2017 2nd International Conference on Architectural Engineering and New Materials (ICAENM 2017)
ISBN: 978-1-60595-436-3

Research on Intelligent Helmet for Safety Monitoring in Coal Mine

Xiucai Guo and Zhen Wu

ABSTRACT

In view of the problems existing in the coal mine underground safety monitoring, such as the blind area of the monitoring and the arrangement of the safety monitoring sensor, it is difficult to keep up with the progress of the mining face, in this paper, the idea of strong mobility and miniaturization is introduced, and the design method of a new kind of intelligent helmet is proposed, which is based on the integration of various sensors and wireless communication. On the basis of the overall design of the system, this paper introduces the design of the sensor node, the voice module, the video module and the wireless communication module, and the algorithm of personnel location is described.[1]

INTRODUCTION

The distribution of coal resources in China is very special, the data show that China's 95% coal mining in coal mine, mine deep underground, harsh natural environment, in addition, China's coal mines are gas mine, the coal seam gas content, low permeability, complex geological structure, these factors lead to China coal mining is difficult, prone to accidents. Therefore, it is very important for the healthy and sustainable development of China's coal industry to do well the coal mine safety monitoring work. At present, the coal mine safety monitoring mainly depends on the fixed sensor installed in the underground tunnel, the sensor coverage is limited. In addition, due to the working face is in a dynamic environment, along with the coal mining process, mining face advancing safety monitoring of the sensor is difficult to

[1]Xiucai Guo, Zhen Wu, Xi’an University of Science and Technology, Xi’an, China, 710054.

keep up with the working face advancing progress, thus delay the monitoring of working face, which brings great hidden trouble to the safe production of coal mine [1].

In view of the current shortage of coal mine working face safety monitoring of coal mine workers, this article brings forward the safety helmet integrated new function module, which not only has the function of lighting and protection, but also is used as the carrier to monitor the environmental data of the local coal mine workers, and according to the changes of the monitoring environment to make a risk prediction, timely warning miners wearing helmets. In addition, intelligent helmet also integrates voice communication, video monitoring and personnel positioning function, can be more convenient to the management of underground workers. The system is based on the Internet of things, to establish a suitable for the use of the Internet of things, which can play an important role in the safety of miners, production scheduling and disaster relief [2].

THE SYSTEM DESIGN

The System Overall Structure

Similar The design of intelligent helmet for coal mine safety monitoring introduces the idea of strong mobility and miniaturization, and a variety of sensor module, wireless communication module, video module and personnel positioning module are integrated on the miner's safety helmet, which can realize the functions of environment parameter acquisition, personnel positioning, video monitoring and voice communication. The hardware consists of ARM11 (S3C6410) as the core, equipped with Wifi wireless network card, the concentration of harmful gas collection module, video module, voice module, alarm module, power module and other equipment, and the software design adopts multi thread programming. The system makes up for the deficiencies of the existing coal mine safety monitoring, and can play an important role in the coal mine safety, production scheduling and disaster prevention and rescue [3].The overall frame design is shown in figure 1.

The Design of Harmful Gas Concentration Acquisition Module

Intelligent helmet with harmful gas concentration acquisition module, can be set to a certain frequency to collect gas concentration. Methane and carbon monoxide gas sensors are used in this system. The output of the sensor is an analog signal, which needs to use the ADC of S3C6410 to convert the analog signal to digital signal and then upload it to the control center. The gas concentration acquisition module operates independently in a thread to complete the collection, transmission and alarm of the gas concentration.

ADC in the Linux is a simple character device, access to them is read and write by character. As shown in Figure 2, the process of writing the driver of Linux character device is generally module initialization, register character devices, create device nodes, write access to the interface function (read, write, etc.), and finally to uninstall the uninstall function. The initialization of the module and the registration of the character device are completed after the execution of the insmod command, and the interface function is executed after calling the function of the same name in the application layer, and the unloading function is executed after executing the rmmod command [4].

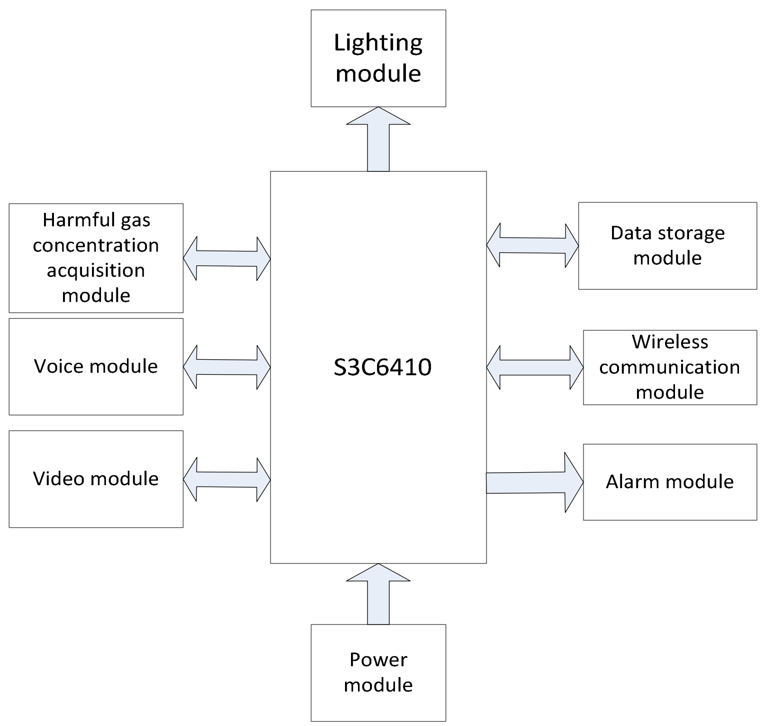

Figure 1. System overall structure.

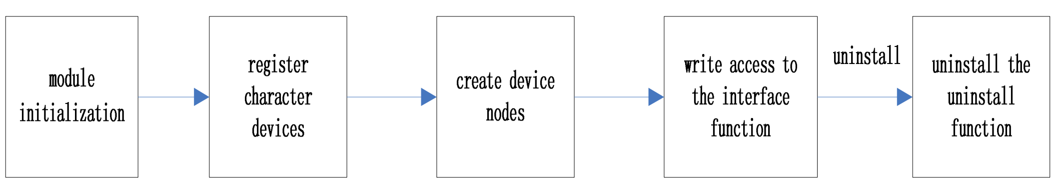

Figure 2. The driver writing process.

At the user level, you first need to use the open() (or fopen) function to open the ADC device node, and then use ioctl() to set the number of channels used for each

ADC conversion. The results of the conversion of gas data will be sent to the monitoring center. The conversion results also were compared with the alarm threshold, if the measured gas concentration to exceed the standard, buzzer alarm.

THE DESIGN AND IMPLEMENTATION OF PERSONNEL POSITIONING

The Selection of Coal Mine Personnel Positioning Method

At present, there are a lot of indoor localization schemes, such as wireless local area network location, infrared positioning, ultrasonic positioning, RFID positioning, etc. For the special environment of coal mine, the RFID positioning method has the advantages of NLOS propagation, without user intervention, low cost, long life, large capacity, used repeatedly, and used in harsh environments, which has become the first choice of underground personnel positioning [5].

The positioning algorithm of RFID system includes: time of arrival, time difference of arrival, angle of arrival and received signal strength (RSSI). In RFID positioning system, RSSI is the most widely used.

The Positioning Principle of RSSI

The positioning principle of RSSI first need to build distance-loss model of test environment label, and then set the reference position of known reading and writing device, by measuring the signal attenuation of contrast signal transmitter and receiver to calculate the distance between the two, and set up a number of readers can use three or multilateral positioning method to complete the positioning of the test label [6].

The process of electromagnetic signal propagation in indoor space, will be affected by the walls and the obstacles, causing energy loss and attenuation, and there is a direct relationship between the propagation attenuation due to external environment caused by the electromagnetic wave in the process of transmitting and receiving distance [7]. The distance-loss model adopted by RSSI is generally a logarithmic distance decay model, and its expression is shown in following formula:

$$P(d) = P(d_0) - 10\eta \lg(\frac{d}{d_0}) + X_\sigma \tag{1}$$

In the formula, d is the distance of the RFID reader to the location of the label; d_0 is the reference distance in the positioning system; η is the path loss index, which changes according to the environment of the wireless signal propagation, the general value of 2~4; X_σ is a normal random noise variable; $P(d_0)$ is the wireless signal power of the reader d_0. By the above formula, the $P(d)$ can be converted to the d of required distance [8]. If the four readers are involved in the positioning, the hyperbolic equations are used to establish the equations. According to the log distance attenuation model, we can get the distance between the tag and the reader, and then the following equations can be established [9].

$$D_{i,1} = D_i - D_1 \tag{2}$$

$$D_i = \sqrt{(X_i - x)^2 + (Y_i - y)^2}\text{, i=1,.....,N} \tag{3}$$

If three readers are involved in positioning, the global model are used to establish the following equations.

$$(X_i - x)^2 + (Y_i - y)^2 = R_i^2\text{ ,i=1,.....,N} \tag{4}$$

THE EXPERIMENTAL RESULT

In Intelligent helmet integrated environmental data acquisition module, audio module, video module and personnel positioning identification card, and the use of wireless communications, to achieve the environmental parameters acquisition, personnel positioning, video monitoring and voice communication function, the model shown in figure 3.

Figure 3. Intelligent helmet model.

CONCLUSION

In view of the current shortage of coal mine working face safety monitoring of coal mine workers, in this paper, the idea of strong mobility and miniaturization is introduced, and a variety of sensor module, wireless communication module, video module and personnel positioning module are integrated on the miner's safety helmet, which can realize the functions of environment parameter acquisition, personnel positioning, video monitoring and voice communication. The system makes up for the deficiencies of the existing coal mine safety monitoring, and can play an important role in the coal mine safety, production scheduling and disaster prevention and rescue. And the system has been successfully applied in a coal mine in Shanxi province, and the field test and application results show that the popularization and application of the system to the coal mine safety production and management has important theoretical significance and engineering value.

REFERENCES

1. Xiucai Guo, Yantao Li, Xiaodong Jing. Study for heterogeneous data integration technology of mine safety monitoring system. EI 20122415104674.2012.04.
2. Bo Cheng, Xin Cheng, Junliang Chen. Lightweight monitoring and control system for coalmine safety using REST style. ISA Transactions, Volume 54, January 2015, Pages 229-239.
3. Shabina, Smart Helmet Using RFF and WSN Technology for Underground Mines Safety[D]. Kuala Lumpur: IEEE, 13.21-26.
4. Song Han, Kam-yiu Lam, Jiantao Wang, Sang Hyuk Son, Aloysius K. Mok. Adaptive co-scheduling for periodic application and update transactions in real-time database systems. Journal of Systems and Software, 2012, 85.
5. AS3990 DATASHEET http:/ /www.austriamicrosystems.com/chi/node_78/RFID.
6. Zhang Ke fei. Underground mining intelligentres ponse and rescuesy stems[J]. Procedia Earth and Planetary Science, 2009:10 44~1053.
7. Hae Donchon. Using RFID for Accurate Positioning[J]. Journal of Global Positioning Systems, 2004, 3:32~39.
8. Ma, Li-hong, Ji, Xiang-jun. The study on the Coal Mine Safety Integrated Monitoring and Early Warning System Design Using the S-MAC Protocol. Journal of Convergence Information Technology, 2013, 86.
9. Heinzalman WR. An application specific protocol architecture for wireless microsensor networks. IEEET rans on Wireless Commun, 2002(4):66-69.