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IIOT IN MINING - POTENTIAL APPLICATION OF "LOW-COST" SENSORS AND THE ARDUINO PLATFORM

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Abstract

The limitations of human senses can be overcome by using various sensors. By integrating them into different objects and connecting them, we create a system capable of interpreting its environment and making intelligent decisions—this is the Internet of Things. When this system is implemented in industry, it becomes the Industrial Internet of Things, which can also be applied in mining. The need to reduce costs has driven research and the use of "low-cost" sensors and microcontroller platforms such as Arduino in IIoT.

Keywords: *IIoT, Sensors, IoT, Arduino, Mining*

1. INTRODUCTION

Artificial sensors and probes allow us to overcome the limitations of our human senses and extend them in new and useful ways by using scientific concepts and approaches [1]. A sensor does exactly what its name suggests: it senses or measures a physical quantity and converts it into a digital display, which is then transmitted to another device for transformation into useful data that can be utilized by intelligent devices or humans [2,3].

There are numerous sensors available for measuring almost anything in the physical world. Sensors can easily be embedded into any physical objects that can be connected to the Internet through wired or wireless networks. This enables the observed objects to communicate with each other as well as with external systems, allowing them to interpret their environment and make intelligent decisions. Connecting sensor devices in this way has introduced the world of IoT (Internet of Things) and a completely new paradigm of business intelligence [2, 3, 4].

2. EXPERIMENTAL

2.1 Aplication of IoT and Arduino in Mining

IoT allows every object to be uniquely identified through its embedded computing system and to operate within the existing Internet infrastructure [2, 3, 4]. IoT acts as a technological revolution that impacts all areas of application, including smart homes, smart cities, agriculture, automobiles, healthcare, industrial manufacturing, transportation, and mining [2, 3, 5]. In this context, industries are faced with the challenge of rethinking their production processes, which has the potential to drive innovations in manufacturing systems on an unprecedented scale [6]. The Industrial Internet of Things (IIoT), which represents the application of IoT in industry, is part of the Industry 4.0 concept, emphasizing the idea of consistent digitization and connectivity of all production units [7], combining the strengths of

traditional industry with internet technologies [8, 9]. The Industrial Internet can also be considered as a convergence of Information Technology (IT) and Operational Technology (OT).

To connect sensors and IoT systems for further automation, integration with electronic platforms is necessary, which can often be quite expensive. Therefore, there is an effort to utilize the Arduino electronic platform, which is a low-cost, open-source technology [10]. Arduino is an open-source electronic platform based on easy-to-use hardware and software. Arduino boards can read various inputs and convert them into outputs, such as activating a motor. The Arduino programming language (based on Wiring) and the Arduino software (IDE), based on Processing, are used for programming the Arduino board. Arduino was created at the Interaction Design Institute Ivrea as a simple tool for rapid prototyping, intended for students without prior knowledge of electronics and programming. Once it reached a wider community, the Arduino board began to evolve to adapt to new needs and challenges, expanding its range from simple 8-bit boards to products for IoT applications, wearable technology, 3D printing, and embedded environments [11].

Arduino has the potential for application in mining in areas such as monitoring, the development of portable measuring devices, and autonomous systems. The Arduino platform can be used to increase productivity and enhance worker safety. The complexity and specific challenges in the mining industry include the heterogeneity of each mine (different layouts depending on natural conditions), difficult transportation in confined spaces, the impossibility of wireless communication through shafts and underground spaces, blasting and tremors, and the continuous change of work sites. These challenges are further emphasized by the need for continuous production of large quantities of extracted ore to meet the goals set to ensure production profitability [5]. Automation, wireless communication, telemetry, and remote visibility through IoT are driving the digital transformation of the mining industry [12, 13]. Any interruption in communication could have serious consequences for the company's operations and human lives in the mining sector. IoT technology guarantees efficient communication, cost reduction in mining operations, and high profits, while maintaining worker safety. IoT is now being used by numerous governments and mining industries for real-time performance planning, implementation, and improvement. They use this technology for accurate monitoring and data analysis to develop a strategic business plan [14]. The coordination of mobile equipment in the mining industry is facilitated by the use of IoT for tracking the location of trucks and the status of loading. In case of an emergency, there are other technologies for tracking individuals [15]. In underground mines, IoT monitoring systems are also used to track the stability of the rock mass [16]. IoT particularly enables the interconnection of low-cost sensors to function as a multipurpose platform and provide data to a central location [17]. Equipment such as drills, trucks, loaders, excavators, and conveyors can be automated, and various valuable data can be collected from them. Efforts have been made to utilize low-cost open-source technology in mining to achieve this goal [10]. The application of the Arduino platform, as a low-cost open-source technology in mining, can be categorized by the type of application, such as in monitoring systems, portable devices, and autonomous systems.

Examples of the application of low-cost open-source technology and IoT in mining have been provided in several studies [18-27]. These studies cover topics related to the potential applications of the Arduino electronic platform and IoT systems in mining, as well as specific examples related to the monitoring and detection of hazardous gases and dust in underground mine ventilation, the design of devices for measuring the pH value of liquid waste from coal mines, the modeling and development of portable devices for

real-time monitoring of ventilation parameters, and the application of Arduino low-cost devices for measuring the detonation speed of detonators.

3. RESULTS AND DISCUSSION

A review of the literature has established the widespread presence of "low-cost" sensors and the Arduino platform in research focused on implementing IIoT systems in mines. The studies have shown promising results; however, there is still work to be done on the durability and longevity of these devices to prevent any negative impact on measurement accuracy. Nonetheless, this platform compensates for most of its shortcomings with its low cost and ease of replacement.

4. CONCLUSION

The results of this research have shown that IIoT is the future of mining and that the use of "low-cost" sensors and microcontroller platforms like Arduino is feasible. However, further research under both laboratory and real-world conditions is necessary for safer and more accurate implementation.

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