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Automated Monitoring System Development for Equipment Modernization

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Abstract:

This study examines a problem that arises from the incompatibility of two factors. The first is the desire to improve the enterprise in accordance with the concept of Industry 4.0. And the second is the lack of sufficient material resources due to the high cost of purchasing new equipment that will meet the requirements of Industry 4.0.

In this article, to solve the problem of modernizing enterprise equipment, it is proposed to create a monitoring system. The development of the system architecture is considered. Hardware complex development on the Arduino platform is also given.

Key words: Industry 4.0, Equipment modernization, Monitoring system, Sensor.

Introduction

It is now impossible to imagine the modern development of production without implementing the principles of the Industry 4.0 concept [1]-[10]. It involves the use of modern equipment equipped with all kinds of sensors, as well as specialized equipment for processing sensor signals and producing appropriate reactions, and making adjustments to the work [11]-[21].

However, the use of such equipment within the framework of the Industry 4.0 concept leads to significant costs for its acquisition. It should be noted that not every enterprise can afford to completely update its equipment fleet [22]-[25]. In this case, a possible solution is to create monitoring systems that can be built into existing equipment, thereby upgrading existing devices at the enterprise [26], [27].

Monitoring system is a component of the enterprise control infrastructure. It consists in the constant observation and periodic analysis of the components of the work processes with the tracking of the dynamics of the changes that occur with it. The key task of monitoring system is to receive, save and analyze information about the state of controlled elements of the company's structure. The development web application allows you to quickly react to a problem in the operation of services, as well as effectively prevent the occurrence of problems. That is why the idea was put forward

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to create a similar system, which will be an automated system for monitoring and managing work processes in production.

Today, in various companies with production, the need for self-monitoring of components used in work processes during the performance of important tasks is growing. The need to find methods of detecting problems in production during the work processes execution is an important component and indicator of the business structure productivity. For the necessary effectiveness, it is necessary to be able to notice and solve such problems in a timely manner, so that they do not allow negative perspectives, critical incidents and do not involve material losses in the company. The monitoring in the technological sphere is especially relevant, because poor-quality use of production capacity or materials can entail a tendency for negative production efficiency and its unprofitability in the distant possible forecast. While having even the simplest monitoring can prevent these bad consequences.

So, in this paper we present our monitoring system development.

Related works

Currently, the development of monitoring systems for enterprises is becoming increasingly important. Such systems are designed to take the existing equipment at the enterprise to a new level. Accordingly, many researchers are developing such systems. This takes into account the specifics of both the enterprise itself and the equipment installed on it. Let us look at some of them.

Authors in [27] propose a reference architecture and construction path for smart factories by analyzing industrial IoT technology and its application in manufacturing workshops.

We consider the development of a monitoring system as a possible solution to the problem of equipment modernization within the framework of the Industry 4.0 concept. Many scientists approach this issue from different angles [28].

Khan, M. A. and co-authors develop a replacement decision framework based on the influencing factors and motivations behind equipment replacement [29]. But we must note that this must first of all be economically justified. Article [30] explores the concepts of diversification and modernization and the factors that influence them. The influence of diversification, modernization, and innovation factors affecting competitiveness is analyzed. Scientists in [31] substantiate the potential of

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nanotechnology in the technology modernization of the power engineering industry enterprises aimed at achieving production efficiency growth. Researchers [32] note that a good alternative is the act of retrofitting existing machinery, by adding new features. As a matter of fact, we are talking about the same thing. In our opinion, it is possible to add new characteristics and functions to existing equipment by creating automatic embedded monitoring systems. Such systems can expand the functionality of existing equipment by providing them with the necessary sensors.

Further in this article we will look at the development of such a system.

Automated monitoring system architecture development

The purpose of this work is to create an automated system for monitoring important indicators during work processes in production with the help of sensors and modern information and technical technologies. Work processes mean the creation of a material product necessary for the existence and development of production as a business structure, and monitoring is a necessary part of improving the efficiency of the creation of this product.

An urgent task is to create an automated system for monitoring lighting, temperature and humidity, noise and vibration – important indicators during work processes in production using sensors and modern IT technologies using AWSAWS is an important part of this system because it is in the web cloud that the deployment of the completed application will take place. The cloud gives an easy access to a wide range of technologies. From infrastructure services such as compute, storage, and databases to IoT, machine learning, data analytics, and more, you can quickly scale resources as needed. We propose to use AWS. It will make the development monitoring system more secure. In order to comply with technological norms during the production of a material product, optimal indicators that can contribute to production efficiency must be maintained. The work will consider sensors that can provide information to the monitoring system, namely: light sensor; temperature and humidity sensor; noise sensor; vibration sensor.

A generic architecture is currently offered that can serve as a standard architecture for any type of manufacturing critical metrics monitoring solution. If you depict this visually, then the following scheme will be obtained, shown in Figure 1.

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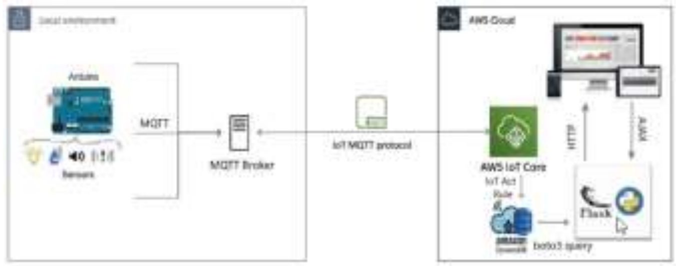

Figure 1: Automated Monitoring System Architecture Scheme

The architecture diagram of the automated monitoring system shows its general operation and infrastructure. There is a sector with hardware, where sensors and the Arduino hardware and software platform are involved, thanks to which IDE it is possible to program the sensors and send data through the Wi-Fi module. Next, the MQTT message broker will be used, which through the MQTT protocol will process data from the Arduino platform and send from the created hardware complex to the virtual environment in AWS, with a combination of AWS IoT Core. In the created cloud, the logic of the web application is built, which receives information from sensors and builds graphics and management. The driver is a Python program using the Flask framework, which is integrated with AWS IoT Core. DynamoDB database will be used for more stable operation of the system. Its use will provide a low response time for metrics requests, which will make the system more efficient.

Hardware complex development on the Arduino platform

The ATmega328P microprocessor on the Arduino UNO platform was taken as the basis of the information processing hardware and software complex. The board is equipped with sets of digital and analog input/output (I/O) pins that can be connected to various expansion boards (shields) and other circuits. The board has 14 digital I/O pins (six PWM capable), 6 analog I/O pins and is programmable using the Arduino IDE (Integrated Development Environment) via a USB type B cable. It can be powered by a USB cable or an external 9V batteries, although it accepts a voltage from 7 V to 20 V. Sensors will be connected to the Arduino UNO, which will be able to provide the necessary external indicators of the monitoring system, namely, a light sensor (a module

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based on an LM393 comparator), a temperature and humidity sensor (DHT11 of the second version) and a vibration sensor (module SW-420 vibration sensor is normally closed). The Wi-Fi module ESP8266/ESP-01 with a serial interface will be used as a Wi-Fi module. Let us start with the Wi-Fi module ESP8266 / ESP-01, the connection diagram to the Arduino UNO is shown in Figure 2.

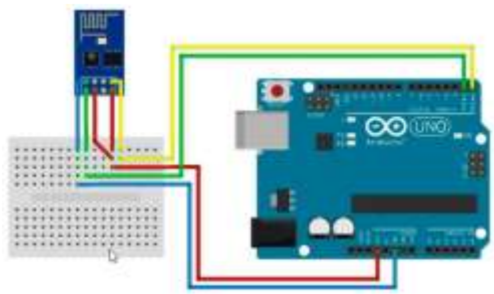

Figure 2: ESP-01 Module Connection Diagram

VCC and GND are the power supply of the module. The module works from 3.3 V. Connect the RX contact to pin 0 on the Arduino and the TX contact is connected to 1 pin. It is also necessary to check the power and ground contacts before switching on. After connecting the power, the red light on the module should light up. Next the connection of the temperature and humidity sensor DHT11 of the second version is performed, the diagram is presented in Figure 3.

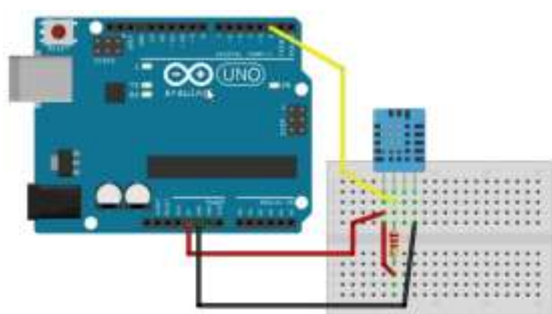

Figure 3: DHT11 Module (v2) Connection Diagram

A 10K resistor and jumpers are required for connection. In our case, a 4-pin model is used, which is connected by the pin (yellow) of the DHT11 to the 3 V of the Arduino UNO, a 10K resistor is connected between pin 1 and pin 2 of the DHT 11, pin

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3 of the DHT 11 sensor remains unconnected and the pin (black) DHT 11 connects to GND on the Arduino UNO.

Next, the SW-420 module is connected, which will serve as a vibration sensor for the hardware set of the monitoring system. The SW-420 vibration sensor module is integrated with SW-420 vibration sensor, LM393 voltage comparator, potentiometer, current limiting resistors that act as voltage dividers, hence current control and capacitors as biasing elements and for noise filtering. The connection diagram to Arduino UNO is presented in Figure 4.

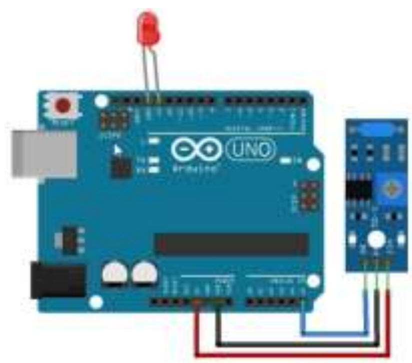

Figure 4: SW-420 Vibration Module Connection Diagram

To adjust the sensitivity of the sensor, a 10 K potentiometer is placed on the module. The sensitivity can be increased or decreased depending on the requirement. This is done by setting a preset or threshold value that is provided by the LM393 as a reference for comparison. The vibration switch SW-420 determines the amount of vibration in the environment. It responds to vibration by opening or closing an electrical contact. A trigger switch can be an electromechanical, relay, or semiconductor component. The module has two LEDs. One of them lights up when the module is powered up, and the other one lights up to indicate a digital output. Also, to demonstrate the operation of the hardware complex, an ordinary LED was connected to check the performance.

Next, the last element of connection to the Arduino UNO will be demonstrated - it is a module based on the LM393 comparator, which serves as a light sensor. The connection scheme is presented in Figure 5.

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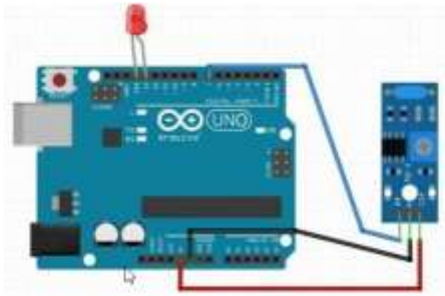

Figure 5: LM393 Light Module Connection Diagram

This module has a highly sensitive vibration sensor and a built-in voltage comparator to generate a digital output signal. When the vibrating switch is in the closed conduction state, the output signal is low and the green light is on. When the vibration switch is disconnected, the output signal is high and the green light is off. It can be directly connected to a microcontroller to read the output level and easily determine the status of the sensor. The output of the sensor indicates whether vibration has been detected in the environment.

You can see all the Arduino UNO elements that were connected according to the diagrams and instructions described above in Figure 6.

Figure 6: All the Arduino Elements Connecting Demonstration

Conclusion

This paper presents the development of a monitoring system that can be used at various enterprises

The automated monitoring system covers important indicators during work processes in production and deals with the processing of data from indicators with the help of sensors and modern information and technical technologies to stabilize and improve the efficiency of creating a material product, which is necessary for the existence and development of production as a business structure.

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In future we plan to use the AWS cloud web service, it will be possible to monitor the necessary lighting, temperature and humidity, noise and vibration. Controlling these indicators will help keep production in an efficient and fault-tolerant state. The automated monitoring system covers important indicators during work processes in production and deals with the processing of data from indicators with the help of sensors and modern information and technical technologies to stabilize and improve the efficiency of creating a material product, which is necessary for the existence and development of production as a business structure. Also, thanks to the use of cloud technologies of the AWS web provider, the developed system will be more protected by the encryption and security methods of the cloud provider's infrastructure and more flexible in completing functions and introducing new capabilities.

Thus, the automation of the process of monitoring indicators will increase the speed of response to problems during production, will allow quality analysis of conditions and will prevent critical situations at the enterprise.

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