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Research on Irregular Warehouse Layout Based on Optimised Genetic Algorithm

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ABSTRACT

Logistics is playing a significant role in supporting economic growth and material security during the epidemic period and it has been experiencing a rapid development in recent years. With the issues of personalisation and cost, the economy and society ask for higher requirements for logistics storage systems. The rational design of the functional area layout is an essential step to improve the operational efficiency of the logistics warehousing system. In reality, due to warehouse design and equipment application, there has been a gradual increase in irregular warehouses. By taking an irregular warehouse as an example, combining the operation status quo, this paper clarifies the functional area settings and constructs a 0–1 integer planning model based on the grid and systematic layout planning method with constraints, such as the unique functional attributes of the grid. We optimised the genetic algorithm based on the warehouse irregularity factor and the grids factor, and then solve it through MATLAB. Finally, by using the Flexsim software, simulation metrics were selected for evaluation, the method feasibility is verified.

KEYWORDS

irregular warehouse; genetic algorithm; layout modelling; Flexsim.

1. INTRODUCTION

China's warehousing industry has developed rapidly in recent years. However, it faces a new situation: warehouses are moving toward intelligence, with irregular warehouses being the most typical. Processes in warehouses are of significant importance for the circulation of goods throughout the supply chain [1]. Warehouse layout is a crucial factor affecting the flow of warehousing operations. The flow of goods in the warehouse and distance directly determine the operational cost of logistics warehousing operations. With the increasingly fierce competition in the warehousing industry, more and more logistics companies focus on warehouse layout optimisation. A reasonable warehouse layout helps them reduce unnecessary time loss in warehousing operations, improve the warehouse's operational efficiency and maximise the overall benefits. Therefore, layout studies for irregular warehouses has specific practical significance.

Some of the research on layout initially focused on the SLP method. Due to its highly logical and practical layout techniques, the SLP method has been widely used for facility layouts. For example, it has been studied at the level of factories [2, 3] and logistics parks [4, 5]. However, it is difficult to achieve the best layout solution by relying on this method. The SLP method is a static layout method with poor quantification capability and accuracy. It is easily influenced by the subjective factors of engineers, which finally leads to different results in the layout process. In addition, the traditional SLP method lacks flow analysis and non-logistics relationship analysis of people or objects in the layout process, which reduces the efficiency of the warehouse and cannot obtain the best layout plan [6].

Since then, it has become a common method for layout design by using the SLP to establish a mathematical model, combined with genetic algorithm to calculate the layout plan. Luo et al. [4] improved the SLP method by constructing the model of multi-objective planning of functional areas in logistics parks and verified the feasibility of the method using genetic algorithms. The same improved method was also applied to optimise the layout of passenger ship cabins with good results [7]. Regarding the warehouse layout optimisation, Hu et al. [8] used the SLP method combined with a genetic algorithm to optimise the layout of an e-commerce warehouse. The results showed that the method was able to reduce the company's material handling costs and improve picking efficiency. Therefore, the SLP method has developed into one of the classical paths used as a primary procedural model in facility planning. In addition to the application of genetic algorithm, Zhang et al. [9] proposed a two-level evolutionary algorithm for automated warehouse layouts. By introducing an auxiliary target fitness approximation model, the warehouse layout space can be effectively explored to achieve predicted warehouse layout results, and a two-stage entrance structure layout is introduced. Zhao et al. [10] pointed out the problem of using only genetic algorithms with local optimisation. For solving this problem, an ant colony genetic algorithm fusion scheme was proposed to prove that the obtained layout maps have better layout relationships. At the same time, there are various methods in the validation for layout schemes, among which the use of simulation software is a common method. For example, software such as Automod [11], Flexsim [12, 13] is used to evaluate factors such as functional area utilisation and manual efficiency. At the same time, there is also an analysis of AGV operating efficiency to help analyse the layout scheme [14].

From the perspective of layout method research, from the beginning of using the SLP method, the results obtained were affected by subjective factors, so researchers began to use genetic algorithms to solve the problems. And after completing the model design, the simulation method is normally used to verify the model. From the perspective of the object of the thesis research, researchers need to conduct more research on irregular warehouses.

Based on warehouse status, this paper takes an irregular warehouse as the research object and considers the impact of irregular shapes on area calculations and functional area relationships, whereby the concept of virtual functional areas is proposed, which means that this area cannot be functionally designed. With the objective of maximising the relevance of each functional area and minimising the total logistics cost, and with constraints such as the uniqueness of grid functional attributes, we conduct an in-depth and systematic study on the irregular warehouse layout method.

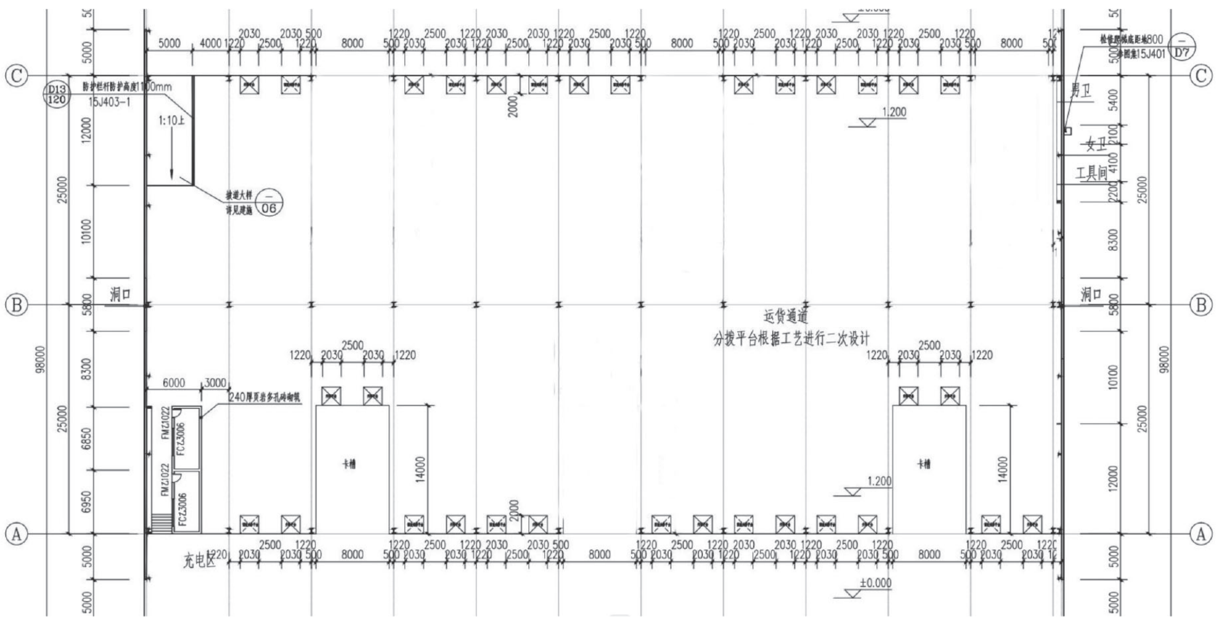


Figure 1 – Warehouse construction design

The first section of this paper describes the importance of warehouse layout and the status of related research and presents the innovation points of this paper. Section 2 describes the construction of the SLP and 0-1 integer programming model as well as genetic algorithm optimisation. Section 3 presents the project background, the collected data and completes the solution. Section 4 describes the use of the Flexsim software, the layout scheme of this paper is simulated and compared with the initial layout of the case and the metrics are selected for verification to prove the feasibility of this paper's method. Section 5 provides the conclusion and outlook.

The object of this study is a 50m × 100m warehouse, characterised by the existence of two 8m × 14m recesses on the sides of the warehouse, caused by the use of a truck lift work platform. At the same time, there is the office area in the corner of the warehouse, which has been pre-designed and is not available for further planning. It reduces the usable area of the original 5000m2 warehouse, thereby, undermining the integrity and regularity of the operating area within the warehouse and making the subsequent model construction difficult. The warehouse construction drawings are shown in *Figure 1*.

2. METHODOLOGY

In this section, based on the warehouse's current situation mentioned in the previous section and combined with the disadvantages of the SLP method, the corresponding constraints and objectives are proposed. A functional area layout design model is established based on the grid and SLP methods, the genetic algorithm is then optimised based on the model characteristics.

2.1 Modelling framework

From the literature review, most of the existing studies of warehouse layout are based on regular rectangular operation areas. With this in mind, the paper further subdivides the warehouse area into grids. The occupation of the operation area by fixed facilities and irregular boundaries is represented by the virtual functional area proposed in the previous section. The specific steps are as follows.

Step 1: By considering the dimensions of the entities in the warehouse, the grid size is determined and the space is divided into a rectangular network consisting of 200 5m×5m grids.

Step 2: Divide the functional area into the virtual functional area and the non-virtual functional area. The former refers to the warehouse where there is no functional area layout. The latter refers to the area where the layout can be carried out.

Step 3: Determine the logistics and non-logistics relationships between functional areas. Propose the objectives of closeness between functional areas and the minimum total logistics cost.

Step 4: Propose the corresponding constraints for functional areas and rasterisation.

Step 5: Combine the model, optimise the genetic algorithm and solve it using MATLAB. Finally get the Shanghai layout scheme.

2.2 Model

The closeness between functional areas: Consider the comprehensive relationship and the distance between functional areas, so that the functional areas with the greater integrated relationship are as close together as possible.

$$\max Z_1 = \sum_{m,n \in M} \sum_{i,j \in A} \frac{r_{mn}}{d_{ij}} \cdot u_{ij}^{mn} \tag{1}$$

where m,n represents index of functional areas in the warehouse. i,j represents grid indexing in the network. A represents the set of grids that can be occupied by non-virtual functional areas. M represents a collection of functional area attributes within the warehouse, where $m \in M$, M={-1,0,1,2,3,4,5,6,7}, m=-1 indicates virtual functional area, the rest of the numbers refer to the inbound and sorting functional areas respectively. r_{mn} represents the integrated correlation between functional area m and functional area n, d_{ij} represents distance between grid i and grid j, u_{ij}^{mn} represents 0–1 auxiliary variable, if the function of grid i is m and the function of grid j is n takes the value of 1, and vice versa take 0.

The total material handling cost between each functional area of the warehouse is minimised: the total logistics cost is obtained by multiplying the handling cost, handling distance and material flow of the grids within the functional area.

$$\min Z_2 = \sum_{m,n \in M} \sum_{i,j \in A} c_{ij} \cdot q_{ij}^{mn} \cdot d_{ij} \cdot u_{ij}^{mn} \tag{2}$$

where c_{ij} represents handling cost per unit cargo volume between grid i and grid j, q_{ij}^{mn} represents the material flow between grid i belonging to functional area m and grid j belonging to functional area n.

The constraints and the explanations and formulas are as follows.

Calculate the integrated correlation degree between grids based on logistic and non-logistic relationships: give a certain weight to the logistic and non-logistic relationships of the grids in the functional area to get the integrated correlation degree of the grids.

$$r_{mn} = \alpha \cdot f_{mn} + \beta \cdot h_{mn} \tag{3}$$

where r_{mn} represents the integrated correlation between functional area m and functional area n, α represents weighting of logistics relationships in the calculation of the integrated correlation, f_{mn} represents the logistics-related relationship between functional area m and functional area n. β represents weighting of non-logistics relationships in the calculation of the integrated correlation, h_{mn} represents non-logistic correlation between functional area m and functional area n.

Arbitrary inter-grid distance formula: considering the handling equipment walking characteristics, choose the Manhattan distance to express the inter-grid distance formula.

$$d_{ij} = |x_i - x_j| + |y_i - y_j| \tag{4}$$

where (x_i, y_i) represents the horizontal and vertical coordinates of the location of grid i.

Grids belonging to the same functional area need to be connected, i.e. at least one of the grids adjacent to a grid should have the same attributes as its functional area.

$$\sum_{j \in A_i} u_{ij}^{mn} \geq 1, \ \forall m \in M, \ i \in A^m \tag{5}$$

where A_i represents the virtual ribbon occupied grid collections, A^m represents the set of grids that the m functional area can occupy, where $A^m \in A$.

To ensure that each function area is not too narrow, set the maximum width of each function area: the distance between the horizontal coordinates of two grids is less than or equal to the set maximum limit.

$$u_{ij}^{mm} \cdot |x_i - x_j| \leq l^m, \ \forall m \in M, \ i,j \in A^m \tag{6}$$

where l^m represents the maximum width of the functional area m.

The number of grids contained in each functional area meets its area requirement: the total number of grids in the same functional area is equal to the number of grids assigned to each functional area.

$$\sum_{i \in A^m} w_i^m = s^m, \ \forall m \in M \tag{7}$$

where w_i^m represents the 0–1 variable, if the functional attribute of the grid i is m take the value of 1, otherwise take 0. s^m represents the number of grids required for the functional area m.

The non-virtual functional area grid belongs to a unique function: each grid can belong to only one functional area in the area where it can be effectively laid out.

$$\sum_{m \in M/\{-1\}} w_i^m = 1, \ \forall i \in A \tag{8}$$

The grid of the virtual ribbon cannot specify the actual function.

$$w_i^{-1} = 1,\ \forall i \in A' \tag{9}$$

where A' represents the virtual ribbon occupied grid collections.

The following new linear constraint is defined by the two decision variables.

$$u_{ij}^{mn} \geq w_i^m,\ \forall m,n \in M,\ i \in A^m \cup A',\ \ j \in A^n \cup A' \tag{10}$$

$$u_{ij}^{mn} \geq w_j^n,\ \forall m,n \in M,\ i \in A^m \cup A',\ \ j \in A^n \cup A' \tag{11}$$

$$u_{ij}^{mn} \geq w_i^m + w_j^n - 1,\ \forall m,n \in M,\ i \in A^m \cup A',\ \ j \in A^n \cup A' \tag{12}$$

The range of the values of decision variables is as follows.

$$w_i^m \in \{0,1\},\ \forall m \in M,\ i \in A^m \cup A' \tag{13}$$

$$u_{ij}^{mn} \in \{0,1\},\ \forall m,n \in M,\ i \in A^m \cup A',\ \ j \in A^n \cup A' \tag{14}$$

2.3 Algorithm

The parameters of the functional area layout model are initialised and the values of the critical parameters of the calibration algorithm are taken. The key parameters of the genetic algorithm include chromosome length (q), population size (p), crossover probability (Pc), variation probability (Pm), the maximum number of iterations (MaxGen) and the maximum solution time (MaxTime).

In this paper, considering the irregular characteristics of the warehouse, the coding method is optimised. Each chromosome represents a functional area layout scheme, the gene positions on the chromosome represent a grid and the values of different gene positions indicate the functional area to which the grid belongs. A value of -1 for a gene position indicates a virtual functional region, the value of 0 indicates that the grid is not assigned to a functional region and the value of 1 indicates that the grid belongs to the functional region k. For example, a 4×4 grid network is shown in *Figure 2*.

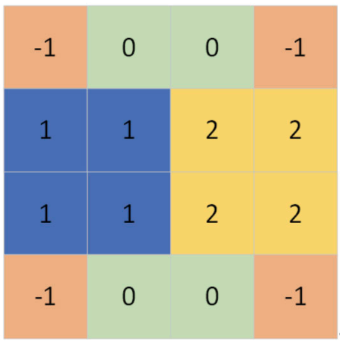
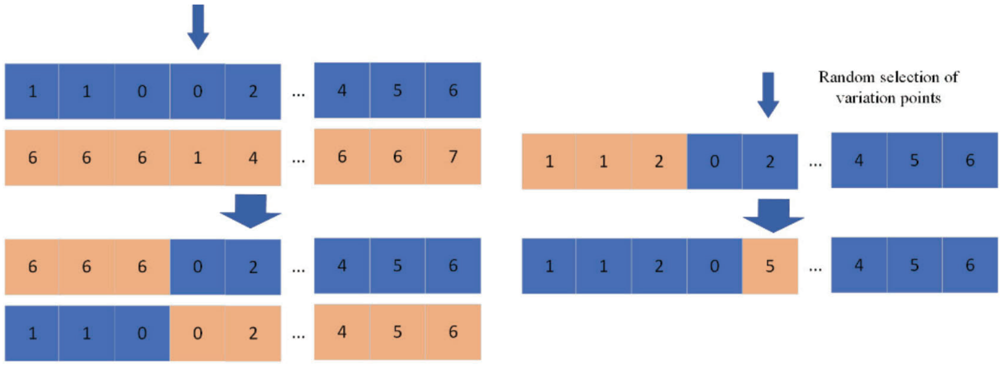


Figure 2 – Schematic diagram of the correspondence between chromosome code and warehouse floor plan

This paper takes into account the space occupied by fixed infrastructure devices in warehouse, the location of the virtual functional area needs to be marked in advance, and the value of the grid occupied by the virtual functional area cannot be changed in the initialisation of the population and the later iterative search. The rest of the paper is based on the area of the functional area calculated in advance, which is converted with the grid size to assign the grid value to the functional area.

The steps for individual selection in this paper are as follows. (1) Calculate the fitness of all individuals in the population. (2) Rank all individuals in the population from the smallest to the largest fitness. (3) Calculate the probability of an individual entering the next generation population according to its position in the population.

The crossover operator in the genetic algorithm exchanges part of the gene sequences between the two paired parent chromosomes to produce a new offspring chromosome. In this paper, a single-point crossover strategy is adopted, as shown in *Figure 3*.



a) b)

Figure 3 – a) Design of the crossover operator, b) Design of the variational operator

In the genetic algorithm of the layout problem, the length of chromosomes is unchangeable, so this paper adopts the classical single-point variation operator, which randomly selects individuals in the population and then randomly determines the position of the variation on the selected individuals.

The fitness function is generally transformed from the objective function. Therefore, the fitness function in this paper is as follows.

$$F = Z_1 - Z_2 \tag{14}$$

3. CASE STUDY

3.1 Data

This part combines the traditional SLP method to derive the correlation between the functional areas of the warehouse based on the logistic relationship-related indicators and non-logistic relationship-related indicators and then brings them into the model to get the layout.

Considering the functions that the warehouse needs to achieve, such as unmanned unloading, flexible sorting, goods storage and goods handling, the corresponding functional areas are proposed. Then, the devices required to realise the warehouse functions are considered. Its unit area utilisation rate as a key indicator for area calculation is determined. Using the formula, the area of the following functional areas is calculated, as shown in *Table 1*.

The logistics relationship between functional areas is determined by the characteristics of the goods category of the operational process in the warehouse and then generating different operating flows.

At the same time, there are many non-logistics factors that affect the relationship between the functional areas of the warehouse as well. To determine the non-logistic relationship, firstly the reasons for determining the connection between functional areas need to be determined, then the importance level is to be analysed,

Table 1 – Summary of main functions and area of the operation area

Functional Area	**Main functions**	**Area [m^2]**
Inbound area	Equipment dispatching, unloading and dropping off, scanning, and warehousing	560
Sorting area	Handling, picking on sorting lines, barcode recognition, goods sorting	280
Storage area	Handling, goods on shelves	920
Dispensing area	Bar code identification, cargo sorting, code pallets, film wrapping	720
Staging area	Cargo palletising and handling	440
Outbound area	Handling, loading	540
Equipment storage area	Equipment storage, charging	260
Roads	Equipment walk	930

and finally the level is determined. This part is easily influenced by subjective impressions, resulting in a lack of rationality. Thus, this paper proposes seven relevant indicators for quantitative determination, which are frequency of round-trip operation between functional areas, frequency of common use of equipment, frequency of common space use, similarity of functions achieved by functional areas, number of material handling, security factors and workflow sequence.

According to the reasons of non-logistic relationship rating, the non-logistics relationship between the functional areas of the warehouse were analysed to obtain the non-logistic relationship analysis table shown in *Table 2*.

After determining the degree of logistic and non-logistic relationships, we need to come up with a comprehensive closeness. Usually, the rank in the non-logistics and logistics relationship is quantified and the numerical value is used to derive the comprehensive relationship table by the method of weighting and finally, the numerical table is graded. The general ranking values are A=4, E=3, I=2, 0=1, U=0. Referring to several previous studies, the ratio of logistics to non-logistics weighting relationship is suggested to be between 3:1 and l:3. Considering that logistics operations account for a larger proportion in this paper, the ratio of logistics to the non-logistics relationship is chosen to be 3:1. A comprehensive logistics relationship diagram is obtained, as shown in *Table 3*.

Table 2 – Analysis of non-logistics interrelationship

Corresponding functional area	Reasons	Corresponding functional area	Reasons
(1–2)	1,7	(3–4)	2,5,7
(1–3)	2,5,7	(3–5)	3,4
(1–4)	-	(3–6)	-
(1–5)	-	(3–7)	-
(1–6)	-	(4–5)	5,7
(1–7)	2	(4–6)	-
(2–3)	1,7	(4–7)	-
(2–4)	-	(5–6)	2,5,7
(2–5)	-	(5–7)	-
(2–6)	-	(6–7)	-
(2–7)	-		

Table 3 – Functional area composite relationship score

Corresponding functional area	Overall relationship score	Corresponding functional area	Overall relationship score
(1–2)	11	(3–5)	9
(1–3)	12	(3–6)	0
(1–4)	3	(3–7)	0
(1–5)	0	(3–8)	1
(1–6)	0	(4–5)	15
(1–7)	1	(4–6)	0
(1–8)	0	(4–7)	0
(2–3)	7	(4–8)	0
(2–4)	3	(5–6)	16
(2–5)	0	(5–7)	0
(2–6)	0	(5–8)	1
(2–7)	0	(6–7)	0
(2–8)	0	(6–8)	0
(3–4)	14	(7–8)	0

Secondly, the cost per unit distance between the input function areas is determined. It is mainly determined by a combination of factors such as charging time of handling equipment, maintenance cost and acquisition cost, and the cost between each grid varies depending on the equipment used. Therefore, this paper assumes that the cost of AGV handling is $0.5 and the cost of unmanned forklift handling is $1.

3.2 RESULTS

After several runs and continuous adjustments of the calculation, this paper tested different parameters, such as variation probability and a number of iterations. The final design variance probability is 0.9 and the maximum number of iterations is 800. MATLAB2022 was used to write the code to implement the model and the objective function curve tends to level off when the algorithm iterates to about 230 generations. As shown in *Figure 4*, we obtained the optimal plan layout scheme corresponding to the value of the objective function. The software-generated floor plan layout is shown in *Figure 5*.

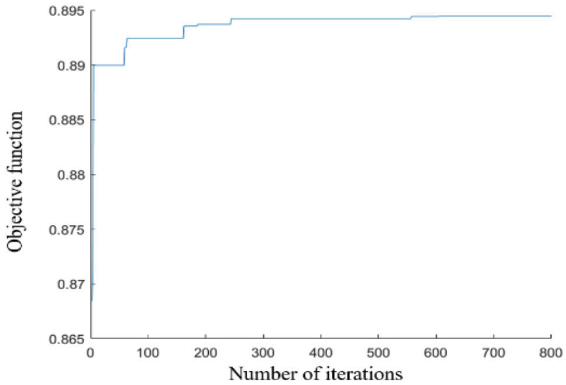


Figure 4 – Number of iterations

G4	G4	G4	G4	G4	G4	G4	G4	G4	G4	G4	G4	G4	G4	G5	G5	G5	G5	G9	G9
G3	G3	G3	G3	G3	G3	G3	G3	G3	G5	G5	G5	G5	G5	G5	G5	G5	G9	G9	G9
G3	G3	G3	G3	G3	G3	G3	G3	G3	G5	G5	G5	G5	G5	G5	G5	G5	G9	G9	G9
G3	G3	G3	G3	G3	G3	G3	G3	G3	G5	G5	G5	G5	G5	G5	G5	G5	G9	G9	G9
G3	G3	G3	G3	G3	G3	G3	G3	G3	G5	G5	G5	G5	G5	G5	G5	G5	G9	G9	G6
G3	G3	G3	G3	G3	G3	G3	G3	G3	G3	G6	G6	G6	G6	G6	G6	G6	G6	G6	G6
G2	G2	G2	G2	G2	G2	G2	G2	G8	G8	G8	G6	G6	G6	G6	G6	G6	G6	G6	G6
G2	G2	G2	G2	G1	G1	G2	G8	G8	G8	G7	G7	G7	G7	G7	G7	G7	G6	G1	G1
G1	G2	G2	G2	G1	G1	G2	G8	G8	G8	G7	G7	G7	G7	G7	G7	G7	G7	G1	G1
G1	G2	G2	G2	G1	G1	G2	G8	G8	G8	G7	G7	G7	G7	G7	G7	G7	G7	G1	G1

Figure 5 – Warehouse layout plan

Note: G1 – virtual area, G2 – inbound area, G3 – storage area, G4 – sorting area, G5 – dispensing area, G6 – staging area, G7 – outbound area, G8 – equipment staging area, G9 – development reserve area.

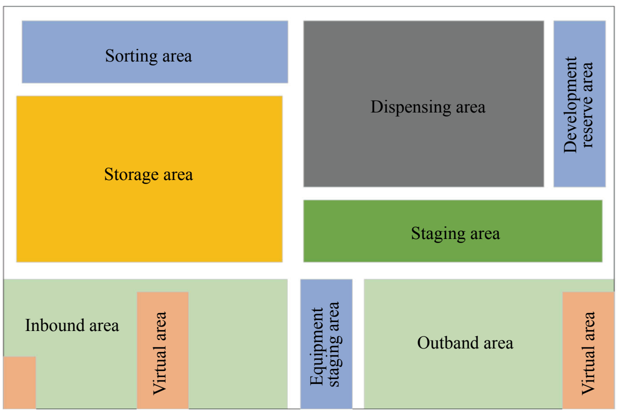


Figure 6 – Final warehouse layout

Since the model in this paper includes the road area inside the functional area, there is no design for the road. Thus, according to the layout scheme diagram derived from Matlab, the road set needs to be added artificially according to the location relationship of functional area. Furthermore, due to the irregular shape of some functional areas, local adjustment is needed. The final layout of *Figure 6* is then obtained.

4. SIMULATION

According to the layout scheme derived above, the feasibility of the method also needs to be verified. In this section, in order to better validate, we compared the scheme obtained in this paper with the initial layout scheme of the warehouse, by using the Flexsim software for simulation. The simulation process began with model assumptions, followed by model construction. Finally, the simulation indicators were selected for comparison.

4.1 Simulation assumptions

Under the premise of ensuring the effective output of the simulation effect, the simulation model needs to be simplified to remove some other factors from interfering; thus, the following instructions were made before building the Flexsim simulation model.

In the simulation of the weighing operation process of the measuring party, this simulation model did not choose to increase the processor that embodies the process by increasing the operating time of the corresponding functional area for model simplification.

All equipment was in continuous operation, during which the maintenance and repair of equipment were not considered.

For the whole pallets of unloading pallets on the sorting line and out of the sorting line on the pallet operation, this simulation is not represented by the synthesiser and decomposer but by increasing the corresponding process when the action time of the robot arm is represented, to achieve the purpose of simplifying the model.

4.2 Simulation model

The simulation system is divided into five subsystems according to the operation process in the warehouse. These are the inbound subsystem, picking subsystem, storage subsystem, distribution subsystem and outbound subsystem. Based on the model construction of these subsystems, this section integrates them organically.

We connected all entities in the model according to the Flexsim software's connection logic, following the correct production flow. Two warehouse space layout schemes were generated. Scheme 1 was determined according to the classical SLP approach, considering only logistic and non-logistic relations, which is the initial layout designed in this paper relying on the topic. Scheme 2 was derived from the model of this paper. The final two layout schemes are shown in *Figures 7 and 8*.

The following will be analysed and compared from three aspects. Firstly, the walking distance of the handling equipment, which is directly affected by the design of the layout scheme. Secondly, the operation

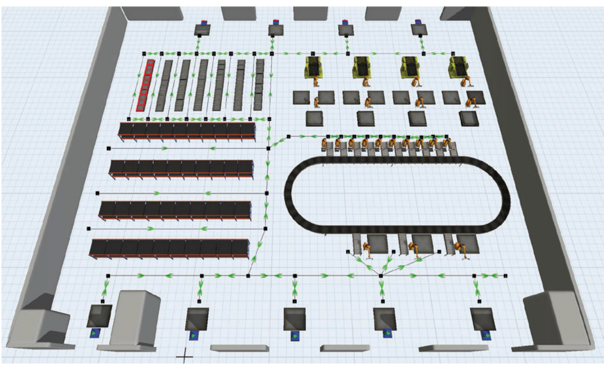


Figure 7 – Scheme 1 simulation layout

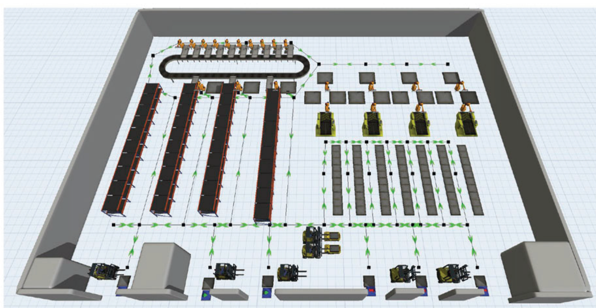


Figure 8 – Scheme 2 simulation layout

status of the functional area, which reflects the layout effect of the warehouse from the side. Thirdly, the analysis of the state of handling equipment and the change in operating efficiency can also be seen in the impact of the layout scheme. Finally, by using the three indicators mentioned above and by comparing the two schemes, we verify the validity of the method in this paper.

As can be seen from *Figure 9*, the total distance to the handling equipment is reduced by 21% in Scheme 2 compared to Scheme 1. The reason is that the location of the sorting area is farther from the incoming storage area, which does not have much influence. Moreover, the proportion of direct access to the sorting area is not high, which makes the storage area closer to the inbound area. The U-shaped layout makes the distribution of car parking spaces in the inbound area more aggregated. The handling distance of the remaining functional areas is reduced to some extent. The sorting area is closer to the storage area in Scheme 2, and the storage area is parallel to the distribution area, reducing the distance between the sorting area and the distribution area equipment.

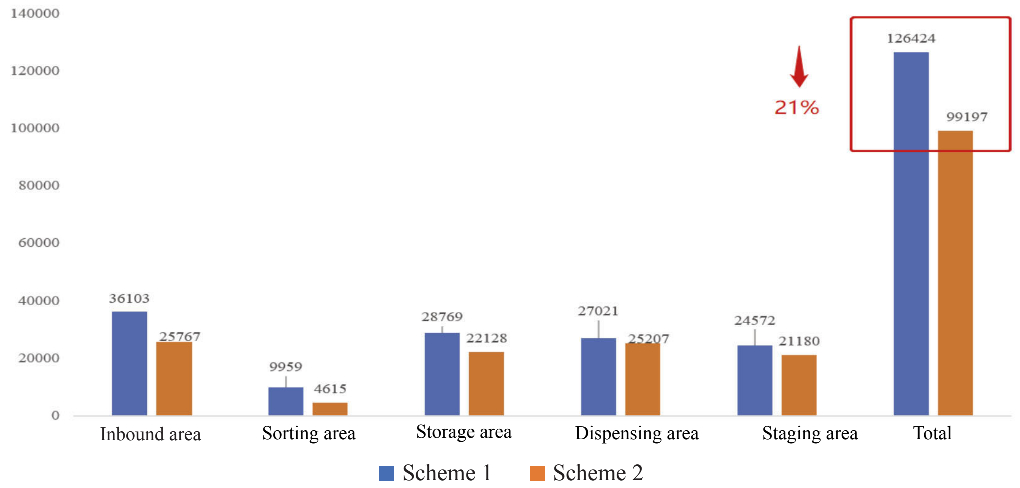
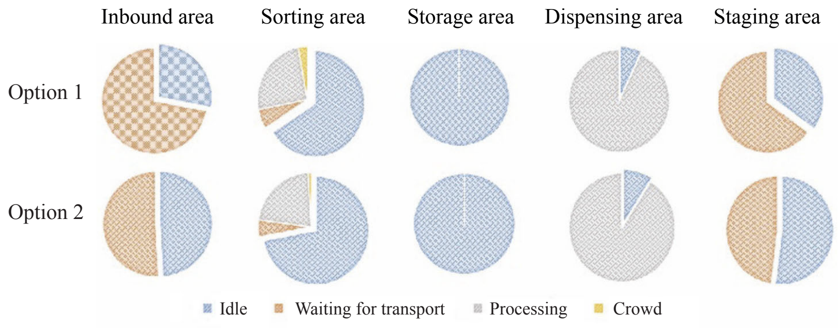


Figure 9 – Comparison of distance travelled by handling equipment

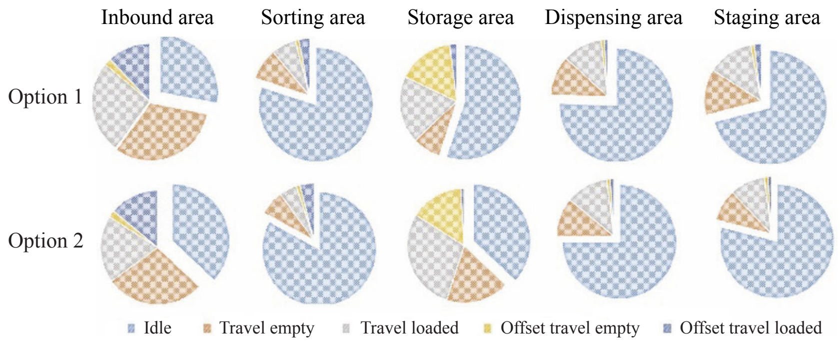
As can be seen from *Figure 10*, by comparing the functional area operation status of the two solutions, the idle status ratio of all functional areas has increased. On average, the idle status of Scheme 2 has increased by 9%, which indicates that the warehouse operation efficiency was improved by changing the warehouse layout. Among them, the inbound area and temporary storage area idle state ratio increased. The main reason for this analysis may be that the U-shaped layout causes the average handling distance and the handling time to be reduced. Thus, the idle time of the parking space increases.

By comparing the transportation status of driverless forklifts of the two layout schemes, the proportion of idle status increases except for the storage area, but the increase is not significant. It is calculated that the average idle state of driverless forklifts in each functional area is equal, which is around 60%. Therefore, the change of layout scheme has a small impact on the operation status of driverless forklifts.

In summary, compared with the simulation results of the two layout schemes, the travel distance of handling equipment was reduced by 21% in Scheme 2 compared to Scheme 1; the idle state in the functional area working condition index has increased by 9.2% on average. In other words, there is a reduction of the handling distance, driving the improvement of the operation efficiency. Moreover, the two schemes are close to each other in the work condition index of handling equipment, which indicates that the optimal adjustment using the model in this paper is feasible and effective compared to the layout scheme obtained by the traditional SLP method. Therefore, the layout scheme obtained using the proposed model in the paper has better efficiency, proving the method's effectiveness in this paper. However, according to the current situation, there is still room for optimisation. For example, the vacancy rate of functional areas is the minimum, and if the rate is too low, there is a waste of space. Thus, this needs to be further optimised.



a)



b)

Figure 10 – a) Comparison of the functional area operation status, b) Comparison of the operation status of handling equipment

5. CONCLUSION

Relying on research data and the current situation of logistics warehouses, this paper used the SLP method to present the concept of virtual functional areas based on the irregular shape of the warehouse. Considering the influence of the irregular boundary of the warehouse, a 0–1 integer planning model based on the grid and SLP methods was established, then genetic algorithms were optimised in accordance with the design of the model. Finally, by using simulation, the effectiveness of the methodology of this paper was demonstrated by comparing it with the initial scheme of the case. The roads between functional areas were neglected when analysing the road relationships between functional areas. This makes it necessary for the road design to be subsequently supplemented according to the location of the functional areas. Meanwhile, the roads outside the functional areas and their corresponding widths are not considered, which is subject to further study.

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基于优化遗传算法的不规则仓库布局研究

摘要：

物流在疫情期间对经济增长和物资的流通起到了重要作用，近年来正在经历快速发展。随着仓储行业面临个性化和成本化的问题，经济和社会对其提出了更高的要求。合理设计功能区布局就是提高物流仓储系统运行效率的重要一步。在现实中，由于仓库设计和设备应用的原因，不规则仓库逐渐增多。本文以某不规则仓库为例，结合其现状，首先明确功能区设计，构建基于珊格和系统布局规划方法的0-1整数规划模型，并设计珊格独特的功能属性等约束。我们基于仓库不规则属性和珊格方法优化遗传算法，然后通过MATLAB求解。最后，利用Flexsim软件，选择仿真指标进行评估，验证方法可行性。

关键词：

不规则仓库；遗传算法；布局模型；Flexsim