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Retraction

Retracted: Application of Intelligent Sensor in Mining Electrical Equipment Collection

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This article has been retracted by Hindawi following an investigation undertaken by the publisher [1]. This investigation has uncovered evidence of one or more of the following indicators of systematic manipulation of the publication process:

(1) Discrepancies in scope
(2) Discrepancies in the description of the research reported
(3) Discrepancies between the availability of data and the research described
(4) Inappropriate citations
(5) Incoherent, meaningless and/or irrelevant content included in the article
(6) Peer-review manipulation

The presence of these indicators undermines our confidence in the integrity of the article's content and we cannot, therefore, vouch for its reliability. Please note that this notice is intended solely to alert readers that the content of this article is unreliable. We have not investigated whether authors were aware of or involved in the systematic manipulation of the publication process.

Wiley and Hindawi regrets that the usual quality checks did not identify these issues before publication and have since put additional measures in place to safeguard research integrity.

We wish to credit our own Research Integrity and Research Publishing teams and anonymous and named external researchers and research integrity experts for contributing to this investigation.

The corresponding author, as the representative of all authors, has been given the opportunity to register their agreement or disagreement to this retraction. We have kept a record of any response received.

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[1] J. Chang, F. Zhang, and Y. Zhu, "Application of Intelligent Sensor in Mining Electrical Equipment Collection," *Journal of Control Science and Engineering*, vol. 2022, Article ID 2633019, 6 pages, 2022.

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Research Article

Application of Intelligent Sensor in Mining Electrical Equipment Collection

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In order to meet the informatization requirements of coal mine safety monitoring, the author proposes a method for the application of smart sensors in the acquisition of mine electrical equipment. The system uses a variety of sensor fusion methods, with the help of Zigbee wireless network nodes, and passes the data collected by the sensor to the MCU core processor; thus, the collected data are processed, and then, the RS-485 communication protocol is used to upload the data to the upper station; finally, the monitoring of coal mine safety is realized through the background monitoring interface. Experimental results show that, among the five randomly selected nodes, most of the errors between the actual measured results and the collected results are concentrated within the 2% error range. *Conclusion*. The effect of the abovementioned acquisition scheme in coal mine application is verified, so as to realize the scientific monitoring of coal mine safety.

1. Introduction

In recent years, the development and utilization of coal resources has always promoted the sustainable development of China's heavy industry and national economy; although China is vigorously developing the new energy industry, in terms of the current domestic industrial development level, coal remains an irreplaceable energy source. With the current recovery of the metallurgical industry, the demand for coal is also increasing, and the mining technology of the coal industry is also continuously updated. Under the premise of the national scientific development concept, the use of advanced technology to solve the unreasonable problems in the process of coal mining has become the main contradiction in coal mining at present; it focuses on the safety of coal mining process, the rationality of resource mining structure layout, and the environmental problems caused by coal mining [1, 2]. In the actual production process in coal mines, we need to face the "five major hazards:" gas, water, fire, coal dust, and roof. In this section, I will introduce the monitoring gas as an example. Since gas is accumulated by organic plants in the process of forming coal, gas is unavoidable and cannot be removed. Gas is highly flammable and explosive, and high temperature, shock waves, and toxic and harmful gases will be generated during the gas explosion, which is a nightmare for coal mine workers. Since the gas is "indestructible," it can only be monitored. "Coal Mine Safety Regulations" expressly stipulates the following. When the gas concentration in the air flow in the return air lane of the mining area and the return air lane of the excavation face exceeds 1%, the work must be stopped, the personnel should be evacuated, and measures should be taken to deal with it. When the gas exceeds the limit, evacuating personnel in time is the best choice to reduce losses. In the production process of coal mines, the most important issue is safety. Coal mines go hundreds or even thousands of meters underground due to the mining of coal seams, and there are many safety hazards such as gas and water seepage in the working face; among them, the most frequent accidents in China's coal mines in recent years are caused by gas explosions, and the casualties and property losses caused by them are immeasurable [3]. In order to avoid accidents in coal mine operation, it is necessary to monitor the production environment, personnel status, and equipment status in real time in the coal mine operation area.

2. Literature Review

Agarwal developed a Pd–Pt-based honeycomb support structure, and using a new catalyst Co_3O_4–Ce O_2, under the condition of 400~600°C, the oxidation reaction of gas is strengthened [4]. Riaz et al proposed a hierarchical porous oxide support structure, which improved the characteristics of the original support being easily sintered into bulk crystals and improved the stability of the sensor; at the same time, the sensitivity and response speed of the sensor are improved [5]. He et al proposed that using La Co O_3 as a catalyst, the complete oxidation of gas can be achieved at 400°C; compared with the oxidation of CO and ethanol at 250°C, it has good selectivity [6]. Using a microelectronic planar process, a Pt film resistor is prepared by sputtering instead of Pt wire, which reduces the initial temperature and temperature rise sensitivity. When the CH_4 concentration reaches 1%, the temperature of the component can still be maintained at 355°C, which meets the requirements of intrinsic safety characteristics [7]. Zhang et al. discovered a new methane low-temperature combustion catalyst, Au–Pt/Co_3O_4, which reduced the minimum total conversion temperature of methane by 50°C [8]. Hanen and Hanzalek have developed three new technologies for gas sensor reliability: catalytic sensor element dynamic pairing process, constant pressure detection method, and sensor sensitivity automatic adjustment method [9]. The constant temperature detection method proposed by Krishnakumar and Rajesh; the gas detection method based on the principle of time-division compensation has greatly improved the detection of gas [10]. Aiming at the development status of wireless sensor network technology and gas monitoring, a network construction scheme of gas monitoring system based on wireless sensor network was proposed, and the hardware structure of gas sensor nodes in the network was designed. Software of the system is analyzed and designed [11]. Vanjale et al conducted research on wireless underground sensor network (WUSN) and solved the path loss of WUSN and the communication problem of interlayer protocol [12].

Existing monitoring systems are difficult to monitor in real time in goafs, fully mechanized mining faces, and other areas where a large amount of gas accumulates. Aiming at the problem that the current wired network is difficult to monitor dynamically and in all directions, a wireless monitoring system solution based on ZigBee technology is proposed.

3. Research Methods

3.1. Zigbee Wireless Technology. Zigbee technology is a technical standard established by the Zigbee Alliance [13]; it is a new wireless network technology operating in the frequency band of 900 MHz and 2.4 GHz, with the characteristics of short distance, low data transmission rate, low power consumption, low cost, and low complexity; it is widely used in the fields of sensing, automatic control, monitoring, and consumer electronics.

Zigbee short-range wireless communication technology has the advantages of wide coverage, large network capacity, low cost, long battery life, and low energy consumption; it is the current mainstream wireless sensor network technology. It is precisely based on Zigbee wireless communication technology that it has many advantages over other short-distance communication methods; it not only can meet the requirements of underground gas concentration monitoring but also make up for the shortcomings of other wireless communication technologies such as poor scalability, poor networking capabilities, and limited space for transmission and monitoring; the author selects Zigbee technology as the wireless sensor technology for gas concentration monitoring network.

Compared with other short-range wireless communication technologies, it can be clearly seen that Zigbee technology has many advantages in wireless gas monitoring in coal mines [14]. Zigbee network has the characteristics of low power consumption, low cost, short delay, large network capacity, reliable short-range, and self-organizing communication.

Regarding low power consumption, it means that the Zigbee node can work for up to 6 months to two years with limited energy; this does not mean that the node energy is unlimited, but through the node programming and energy consumption strategy, the node can work for a longer time [15]. The main reason for the low power consumption of Zigbee node devices is the low duty cycle mechanism, and the node sets the sleep mechanism.

The reasons why Zigbee technology can be widely used in various industries are as follows: low cost is one of its major advantages, the protocol used by Zigbee technology has no patent fees, 2.4 GHz is global coverage, and its core RF chip cost is low, for example, the current Zigbee CC2530 minimum module price is about 6–8 US dollars; with the competition in the market and mass production, there is still a lot of room for its cost reduction [16].

The Zigbee network has a fast response speed, and the communication delay, search delay, and sleep state activation delay of node devices are very short, the sleep activation delay is only 15 ms, and it only takes 30 ms to enter the network and start working. In comparison, it takes 3 s for wifi and 3 to 10 s for Bluetooth.

Zigbee network topology can adopt three network structures of star, sheet, and mesh; a star network topology can accommodate up to 254 slave devices and a master device, and a mesh topology can have up to 216 Zigbee network nodes [17]. The transmission distance between two adjacent nodes is 10–100 m; in the environment of complex underground tunnels, if some high-power RF modules are added, the direct transmission distance can also reach up to 1000 m. However, by adjusting network node routing and node self-organizing multihop networking, it is also possible to transmit longer distances and ensure network connectivity.

3.2. Hardware Design of Nodes. Under the mine, in order to ensure the reliable transmission of information, one node is fixedly installed on the roadway at intervals (such as 40 m). Therefore, nodes are divided into fixed nodes and mobile

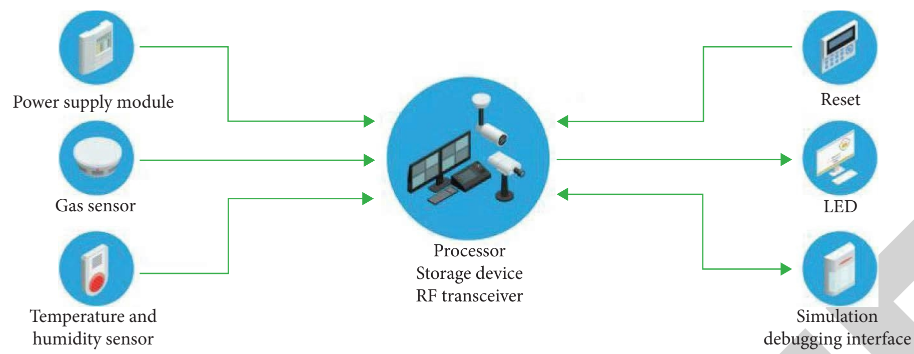

Figure 1: Block diagram of node structure.

nodes according to their states. A mobile node is a node worn by a miner, and its position is not fixed as he moves around. These nodes form a mesh network and transmit wirelessly through the ZigBee protocol. The main function of the ZigBee node is to collect gas concentration and ambient temperature and humidity and send the data to the ZigBee base station. ZigBee node is mainly composed of wireless processor module, power supply module, sensor module, simulation debugging interface, reset, and LED display circuit. The structure diagram is shown in Figure 1. The wireless processor adopts the CC2430 chip with a flash memory of 128 KB from Chipcon that conforms to the IEEE802.15.4 standard [18]. The hardware structure of the fixed node and the mobile node is the same, but the power modules are different. Because the fixed node acts as a coordinator or router, its power consumption is much larger than that of the mobile node, so it is powered by a mine-specific explosion-proof storage power source.

3.2.1. CC2430. The CC2430 integrates a ZigBee radio frequency (RF) front-end, memory and microcontroller on a single CC2420 chip, and the hardware design saves the number of components, simplifies the design circuit wiring density, and improves the reliability of the system. Its selectivity and sensitivity indices exceed the requirements of the IEEE802.15.4 standard, ensuring the effectiveness and reliability of short-range communications. The chip works in a wide voltage range of 2.0 V~3.6 V, with less than 0.6 current consumption in standby mode, and supports digital RSSI (Received Signal Strength Indication)/LQI (Link Quality Indication) support and powerful DMA (Direct memory access) function [19]. Its peripheral circuits include crystal oscillator clock circuit and radio frequency input/output matching circuit. Its local oscillator signal can be provided either by an external active crystal oscillator or by an internal circuit. The clock provided by the internal circuit requires an external crystal oscillator and two load capacitors; the size of the capacitor depends on the frequency of the crystal and the input capacitance and other parameters. The RF input/output circuit consists of a power amplifier (PA) and a low noise amplifier (LNA) with an external antenna. The circuit uses an unbalanced antenna, and the antenna performance can be improved by connecting the unbalanced transformer. The balun transformer in the circuit is composed of capacitor C341, inductors L341, L321, and L331, and a PCB microwave transmission line; the whole structure meets the requirements of RF input/output matching resistance (50).

3.2.2. Sensor Module. The sensor module of ZigBee node is responsible for the collection and data conversion of monitoring area information; in this design, the sensor module adopts gas sensor and temperature and humidity sensor.

The temperature and humidity sensor adopts the SHTxx series, which supports low power consumption mode, and automatically switches to sleep mode after collecting data, and the current is less than 1 μA. This design uses SHT11 temperature and humidity sensor, SHT11 is a digital temperature and humidity sensor chip introduced by Swiss Scnsirion Company [20]. The SHT11 temperature and humidity sensor adopts SMD (LCC) surface mount package, and the interface is very simple, as shown in Figure 2.

The gas sensor adopts KGS-20 low-power gas sensor, as shown in Figure 3. KGS-20 uses tin dioxide as the basic sensitive material, a semiconductor gas sensor specially used for the detection of combustible gas concentration [21]. Its basic features are extremely high sensitivity and extremely fast response speed and low power consumption. KGS-20 combustible gas sensor is suitable for detecting the concentration of combustible gas such as gas and is used in gas alarms, combustible gas alarms, gas detectors, etc. The sensor is small in size, low in power consumption, simple in application circuit, alarm concentration is methane ≥1%, response time ≤20 s, recovery time ≤30 s, operating temperature range−15°C~+50°C, humidity ≤97%RH, static power consumption is 150 mW, alarm state power consumption is 300 mW, and power supply voltage is 3~5VDC. Changes in the resistance RS of the sensitive components of the sensor appear as voltage changes across the load resistance RL. The values of the driving voltage VH, the load resistance RL, and the detection voltage VD refer to the typical data provided by the company to make the sensor in the best working condition.

3.2.3. Power Module. There are many types of batteries, and the energy storage size of the battery is related to factors such as shape, diffusion rate of active ions, and selection of

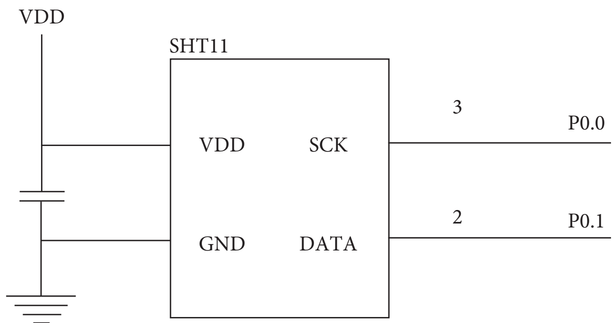

Figure 2: Temperature and humidity sensor module.

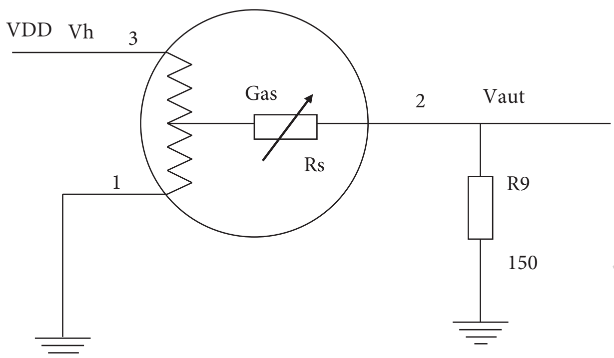

Figure 3: Gas sensor module.

electrode materials. The battery of the wireless sensor network node is generally not easy to replace, so the selection of the battery is very important, and the efficiency of the DCDC module is also very important. Based on these factors and special applications in coal mines, fixed nodes use mine-specific explosion-proof batteries, and mobile node power modules use a 3 V rechargeable button battery. We mainly analyze the power module of the mobile node; when it is detected that the voltage of the button battery is less than 2.2 V, it needs to be charged, and the power supply VCC supplies power to the node. When the coin cell battery is charged to 3V, the battery charges the node.

3.2.4. Reset and LED Display. The reset circuit adopts a button-level reset circuit. When an unexpected situation occurs, press the button to reset it when it crashes. The LED display circuit has LED1~LED2; LED1 is the power indicator; it is off when the battery power is sufficient or in the charging state, and it is on when the battery power is tight. LED2 is the communication status light; when there are data sent or received, it will flash once.

3.3. Node Software Design. The main function of a node is to collect temperature, humidity, and gas information after it joins the network, then send the information to neighboring nodes, and finally to monitoring equipment to monitor these parameter information [22].

In order to overcome the influence of the dynamic change of the network on the information transmission, the network QoS monitoring technology is introduced, and the real-time monitoring is used to lay a good foundation for the intelligent transmission control. Add timestamps at the protocol layer to monitor network delays, add two fields to each packet, and record the last received timestamp (LRT) and the current sent timestamp (CST). After receiving the packet, the receiving end calculates the local packet sending delay according to the LRT and SCT of the packet. At the same time, according to the last packet sending time stamp (LST) saved by the receiving end and the current time of receiving the packet, the processing delay of the opposite end is subtracted; then, the processing delay of the packet in the network can be obtained.

When B-end replies to A,

$$\begin{aligned} LRT &= TB + \Delta t1, \\ CST &= TB + \Delta t1 + \Delta t2. \end{aligned} \quad (1)$$

When end A receives the message from end B,

$$LRT = TA + \Delta t1. \quad (2)$$

And its current time is

$$CT = TA + \Delta t1 + \Delta t2 + \Delta t3. \quad (3)$$

At this time, the two-way delay of packet sending can be calculated as

$$CT - LST - (CST - LRT). \quad (4)$$

3.4. Main Program Design. For the software part of the system, it is divided into two parts: the upper and lower camera positions. Among them, the VB programming language is used for the development of the upper camera monitoring software, and the C language is used for the lower camera development. The modules in the lower position mainly include MCU core processor, data acquisition, wireless node transmission, central node service, RS-485 communication, and other modules [23]. Among them, the main program is responsible for calling and assigning tasks, while the communication module mainly realizes the link connection to the wireless node and is responsible for transmitting the collected tunnel collection parameters;, finally, through RS-485, the data are packaged and sent, and the data are uploaded to the upper camera. The main program flow is shown in Figure 4.

3.5. Communication Protocol Design. In the design of Zigbee wireless network protocol, the communication between sensor node and wireless gateway is mainly realized. The wireless sensor network transmits the collected parameters to the Zigbee gateway, and the Zigbee gateway completes the data interaction with the background software through the RS-485 protocol.

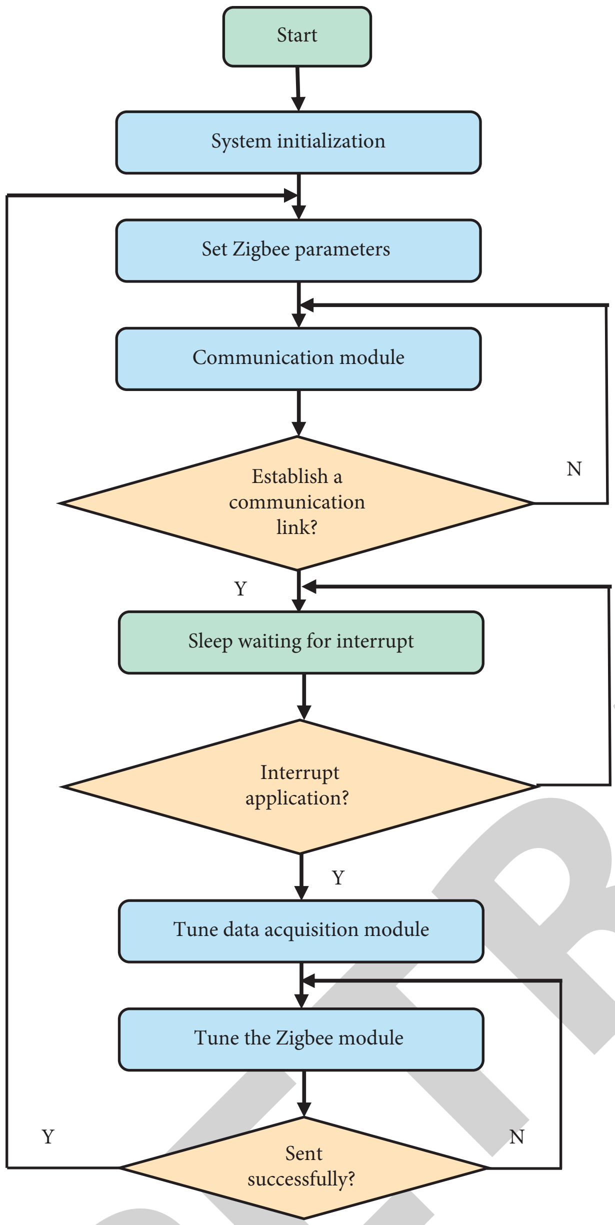

Figure 4: The main program design of the lower camera position.

4. Analysis of Results

4.1. Construction of System Development Platform. The development of this system mainly includes the development of two parts: one is the development of on-site hardware and monitoring and the other is the development of on-site software [24]. For the development of the collection site software, the Windows CE software is used for development, and for the development of the background monitoring software, the Visual C# language is used to develop the system, the database uses Access, and the connection to the database is accessed using the JDBC interface driver [25].

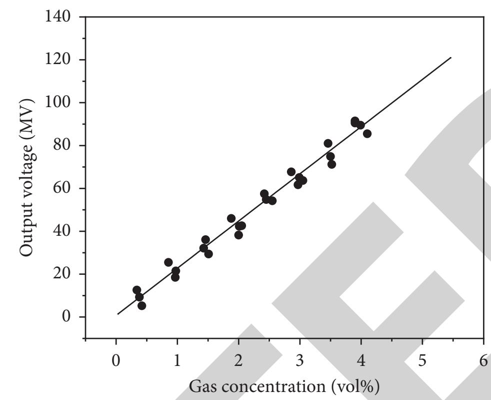

Figure 5: Test results of gas concentration acquisition module.

Table 1: Comparison of methane concentration collection data.

Node number	Node testing concentration (%)	Actual measured concentration (%)	Error (%)
A	1.61	1.53	5.2
B	1.72	1.75	1.7
C	2.37	2.34	1.3
D	3.25	3.30	1.5
E	2.82	2.71	4.1

4.2. System Test. In order to verify the correctness and feasibility of the above program development, a coal mine tunnel was used as the test environment; at the same time, since there is a large amount of gas in the coal mine tunnel, the gas concentration is collected, and the differential voltage value Vd (mV) and methane concentration value (Vol%) collected by the ZigBee node are checked; thus, the change curve shown in Figure 5 is obtained through the test.

In addition, in order to determine the accuracy of the wireless acquisition method, the concentrations collected from the five nodes in the coal mine tunnel were compared with the actual measured concentrations, and the comparison results shown in Table 1 were obtained.

From the comparison results in Table 1, it can be seen that, among the five randomly selected nodes, most of the errors between the actual measured results and the collected results are within the error range of 2%; it can be seen that the acquisition system designed by the author has high accuracy in acquisition and can be applied in practice.

5. Conclusion

The ZigBee wireless sensor network, which has the characteristics of large coverage area, many supporting nodes, flexible networking, low cost, and low power consumption, can improve the scalability of the entire monitoring system while meeting the needs of underground safety production management; at the same time, the cost of constructing safety system communication in coal mining is reduced, and the application value of coal mine safety monitoring and the practical value of coal mine safety monitoring and control information system are improved.

Data Availability

The data used to support the findings of this study can be obtained from the corresponding author upon request.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

Acknowledgments

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