Logistics Engineering Simulation Using Computer 3D Modeling Technology

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\textbf{Abstract.} 3D modeling technology is an important branch of interdisciplinary fields such as computer graphics, intelligent information processing, computer vision, and artificial intelligence. Through computer digitization, collecting three-dimensional data information of the target object, and then processing and simulation reproduction through computer technology, plays an important role in logistics engineering (LE). The purpose of this paper is the simulation research of LE based on computer three-dimensional modeling technology. This paper takes LE as the research object, firstly elaborates the functional and non-functional requirements of the system separately, and establishes an intelligent logistics system. This paper uses Flexsim simulation software to establish a logistics distribution simulation model. Based on the data collected in the survey, the model is parameterized. Through the data output from the simulation, the simulation data of the original logistics system and the logistics system designed in this paper are compared and analyzed. The simulation output data shows that the total number of products transported in and out of the warehouse of the original system's 6 transport planes is 15,559, and the total number of products transported in and out of the warehouse of the 6 transport planes in the logistics system proposed in this paper is 17,144 pieces. It can be seen that this system has strong transportation efficiency in LE.

\textbf{Key words:} 3D Modeling, Logistics Engineering, Logistics System, Intelligent Algorithm

1. Introduction

With the continuous maturity and development of computer technology, people are no longer satisfied with the experience on the two-dimensional plane, which makes three-dimensional modeling technology more and more applications [1-2]. Among them, the in-depth application of LE system simulation based on computer three-dimensional modeling technology can make the entire transportation process flexible and controllable, so that enterprise production activities can be carried out in an orderly and efficient manner. It is an important module indispensable for the efficient operation of LE[3-4].

Regarding the research of 3D modeling technology and LE, many scholars have carried out experimental research on it. For example, Zhang Y used 3Dmax software to model the workshop entity and Post Engineer software for the modeling problem of 3D virtual workshop. The lightweight
processing of the model, the simulation design of the operation mode of production logistics, and the improvement of the production efficiency of the actual workshop [5]; Liu C conducts simulation analysis of the logistics system of the company’s distribution center, uses AnyLogic software to establish a simulation model, uses LE methods to optimize, and verifies the feasibility of his proposed scheme through simulation [6].

The purpose of this paper is the simulation research of LE based on computer three-dimensional modeling technology. This paper takes LE as the research object, firstly elaborates the functional and non-functional requirements of the system separately, and establishes an intelligent logistics system. This paper uses Flexsim simulation software to establish a logistics distribution simulation model. Based on the data collected in the survey, the model is parameterized. Through the data output from the simulation, the simulation data of the original logistics system and the logistics system designed in this paper are compared and analyzed.

2. LE Simulation Based on Computer 3D Modeling Technology

2.1. Logistics System Demand Analysis

(1) Demand analysis of order management
The order management part is the "starting point" of the system, which mainly includes the import, modification, deletion, review and processing of orders. First of all, the system must ensure that the received orders are legal (legal customers, reasonable goods and quantities, and other order information is accurate, etc.), so as to avoid unnecessary losses caused by orders in the storage process and reduce [7]. And the system can enter multiple orders: manual import, batch import, etc.

(2) Warehousing management demand analysis
The logistics system manages multiple areas, and each area contains different warehouses of different sizes. The task of the warehouse management subsystem is to accurately reflect the location, age, batch, etc. of the goods in the warehouse, and provide inbound and outbound goods. The warehouse, moving warehouse, inventory, and loading functions are divided into modules to handle warehouse management operations of different businesses. The logistics system fully solves the warehouse manual accounting problem and guarantees the timeliness of the inbound and outbound accounting processing, providing a basis for the key decision-making of the logistics system management.

(3) Analysis of transportation management needs
Process the tasks that have been loaded by the system, match the appropriate vehicle to the waybill, realize intelligent loading of trucks and goods, minimize transportation costs and improve business efficiency; query the transportation status of in-transit orders, and grasp the latest transportation status in real time; retrieve historical transportation orders, realize transportation process tracking and cargo traceability.

2.2. Logistics System Design

(1) System architecture design
The whole system adopts a three-layer design: interaction layer, control layer and data layer. Then adopt the development idea of separation of front and back ends. User interaction and data processing are completely separated. Users only need to use the browser to access the application homepage, without feeling the huge back-end data area. At the same time, the front-end and back-end separation mode is easy for system development and testing, so that the system has good operability and interactivity [8-9].

(2) Module design
The order management module mainly manages the entry, review, modification and deletion of system orders. It is the starting point of the system business process. The function of order review is to verify the correctness of the entered order information.

The warehouse management module is to manage the goods in the warehouse in the park. It includes generating goods waybills according to the order, warehousing, outgoing, relocation, and warehouse inventory. Relocation is a special kind of in and out of warehouses, which is the transfer of goods between warehouses in the park.

The transportation management module is responsible for system vehicle management and waybill management during transportation. It includes vehicle information query, in-transit information upload, waybill status update, waybill query, and vehicle and cargo recommendation algorithm. On the one hand, the in-transit information upload is for real-time update of the waybill position for convenience the administrator and the cargo owner supervise, on the other hand, it records the driver's historical route to provide data support for the vehicle-to-cargo matching recommendation algorithm.

All users who want to use this system need to register. The registration needs to fill in and upload different information according to different roles, and then wait for the administrator to review. After the review is passed, the user will get a unique user ID (blockchain address), there is a one-to-one relationship between user and ID, and user ID is the only pass for the entire system [10-11].

2.3. Particle Swarm Hybrid Cuckoo Algorithm Based on Logistics Distribution Route Optimization

The cuckoo algorithm has good global search capabilities and flexibility, and the application of parameters is simple and easy, but it has the problems of slow convergence and insufficient convergence accuracy in the later stage [12]. Therefore, in order to optimize the convergence speed and solution accuracy of the cuckoo algorithm, a particle swarm hybrid cuckoo algorithm is proposed, which mixes the cuckoo algorithm with the particle swarm algorithm, uses adaptive parameter updates, and introduces fitness weight factor to enhance the information exchange between individuals in the population.

(1) Adaptive parameter adjustment

In the standard cuckoo algorithm, it is found that the probability $P_a$ and the step size control factor $a_{step}$ are constants, which is not conducive to the later convergence speed and accuracy of the algorithm. If $P_a$ is always larger and $a_{step}$ is smaller, it will shorten the algorithm convergence time, but it is easy to converge the local optimum; and if $P_a$ is smaller and $a_{step}$ is larger, the convergence speed will be slower. Therefore, $P_a$ and $a_{step}$ can be adjusted to improve the cuckoo algorithm. An adaptive parameter adjustment strategy is made here, so that the key parameters of the cuckoo algorithm can be adjusted adaptively with the number of iterations. The calculation method is as follows:

$$P_a(t) = P_{a_{max}} - \frac{P_{a_{max}} - P_{a_{min}}}{T} \cdot t \quad (1)$$

$$a_{step}(t) = a_{\max} - \frac{a_{\max} - a_{\min}}{T} \cdot t \quad (2)$$

Among them, $P_{a_{\min}}$ and $P_{a_{\max}}$ control the upper and lower bounds of the discovery probability, and the upper and lower bounds of the $a_{\max}$ and $a_{\min}$ step control factors, T is the maximum number of iterations, and t is the current number.

(2) Fitness weight

The cuckoo algorithm mainly updates the position through the individual Levy flight and random
walk. There is no information exchange between groups and lack of group intelligence to improve its search ability. High-quality individuals should influence the generation of new solutions with a certain weight. The quality of an individual can be measured by fitness. Therefore, the concept of the fitness weight of the cuckoo algorithm is introduced here. The calculation formula for the fitness weight of the i-th cuckoo individual is as follows:

$$w_i = \frac{|f_{\text{best}} - f_i|}{f_{\text{worst}} - f_{\text{best}}}$$  \hspace{1cm} (3)

Among them, $f_i$ represents the fitness value of the i-th cuckoo individual. $f_{\text{best}}$ and $f_{\text{worst}}$ represent the optimal fitness value and the worst fitness value.

3. LE Simulation Experiment Based on Computer Three-Dimensional Modeling Technology

3.1. Simulation Model Construction

(1) Computer simulation software
This experiment uses Flexsim software for simulation, which can realize the intuitive observation of the model. Flexsim has a 3D field of view, and the observation of the model is relatively clear, and it can intuitively observe the spatial problems of the model during its operation.

(2) Model parameter setting

1) Generator parameter setting
Therefore, when setting the generator parameters, select "arrivequeue" as the arrival mode. Taking the evaporator as an example, the single handling capacity of each line is 50, and there are three assembly lines that require the evaporator, so the generator batch should be set to 150.

2) Parameter setting of transport aircraft
In the Flexsim simulation model, a conveyor is used to simulate a forklift to move materials. There are various equipment and a large number of staff in the warehouse. Therefore, the maximum speed of the forklift in the warehouse cannot exceed 5 kilometers per hour. Set its maximum capacity to 1, the conveyor speed is 1.4m/s, the acceleration is 1.5m/s, and the deceleration is 1m/s. The forklift loading and unloading time is 30 seconds.

3) Processor parameter setting
The processor is used to simulate the actual situation of the equipment and operation, and the time is uniformly distributed. Take the air conditioner outdoor unit assembly line as an example. The standard time of the entity is 14s. Because the manual processing time will have a certain error, the assembly time of the processor and the synthesizer is set to be evenly distributed, because each device cannot be at the same time assemble multiple products, so the capacity is 1. In addition, processors 9~20 are operating equipment that simulates the parts processing area in the warehouse. According to the assumption of the model, before the start of the final assembly, the corresponding materials are ready, and there is no shortage of materials. Therefore, the physical arrival time and processing time of these processors are set to "0".

4) Synthesizer parameter settings
The most basic function of a warehouse is to assemble materials and process many materials into one product. Therefore, it is necessary to use a synthesizer to synthesize the temporary entities when establishing the simulation model. The specific setting method is to set the parameters of the synthesizer to "box", recycle to "Box", and set the Target Quantity to "1".
4. LE Simulation Data Analysis Based on Computer Three-Dimensional Modeling Technology

4.1. Analysis of the Number of Products in and out of the Warehouse
The number of products is the output, and the statistics of the output indicators in the simulation model are obtained from the absorber. According to statistics, the number of products transported in and out of the warehouse in each simulation model of the warehouse logistics system is shown in Table 1. Among them, the total number of products transported in and out of the warehouse by the 6 transport planes in the original system is 15559 pieces. In the logistics system proposed in this paper, the total number of products transported in and out of the warehouse by the 6 transport planes is 17,144 pieces.

| Handling tools | Original system | This system |
|----------------|-----------------|-------------|
| Transport 1    | 2914            | 2999        |
| Transport 2    | 2876            | 3007        |
| Transport 3    | 2880            | 3269        |
| Transport 4    | 2293            | 2527        |
| Transport 5    | 2325            | 2546        |
| Transport 6    | 2291            | 2796        |

Table 1. Quantity of products transported in and out of the warehouse

![Figure 1](image-url) Figure 1. Quantity of products transported in and out of the warehouse

It can be seen from Figure 1 that in the simulation model, the inbound and outbound transportation volume of various models in this system is 85, 131, 389, 234, 221, and 258 higher than the original system respectively, of which the highest is 122.04% of the original system. It can be seen that the number of products transported in and out of the warehouse of this system is higher than that of the original logistics system.

4.2. Analysis of Handling Equipment Utilization
The performance of the system is verified by comparing and analyzing the waiting time of the transportation tools in the original system and this system. Table 2 shows the related data of the waiting time of handling equipment and the average waiting time of each transport aircraft during the simulation process of empty-load operation:
Table 2. Utilization rate of handling equipment

| Handling tools | Original system | This system |
|----------------|-----------------|-------------|
|                | Waiting time (s) | No-load operation (%) | Waiting time (s) | No-load operation (%) |
| Transport 1    | 11.54           | 7.36         | 10.22           | 3.78          |
| Transport 2    | 12.64           | 6.78         | 11.46           | 3.15          |
| Transport 3    | 16.71           | 7.04         | 13.00           | 3.39          |
| Transport 4    | 27.34           | 12.54        | 17.64           | 6.75          |
| Transport 5    | 35.66           | 8.79         | 24.69           | 4.78          |
| Transport 6    | 37.49           | 9.12         | 28.16           | 5.04          |

Figure 2. Utilization rate of handling equipment

Waiting time and no-load operation rate are two important indicators to measure the utilization of handling equipment. According to the analysis of Table 2 and Figure 2, in the original system simulation model, the average waiting time of the transport aircraft is 23.56 seconds, and the average waiting time of this system is 17.53 seconds. In terms of average waiting time, compared with the simulation model of the original system, this system is shortened by 6.03 seconds. In terms of the average no-load operation rate, the original system and this system were 13.38% and 4.48% respectively, which verified the higher transportation efficiency of this system in LE.

5. Conclusion

In the LE based on digital technology and information technology, the application of computer three-dimensional modeling technology to verify and evaluate the LE plan and plan can reduce the logistics investment cost and energy of the plan. At the same time, the process of program evaluation is also changed under the intelligent logistics mode. Traditional programs are mostly based on empirical principles, and the reliability of implementation cannot be verified. The LE system simulation based on computer three-dimensional modeling technology can integrate optimized decision-making models and high efficiency. The solution algorithm to achieve the improvement of system reliability and planning rationality. Real-time simulation and predictable process are also the highlights of computer
three-dimensional modeling technology. The Internet of Things at the information perception layer provides technical support for data collection for the simulation of the logistics system, and the data processing and mining technology at the data analysis layer is the simulation of the logistics system, prediction, diagnosis and optimization provide analysis conditions, and the system simulation layer provides basis, support and guarantee for equipment and system decision-making, such as diagnosing the health status of the handling carrier, evaluating the feasibility of the plan, etc.

Acknowledgments
Key Major Construction Project of Logistics Engineering Nanning University In 2017.(No: 2017XJZDZY03)

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