Development of Intelligent Safety Monitoring Helmet for Electric Power Construction based on Internet of Things Technology

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Abstract

The power industry is the guarantee of social stability and economic progress. Reliable power supply plays a vital role in the healthy and rapid development of the national economy. Since the reform of the power system, the government has had a certain negative impact on the weakening of the standardization management of power companies. The problem of power engineering safety is particularly prominent: on the one hand, the rules and regulations of power engineering safety are too old to adapt to the rapid development of power construction. On the other hand, electric power construction safety equipment is also too backward, which greatly increases the danger of electric power construction. As society's demand for electricity continues to grow, the inevitable result is that energy projects continue to grow. Many unfavorable factors and some problems that affect the safety of power engineering will gradually appear, which seriously affect the safety and reliability of power engineering, and must be paid special attention. The purpose of this paper is to study the development of an intelligent safety monitoring helmet for electric power construction based on the Internet of Things technology, and propose the design and development of an intelligent safety monitoring helmet for electric power construction based on the Internet of Things technology. Under the guidance of modern complex mechanical system management, modern safety management and intelligent construction theory, exploratory design and research of new intelligent safety monitoring helmets. During the research process, the feasibility analysis and research on the overall architecture of the intelligent security monitoring helmet system were carried out to achieve the purpose of realizing the basic functions. Experimental research shows that based on the application of the Internet of Things technology proposed in this paper on the intelligent safety monitoring helmet, the accuracy of the dangerous action judgment in the experiment is about 90%, and the heart rate monitoring error does not exceed 2, which meets the expectations of the experiment. It proves that this article has specific practical reference value for the research of smart helmets.

Keywords

Internet of Things Technology; Power Construction Safety; Smart Helmets; Safety Monitoring.

1. Introduction

With the rapid development of Internet technology and communication technology, the process of urbanization is accelerating, and mankind has also entered a new information age. All walks of life are close to the Internet and highly integrated into the Internet to promote human development and accelerate human progress. The same is true for power construction [1]. With the baptism of wireless information technology on the Internet, traditional helmets have been updated and upgraded, which is particularly important for the personal safety and work efficiency of electric power construction

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personnel. The intelligent safety monitoring helmet developed for power generation is used in the power field. Simplification of traditional helmets through various communication technologies not only reduces the cable equipment worn by electricians, but also monitors the safety status of electricians in real time, significantly improves power generation efficiency, and ensures the safety of construction personnel [2].

In the research of the intelligent safety monitoring helmet for electric power construction based on the Internet of Things technology, many researchers have conducted research on it and have drawn many conclusions. MasudaT has proposed a method to create 4D models and has been verified in practice. The visual model controls and manages the progress of the project, and provides feedback through the use of the visual model, and immediately submits suggestions and precautions during the use process [3]. MacdonaldN has studied the relevant methods and procedures for collecting information from the diffuse reflection computing environment, and provided a reference method for the functional design of the smart helmet system [4]. QiY studied the impact analysis of 4D information model on the manufacturing process, and explained the impact of imaging model on the manufacturing process from the aspects of simulation, analysis, management, etc. This provides a technical path diagram for the integration of intelligent safety monitoring helmets for engineering construction into the visual information platform [5]. These researchers have done a lot of research on the intelligent safety monitoring helmet for building electricity based on the Internet of Things technology, which provides a good theoretical and research foundation for this article.

This paper analyzes its design principles and research methods used in the research of intelligent safety monitoring helmets, and conducts experiments after proposing research methods, such as heart rate monitoring experiments and dangerous action recognition experiments. And compare the parameters with standard reference data. Proving the applicability of helmets in practice has played a role in promoting and popularizing the integrated research of the Internet of Things technology and the design and application of traditional helmets.

2. Analysis of Research Methods and Design Principles of Intelligent Safety Monitoring Helmets For Electric Power Construction Based on The Internet of Things

2.1 Internet of Things Technology

The Internet of Things technology in information technology is a new revolution and is the result of the continuous deepening and expansion of the development and application of the Internet. It includes three aspects of technology: perception, transmission and intelligent processing [6]. From a development perspective, the basic supporting theories and key application technologies of the Internet of Things are still being explored, and their applications in specific fields have become research hotspots. At this stage, various devices are developing rapidly, such as smart sensor perception and communication technology. Radio frequency identification technology application equipment and some new smart terminal sensing equipment have been connected to Internet applications, which may eventually form big data applications [7].

2.2 Real-Time Recognition Method of Construction Behavior Based on Image

This method converts the employee's real-time actions and predefined pre-built behaviors into general parameters, compares the two parameter values to determine whether the employee's real-time actions are pre-construction actions, and then judges whether the worker actions belong to the target construction actions [8]. Therefore, the problem of building behavior crisis has become a problem of numerical crisis, so energy can be identified simply and quickly. The method includes three modules: construction behavior database, real-time data collection module and construction behavior judgment module. The construction behavior database contains common construction behaviors, and defines the parameter range of each behavior through parameterized expressions, and provides a template for behavior recognition [9]. When acquiring images in real time, the real-time data acquisition unit

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creates a frame-based image model and configures the model. Construct a behavioral crisis module to determine whether the employee's behavioral parameters belong to a specific behavioral model parameter range. If it is, it means that the employee is performing the behavior corresponding to the template [10].

2.3 Design Principles

2.3.1 Principle of integration

The intelligent safety monitoring helmet system is designed to be able to display scattered on-site personnel information on the same management platform. The people involved in the construction project can be divided into different types according to their identities and grades. Can be defined as the corresponding identity. Tags, through the RFID technology sensor to obtain the terminal integration of scattered personnel information, and through the integration of information to achieve macro control of all personnel and objects on the construction site by the monitoring personnel.

2.3.2 Principle of precision

Effective, complete, and real-time safety inspections must be conducted on the project site to improve the effectiveness of safety production supervision and management to ensure the safety of life and property during the construction process. Unreliable human actions, especially the deviation of the trajectory of manufacturers and construction equipment from the rules and scope, often lead to accidents. This should consider using some smart devices to replace manual and assisted intuitive management operations, such as designing an alarm system based on a smart safety monitoring helmet. When people and objects leave or approach the source of danger, the system will provide different levels of accident prevention warnings in time. Therefore, when designing an intelligent safety monitoring helmet system, it is necessary to ensure the accuracy of personnel information in order to accurately judge people and objects in dangerous situations and take appropriate precautions [11].

2.3.3 Timeliness principle

The design of the intelligent safety monitoring helmet adopts the Internet of Things information technology to transmit the information of the on-site personnel to the control system in real time through the wireless network, and install the corresponding intelligent equipment in the hidden danger part of the site. When the target is in the dangerous range, a safety alarm is issued. For people approaching the object, a security alarm will be triggered automatically. This kind of automatic alarm equipment has a strong application, especially for construction workers. Many construction workers have no safety awareness. At present, the behavior that can remind them through alarms is the easiest to popularize and manage. On the other hand, when the target is in the dangerous range, the target information can also be transmitted to the terminal by radio, so that the administrator can intuitively understand the situation on the spot and take corresponding preventive measures [12].

3. Experimental Research on The Intelligent Safety Monitoring Helmet For Electric Power Construction Based on The Internet of Things

3.1 Heart Rate Signal Feature Extraction Algorithm Model

In the introduction to the research status at home and abroad, it can be known that the processing and analysis of heart rate signals has undergone a long and extensive research. Researchers at home and abroad have demonstrated the strengths and limitations of different methods through continuous experimentation and exploration. Among the various methods of time domain, frequency domain, and time-frequency, the more recognized method is time-frequency analysis. Wavelet analysis is a representative of time-frequency analysis. It was gradually developed in the late 1980s and belongs to a branch of applied mathematics. It plays an extremely important role in engineering applications, especially in the field of signal processing. Its good time-frequency domain analysis characteristics can effectively avoid signal distortion during processing. It has great advantages in heart rate signal processing and overcomes the limitations of traditional filtering methods in many aspects, but because

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of its computational complexity Large, there is a certain degree of difficulty in hardware implementation. In the analysis of ECG signals, wavelet transform is often used for denoising and variability analysis. When a certain pulse wave finds the modulus extreme value pair, if the determined modulus maximum point is the distance between the modulus maximum point in the modulus extreme value pair found in the previous pulse wave (indicated by MV). The heart rate (HR) can be estimated by formula (1) according to the sampling rate (SR):

$$HR = \frac{SR}{MV} \times 60 \tag{1}$$

When 6 MV values are obtained, filter out the MV values with a deviation of more than 25%, then average the remaining modulus extreme values and substitute it back into formula (1) to calculate the heart rate. When the pulse signal frequency changes, the average number will also change immediately, then the adaptive update calculation formula of the variable can be obtained:

$$SMIN = \overline{MV} \times 0.2 \tag{2}$$

3.2 Unsafe Behavior Identification Experiment

This experiment takes the detection of hazardous behaviors of construction site workers as an example, through the test method to determine the value range of the basic parameters and the pre-action of the target behavior, determine the test method, verify the feasibility of the data collection method, and provide data to check the accuracy of the method support. This study first selects common dangerous place behaviors as the research object, and then based on the mathematical model of pre-action and human bones, these behaviors are subtracted from public parameters, the corresponding parameters of different behaviors are determined through experiments, and then the target behaviors of each range of the module are defined Parameters and define classification criteria for different behaviors.

4. Analysis of The Experimental Results of The Intelligent Safety Monitoring Helmet For Electric Power Construction Based on The Internet of Things

4.1 Heart Rate Monitoring Comparison Test

Taking the lead heart rate belt as a reference standard, the heart rate monitoring part of the smart safety monitoring helmet and the smart bracelet on the market were compared three times by the same experimenter and at the same time. The experimental results are shown in Table 1:

Table 1. Heart rate test table

Number of experiments	Lead heart rate belt	smart wristband	Smart helmet
1	73	79	75
2	76	78	77
3	75	72	76

The state of the experimenter is still. The results obtained are shown in Table 1. It can be seen that the accuracy of the heart rate monitoring function of the smart safety monitoring helmet is better than that of the smart bracelet on the market, and its error does not exceed 2, which is closer to the reference device.

4.2 Behavior Real-Time Monitoring Experiment

During the experiment, the experimenter performed pre-actions for specific dangerous behaviors according to instructions. When no instructions are received, the person can move at will. A standard RGB camera and a Kinect camera record the entire experiment at the same time, and the recording frequency of both is 30 frames per second. Use a laptop to edit and display the human skeleton model and joint parameters obtained from Kinect in real time. When Kinect believes that an employee is committing a dangerous behavior, the color of the window where the computer's human skeleton is

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located will change from black to white. There are two poses for each action: safe and dangerous. The experimental results are shown in Table 2:

Table 2. Analysis table of experimental results

Action type	Safety	Danger	Number of misjudgments	Correct rate(%)
Leaning against telephone poles	132	63	26	87
Twisted cable	128	72	21	89.5
Climbing ladder	130	70	23	88.5

It can be seen from Table 2 that as the complexity of the action increases, the accuracy of the helmet's correct recognition of the action also increases slightly. This is because the more responsible the experimenter's actions, the more the joints and bones make more actions, and the more accurate the data. The correct rate is about 90%, which realizes the basic functions of an intelligent safety monitoring helmet.

5. Conclusion

The current helmet development in this article is a modification of the traditional helmet, which does not affect the practicability of the helmet and can be put into electric construction production. Due to work limitations, this article still has some shortcomings: there are many functions that can be added to the smart helmet, and more sensors can be added to the worker, such as body temperature information, breathing rate, etc., to measure the physical energy of the constructor Measure the data and detect the physical condition of the construction personnel in time. At the same time, add some sensors outside the helmet to measure the surrounding data of the construction environment, such as GPS information, temperature, humidity, etc. These are important information for electric power construction. If this information is integrated on a smart helmet, it can better protect the safety of construction workers and help the construction of the project. Hope to continue to improve in follow-up experiments.

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