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Research on management method of construction schedule based on genetic algorithm fusion BIM model

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Abstract. In order to improve the reliability of the management method of construction progress, a research method of management method based on genetic algorithm fusion BIM model in construction progress is proposed. Firstly, using the BIM model to construct the quantitative index of project evaluation results and establishing the comparison matrix of project construction progress, and providing the model basis for decision analysis; second, introducing BIM model of building construction schedule management to introduce genetic algorithm to optimize the construction schedule. Finally, the validity of the algorithm is verified through simulation experiments.

Key words. Genetic algorithm, BIM model, Construction schedule, Optimization prediction
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1. Introduction

Construction progress analysis involves the procurement of raw materials, transportation, recycling, maintenance and other links. Using BIM model for construction progress assessment and tracking control is one of the hot areas in the area of construction cost control [1, 2].

The literature [3] uses the BIM model to research and analyze the components related to the progress of the construction, forming a simplified form of the building components. Literature [4] uses BIM model to evaluate the progress of construction projects. Literature [5] builds an assessment system for the life cycle of a building and studies the interference of the life cycle building environment. In Literature [6], based on the construction progress assessment model, builds the assessment model under the influence of the construction progress, so as to gain the environmental interference of building examples. BIM-based building model building has more

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obvious advantages, which is widely used in building assessment applications. At present, the related research on the construction schedule model, the 3D model evaluation framework adopting the project BIM technology is a practical way to influence the construction progress factors [7, 8].

In this paper, mainly for construction project construction progress analysis point of view, based on genetic algorithm fusion BIM model construction schedule management method research algorithm, building materials and BIM elements of the relationship between the model to form a quantitative evaluation of building components to improve the construction The reliability of the progress assessment.

2. Definition of BIM-based project construction schedule

2.1. Definition Description

The fine management of the progress of the construction is to refine the management of each stage of the project and realize the stage-wise management of the cost construction progress. For all stages of project implementation, resources are optimally allocated to effectively avoid the "three super" phenomenon. Fine construction progress management aspects are: design, decision-making, construction, bidding, completion of five stages, the five stages involved in the construction schedule management and related subjects, see Figure 1 below.

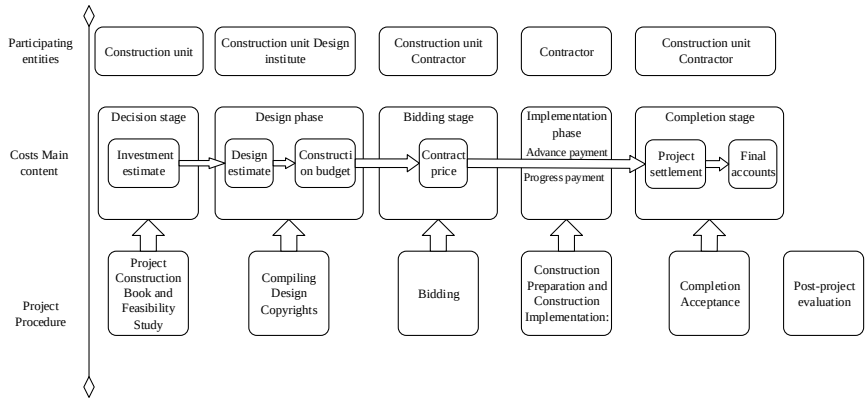

Fig. 1. Construction schedule management of green building

Fine construction progress management is the premise to determine and control the progress of construction. In order to achieve a reasonable assessment of investment, it is necessary to first ensure that it falls within the scope of the total construction schedule control quota. In particular, during the design phase of construction progress assessment, it is necessary to ensure that the construction progress assessment value is more reasonable than the construction phase assessment value in the investment phase and is affected by the estimation of construction progress in the investment phase. For the construction drawings design phase of the construc-

tion progress estimates, it needs to follow the construction drawings design ideas and data for further refinement assessment. For the green building construction schedule management, the key to assess the progress of the construction is to handle the bidding construction progress between the construction unit and the contractor. For the progress of the process construction project and the management of prepaid capital matters, it is necessary to combine the construction actualities with the two key aspects of the pre-project design. For the green building project accounting and settlement management links, we need not only to summary the actual progress of the construction project, but also need to control the progress of the construction phase of the project.

2.2. BIM quantitative evaluation model

In this paper, the construction progress management process of a research building in a university in China is taken as the research object, and the construction progress management of the construction project is taken as the research object to analyze the construction progress. After confirming the construction progress assessment interval, the model relationship between green building materials and BIM elements needs to be established. The specific types of green building materials are shown in Table 1.

Table 1. BIM-Tally correspondence

No.	Material Name	Model Family Name	Volume
1	Concrete - fine stone concrete	100+150	74.168
2	Concrete - steel	100+150	18.532
3	Concrete - fine stone concrete	100+200	19.918
4	Concrete - steel	100+200	5.974
5	Concrete - steel	150	0.218
6	Concrete - steel	FW-150	118.156
7	Concrete - steel	JT-150	15.142
8	Concrete - steel	SH-150	290.128

Once concrete reinforcement green building materials have been identified, the impact of green building materials on the progress of green building projects can be calculated. It mainly involves the following three stages: (1) project construction phase. In the process of project construction, the influencing factors for the progress of various types of green building are sorted according to their size. Because the proportion of primary energy and non-renewable energy consumed in the construction of green building accounts for more than 80% of the total construction progress during the construction phase of green building. The selection of materials such as steel bars and concrete with a lower construction schedule will help reduce the progress of the entire project. (2) Project maintenance and operation phase. At this stage, the recycling and reuse of waste water and other raw materials in the project construction should be strengthened to further reduce the construction progress of the project. (3) Stage of recycling of green building materials. The process mainly

involves the recycling of scrap steel, and the rational recovery of floor scraps for new green building construction, which is of great significance to reduce the progress of construction.

2.3. Model evaluation index

The assessment indicators of the construction project construction progress are: technology, environment and cost of the three major indicators. According to the characteristics of the above factors, the model of association between indicators and the uniqueness of subsystems can be established, and a hierarchical structure evaluation model of construction schedule management with complex factors can be constructed. The model is divided into three groups at different levels: (1) comprehensive environmental impact parameters; 2) economic indicators, engineering indicators, environmental indicators; (3) specific assessment indicators, shown in Table 2.

Table 2. Assessment indicators of the Construction project progress

Target level	Second-level indicators	Third-level indicators
Integrated environmental	engineering feature	components structure surface area
ZInfluence coefficient		component volume
	Economic Indicators	components material prices
		Environmental governance input
	Environmental Indicators	Primary Energy Demand
		Non-renewable energy consumption
		Renewable energy consumption

The complete construction progress assessment process usually involves three stages of production, operation construction and maintenance. Based on the eight sets of floor components of the slab production shown in Table 1, the assessment of the impact on the construction progress assessment during the production process is conducted. The results of the relevant indicators related to economic indicators, namely, environmental governance inputs and construction materials prices, these two variables as a variable, and use the BIM model to calculate the remaining indicators.

3. Genetic algorithm synchronization selection characteristics and BIM construction progress model NN parameters

3.1. Basic Genetic Algorithm

From 1975, in the United States, J.Holland et put forward the genetic algorithm (Genetic Algorithm), compared with the traditional search algorithm, he used the random search algorithm in the evolution law of the biological evolution, the basic

workflow is shown in Figure 2.

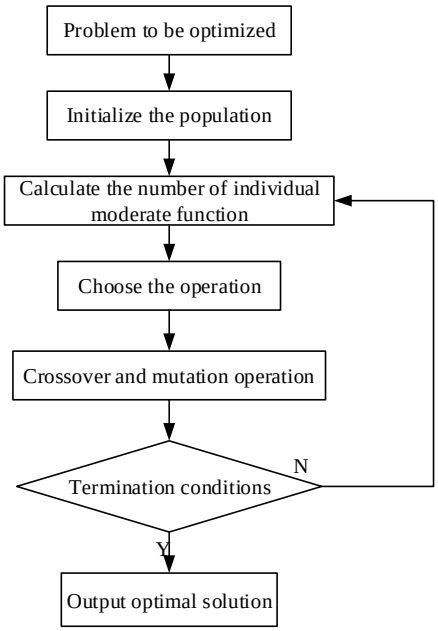

Fig. 2. Basic genetic algorithm workflow

A large number of studies have shown that the basic genetic algorithm is easy to fall into the local optimal solution, and has the convergence of low efficiency defects. BIM model is a multi-parameter and complex combinatorial optimization problem, which not only needs to get the correct rate of construction progress but also requires high detection efficiency. Therefore, according to the progress of building construction and BIM construction Progress model NN parameter synchronization optimization problem, we need to improve the genetic algorithm in order to obtain a better assessment of the accuracy of the construction schedule.

3.2. Design of improving genetic algorithm

(1) Coding method

Researching solution space is the optimal combination of selecting the progress of building construction and BIM construction schedule model. Therefore, the binary system should be adopted. Each individual location is composed of two parts, the first part shows the construction progress characteristics; the second part represents the BIM construction schedule model. In the first part , choosing 0 in the i bit means no-select features i, 1 for the selected feature i; in the second part, BIM construction progress model is obtained from formula (1).

$$p = \min_p + \frac{\max_p - \min_p}{2^l - 1} \times d\,. \tag{1}$$

Where, p represents the converted BIM construction progress model parameter value; l represents the length of the digital string section of the BIM construction progress model; max_p and min_p minp are respectively the maximum value and the minimum value; and d is a binary value.

(2) Design fitness function

For the genetic algorithm, the fitness function guides its evolutionary direction, so it is very important that the fitness function should meet two goals: (1) the dimension of the feature subset should be as little as possible; (2) improve the accuracy of the construction schedule. Supposing Xi be a subset of features, and its corresponding fitness function f (Xi) is calculated as follows:

$$f(X_i) = \frac{\exp(A_{X_i} - \eta \cdot A)}{\gamma.(\sum_{j=1}^{n} x_j)/n}. \tag{2}$$

In the formula, n is the total number of features, A_{X_i} is the training accuracy corresponding by X_i, A is training accuracy when all features are included, and two parameters η γ are used to adjust the BIM construction schedule accuracy rate threshold and feature reduction contribution to the fitness function Weights.

From (2), when the number of features contained in a feature subset is smaller and the construction accuracy is higher, the feature subset is better, and the individual fitness function value of genetic algorithm is larger.

(3) Choosing operation

The selection operation is to evaluate the merits of individuals based on fitness values, selecting some of the best individuals, out of some inferior individuals, to ensure that groups continue to evolve, and find the most optimal solution to the problems. In this study, we first preserve the best individuals of the previous generation by using the strategy of superiority, and then select the remaining individuals by the roulette method, so that the probability of the better next generation will increase.

(4) Cross operation

Cross is the main way to generate new individuals, which mainly includes single point crossover, multi-point crossover and even crossover. Because the individual of this study consists of two parts, we hence use subdivision and single-point crossover operation. However, due to the lack of traditional single-point crossover, we improve it by first selecting 1 intersection randomly and then generating 0, 1. If the random number is 0, then the probability cross is operated in the first part; if 1, the basic single-point crossover is adopted.

Figure 3 shows the basic single-point crossover operator in the condition that random number is 0. As can be seen from Figure 3, basic single-point crossover can only exchange sub-strings behind the cross-point.

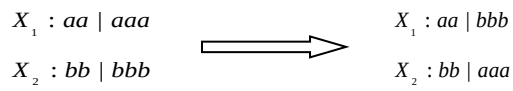

Fig. 3. The single-point cross-operation diagram

Figure 4 is the cross case of improved single-point crossover operator when the random number is 0. From Fig. 4, the improved crossover operator selects the crossover method based on random numbers to be more flexible and enhances the search degree of genetic algorithm. The construction progress characteristic and the BIM construction schedule model NN parameter combination can be constructed.

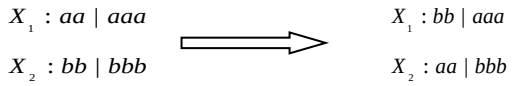

Fig. 4. Improved cross-operation diagram

(5)Variation operation

Mutation operators are mainly for local fine search to maintain the diversity of the population, using the basic bit mutation operation.

Work steps of building construction progress model

The working steps of the construction schedule model based on genetic algorithm to select the nearest neighbor parameters and features are as follows:

1) Collect the equipment status of the construction progress and pre-process the collected data.

2) initialize the population. The uniform method is used to generate a population of n individuals, each of which includes a subset of the state of progress of the building construction and a BIM construction progress model.

3) According to the binary decoding scheme, each individual is decoded to a subset of candidate features, BIM construction progress model, dimension reduction according to the feature subset, and then input to the BIM construction progress model to establish the construction progress Model, and according to (9) calculate each individual fitness value.

4) Genetics operations such as selection, crossover and mutation of populations, resulting in a new generation of populations.

5) Judge the termination condition, and if it is satisfied, take the individual with the best fitness as the final selection result; otherwise, go to step (3) and continue the evolution operation.

6) The optimal individual is decoded to get the best sub-set of construction progress characteristics and BIM construction schedule model.

7) Re-train the training samples according to the optimal feature subset and BIM construction schedule model parameters, and establish the optimal construction schedule model.

8) According to the established optimal construction schedule model, the progress of the construction is tested to verify the validity and feasibility of the model.

4. Experimental analysis

4.1. Genetic Algorithm Performance Analysis

The proposed algorithm is compared with the standard genetic algorithm and the algorithm in [10]. The test functions used are: $f1$ is Dejong function, $f2$ is Griewank function, $f3$ is Rastrigin function and $f4$ is Schaffer function. The global optimal value of function $f1 \sim f3$ is 0, the global optimal value of the function $f4$ is -1.

$$f1 = \sum_{i=1}^{n} x_i^2 \,.$$

$$f2 = \frac{1}{4000} \sum_{i=1}^{n} x_i^2 - \prod_{i=1}^{n} \cos\left(x_i/\sqrt{i}\right) + 1 \,.$$

$$f3 = \sum_{i=1}^{n} \left(x_i^2 - 10\cos\left(2\pi x_i\right) + 10\right) .$$

$$f4 = \frac{\sin^2\left(\sqrt{x_1^2 + x_2^2}\right) - 0.5}{\left(1 + 0.001\left(x_1^2 + x_2^2\right)\right)^2} - 0.5 \,.$$

In order to show the advantage of this algorithm in large space search, the initial search space is $x_i \in \left[-10^6, 10^6\right]$ set as the simulation parameters: dimension $D = 30$, population size $NP = 200$, the maximum number of iterations is 20000, crossover probability factor $CR = 1$ and scaling factor $F = 1$. To highlight the advantages of this algorithm, Algorithm, the literature [10] algorithm and the standard genetic algorithm algorithm are set with the same parameters, and all adopt the standard genetic algorithm / rand / 1 / bin variation way, change the space cycle $NC = 10$. Make 30 times the simulation average on $f1 \sim f4$, the results are shown in Table 3.

The order of the convergence speed is that the algorithm in this paper>literature [10] algorithm> standard genetic algorithm, while in the convergence accuracy, this algorithm in this paper is slightly better than the literature [10] algorithm, the accuracy of both is better than the standard genetic algorithm, especially is more obvious in the performance of the standard $f3f4$. The basic standard genetic algorithm are premature phenomenon in the two functions, which are far away from the optimal value, and the algorithm in this paper and literature [10] algorithm can find the global optimal point. Among the variance of convergence, the proposed algorithm is smaller than the one in [10], both of them are smaller than the standard one, which shows that the algorithm is the most robust in terms of CPU time.In this paper, The standard GA algorithm adds a lot of judgment steps and increases the computational complexity of the algorithm, so the running time is relatively long, but the running time of the algorithm in this paper is less than the algorithm in literature[10].

Table 3. Algorithm in this paper, literature [10] algorithm, the standard genetic algorithm, each run 30 times for the average

		Optimal performance	Average performance	Number of iterations	Variance	CPU time / s
$f1$	Algorithm in this paper	5.96×10^{-9}	7.92×10^{-9}	1574	1.77×10^{-18}	83.0
	Literature [10] algorithm	6.36×10^{-9}	8.16×10^{-9}	2645	2.32×10^{-18}	130.7
	Standard Genetic Algorithm	8.11×10^{-9}	9.19×10^{-9}	4384	3.69×10^{-18}	50.8
$f2$	Algorithm in this paper	5.53×10^{-9}	7.81×10^{-9}	1359	4.25×10^{-18}	95.0
	Literature [10] algorithm	6.51×10^{-9}	8.52×10^{-9}	2322	5.35×10^{-18}	142.3
	Standard Genetic Algorithm	7.48×10^{-9}	9.11×10^{-9}	4478	8.10×10^{-18}	70.3
$f3$	Algorithm in this paper	6.47×10^{-9}	7.08×10^{-9}	1781	4.82×10^{-18}	149.9
	Literature [10] algorithm	7.01×10^{-9}	8.15×10^{-9}	2760	6.43×10^{-18}	188.5
	Standard Genetic Algorithm	1.60×10^{2}	1.63×10^{2}	20000	4.22	224.0
$f4$	Algorithm in this paper	-1	-1	273	9.32×10^{-18}	0.42
	Literature [10] algorithm	-0.99	-1	640	2.20×10^{-5}	10.0
	Standard Genetic Algorithm	-0.87	-0.54	20000	1.39×10^{-2}	22.1

4.2. Indicator anaysis

Here, we select the three BIM construction progress softwares from Tsinghua VW, GuangLianDa and Luban as the basic modeling software and carry out the index analysis based on the proposed algorithm. The evaluation indexes are as follows: software installation, safety evaluation and function universality. Comparison decision algorithm selected literature [10] algorithm.

According to the needs of the decision-making evaluation process, the criteria are divided into five categories: "bad", "worse", "normal", "good" and "better". On this basis, the remarks could be obtained $V = \{v_1, v_2, v_3, v_4, v_5\}$ = Poor, poorer, average, good, better}. For the worst grade v_1, assign it a value of 50, and for the best grade v_5, assign it a value of 100, you can get a quantified grade vector:

$$B = \{50, 60, 80, 90, 100\} \ . \tag{3}$$

Literature [10] makes construction progress analysis based on the expert assessment form, first of all, assessing according to the evaluation of the rating of experts,

and based on mathematical statistics to achieve statistical analysis of evaluation data to obtain membership values. For example, 10 experts from different fields assessed the construction progress indicators. If 0 people select V_1 and V_2, 2 selected V_3. and 5 selected V_4, 3 selected V_5 , then the fuzzy evaluation index of construction progress software index is (0, 0, 0.2, 0.5, 0.3).

Table 4 shows the fuzzy evaluation scores of the proposed algorithm + (Tsinghua VW, Broadlink, and Luban) and [11] + (Tsinghua VW, Broadlink, and Luban).

Table 4. Fuzzy evaluation

Evaluation Index	Software	Algorithm	Value
Software installation	Broadlink	Algorithm in this paper	91.2
		Reference [11]	89.8
	Tsinghua VW	Algorithm in this paper	89.7
		[11]Reference [11]	88.6
	Luban	Algorithm in this paper	88.3
		[11]Reference [11]	86.2
Safety evaluation	Broadlink	Algorithm in this paper	82.36
		[11]Reference [11]	80.1
	Tsinghua VW	Algorithm in this paper	89.4
		[11]Reference [11]	86.3
	Luban	Algorithm in this paper	92.7
		[11]Reference [11]	89.2
Function suitability	Broadlink	Algorithm in this paper	86.9
			84.3
	Tsinghua VW	Algorithm in this paper	88.2
			85.4
	Luban	Algorithm in this paper	89.9
		[11]Reference [11]	86.7
Comprehensive Evaluation	Luban	Algorithm in this paper	88.2
			84.9
	Broadlink	Algorithm in this paper	89.4
		[11]Reference [11]	86.2
	Tsinghua VW	Algorithm in this paper	89.5
		[11]Reference [11]	84.3

From the data in Table 4, we can see that in all the evaluation indexes, the evaluation scores obtained by the algorithm + (Tsinghua Vw, Broadlink and Luban) model are better than those in [11] + (Tsinghua VW, Luban) evaluation score. This shows the effectiveness of the proposed algorithm. At the same time, for the three types of BIM softwares, Tsinghua VW, Broadlink and Luban, Broadlink scored the lowest, Tsinghua Wvelwell and Luban scoring teams were better, and overall quality preference of Tsinghua VW and Luban construction progress.

The running time of the algorithm + (Tsinghua Vw, Broadlink and Luban) and the algorithm [11] + (Tsinghua Vw, Broadlink and Luban) in this paper is shown in Fig.5.

According to the algorithm operating efficiency in Fig. 5, we can see that the pro-

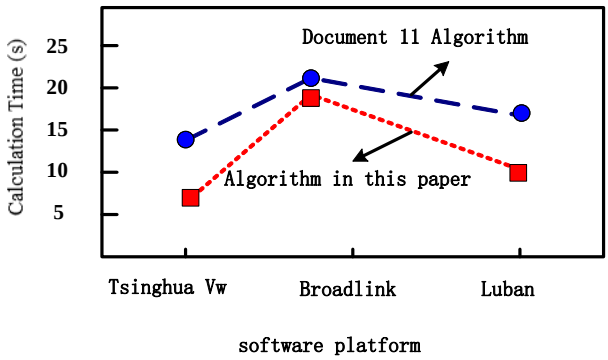

Fig. 5. Comparison of algorithm efficiency

posed algorithm is superior to the selected algorithm [11] in terms of computational efficiency, and that the running of Luban and Tsinghua VW Software compared with the three softwares of Tsinghua VW, Broadlink and Luban High efficiency, low operating efficiency Broadlink.

According to the results shown in this algorithm model, the economic indicators of the standardization of a comprehensive weighted analysis, the price variable set conditions, can be shown in Table 4, 1 to 8 components of the construction progress evaluation results:

$$D_1 = 0.132P_1 + 0.0213, D_2 = 0.132P_1 + 0.0216$$

$$D_3 = 0.132P_1 + 0.0173, D_4 = 0.132P_1 + 0.0068$$

$$D_5 = 0.132P_1 + 0.0007, D_6 = 0.132P_1 + 0.1876$$

$$D_7 = 0.132P_1 + 0.0246, D_8 = 0.132P_1 + 0.4876$$

Based on the above analysis results, it is found that the construction progress of the eighth group of eight components has the greatest influence on the construction schedule because the component of the structure has a larger volume of the structure than other components. For components 2, 3 and 7, they have a similar effect on the evaluation of construction progress, showing the difference in the impact of different building material selection on the assessment of construction progress. In addition, based on the above analysis results, environmental impact factors should be emphatically considered to further refine the calculation differences of different component elements.

5. Conclusion

In this paper, we propose a research method based on genetic algorithm fusion BIM model in the construction schedule of construction management methods, the use of BIM model to build project evaluation results of quantitative indicators to

establish the project construction schedule comparison matrix, the introduction of genetic algorithms on the construction schedule management BIM Model to study and optimize the construction progress forecast. The article also needs to be perfected is the research on the aspects of algorithm convergence and the comparison between the algorithm and other international effective methods, which is the main work of the next step.

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