Research on Optimal Layout of the Mobile Project Department based on Internet technology

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Abstract: Diversified mobile project department layout has a positive impact on the formation of a guiding design of scheme. In this paper, the parametric analysis of design elements are carried out. And the random of generations and optimization of the schemes are simulated by Grasshopper and Excel. Firstly, the initial parameter input options are set. After the size of each partition is limited, the random generation is carried out, and the overall layout shape of each partition is recommended forming a variety of design schemes. Finally, the schemes are screened by combining the constraint of conditions, and the scheme is optimized by using the Galapagos genetic algorithm in Grasshopper [1] to generate the final scheme.

1. Introduction
Mobile project department is a temporary building set up by the construction unit. Most of the current project of department lacks design and practicability, and architects often lack diversity in the layout design, which is unfavorable to the later development of the project department. In order to apply Internet technology and realize intelligent and diversified design results, this project parameterized the design scheme, established data analysis model, and used computer simulation to obtain a variety of layouts, which saved time and human resources and expanded the design results. In this project, the genetic algorithm of Grasshopper and Excel were combined to explore and study the scheme generation and arrangement optimization of the mobile project department.

2. Initial parameter setting
The mobile project department is divided into the office module, the life module and the auxiliary module according to the functional partition. On the basis of meeting the basic layout rules, each module determines the number and layout of box rooms according to the project positioning (economic/comfort type) and the number of people. How to realize the intelligent generation and optimization selection of the design scheme of the mobile project department through algorithm on the basis of clear number and location has become the key problem we need to solve.

According to the actual investigation, we obtained the relationship between the number of box rooms and the project positioning and the number of people in different functional areas. The results are shown in Table 1:

| Functional partition | Project positioning | The relationship between the number of box rooms N and the number of people N |
|----------------------|---------------------|--------------------------------------------------------------------------------|
| Office module        | economical          | N=0.6*n                                                                          |

Table 1 Relationship between the number of box rooms, project positioning and number of people.
| Life module | comfort | N=0.75*n |
|-------------|---------|----------|
| economical | N=0.4*n |
| comfort     | N=0.5*n |
| Auxiliary module | economical | N=0.2*n |
| comfort     | N=0.25*n |

The number of economic box type rooms = the number of comfort box type rooms * 0.8.
Office: Living: Auxiliary box type room number ratio is 3:2:1.
Therefore, after the per capita floor area is determined, options can be set in Grasshopper. At the beginning of the algorithm, economical/comfort type and number of people can be selected, so as to determine the number of box rooms in each functional partition in advance according to different parameters.

Figure 1 sets the initial input options

3. Generate random arrangement scheme

3.1 Determine the rectangular areas of each partition

3.1.1 Set surface proportion and length-width ratio range

According to the research results and the existing partition which is setting scheme of the project department, and setting the five partitions of the mobile project department as rectangles, then setting their faces of proportion and aspect ratio range as shown in Table 2:

| Functional partition       | Area ratio | Aspect ratio (A) range |
|----------------------------|------------|-----------------------|
| Office area                | 30%        | [1,3]                 |
| Living quarters            | 30%        | [1,2]                 |
| Accommodation area         | 25%        | [4,10]                |
| Parking lot                | 12.5%      | [3,6]                 |
| Auxiliary occupancy        | 12.5%      | [2,4]                 |

Among them, the random number within the desirable range of the ratio of length to width of each partition.

3.1.2 Take the length and width of the partition within a given range

Below, the wide edge (b) of each partition is limited, and the area of each partition is set as S, then $b_{min}=(s/a_{max})^{1/2}$, $b_{max}=(s/a_{min})^{1/2}$. Wide edge b can be a random number within the range of $[b_{min}, b_{max}]$, corresponding long edge $l=s/b$. 


3.1.3 Homogeneity randomness
The orientation of the location of each partition and the whole area can be set to 0 or 1, 0 indicates that
the long side of the area is in the same direction as the long side of the whole area, while 1 means that
the wide side of the area is in the same direction as the long side of the whole area.

3.2 Determine the overall shape of buildings in each zone
After determining the size and placement of each zone, the shape possibilities of the whole building in
the zone are generated and listed as follows:

3.2.1 L-shape
A rectangle is generated by cutting one of the four corners of the rectangle (the specific position of the
cut rectangle should be toward the center of the rectangle), where the proportion range of the long side
of the cut rectangle can be set as $[0.3,0.7]$ and the proportion range of the wide side as $[0.2,0.5]$.

3.2.2 Back glyph
A rectangle is generated by cutting the center of the rectangle, where the proportion range of the long
side of the rectangle can be set as $[0.1,0.25]$ and the proportion range of the wide side as $[0.1,0.2]$.

3.2.3 Double rectangle
By deleting the rectangle with the same width or length, two rectangles with the same width or length
is generated. The position of the rectangle is between $[0.3,0.4]$, and the width of the rectangle is between
$[0.1,0.2]$, as shown in the figure below:

3.2.4 T-shape
By deleting two equally large rectangles at the lower left and right corners of the rectangle, the position
of the rectangle is between $[0.15,0.3]$, and the width of the rectangle is between $[0.1,0.3]$. 
3.2.5 Concave font
Similar to the way of generating a font, a concave font only needs to move the cut rectangle up and down and align one side of the peripheral rectangle, where the proportion range of the long side of the cut rectangle can be set as \([0.15,0.4]\) and the proportion range of the wide side is between \([0.1,0.3]\).

\[
\begin{array}{c|c|c}
(0.15-0.4)\times L & (0.1-0.3)\times b & (0.15-0.4)\times L \\
\hline
b & (0.1-0.3)\times b & b \\
\end{array}
\]

3.3 Operation Process
In view of the clear mathematical relationship of the above realization ideas, the operation steps are illustrated by taking the 65*50 site as an example through Excel table:

1. Determine the zoning area
   According to the proportion of each division, the area is: office area: 975 m², living area: 975 m², accommodation area: 487.5 m², parking area: 406.25 m², and auxiliary room: 406.25 m².

2. Generate the length and width values of each partition
   The lower limit of the width of each partition can be obtained according to the given length-width ratio, and a set of reasonable length-width values of each partition can be obtained through random number, as shown in the figure below:

   ![Figure 2: Generate tables for each partition parameter](image)

   | So         | 2 | B | L | bmin | min | max  |
   |------------|---|---|---|------|-----|------|
   | S          |   |   |   |      |     |      |
   |            |   |   |   |      |     |      |
   | Office area| 975|25 |39 |1 |3   |18.02775638 |54.08326913 |31.22498999 |31.22498999 |
   | Living quarters | 975|30 |32 |1 |2   |22.0794021 |44.15880433 |31.22498999 |31.22498999 |
   | Parking lot | 406.25|11 |38 |3 |6   |8.228507358 |49.37104415 |11.6368667 |34.91060011 |
   | Auxiliary occupancy | 406.25|13 |32 |2 |4 |10.07782219 |40.31128874 |14.25219281 |28.50438563 |
   | Accommodation area | 487.5|9 |56 |4 |10 |6.982120022 |69.82120022 |11.03970108 |44.15880433 |

   ![Figure 3: Example of random Numbers and lead to relationships](image)

   (3) Determine accessibility
   Generate a random number of 0-1 for each partition, and determine whether it is in the same direction or different direction with the whole region according to its proximity to 0,1.

   | Directivity |   |
   |-------------|---|
   | 1 | 0.96892622 |
   | 1 | 0.79298624 |
   | 0 | 0.21082477 |
   | 0 | 0.48738461 |
   | 1 | 0.78569375 |
(4) Arrange each division
The whole is arranged in order from top to bottom and from left to right. The method of sorting also has some random properties. The arrangement order of each partition can be determined to the random number. In the process of arrangement, whether there are some overlaps between the remaining area and the size of the next partition are calculated at the same time. If there is any, the arrangement will be terminated and changed to another random arrangement scheme. If not, continue and continue until a reasonable scheme is generated.

(5) Determine the overall building shape of each district
Based on the determined aspect ratio data of each partition, the shape of the partition is suggested. The overall shape of the parking lot, auxiliary housing and accommodation area would not be changed. It is assumed that there are three possibilities of L-shape 1, rectangle 2 and palindrome 3 in the office area, and L-shape 1, rectangle 2, T-shape 3, concave shape 4 and double rectangle 5 in the living area.

| Eliminate the proportion       | L         | B          |
|-------------------------------|-----------|------------|
| L-Type                        | 0.52894457| 0.20102683 |
| Central elimination ratio     |           |            |
| Palindrome                    | 0.21171017| 0.10006823 |
| Double rectangle              | 0.36901356| 0.19095763 |
| Symmetry to eliminate         |           |            |
| T-type                        | 0.22088121| 0.13812706 |
| Concave type                  | 0.37872227| 0.14418974 |

Figure 4 shows an example of suggested shapes for each partition

After the shape is determined, the shape and specific parameters of each partition would be determined and converted into Grasshopper code language to complete the layout and the scheme generation of the whole region.

4. Constraints

4.1 Orientation restriction
The office module faces towards the main entrance and the living module always faces the south.
Mark the north-south entrance as "0" and the east-west orientation as "1", and change the depth and width of each box accordingly.

Figure 5. 20 base models

4.2 Spacing limitation
(1) Fire protection distance: the fire distance of auxiliary modules and other modules shall not be less than 5m. The grid of the auxiliary module is set to the interior with the boundary of 5 in length and width.
(2) Sunshine distance: in the office module and the living module, the building spacing between
north-south buildings is the minimum sunshine distance, and the building distance $\geq 3n \times 1.35$ (n is the number of buildings on the south side, and 1.35 is the sunshine coefficient in xi 'an). Calculate the distance between the center of box rooms in the same column from the south to north, take its minimum value, and only keep the minimum value to meet the sunshine distance scheme.

![FIG. 6 Algorithm battery with limited sunshine spacing](image)

4.3 Other Restrictions

In order to avoid too dense layout of box-type rooms and produce a more realistic layout scheme, constraints on the contact of four sides of each box-type room are increased as below: calculate the number of repeated points on the center point of four sides of each box-type room, that is, contact number, and set it to be less than or equal to 2.

![FIG. 7 Algorithm battery for limiting contact](image)

5. Scheme Optimization

The above process has produced a variety of schemes in line with the basic norms, but in consideration of the integrity and aesthetics of the building, some schemes are obviously unreasonable. Therefore, preliminary screening and recording is conducted to mark the schemes with strong feasibility.

Then, in combination with the mobile project department, in order to keep each functional partition arranged around the boundary as far as possible, the tightness of the project department was defined: the geometric center of each building was connected, and the length of the lines was summed, and the value was the tightness. The greater the density, the closer the layout of each functional module in the building is to the boundary. Therefore, the Galapagos genetic algorithm battery, the possibility of the arrangement of the variable segments connecting each functional partition and the calculation result of the tightness of the fitness function value end was used to carry out optimization solution\(^2\), so as to obtain part of the scheme that meets the requirements and realize the final optimization.
6. Conclusion
It is an attempt to change from manual design to computer-generated design by selecting the optimization method based on genetic algorithm and combining with the arithmetic unit to realize the automatic layout of the mobile project department under the specification constraint. Although a variety of layout forms that meet the constraint conditions are automatically generated in the experiment, it is still a relatively basic construction in the strict sense. The problems faced by the planning and layout in reality are more practical and complex. Many design objectives have not been converted into digital logic. However, there are still feasible achievements to promote the design progress of intelligence.

(1) Parameterization of design elements was completed, a complete system of parameter analysis was established, and the feasibility was confirmed by Excel operation simulation.

(2) Use Galapagos genetic algorithm battery, variable segments to connect the possibility of arrangement of each functional partition, and the calculation result of fitness function value end connection tightness to carry out optimization solution and achieve the final optimization.

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