Research on Optimization Algorithm of Residential Decoration Design Layout Based on Building Information Model

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Abstract. Building information modeling technology creates and utilizes digital models for the design, construction, and operation management of projects", organizing various building information into a whole. The algorithms of each era are limited by the level of research at that time: the first generation The problem faced by the evolutionary multi-objective optimization algorithm is how to combine the evolutionary algorithm with the multi-objective optimization problem organically. How to deal with the problem of high-dimensional multi-objective optimization. Evolutionary multi-objective optimization has developed to the present, and gradually shows the characteristics of diversity. In the process of single-objective optimization, when the fitness value of individuals in the population does not increase within a certain algebra, it can be It is determined that the algorithm can be stopped. This stopping strategy cannot be simply applied to multi-objective optimization. Finally, the superiority of the algorithm in this paper is obtained.

Keywords: building information model; efficiency; multi-objective optimization; high-dimensional multi-objective algorithm.

1. Overview

Building information modeling technology creates and uses digital models to design, construct and operate projects", organize various building information into a whole, and run through the whole life cycle process of buildings. The comprehensive application of BM in China will help the development of the construction industry. It will bring huge benefits and significantly improve the quality and efficiency of design and even the whole project. BM will directly promote the reform and development of various fields of the construction industry; it will make profound changes in the thinking mode and habitual methods of the construction industry; New organizational methods and new industry rules are generated in the process of and operation. At present, the application of BM in China's construction industry has begun, and it is urgent to conduct standardized research on BM to facilitate the sharing and application of BM in all relevant industrial chain links in the construction industry [1]. This paper studies the Chinese BM standard framework.

2. BIM model checking software

BIM model checking software can be used to check the quality and integrity of the model itself, such as whether there is overlap between spaces? Is the space enclosed by appropriate components? Are there conflicts between components, etc.; it can also be used to check whether the design is It does not meet the requirements of the owner, whether it meets the requirements of the specification, etc. [2].

At present, the BIM model checking software with market influence is Solibri Model Checker. Figure 2 is the basic information of the software [3].

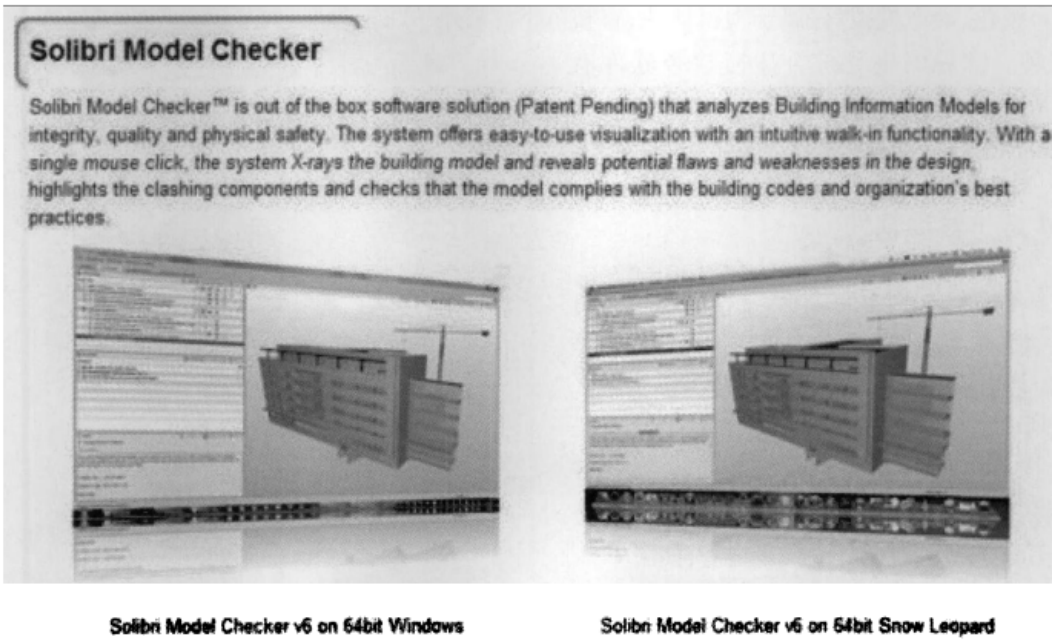


Figure 1 BIM model checking software

3. BIM core modeling software

This kind of software is usually called "BIM Authoring Software-ware" in English, which is the basis for BIM to become BIM. In other words, it is precisely because of these software that BIM exists, and it is also the first type of BIM software to be encountered by peers engaged in BIM. Therefore, we call them "BIM core modeling software", referred to as "BIM modeling software" [4]. The commonly used BIM modeling software is shown in Figure 1.

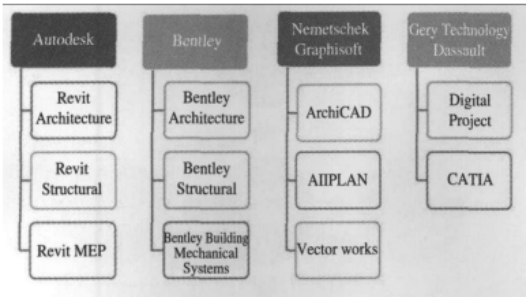


Figure 2 BIM modeling software

As can be seen from the figure, BIM core modeling software mainly has the following four schools:

(1) Autodesk's Revit architectural, structural and electromechanical series has a very good market performance in the civil construction market with the help of the natural advantages of AutoCAD;

(2) Bentley building, structure and equipment series, Bentley products have indisputable advantages in the field of factory design and infrastructure [5];

(3)The three products of ArchiCAD/AllPLAN/VectorWorks are classified into the same school, among which Ar-chiCAD is the most familiar to domestic counterparts, which is a product for the global market and the earliest BIM with market influence Core modeling software [6].

3.1 BIM model comprehensive collision check software

There are two fundamental reasons that lead directly to the emergence of model-integrated collision checking software:

(1) Different professionals use their own BIM core modeling software to establish their own professional-related BIM models. These models need to be integrated in one environment to complete

the design, analysis, and simulation of the entire project. These different BIM core modeling software Software cannot achieve this;

(2) For large-scale projects, the limitation of hardware conditions makes it impossible for the BIM core modeling software to operate the entire project model in one file, but these separately created local models must be integrated to study the design, construction and design of the entire project. its operational status[7].

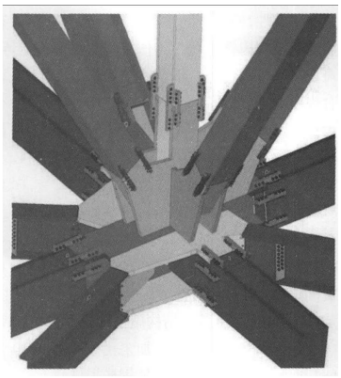


Figure 3 BIM model comprehensive structure diagram

Attribute is the basic unit that constitutes an attribute set, which can be divided into two types: simple attribute and complex attribute, among which simple attribute can be divided into various types according to the characteristics of the described object. These different property types all inherit from the abstract base type IfcProperty, see Figure 4. The Name and Description of IfcProperty store the name and description of the property, and the specific value of the property is stored in the subtype of IfeProperty.

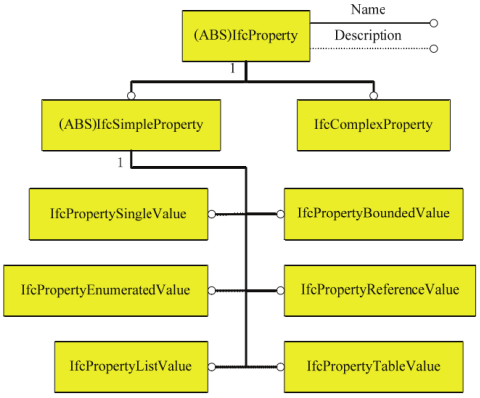


Figure 4 IfcProperty derived class diagram

3.2 Mathematical description of multi-objective optimization problems

Multi-objective optimization problems are also known as multi-criteria optimization problems. Without loss of generality, a multi-objective optimization problem 3 with n decision variables and m objective variables can be expressed as Equation 1.

$$\begin{cases} \min & y = F(x) = (f_1(x), f_2(x), \ldots, f_m(x))^T \\ \text{s.t.} & g_i(x) \le 0, \quad i = 1, 2, \ldots, q \\ & h_j(x) = 0, \quad j = 1, 2, \ldots, p \end{cases} \tag{1}$$

Where, $x = (x, \ldots, x_n) \in X \subset R^n$ is an n-dimensional decision vector, and X is an n-dimensional decision space $y = (y_1, \ldots, y_m) \in Y \subset R^m$ is the m-dimensional target vector, ￥ is the m-dimensional target space.The objective function F(x) defines m mapping functions from the decision space to the target space:g(i)≤(1,2,…,)q inequality constraints are defined; $h_i(x) \le 0 (j = 1, 2, \ldots, p)$ p equality constraints are defined.

In order to simultaneously evaluate the convergence of the solution and the uniformity of the solution distribution, we adopt the Convergence Metric proposed by Deb et al. and the Spacing proposed by Schott. These two metrics are defined as follows: $P^* = \left(p_1, p_2, p_3, \ldots, p_{|P^0|} \right)$ is the set of uniformly distributed Pareto optimal solutions on the ideal Pareto front, $A = \left(a_1, a_2, a_3, \ldots, a_{|A|} \right)$ is the approximate Pareto optimal solution set obtained by the EMO algorithm. For each solution α in the set A, we can obtain the minimum normalized Euclidean distance of the solution distance P* by the following formula [8]:

$$d_i = \min_{j=1} \left| \overrightarrow{P^*} \right| \sum_{m=1}^{k} \left(\frac{f_m(a_i) - f_m(p_j)}{f_m^{\max} - f_m^{\min}} \right)^2 \tag{2}$$

$$d_i = \min_j \left\{ \sum_{m=1}^{k} \left| f_m(a_i) - f_m(a_j) \right| \right\}, \quad a_i, a_j \in A, \quad i, j = 1, 2, \ldots, |A| \tag{3}$$

Among them, d is the number of objective functions on the average of all d. If the value of this indicator is 0, it means that the non-dominated solutions we get are equally spaced in the target space [9].

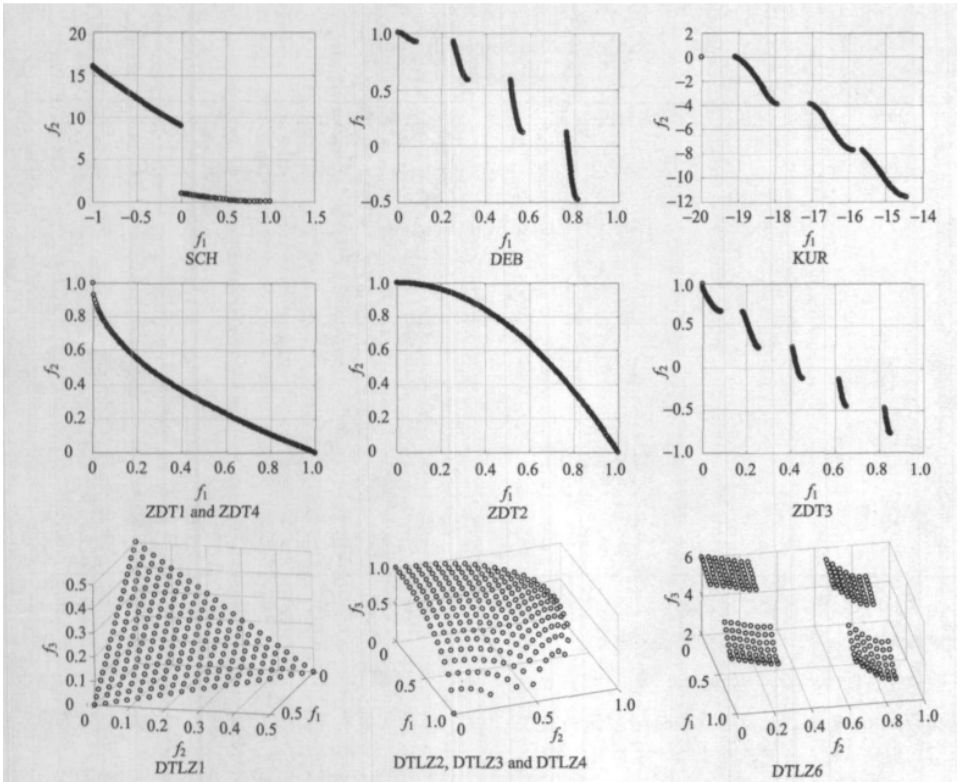


Figure 5. 200 sampling points uniformly distributed on the front edge of the test function Paerot

4. Experimental results

We use boxplots to represent the statistical results of each algorithm for each test problem. Box plots have always been an important tool for statistical analysis in the field of economics, which can well reflect the statistical distribution of data. In this paper, this tool is used to express the statistical properties of the solutions obtained by running the four algorithms independently for 30 times. Among them, the upper and lower lines of the box represent the upper and lower quartiles of the sample respectively, and the horizontal line in the middle of the box is the median of the sample. The dashed line above and below the box represents the rest of the sample, the maximum value of the

sample is the top of the dashed line, the minimum value of the sample is the bottom of the dashed line, "+" represents the outlier, and the cutout of the box is the confidence interval of the sample [10].

Table 1 Parameter settings

Parameter	PESA-2	SPEA2	NSGA-2	NNIA
Crossover probability pc	0.8	0.8	0.8	1
Distribution index for crossover	15	15	15	15
Mutation probability pm	1/n	1/n	1/n	1/n
Distribution index for mutation	20	20	20	20

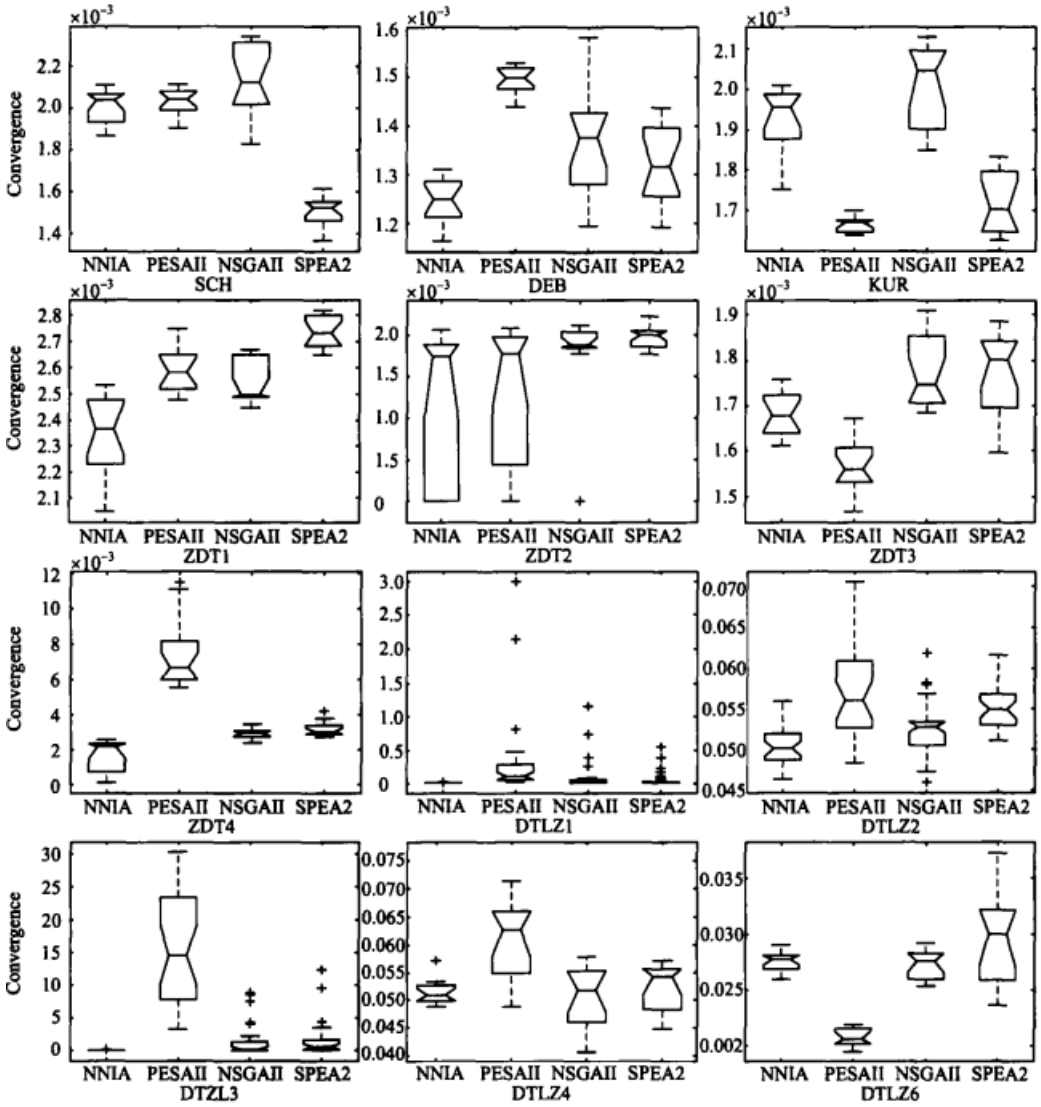


Figure 6 Statistical experimental results of the convergence index

It can be seen from Figure 6 that for SCH, DEB, KUR and 4 ZDT problems, in the results of running 4 algorithms for 30 times, the convergence index value obtained almost every time is less than 103. Among them, DEB, ZDT1, ZDT2 and For the four problems of ZDT4, NNIA performed the best; for the two problems of KUR and ZDT3, PESA-Il performed the best; for the SCH problem, SPEA2 performed the best [11]. For the five more complex DTLZ problems, The performance of NNIA in solving DTLZ1, DTLZ2 and DTLZ3 is obviously better than that of the other three methods; PESA-II has the best convergence in solving DTLZ6; for DTLZ4, except for PESA-II II, the performance of the other three algorithms is very close[12].

5. Acknowledgement

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6. Conclusion

This paper first briefly introduces the general situation of evolutionary multi-objective optimization research, and points out the necessity of writing this review, then gives the mathematical description of multi-objective optimization problem, Pareto optimal solution, and Pareto dominance relationship, and then analyzes the first Classical algorithms for evolutionary multi-objective optimization of the first and second generations. This paper focuses on the analysis of several latest evolutionary multi-objective optimization algorithms. Most of these algorithms are research results published in top international journals in the field of evolutionary computing, representing the current development trend and trend of evolutionary multi-objective optimization. Partial summaries are rarely seen. Finally, we give experimental performance comparisons of representative algorithms.

Ackonledegments

Urban and Rural Housing Construction and Science & Technology Project in Shandong Province：Application research of Green House decoration design based on BIM technology with the evaluation of LEED as the standard Project number:2021-K5-10.

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