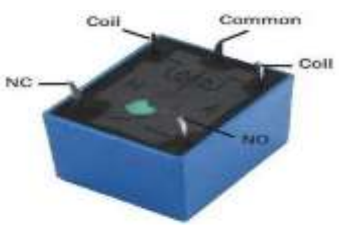

Figure 5 Relay Module

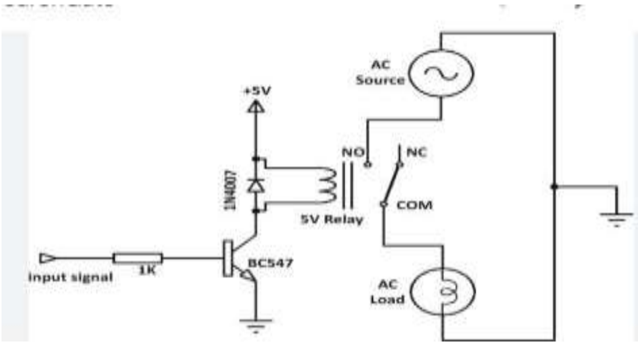

Figure 6 Circuit Diagram of Relay Module

Relay
In layman terms, a relay is a switch. Technically speaking, relay is an electromagnetic switch where a small control signal (usually from a microcontroller) at the input of the Relay will control a high voltage supply (usually AC mains). Since this is a Raspberry Pi based project, let us talk with respect to Raspberry Pi. The Raspberry Pi computer, although a powerful device, works on a 3.3V Logic. If you want this powerful computer to control your electrical loads, like an LED strip running along your garden or kitchen, you cannot interface them directly as the electrical loads work on AC Mains supply and the Raspberry Pi works on 3.3V. The circuit shown above will drive a relay with minimum number of components (a Transistor, a current limiting resistor, a Relay and a Diode). A Relay Module is a simple circuit board that consists of the relay itself and all the necessary components that are required to drive a relay and also the required connectors to connect the load. I have used a four channel relay module in this project. It is basically, four relays with all the circuitry on a single board.

Figure 7 Relay Module Plate

Temperature Sensor

A temperature sensor is an electronic device that measures the temperature of its environment and converts the input data into electronic data to record, monitor, or signal

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temperature changes. The DS18B20 temperature sensor is perfect for projects like weather stations and automation systems. these sensors are easy to set up on the Raspberry Pi. They're the same size as a transistor and use only one wire for the data signal

Figure 8 Temprature sensor

Humidity Sensor

The DHT11 is a low-cost temperature and humidity sensor. It isn't the fastest sensor around but its cheap price makes it useful for experimenting or projects where you don't require new readings multiple times a second. The device only requires three connections to the Pi. +3.3v, ground and one GPIO pin.

Figure 9 Humidity Sensor

3.3.4 Wifi Module

Low-power, low-cost Wi-Fi modules have changed the landscape of wireless sensor networks. Autonomous, Wi-Fi sensors connect to common, widely available wireless network infrastructure. They send sensor data over standard TCP/IP making their information anywhere in the world from any computer or smart phone.Previously, wireless sensors networks have been built on top of proprietary protocols running on sub- gigahertz radios. These systems have the benefit of covering long distances however they are closed systems. Likewise sensors networks based Zigbee radios are also closed system. Both of these wireless sensor networks require additional gateway hardware devices to get sensor data onto the internet or users LAN. Gateways introduce a single point of failure and additional cost.

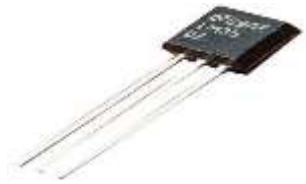

Figure 10 Wifi Module

For an IoT-based Smart Industrial Fault Monitoring System, a Wi-Fi module plays a crucial role in enabling wireless communication between the sensors and the cloud or central monitoring system. Among the most commonly used Wi-Fi modules, the ESP8266 and ESP32 stand out due to their affordability, reliability, and ease of integration. The ESP8266 is a low-cost module suitable for basic applications, offering built-in Wi-Fi and GPIO pins for connecting sensors. For more advanced needs, the ESP32 is preferred because it features dual-core processing, more GPIOs, and supports both Wi-Fi and Bluetooth, making it ideal for real-time fault detection and data transmission in industrial environments. Alternatively, a Raspberry Pi with built-in Wi-Fi can be used for more complex systems that require local data processing or edge computing.

3.4 Software Use

3..4.1 Raspbian OS

Raspbian is a free working framework in based on Debian. It is based on the Raspberry Pi module. A working framework is the arrangement of fundamental programs and utilities that make your Raspberry Pi run. It gives essentially speedier execution to applications that make substantial utilization for floating point arithmetic operations. Every single other application will likewise increase some execution speed because of advanced instruction of the ARM11 CPU in Raspberry Pi.

3.4.2 Apache HTTP Server:

The Apache HTTP Server which is called as Apache is the world's most famous web server software. It is based on the NCSA HTTP server. Apache has a big role in the initial growth of the World Wide Web. An open community of developers under the auspices of the Apache Software Foundation have developed and maintained Apache. This is most commonly used on a Linux; this software is available for a wide variety of operating systems, including UNIX, FreeBSD, Linux and Solaris.

3.4.3 TCP IP Protocol :

The same layered structure as used in the TCP/IP protocol

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suite is used by the software running on the embedded web server. The TCP/IP protocol suite permits PCs of all sizes, running distinctive operating systems to communicate with each other. The TCP/IP protocol suite is a blend of various conventions at different layers as appeared in Figure. Figure demonstrates Layers of TCP/IP protocol suit. Each layer is independent from each other. The Link Layer generally incorporates the device driver in the operating system and corresponding network interface (card) in the PC. An Ethernet controller driver controls the Ethernet interface and the network layer controls the communication.

IMPLEMENTATION

The first step in implementing the IoT-based Smart Industrial Fault Monitoring System is to select and install appropriate sensors on the industrial equipment. These sensors continuously measure critical parameters such as temperature, vibration, and electrical current, which are key indicators of machine health. The sensors send raw data to a microcontroller unit like an Arduino or ESP32, which acts as the system's central processing unit.

Next, the microcontroller processes the sensor data and transmits it wirelessly to a cloud-based platform using communication protocols such as Wi-Fi or GSM. This enables remote monitoring and data storage, allowing authorized personnel to access machine status from anywhere at any time. The cloud platform is also responsible for running algorithms that analyze the incoming data to detect any abnormalities or fault conditions.

To ensure the system is user-friendly, a web or mobile dashboard is developed. This dashboard visualizes real-time data, historical trends, and fault alerts, enabling maintenance teams to quickly understand the equipment's condition and take proactive actions. Additionally, automatic alert systems send notifications via SMS or email whenever a potential fault is detected, minimizing the risk of unexpected breakdowns.

Finally, the entire system undergoes rigorous testing and calibration. Fault scenarios are simulated to validate the accuracy of sensors and the effectiveness of the fault detection algorithms. Once validated, the system is deployed on the industrial floor for continuous monitoring, helping to reduce downtime, improve maintenance scheduling, and extend the lifespan of machinery.

Raspberry pi 5 OS Installation and setup

Step1 Prepare the microSD Card Step 2 Boot the Raspberry Pi Step 3 Connect and Configure Step4 Basic Configuration

Step5 Update the System

Setting up a Raspberry Pi involves several key steps to get it up and running. First, you'll need a Raspberry Pi board (such as the Raspberry Pi 4 or Zero), a microSD card (at least 8GB, Class 10 recommended), a power supply (5V 3A for the Raspberry Pi 4), and peripherals like a keyboard, mouse, and monitor. Start by downloading the Raspberry Pi OS (formerly Raspbian) from the official Raspberry Pi website and use a tool like Raspberry Pi Imager or Balena Etcher to flash the OS onto your microSD card. Once the OS is written, insert the microSD card into the Raspberry Pi, connect your peripherals (keyboard, mouse, and display), and then plug in the power supply. The Pi should boot up, and you'll be guided through the initial setup process, which includes setting up your locale, time zone, Wi-Fi, and password. After that, you'll have access to the desktop environment, where you can start installing additional software and configuring your Pi for various projects. To ensure your system is up to date, it's good practice to run sudo apt update and sudo apt upgrade from the terminal after the initial setup.

RESULT

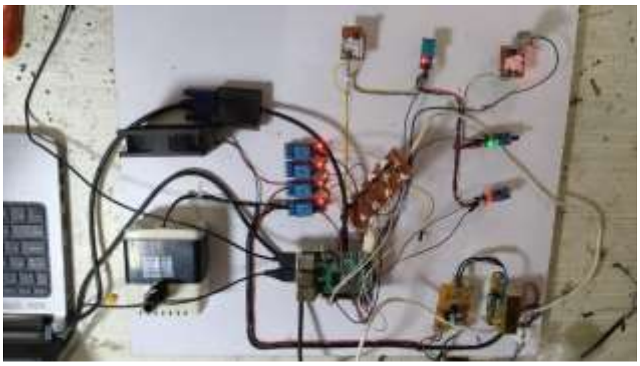

Figure 12 Sensor Data Chart

A good comparison done by the author in which why to use raspberry pi in industrial propose is explained. As raspberry pi is small in size and also consumed less power along with doing complex processing of collected data. There are lots of wastage in energy at workstation and industries by hiding the real status of the installed system through workers or may be the middle hierarchy of industries. This system try to minimize the energy waste by providing sufficient information to the owner or top level hierarchy persons via remotely and can be made appropriate decision. It also helps to analyze the overview consumption of power and material requirement. In this system, blade aging of the cutter tool is monitored by observing the energy consumption of cutter tools.

CONCLUSIONS

As mentioned in the Section II, we get the information of the SOA-IoT that is Service Oriented Architecture IoT. We also get the idea about the System overview of raspberry pi. We are aware from the new trends in the Industrial automation and IoT technologies. The authors also discuss the various challenges in the IoT and also in Industrial automation constrain. How handle this challenge is also discussed by the authors. The authors also survey the industrial marketplace considering the IoT perspective. The embedded internet network was discussed by the author in which IEC 62591 that is wirelessHART standard was

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