Design of a Logistics Allocation Scheme Based on the Approximate: Relaxed Approach to Batching Algorithm

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Abstract: The Ministry of Commerce, the Central Internet Information Office and the Development and Reform Commission jointly released the "14th Five-Year Plan" for the development of e-commerce, whih provides a top-level design for the development of e-commerce in China during the 14th Five-Year Plan period. With the deepening impact of e-commerce on the social economy, the role of e-commerce on the industrial chain and supply chain is becoming stronger and stronger, and the innovative functions proposed in the industrial chain and supply chain will enable e-commerce to better support the industrial chain and supply chain. As online shopping gradually becomes an important consumption mode in today's market. Efficient logistics and transportation gradually become a concern. The warehouse, as the starting point for the discharge of goods, has a significant impact on the efficiency of logistics and transportation. In this paper, for a simplified sorting system, the batching algorithm is designed using the approximate system-relaxation algorithm, the goods placement problem is optimised using the simulated annealing algorithm, and the assignment of sorting tasks is finally completed by cross-referencing specific scenarios. (No effect of the paper was seen, i.e. whether there was any improvement in the data, or whether anything new was proposed).

1 INTRODUCTION

This template, modified in MS Word 2007 and saved as a "Word 97-2003 Document" for the PC (Yao, 2022), provides authors with most of the formatting specifications needed for preparing electronic versions of their papers (Huang, 2017). In recent years, online shopping has developed very rapidly in China. The convenience and affordability of e-commerce has made it rapidly popular in China (Yao, 2022). As the logistics support for the e-commerce industry, the express delivery industry is also growing rapidly with the development of the e-commerce market scale (Huang, 2017; Zhao, 2021; Li, 2022). At the same time, China's governments at all levels also attach great importance to the development of e-commerce and express industry, in the "express into the village" and many other people-friendly policies, the development of China's express industry has expanded rapidly, the number of major courier companies handle more and more express every day. 2016 is already expected to exceed 40 billion express business volume in China (Reports, 2017). And according to the "2021 China Express Development Index Report" released by the State Post Bureau, the national express business volume in 2021 completed 108.3 billion pieces, with an average daily express mail handling volume of nearly 300 million pieces. Among them, Jinhua City's annual express business volume exceeded 10 billion pieces, becoming the first city in the country to move into the 10 billion scale (Xu, 2021). In the face of so many express, how the courier companies in the accurate and safe premise, as soon as possible to the hands of customers express is a widely concerned about the issue. And speeding up the sorting speed is undoubtedly the most important part of speeding up the logistics speed, and is also an important means for major courier companies to improve their market competitiveness.

Sorting is the process of stacking couriers by order, type and order of entry and exit. In the beginning, the most primitive manual sorting was used. At that time, the flow of goods was small and manual sorting was sufficient to meet demand, but as the economy became more global and the number of goods in circulation grew, manual sorting became difficult to meet. In the 1920s the Dutch company Erma developed the world's first letter sorting machine, which marked the birth of automatic sorting equipment. After the Second World War a number of developed countries began to work on automatic

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sorting techniques and equipment and applied them in practice (Li, 2013). With the popularisation and development of computers and the subsequent application of technologies such as big data and the internet in automatic sorting, logistics sorting systems in foreign countries became increasingly sophisticated (Le, 2022). Although China's logistics industry has made good progress since the reform and opening up, especially in the 21st century, not only in land logistics, but also in air logistics and water logistics (Li, 2022; Huang, 2021), automated sorting in China started very late, so there is still a certain distance between the overall level and the world's advanced level, especially in the area of sorting speed.

However, China has a great demand for the development of the express delivery industry, and the modern logistics industry plays an important fundamental and pioneering role in the national economy and social development (Xu, 2022). The scale of China's express business continues to rank first in the world, accounting for more than 40% of the global share, and contributing 60% to the growth of the world's express business, which has become a new engine for the development of the global express market (Yang, 2017). The 14th Five-Year Plan and the 20th Five-Year Plan are the most important and most important of all. The Outline of the 14th Five-Year Plan and Vision 2035 proposes to "optimise international logistics channels and accelerate the formation of a safe and efficient logistics network with internal and external connections" (Li, 2021; Wang, 2022). Sorting efficiency is a major focus on the competitiveness of the express industry. In order to enable the rapid development of China's express industry, to achieve efficient automated sorting as early as possible, to promote the mechanisation and modernisation of the entire industry and to improve the competitiveness of enterprises internationally, it is essential to study and analyse sorting algorithms. In response to this call, and also out of practical considerations, major logistics companies are striving to find faster and more efficient sorting methods.

2 PREVIOUS WORK

2.1 Problem Analysis

In order to improve the sorting efficiency of e-commerce systems and provide algorithmic support and theoretical basis for the next step of e-commerce automation, we select three steps: goods aggregation, goods on shelves, and assigned sorting according to the existing courier delivery workflow, refine the objective functions for these three steps, and carry out modelling and optimisation respectively. The optimal solution for the three steps in the target scenario is finally derived, forming an optimal courier picking solution for existing e-commerce conditions.

2.2 Introduction to the Approximate, Relaxation Algorithm

Constraint and relaxation algorithms are common algorithms for making abstract problems concrete, and initially researchers put this idea into practice in order to find better transfer equations and to ensure that the resulting solution is optimised in an attempt to transfer the equation. The 'constraint' approach is generally described as adding conditions and restrictions that are appropriate and more realistic to ensure that the solution is still obtained after the addition of these conditions and restrictions. The 'relaxation' approach, on the other hand, relaxes the harsh and unreasonable conditions and restrictions of the abstract problem and ensures that the solution is still found after relaxing these conditions and restrictions. The current constraint and relaxation algorithm is very effective in optimising known solutions to reasonable problem constraints. Figure 1 is the flow chart of the restriction relaxation algorithm.

2.3 Constraint, Relaxation Algorithm Implementation Steps

Step 1: add appropriate constraints, compare the initial solution with the new solution and update the values of the more optimal solution.

Step 2: Remove some of the stringent conditions, compare the initial solution with the new solution, the increment of the objective function and update the values of the more optimal solution.

Step 3: If the solution is still obtained by modifying the constraints, repeat steps 1 and 2 until the more optimal solution no longer changes.

2.4 Introduction to the Simulated Annealing Algorithm

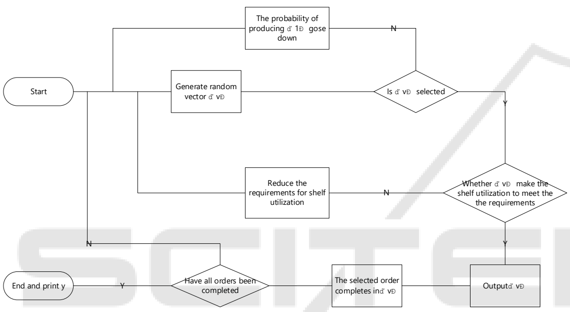
The simulated annealing algorithm is a commonly used optimization algorithm based on Monte-Carlo iterative solving. Initially, researchers combined the general combinatorial optimization problem in optimal combinatorial problems with the solid annealing process in thermodynamics, trying to break through the local optimum and find the global optimum with a certain probability. Today, this algorithm has become the classical algorithm for finding globally optimal patterns.

2.5 Simulated Annealing Algorithm Model Construction Steps

Step 1: Generate the initial solution randomly, update the optimal solution as the initial solution and calculate the corresponding objective function taking values.

Step 2: generate new solutions randomly in the domain of the optimal solution, calculate the increment of the objective function between the optimal solution and the new solution, and update the optimal solution when the increment of the objective function is greater than zero.

Step 3: Repeat step 2 until the optimal solution no longer changes.



3 METHODOLOGY

3.1 Design of Batching Algorithms Using the Approximate - Relaxed Approach

First create a matrix representing the orders of the day.

$$A=\begin{pmatrix} a_{11} & a_{12} & \cdots & a_{1n} \\ a_{21} & a_{22} & \cdots & a_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ a_{m1} & a_{m2} & \cdots & a_{mn} \end{pmatrix}$$

where the rows represent the order number and the columns represent the type of goods, so that $m = 932, n = 1941$, and

$$a_{ij}=\begin{cases} 0 & No \text{ item j in the } i^{th} \text{ order} \\ 1 & \text{The } j^{th} \text{ item in the } i^{th} \text{ order} \end{cases}$$

Next, construct the selection matrix:

$$X=\begin{pmatrix} x_{11} & x_{12} & \cdots & x_{1m} \\ x_{21} & x_{22} & \cdots & x_{2m} \\ \vdots & \vdots & \ddots & \vdots \\ x_{g1} & x_{g2} & \cdots & x_{gm} \end{pmatrix}$$

where the rows represent order batches and the columns represent order numbers, i.e. $m = 932$, and

$$x_{ij}=\begin{cases} 0 & Batch\ i\ not\ selected\ j^{th} \text{order} \\ 1 & Batch\ i\ not\ selected\ j^{th} \text{order} \end{cases}$$

where the rows represent order batches and the columns represent order numbers, i.e. $m = 932$, and

$$x_{ij}=\begin{cases} 0 & Batch\ i\ not\ selected\ j^{th} \text{order} \\ 1 & Batch\ i\ not\ selected\ j^{th} \text{order} \end{cases}$$

Let the matrix $Y = X \times A$, then it is easy to see that

$$y_{ij} = \begin{cases} 0 & \text{There are no j goods in } i^{th} \text{ the batch} \\ \text{else} & \text{There are j goods in } i^{th} \text{ the batch} \end{cases}$$

To facilitate the calculation, the numbers in Y all numbers greater than 1 are set to 1, i.e.

$$y_{ij} = \begin{cases} 0 & \text{There are no j goods in } i^{th} \text{ the batch} \\ 1 & \text{There are j goods in } i^{th} \text{ the batch} \end{cases}$$

In this way, the objective translates into minimizing the value of$g$ the minimum value of the constraint as follows:

$$s.t. = \begin{cases} \sum_{j=1}^{n} Y_{ij} \le 200 & (1) \\ \sum_{i=1}^{g} X_{ij} = 1 & (2) \end{cases}$$

Thus, it is sufficient to find such a matrix$X$ The problem can be solved by finding such a matrix that satisfies the above conditions and has the minimum number of rows, but such a matrix is not easy to find because, firstly, the number of rows is unknown and the matrix cannot be set up in the first place. Secondly, the number of columns in the matrix is too large to traverse to find the optimal matrix.

Therefore, abandoning the search for the optimal solution and moving to an approximate solution, one can split$X$ splitting each row of the$0-1$ matrix of rows and solving for them separately.

$$v_i = \begin{cases} 0 & \text{The } i^{th} \text{ order is not selected in this selection} \\ 1 & \text{The } i^{th} \text{ order is selected in this selection} \end{cases}$$

such that v its multiplication with the matrix A multiply it with the matrix and make the result satisfy the constraint (1) so that this row matrix is said to v is a correct choice, otherwise it is an incorrect choice.

Each correct selection is saved in a row of the matrix X in one row of the matrix, and subsequent selections are made without reselecting X the orders already selected in the matrix. When the matrix X satisfies the constraint (2) the selection is complete, at which point the X can be used as a solution to this problem.

The solution sought for this question X The number of rows should be as small as possible, and for this reason, as many orders as possible should be selected for each choice.

Adjusting $0-1$ The probability of the random number being generated is initially set to 1 with a probability of 1 and when a loop of 100 When the correct choice is not found after several attempts, reduce this probability by 0.005. In this way, the final choice generated has as many orders selected each time as possible. The solution found is also better than before.

To further optimise the solution, a further condition can be added, requiring the highest possible utilisation of the shelves, in a similar way to before, setting the minimum number of shelves to be utilised initially as 200, and discard if the found choice cannot be satisfied. If the number of consecutive 10 is not satisfied, then the minimum utilisation number is set to -1. After using this method of calculation, the approximate solution to the problem is eventually found, using 92 The order is processed in batches.

3.2 Optimising the Placement of Goods Using Simulated Annealing Algorithms

The equations are an exception to the prescribed specifications of this template. You will need to determine whether or not your equation should be typed using either the Times New Roman or the Symbol font (please no other font). To create multileveled equations, it may be necessary to treat the equation as a graphic and insert it into the text after your paper is styled.

Based on the results obtained in the previous section, it is possible to obtain the number of orders completed in each batch and to calculate the types of goods contained therein according to the previous method. The objective is to find a sequence of goods that minimises the total picking distance of a batch of orders. That is, to find a sequence of equal length to the number of goods in a batch, so that when the goods are arranged according to this sequence, the total picking distance is minimised.

In this way, the problem is transformed into finding a sequence that minimises the objective function, which can be equated to TSP problem. Let the first m order contains the set of item numbers as g_m and the total picking distance for all orders is $S(m)$, then use the following formula.

$$S(m) = \sum_{k \in g_m} d(O_k) \quad (3)$$

In this way $S(m)$ is the total picking distance to be found, which should next be minimized.

For each batch of orders obtained from the previous results, the number of occupied shelves is relatively large and it is not computationally feasible to traverse the entire arrangement, so a simulated annealing algorithm is used to find an approximate solution.

with $S(m)$ as the main function, the m The order of the goods contained in the batch of orders is the input, and the inverse order and the pair of orders are used to find the proximity solution, and the initial temperature is set to 1000 and the end temperature is set to 8 and the cooling rate is set to 0.94 The results obtained by the two methods are compared and the better one is used as the best order for this batch of orders.

From the results, it can be seen that the solution sequences obtained by both the pairwise and inverse order methods of finding proximity solutions are each good or bad in different orders but do not differ much, so the solution sequence with the smallest total picking distance is taken directly as the final solution sequence.

3.3 Assignment of Sorting Tasks

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In this question there are 5 sorters, initially located on 1 shelf number, and based on the results in (2) the results in this question, calculate the number of orders to be picked from the current position after picking the first i after picking the first order, from the current position P_i The picking of the next order starts at the current position. At this point there are four scenarios. The following is the first case:

$$P_i < \min_{i \in O_k}(i) \quad (4)$$

At this point the sorter simply moves from the current position to the highest numbered shelf position where the goods in the order are located, moving a distance of $\max_{i \in O_k} S(i) - P_i$.

This is the second case:

$$P_i > \max_{i \in O_k} S(i) \quad (5)$$

At this point the sorter simply moves from the current position to the lowest numbered shelf position where the goods in the order are located, moving a distance of $P_i - \min_{i \in O_k} S(i)$.

This is the third case:

$$\min_{i \in O_k} S(i) < P_i < \frac{\min_{i \in O_k} S(i) + \max_{i \in O_k} S(i)}{2} \quad (6)$$

The shortest distance the sorter can move is from the current position to the mini∈O k S(i) position and then to the maxi∈O k S(i)

position, the total distance moved is $\left[P_i - \min_{i \in O_k} S(i)\right] + \left[\max_{i \in O_k} S(i) - \min_{i \in O_k} S(i)\right]$

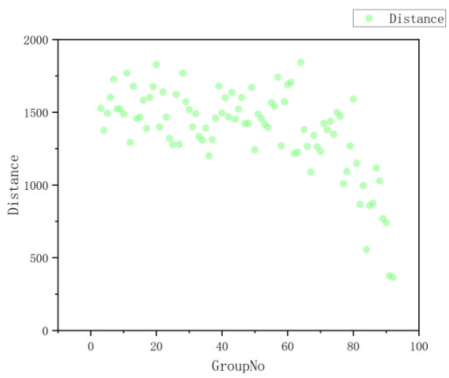
This is the forth case:

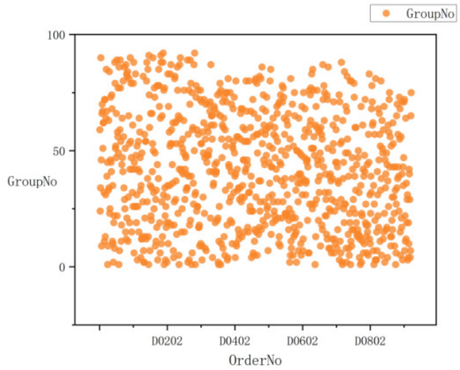
$$\frac{\min_{i \in O_k} S(i) + \max_{i \in O_k} S(i)}{2} < P_i < \max_{i \in O_k} S(i) \quad (7)$$

The shortest distance the sorter can move at this point is from the current position to position$\max_{i \in O_k} S(i)$ and then to $\min_{i \in O_k} S(i)$ The total distance travelled is $\left[P_i - \min_{i \in O_k} S(i)\right] + \left[\max_{i \in O_k} S(i) - \min_{i \in O_k} S(i)\right]$ Initially, any sorter is first asked to complete the first batch of orders and the distance travelled is calculated, and subsequent orders are picked by the sorter who has travelled the least distance, so that the picking task is as even as possible.

4 RESULT AND DISCUSSION

The following two results are scatter plots of the distance of the express sorting system and the sorting results between different groups after using the annealing algorithm and the restriction relaxation algorithm.





4.1 Analysis of Results

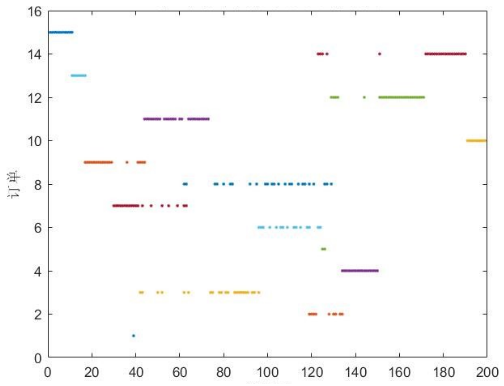
This paper provides a model for the order batching method, the order in which different goods are placed and the task allocation of pickers in the courier distribution process, and tests this model in one case. And as can be seen from these results, this model solves the problem of determining the batching method in order batch processing very well, resulting in high shelf utilisation and the ability to process a large number of orders at once.

In solving the problem of how goods are placed on the shelves, the diagram below shows that individual goods of the same order are placed in relatively centralised locations, which greatly facilitates the picking process for the pickers. When assigning picking tasks, this paper provides a more general model that can be used to adjust the weights between distance travelled and mutual averaging, or even add new judgement factors, according to specific business needs, without affecting the normal use of the model. The results are obtained to meet the specific situation. The shortcomings of the model in this paper are as follows:

A. When dealing with order batching problems for orders containing fewer types of goods have good results, but for large orders, there is a certain probability of low shelf utilisation and fewer orders being processed in a single run.

B. In solving the goods placement problem, the speed of computing is sacrificed to get better results, and the practical application still requires more computer arithmetic.

C. The models shown in this paper are approximate solutions and should not be used when the number of orders is small and optimal solutions are available.



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