Calculation and Analysis of Manual Efficiency in Power Grid Engineering Based on Smart Safety Helmet Data Collection

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Abstract: With the continuous advancement of society and technology, the scale of power grid projects continues to expand. Traditional manual ergonomics data collection has limitations such as strong subjectivity and difficulty in data collection, making it difficult to adapt to the fast-paced construction speed of power grid projects and the rapid development of technological progress. In order to further improve the real-time and accuracy of manual ergonomics calculation in power grid engineering, this paper constructs a power grid engineering manual ergonomics analysis and calculation model based on smart helmet data collection, which can effectively improve the timeliness and scientific processing and analysis of manual ergonomics data. Use smart helmet data to conduct case analysis of artificial ergonomics to verify the scientificity and rationality of the artificial ergonomics analysis and calculation model.

Keywords: artificial ergonomics; smart helmets; analytic hierarchy process; support vector regression

1 Introduction

With the acceleration of the power market reform and the transformation and upgrading of the power system, new requirements have been put forward to improve the level of cost control of power grid projects. Labor ergonomics is the basis for determining the cost of labor for construction and installation products, effective control of labor cost is crucial to lean management of engineering cost [0]. For some complex work tasks and some special working environments, traditional manual ergonomics data collection has limitations such as strong subjectivity and difficulty in data collection. With the vigorous development and widespread application of intelligent and digital technologies, the smart construction site system is gradually becoming popular in the electric power industry [0]. Therefore, using smart safety helmets[0][0] for data collection and analysis provides new ideas for improving the collection of manual efficiency data in power grid projects and becomes a new solution.

ICBBEM 2024, March 29-31, Wuhan, People's Republic of China

DOI 10.4108/eai.29-3-2024.2347328

2 Manual ergonomics data collection method based on smart safety helmet

As an emerging technology, smart helmets can collect various data of workers in real time through positioning, sensing and other functions, such as working hours, working location, etc., providing more accurate data and reference basis for manual ergonomics analysis.[0] The idea is shown in Fig. 1.

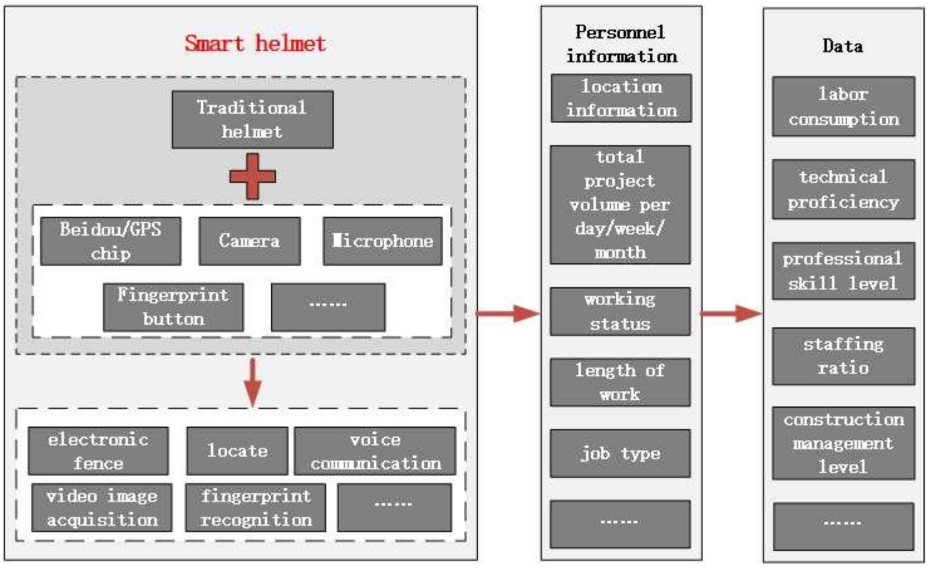

Fig. 1. Data collection idea diagram of labor consumption and influencing factors supported by smart helmet technology

3 Power grid engineering manual efficiency analysis and calculation model based on smart safety helmet data collection

3.1 Determination of factors affecting labor efficiency

On the basis of comprehensively sorting out the influencing factors of labor consumption, using the analytic hierarchy process, experts are invited to evaluate the importance of various influencing factors of labor consumption, thereby screening out the main factors affecting labor consumption. Calculate the comprehensive weight of each influencing factor according to the steps of the analytic hierarchy process. The specific steps are shown in the Fig. 2.

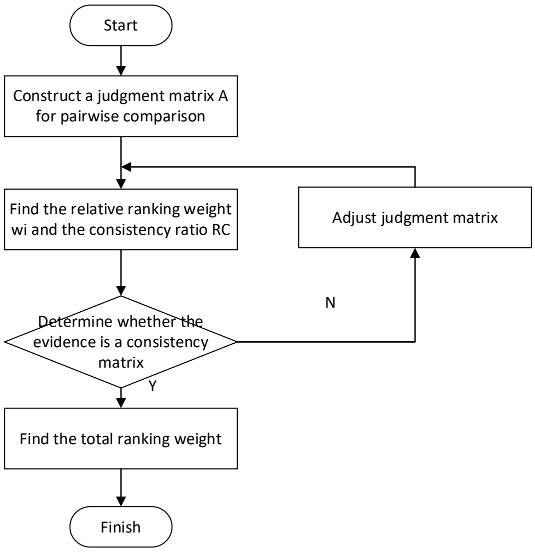

Fig. 2. AHP weight determination flow chart

3.2 Construction of artificial efficiency analysis and calculation model

Support vector machine (SVM) is a data mining method based on statistical theory and can be widely used in statistical classification and regression analysis. [0]

Assume that there is a set of sample sets corresponding to the original data of artificial consumption and influencing factors (y_1, x_1),……, (y_i, x_i), $\mathrm{y} \in \mathbf{R}$, and the linear equation of the regression function is shown in Equation 1:

$$\mathrm{f(x)}=\omega \cdot \varphi(x_i)+b \tag{1}$$

In the formula: $\mathrm{f}(x)$ is the artificial consumption regression function; ω is the function coefficient of the influencing factor variable x ; b is the bias constant; $i=1,2,\cdots,\mathrm{n}$.

Considering the allowable fitting error, the relaxation factors $\xi_i \geq 0$ and $\xi_i^* \geq 0$ are introduced, and the optimal regression function is found through the minimum value of the function, as shown in Equation 2:

$$\min \frac{1}{2}\omega^T\omega + C\sum_{i=1}^{\mathrm{n}}(\xi_i + \xi_i^*) \tag{2}$$

In the formula, ξ_i and ξ_i^* are slack variables, where ξ is the upper limit, ξ^* is the lower limit, and C is the balance factor. The Lagrangian function is introduced to transform the objective function into an unconstrained form, and an appropriate kernel function is selected and substituted into the Lagrangian function to obtain the dual optimization formula:

$$\max\left\{-\frac{1}{2}\sum_{i,j=1}^{n}(\xi_i-\xi_i^*)(\xi_j-\xi_j^*)K\left\langle x_i,x_j\right\rangle-\varepsilon\sum_{i=1}^{n}(\xi_i+\xi_i^*)+\sum_{i=1}^{n}y_i(\xi_i-\xi_i^*)\right\} \tag{3}$$

The constraints are shown in Equation 4.

$$s.t\begin{cases}\sum_{i=1}^{n}(\xi_i-\xi_t^*)=0\\ \xi_i\cdot\xi_t^*\in\left[0,C\right]\end{cases} \tag{4}$$

After solving the relaxation factor, the support vector machine regression function can be obtained. Consider the kernel function instead of calculating the inner product after the sample is mapped to the feature space. The final regression function is shown in Equation 5.

$$f\left(x\right)=\sum_{i}^{n}(\xi_i-\xi_i^*)K\left\langle x_i,x_j\right\rangle+b \tag{5}$$

4 Case Analysis

This section collects the labor consumption and influencing factors of 32 cable laying construction processes in Nantong area, and uses installation technicians as an example to analyze the labor consumption. After indiscriminate screening of the original sample data, abnormal mutation samples were eliminated, and finally 30 sets of valid sample data were obtained. The specific information are shown in the **Table 1**.

Table 1. Table of effective samples for measuring labor consumption under typical con-struction methods of GIS installation projects

Type of work	number	Time (h)	Personnel quality factors		construction management factors		Job site factors		Job object factors		
			professional skill level	technical proficiency	Staffing ratio	Construction management level	On-site road conditions	Process connection	Number of cores	Nominal cross section (mm^2)	Laying length (m)
Installation technician	1	21.6	1	1	3	2	2	2	2	35	1500
	2	15.2	2	2	2	2	2	2	2	35	1500
	…	…	…	…	…	…	…	…	…	…	…
	30	16.8	1	2	1.5	2	1	2	1	10	1000

Randomly select 80% of all sample data as a training set and input it into the support vector machine model, and the remaining 20% of the data in the sample as a test set and input it into the trained model, and use it as a test sample to check the calculation accuracy of the model. The calculated errors in manual consumption calculated by the model are shown in **Table 2**.

Table 2. Comparison table between artificial consumption model calculation results and actual results

	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Sample 6
Model output results	0.1930	0.1661	0.2146	0.1925	0.1913	0.2179
actual value	0.1960	0.1920	0.2080	0.1900	0.1920	0.21634
error	-0.0029	-0.0258	0.0066	0.0025	-0.0006	0.0016

The calculated MAPE value of the 6 samples in the test set is 3.77%, which is within the acceptable range, indicating that the support vector machine data processing model based on ergonomics analysis and multiple regression has sufficient accuracy.

5 Conclusion

this article collects a large amount of relevant literature and materials, and based on the existing data collection functions of smart helmets, determines a reasonable manual ergonomics data collection method to complete the manual ergonomics data collection based on smart helmets, and builds a manual ergonomics calculation model, improve the timeliness and accuracy of manual ergonomics analysis, and better manage project construction. This article provides a reference and generalizable measurement method for the reasonable preparation of consumption quotas, provides practical support for the informatization development of the engineering cost industry, and has practical application value.

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