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Research Article

Evaluation and of University Building Design Effect Based on Multisensor Perception and Data Security

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The development of the smart cities with new and integrated information and communication technologies has changed the traditional industries' processes. One of the domains is construction industry which plays an important supporting role for the economic development of a country, but at the same time, the construction industry is also an industry with high energy consumption and high pollution. Therefore, in order to alleviate the contradiction between economic development and resources and the environment, the construction industry must achieve sustainable development and take the road of green construction. In order to carry out the evaluation of the design effect of colleges and universities, this paper introduces the multisensor perception and fuzzy comprehensive evaluation methods. First, through the design and analysis of the sensor perception system used in the building environment, the collection, acquisition, analysis, and processing of complex information of heterogeneous multiterminals are obtained. Secondly, cluster analysis and genetic algorithms are used in the processing and analysis process of building multiterminal sensor data. The security aspect is also taking into account to design the methods. The system test verifies the performance of the university building design effect evaluation model, which can provide a reference for the sustainable development of the construction industry.

1. Introduction

People's requirements for buildings are getting higher and higher, and the complexity of buildings is increasing. Huge changes have taken place in the types, scales, and forms of modern architecture. This is also the requirement of the rapid development of modern sciences and technologies and social economy and is the inevitable result of the development of the discipline of architecture [1–3]. The complexity of building functions and the diversification of usage requirements have increased the technical problems involved in the use of indoor spaces. The development of architecture inevitably requires the cooperation of various disciplines. In the design stage, different disciplines are considered the construction of buildings from different angles, so as to continuously improve indoor space environment [4, 5]. The work related to building construction includes construction, structure, water supply and drainage, electrical, heating, ventilation, and other professional content. All majors determine all aspects of the building in the design, and most of the energy-related design decisions occur in the early design stage [6]. When a building reaches the construction stage, the significance of building energy saving and emission reduction is only whether it can meet the requirements of building design. The characteristics of the building have been basically determined in the design stage and realized through the construction process [7–9].

Modern technologies have gradually refined the division of human activities. Architectural design is also completed by the cooperation of multiple disciplines, and more and more factors are considered by each discipline. Architects should not only consider space requirements and architecture. The aesthetic principles of form also need to consider building energy-saving design [10]. Authors in [11] analyzed the energy consumption costs of 12 types of buildings in 16 cities and calculated that traditional energy-saving technologies can save energy by 20% to 30%, and some buildings can even achieve energy saving of 40%. Further, confirm the necessity and feasibility of energy saving and emission reduction. Authors in [12] discussed the sensitivity of building envelopes, including the impact of multilayered wall buildings (36 categories) and different sizes of glass (10-90%) on building energy consumption, and studied the impact of envelopes on building low-carbon impact of development. Authors in [13] took the development of a community in Northern Europe as an example, studied the resource input and carbon emissions of high-energy-efficiency buildings in the construction phase, and proposed excessively improving the energy efficiency of buildings, increasing the input of building materials and energy during the construction phase. Increasing carbon emissions during the construction period and forming a peak of carbon emissions before the building are used and are not conducive to the realization of the short-term carbon reduction target. Attention should be paid to the emission reduction during the construction phase and included in relevant policy formulation. Shaikh et al. [14] conducted research and verification on existing building energy consumption simulation software and believed that climate parameters are the main parameters that affect building energy consumption simulation. For the energy consumption simulation of the entire building, accurate climate data is to achieve accurate quantification. It is an important component of the analysis and discusses that different simulation targets should be selected by different climate data.

Architectural design, as planning before building construction, integrates the requirements of architectural function, architectural technology, and architectural art and is a comprehensive display of various technical means on the basis of satisfying the use of functions [15, 16]. Human requirements for the indoor and outdoor space functions of buildings always change with the development of the times. To meet these ever-changing and increasing requirements, all participants are researching and improving the design. From ancient craftsmen at home and abroad to today's engineers and scholars in many fields such as architecture, engineering, environment, and materials, a lot of research on architectural design has been carried out [17, 18]. However, the construction industry is also an industry with high energy consumption and high pollution. Therefore, in order to alleviate the contradiction between economic development and resources and environment, the construction industry must achieve sustainable development and take the road of green building. In order to carry out the evaluation of the design effect of colleges and universities, this paper introduces the multisensor perception and fuzzy comprehensive evaluation methods. The system test verifies the performance of the university building design effect evaluation model, which can provide a reference for the sustainable development of the construction industry. The paper also presents the security architecture to secure the data of the model. The main objectives of this paper are as follows:

(i) Design multisensor perception and fuzzy comprehensive evaluation methods for the sustainable development of the construction industry

(ii) Design a security model for the sustainable development-related data security

The rest of the paper is organized as follows: Section 2 discusses the architecture design effects and its evaluation. Section 3 presents the multisensor sensing model. Section 4 discusses the evaluation of the effect of college building design based on multisensor perception. Section 5 presents the security model for development data. Section 6 concludes the paper with future direction.

2. Overview of Architectural Design Effect Evaluation

Due to the lack of bottom-up postuse evaluation applications, the above-mentioned problems have further lost the opportunity to give feedback to planning builders and designers. Friedman defined it as a "degree" evaluation in his POE (Post Occupancy Evaluation) book [19, 20]. How to support and meet people's expressly or implicitly expressed needs after the completion of the environment. Each construction practice project is a complete system composed of five stages, which is divided into construction project approval, stationing planning, architectural design, building construction, building operation, and post-use evaluation [21]. The postuse evaluation of penetration at various stages continuously provides feedback and corrections for the smooth implementation and good operation of an engineering construction project [4, 22]. However, as far as the existing research is concerned, the postuse evaluation is mainly used by architects, and only feeds back to the "architectural design" stage, while ignoring the remaining four stages. But only if these five stages are consistently revised can the final architectural quality be improved. Figure 1 shows the closed-loop diagram of the whole process of architectural creation.

Postuse evaluation has three values: short-term, mid-term, and long-term. The short-term value lies in the timely assessment of the existing problems in the building and the proposal of targeted correction strategies to avoid loss and expansion; the medium-term value lies in the collection of preliminary project data for large-scale renovation or reconstruction; the long-term value lies in summarizing the design experience of the same type of project and forming available reference basis or industry norms [23, 24]. The evaluation method includes two aspects: quantitative analysis and qualitative analysis. For the construction industry, quantitative analysis is the main method adopted for objective evaluation, while qualitative analysis is the main method adopted for subjective evaluation. The objective evaluation is based on the building design specification documents of different building types, and the data contained in the specifications are determined in a certain period of time. Subjective evaluation refers to the psychological feelings of people entering the building after it is completed. Subjective evaluation has individual differences and is related to people's educational level, personal accomplishment, experience, and rationality. Evaluation is based on people, and people's subjective evaluation of a commercial building is often more direct and

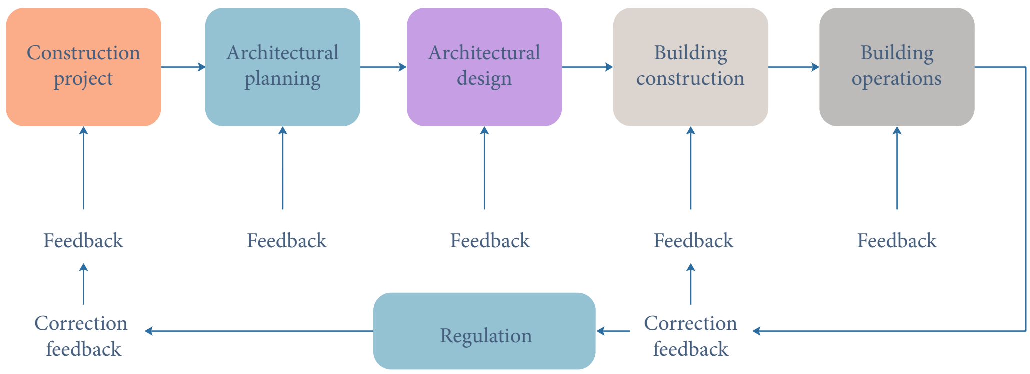

FIGURE 1: Closed-loop diagram of the whole process of architectural creation.

specific. This is something that designers tend to ignore. The content of the evaluation for commercial buildings includes the age of the evaluator, culture, outdoor environment design of the building, the integrated design of the traffic around the building, the circulation, space, function of the building, the parking design of the building, and the age of the evaluator.

3. Multisensor Sensing

Sensors play an important role in smart transportation, smart home, smart agriculture, and national defense security. These applications have one thing in common, that is, a wide coverage. Therefore, in order to realize these distributed applications, the system must first have a key function, that is, the information sharing capability of the sensor [25]. At present, most sensor application systems usually use different devices to build sensors, which is an important part of the wireless sensor network. It can be seen from the above that the realization of perception depends on sensitive devices, although researchers in the field of materials have been striving to find suitable production materials. However, sensitive devices will be greatly affected in certain environments, such as high temperature, corrosion, humidity, dust, and electromagnetic fields [26]. Figure 2 shows a schematic diagram of a typical sensor component.

Therefore, static characteristics can use range and measurement range, linearity, hysteresis, repeatability, sensitivity, etc., as its indicators. The dynamic characteristic refers to the response characteristic that the output of the sensor changes accordingly when the input quantity changes dynamically with time [27]. The dynamic characteristic of the sensor firstly depends on the sensor itself, which is determined by the dynamic characteristic of the link that plays a major role in the sensor. The bottom node directly contacts the analog signal in the physical world environment to collect and uses the embedded processor architecture to realize the perception function [28]. The middle layer is responsible for the collection and integration of the bottom-level section information with only a single intelligent combination and high-speed real-time upload. At the same time, the high-level decision information is downloaded to the corresponding node and executed. This layer can be a module, or it can be set as a powerful module according to system requirements. The uppermost layer gathers all perceptual information and has threshold judgment and decision-making functions, and the PC can be used as a decision support node.

4. Evaluation of the Effect of College Building Design Based on Multisensor Perception

4.1. Cluster Analysis of Building Location. This paper selects the data of the geographical location of the completed building and makes a cluster analysis of its latitude and longitude. Cluster analysis is a multivariate statistical analysis to quantitatively study classification problems according to the characteristics of things themselves [29]. It is a classification method of multivariate statistics "things to cluster." The basic idea is to divide the location into several categories according to the distance, so that the difference of the data within the category is as small as possible, and the difference between the categories is as large as possible.

Step 1. Data standardization.

Supposing domain $x = \{x_1, x_2, \cdots x_n\}$ is the object to be classified, and each object is represented by m indicators, then each variable can be expressed as x_{ij}.

Mean:

$$x_j = \frac{1}{n}\sum_{i=1}^{n} x_{ij}. \quad (1)$$

Standard deviation:

$$s_{ij} = \sqrt{\frac{1}{n-1}\sum_{i=1}^{n}\left(x_{ij} - x_{ij}\right)^2}. \quad (2)$$

After standardization:

$$x_{ij}^{*} = \frac{x_{ij} - x_j}{s_j}\left(s_j \neq 0\right). \quad (3)$$

Step 2. Determine the similarity coefficient r_{ij} using the Euclidean distance method for cluster analysis.

Each task position can be regarded as a point in the three-dimensional space. The task position constitutes the

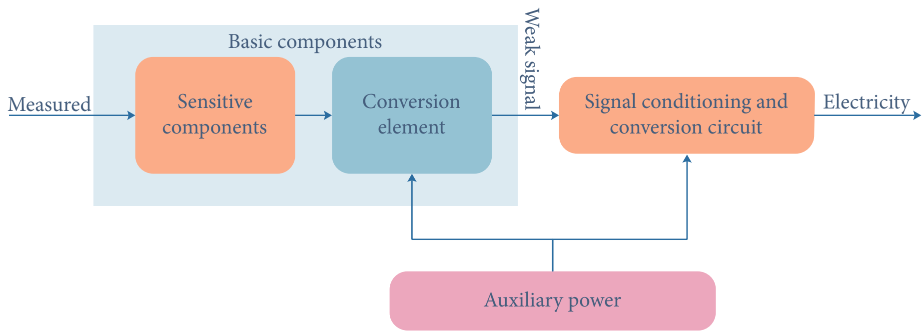

FIGURE 2: Schematic diagram of sensor components.

TABLE 1: The latitude and longitude coordinates of the clustering points and the number of various tasks.

Cluster points	1	2	3	4	5
Latitude of cluster points	23.066	23.565	22.958	22.713	23.101
Cluster point longitude	113.03	113.55	113.75	114.06	113.30
Number of buildings in cluster area	80	23	159	72	187

point in the three-dimensional space. A matrix is formed between the task position and the cluster center, and the Euclidean distance between the task position and the cluster center is calculated. Let x_i denote the ith cluster center $i = 1, 2, 3, 4, 5$ and denote the distance between the ith cluster point and the jth task position, the Euclidean distance calculation method is

$$d_{ij}(2) = \left[\sum_{k=1}^{n} \left(x_{ik} - x_{jk}\right)^2\right]^{1/2} (i, j = 1, 2, \cdots, n). \quad (4)$$

Step 3. Use SPSS to analyze the data completed by the tasks in Annex 1, and we have obtained the latitude and longitude coordinates of the cluster center point and the number of tasks in each category. The latitude and longitude coordinates of the clustering points and the number of tasks are shown in Table 1.

4.2. Establishment and Solution of Multiple Regression Model. First, analyze the Pearson correlation coefficient of the four indicators to determine whether they are linearly correlated [30]. First, integrate the data to calculate the Pearson correlation coefficient of each indicator and the rest of the indicators, and then obtain the average of the square sum of the Pearson correlation coefficients of a certain indicator and the rest of the indicators and obtain the A of each indicator R_{vi}^2.

The definition of Pearson's correlation coefficient is B:

$$R = \frac{1}{n}\sum_{i=1}^{n}\left(\frac{y_i - y}{s_y}\right)\left(\frac{x_i - x}{s_x}\right) = \frac{\text{cov}\,(Y, X)}{s_y s_x}. \quad (5)$$

If $|R| \approx 0$, it indicates that there is no linear correlation between the two variables. If $|R| \approx 1$, it shows that the two variables are completely linearly related. The direction of linear correlation is indicated by the sign of the correlation coefficient, "+" means positive correlation, and "-" means negative correlation.

TABLE 2: The mean value of the sum of squares of the correlation coefficients of each indicator and the other indicators.

Index	v_1	v_2	v_3	v_4
Mean sum of squares	0.856	0.758	0.625	0.791

$$\bar{R_{vi}}^2 = \frac{\sum_{j=1}^{m} R^2{}_{vivj}}{m-1}, \quad j = 1, 2, \cdots m, j \neq i. \quad (6)$$

In the formula, v_i is the index code, v_1 is the task location, $\boldsymbol{v_2}$ is the member density, $\boldsymbol{v_3}$ is the distance between the task and the member, and v_4 is the reputation value within a certain range. $R^{\bar{2}}{}_{vi}$ represents the average of the sum of squares of the Pearson correlation coefficient R of the indicator v_i and the remaining variables $v_j (i \neq j)$. m is the number of variables.

Finally, it is determined whether there is a linear relationship between the three indicators of building geographic location, personnel density, and the distance between building geographic location and personnel and task pricing. The postuse evaluation of penetration at various stages continuously provides feedback and corrections for the smooth implementation and good operation of an engineering construction project. Table 2 describes the mean value of the sum of squares of the correlation coefficients of each indicator and the other indicators.

It can be seen from Table 2 that the minimum value of $R^{\bar{2}}{}_{vi}$ is 0.625, and the linear relationship between various variables is strong. The linear relationship between v_1, v_2, v_3, and v_4 and task pricing y can be expressed by the linear regression equation.

$$y = b_0 + b_1 x_1 + \cdots + b_p x_p + \varepsilon, \quad \varepsilon \sim N\left(0, \sigma^2\right). \quad (7)$$

In the formula, $b_0, b_1, \cdots b_p, \sigma$ is an unknown parameter that has nothing to do with $x_1, x_2, \cdots, x_p$.

Let $(x_{11}, x_{12}, \cdots, x_{1p}, y_1), \cdots (x_{n1}, x_{n2}, \cdots, x_{np}, y_n)$ be a sample. Estimate the parameters using the least square method.

$$Q = \sum_{i=1}^{n} \left(y_i - b_0 - b_1 x_n - \cdots - b_p x_{1p}\right)^2. \tag{8}$$

Take the partial derivatives of Q with respect to $b_0, b_1, \cdots b_p$, and set them equal to zero, we get

$$\frac{\partial Q}{\partial b_j} = -2 \sum_{i=0}^{n} \left(y_i - b_0 - b_1 x_{i1} - \cdots - b_p x_{ip}\right) x_{ij} = 0, \quad (j = 1, 2, \cdots, p). \tag{9}$$

Simplify the above formula to

$$b_0 \sum_{i=1}^{n} x_{i1} + b_1 \sum_{i=1}^{n} x_{i1}{}^2 + b_2 \sum_{i=1}^{n} x_{i2} x_{i1} + \cdots + b_p \sum_{i=1}^{n} x_{ip} x_{i1} = \sum_{i=1}^{n} y_i x_{i1}, \tag{10}$$

that is, the maximum likelihood estimation of the unknown parameter $(b_0, b_1, \cdots, b_p)$. So the linear regression equation is

$$\hat{y} = b_0 + b_1 x_1 + \cdots + b_p x_p. \tag{11}$$

Calculated with SPSS19.0 software:

$$y = -23.56 + 0.35 v_1 - 0.64 v_2 + 0.26 v_3 + 0.15 v_4, \quad R^2 = 0.58. \tag{12}$$

$R^2 = 0.58$ indicates that 58% of the relationship between the geographic location of the building and the four indicators can be determined by the regression equation.

Assume that the functional relationship between task pricing on the 4 indicators is

$$y = a_1 v_1 + a_2 v_2 + a_3 v_3 + a_4 v_4 + b. \tag{13}$$

Among them, a_i is the parameter to be estimated, and b is a constant. Estimated by the least square method: $y = -23.56 + 0.35 v_1 - 0.64 v_2 + 0.26 v_3 + 0.15 v_4$; the p value corresponding to parameter v_1, v_2, v_3, and v_4 is 0.46, 0.47, 0.008, and 0.097. Perform a heteroscedasticity test on the model to get $p = 0.891$. The original hypothesis is that the model is homoscedastic. Accept the original condition, that is, there is no heteroscedasticity. The serial correlation test $DW = d = 1.85$, $d_u = 1.83$ satisfies $d_u < d < 4 - d_u$, and it is judged that there is no serial autocorrelation in this regression equation. Use the least square method to find the regression estimation equations for each explanatory variable one by one, and the results are shown in Table 3.

When the significance level is 0.05, $F(1, 29) = 4.18$ is found. Because the independent variable v_4 is $F = 1.41 < F_{0.05}(1, 29) = 4.18$, and the p value of the parameter estimation is too large, it shows that the regression model of v_4 to y is not significant, indicating that the member reputation value has no great relationship with task pricing. Regarding the independent variable v_2, the regression significance is not high, but for the variable v_1, you can continue to the next step of regression. Select v_1 with better test results in all aspects as the first selected variable, remove the influence of v_4 on y, and do the second time return. Table 4 shows the results of the second regression analysis.

Table 3: Results of the first regression.

Equation	R^2	The estimated p value of the parameter	F	Residual sum of squares
$y = 23.16 + 56.12 v_1$	0.056	0.2589	14.55	304.12
$y = 14.23 - 15.89 v_2$	0.325	0.2345	9.36	204.23
$y = 0.258 + 0.68 v_3$	0.256	0.025	17.58	160.25

Table 4: The second regression analysis.

Equation	R^2	The estimated p value of the parameter	F	Residual sum of squares
$y = 0.561 v_1 - 0.398 v_2 + 0.256$	0.741	0.063	42.1	58.1
$y = 0.38 v_1 + 0.24 v_3 - 0.368$	0.76	0.025	51.2	87.9

When the significance level is 0.05, $F_{0.05}(2, 28) = 3.34$ and $F_{0.05}(1, 28) = 4.20$ are obtained by looking up the table. As the variables are added one by one, the improvement of the variable y equation is basically unchanged. Since $F_1 = 42.1$ and $F_2 = 51.2$, and both are greater than $F_{0.05}(1, 18) = 4.41$, it shows that the model is significant as a whole. The heterogeneous test of the model is $p = 0.87$, which means that there is no variance in the model; the serial correlation test is performed on the model. Since $DW = d = 2.02$ and $d_u = 1.67$ meet $d_u < d < 4 - d$, it means that the model does not have serial autocorrelation. So this model is the optimal model.

4.3. Optimization of Geographical Location of Buildings Based on Genetic Algorithm. Objective function expression:

$$\max f = \sum_{i \in m} \sum_{j \in m} x_{jk} y_{ijk} z - \sum_{g \in n} p_g \forall k \in p, \tag{14}$$

where m is the node set, $\{0, 1, 2 \cdots i\}$, n is the node collection of the task point, $\{1, 2, \cdots, g\}$, p is a collection of crowdsourced member tasks participating in the task, $\{1, 2, , \cdots, k\}$, x_{jk} is the amount of tasks the member accepts at the task point, and z is the member's income for each task completed.

Constraints on task points, membership amount, and completion ability at each point. The amount of tasks

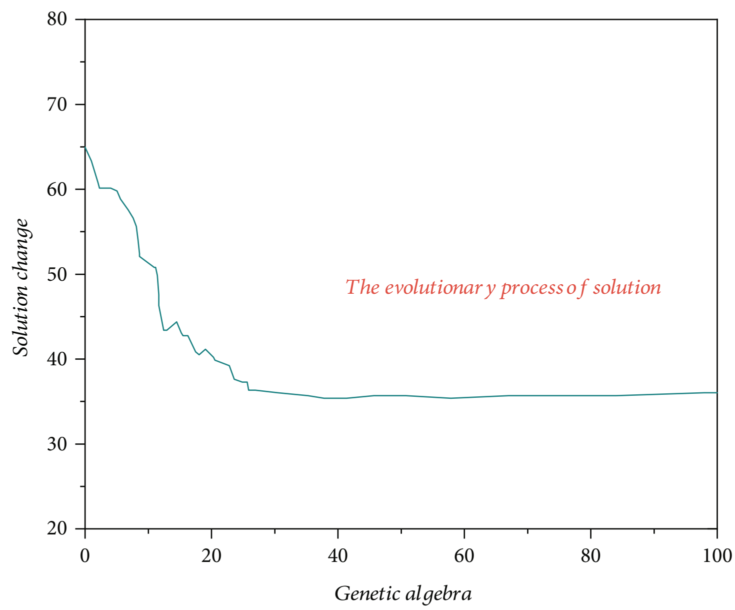

FIGURE 3: Evolution process of genetic algorithm.

completed by new members in a single time must not be less than the minimum amount of tasks completed:

$$\sum_{i\in m}\sum_{j\in m} x_{jk} y_{jk} \geq N. \quad (15)$$

The sum of the tasks accepted by all members is not greater than the sum of the tasks generated by the positions of all the characters:

$$\sum_{i\in m}\sum_{j\in m}\sum_{k\in p} x_{jk} y_{jk} \leq Q. \quad (16)$$

The task accepted by each task person is not greater than its maximum task completion ability:

$$\sum_{i\in m}\sum_{j\in m\cup N^*}\sum_{k\in p} x_{jk} y_{jk} \leq M. \quad (17)$$

Time window constraints:

$$T_{jk} = y_{jk}\left(T_{jk} + t_{ij} + t_i{}'\right), \quad (18)$$

$$T_{jk} = y_{jgk} t_{jg} T_{hk} = y_{ghk}\left(T_{jk} + T_{jgk} + t_{gh}\right) t_{oj} = 0. \quad (19)$$

Relational constraints between sets:

$$\begin{aligned} L &= L' + \sum_{e\in E} L_e, \\ R &= R' + \sum_{e\in E} L_e. \end{aligned} \quad (20)$$

Penalty function constraint:

$$P_g = \begin{cases} \beta \times (T_{\mathrm{hk}} - LT_h), & T_{\mathrm{hk}} \succ LT_{\mathrm{h}}, \\ 0, & T_{hk} \leq LT_{\mathrm{h}}. \end{cases} \quad (21)$$

Decision variable constraints:

$$\begin{aligned} &y_{jgk} = \min\left\{y_{ijk}, y_{ghk}\right\}, \\ &y_{ijk}, y_{jgk}, y_{ghk} \in \{0, 1\}. \end{aligned} \quad (22)$$

The genetic algorithm is used to solve the problem by programming, and the iterative process of the solution of the model is shown in Figure 3.

The genetic algorithm used in this paper has been iterated 100 times and found that after roughly 27 iterations, the solution obtained has stabilized. The results obtained clearly solve the problems of optimizing paths and merging tasks. Table 5 shows the solution results of the optimization model.

According to the above optimization results, a comparison between before and after optimization can be obtained. Table 6 shows the comparison between before and after optimization.

Cluster analysis and genetic algorithm are used in the processing and analysis process of building multiterminal sensor data. In this paper, a genetic algorithm is used to process and optimize the sensor information, and the performance of the university building design effect evaluation model is verified through system testing, which can provide a reference for the sustainable development of the construction industry.

Table 5: Solution results of the optimized model.

Personnel number	Member task completion path after optimization	Number of tasks	Member income	Completion
1	$A9 \longrightarrow A1 \longrightarrow B1 \longrightarrow B3 \longrightarrow B11$	5	325	$1+1+1+1+1$
2	$A8 \longrightarrow A9 \longrightarrow A2$	3	210	$1+1+1$
3	$A9 \longrightarrow A6 \longrightarrow B4 \longrightarrow B1$	4	199.5	$1+1+1$
4	$A3 \longrightarrow A5 \longrightarrow A4 \longrightarrow B5 \longrightarrow B2$	5	268	$1+1+1+1$
5	$A1 \longrightarrow A6 \longrightarrow B3 \longrightarrow B10$	4	240	$1+1+1$

Table 6: Comparison of before and after optimization.

	Before optimization	Optimized
The number of members needed (person)	68	46
Average single task evaluation (%)	66.5	86
Mission completion	62.39%	60.23%

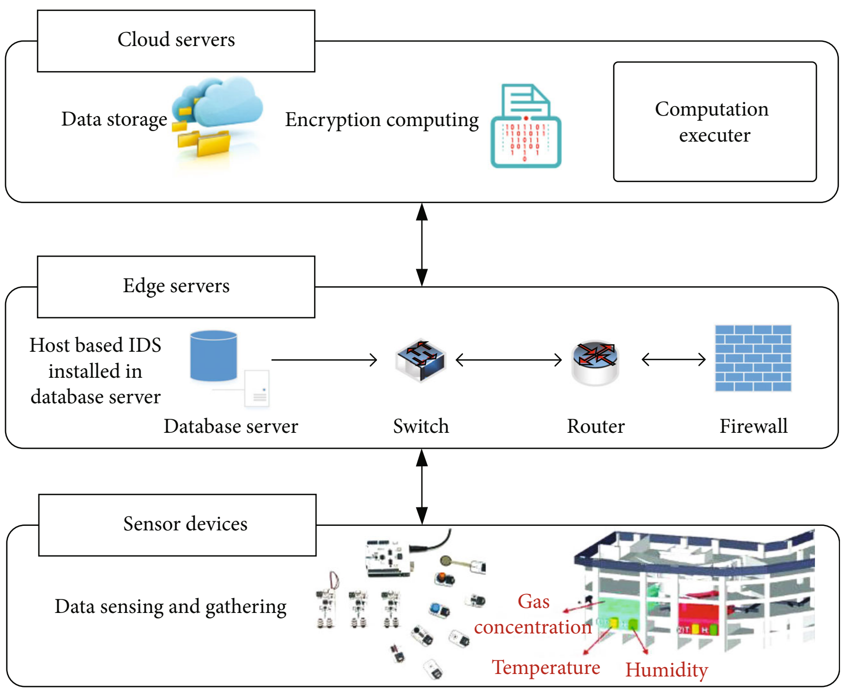

Figure 4: IDS system for edge computing.

5. Security Model for the Sustainable Development-Related Data Security

The huge data is collected from the systems and sensor nodes. The centralized database stores all the data for further processing and analyzing. The data is collected from the construction activities that start from planning and completion phases [31, 32]. As security is one of the challenge especially when the data transmitted to the edge computing or to the cloud for further decision making, we proposed a IDS solution at the edge computing side to protect all the data coming from ground network and sensor devices. The Intrusion Detection System (IDS) is installed at the edge computing side to filter the data and detection and prevent the data from any sort of malicious activities in the network. Figure 4 shows the IDS deployment at the edge side to protect the building data from unauthorized access.

6. Conclusion

The buildings obtained from the construction activities according to the drawings are the true manifestation of the design results. The goals must be determined in the project planning stage, and the specific implementation plan must be determined in the design stage. Through a reasonable design plan, the carbon emissions of the building's life cycle can be reduced. Architectural design, as a planning before building construction, integrates the requirements of architectural function, architectural technology, and architectural art and is a comprehensive display of various technical means on the basis of satisfying the use of functions. Therefore, this article has carried out an evaluation of the effect of architectural design. At present, the research on building energy efficiency mainly focuses on building design or the whole life cycle. There are not many researches on the operation phase. The existing research mainly includes the discussion of the owner and property management mode and the development of the energy-consuming equipment database during the operation. The research on energy consumption evaluation standards needs to be further in-depth. Building energy efficiency is a hot topic today. In the face of my country's current national conditions, the most direct and effective energy saving should start from the operation of existing buildings. The research done on this subject still needs to be expanded in the following aspects. The research on the energy-saving coefficient during operation still needs to be further explored, guided by practicality, operability, and effectiveness, to provide effective theoretical tools and measurement scales for building energy saving. This paper also presented the IDS system deployment model at the edge computing side for data traffic detection and prevention form any malicious activities in the network. Based on the research content of this article, in the next step, we will try to place the sensing method in different experimental environments, further enrich the sensing model, establish a complete sensor information database, and facilitate the addition and identification of various sensors, while also standardizing the manufacture of sensors.

Data Availability

The data in the paper has been included in the article.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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