Study on a Shipping Slip Assignment Method for Efficiency Improvement of Picking in a Warehouse

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Abstract

In the distribution industry, it has become important to improve the efficiency of the logistics system to realize lower prices while maintaining product quality. However, the efficiency of “picking” has not yet been improved, and its work cost accounts for a large percentage of the entire logistics cost.

Therefore, in this paper, we propose a shipping slip assignment method that reduces the walking distance of picking workers to improve picking efficiency in a warehouse. Specifically, we grouped the slips based on the location information of the ordered commodity, and allocated the grouped slips to the workers, thereby improving the efficiency of the picking operation. Furthermore, we conducted a simulation of the route guidance during the picking work by assuming practical work, compared the walking distances with those under the case of no grouping, and evaluated the usefulness of the proposed method.

Keywords: warehouse, picking, slip assignment, GA

1. Introduction

In recent years, in the distribution industry, it has become important to reduce logistics cost to achieve lower prices while maintaining product quality⁽¹⁾. However, although a “warehouse” is an important component of the logistics system, its efficiency has not been improved in many aspects. In particular, “picking,” which indicates performing collection work in the racks in a warehouse, accounts for a large percentage of the overall logistics cost, and an improvement in its efficiency contributes to the reduction of the operation cost of the entire logistics system⁽²⁾.

The authors have proposed an optimal route selection method⁽³⁾ (traveling route derivation method) in a warehouse using a genetic algorithm⁽⁴⁾ (GA) and a method for determining commodity location⁽⁵⁾ in a warehouse for making picking work more efficient. However, “slip assignment,” which is an important factor in improving the efficiency of picking work, has not yet been considered.

According to expert knowledge, optimization of slip assignment to workers is considered to contribute considerably to the reduction of working time. In particular, in online shopping, as the number of ordered commodities is small and there are many orders of various types, grouping slips according to the correlation of ordered commodities contributes to the improvement of work efficiency.

Therefore, in this paper, we propose a shipping slip assignment method that reduces the walking distance of picking workers to improve picking work efficiency in a warehouse.

2. Slip Assignment

A shipping slip used for picking work is composed of multiple slips, and the picker works in the order of assigned shipping slips. According to expert knowledge, the main assignment method adopted for shipping slips is collective distribution to workers in the order of receipt of slips. In this method, there is a high possibility of generation of waste—for example, slips having high placement correlation of ordered products will be assigned to different workers. This will reduce the overall operation efficiency. Therefore, optimization of slip assignment is essential to improve picking efficiency.

3. Picking Support System

The authors have been developing systems to support picking workers (picking support system). The shipping slip assignment method proposed herein is assumed to be incorporated into the picking support system. A typical logistics warehouse is composed of multiple zones with different numbers of rows and columns, as well as rack sizes (width and depth). Fig. 1 shows an example of a zone layout in a warehouse. In the picking support system, the user can arbitrarily set the number of zones and the zone layout in the warehouse, and based on the setting information, the warehouse layout used for the simulation is constructed.

Fig. 2 shows a zone layout that can be set by users. At the time of warehouse layout construction, the position information of the rack set by the users is stored as coordinate values and used for the derivation of the traveling route. After building the warehouse layout, by inputting order slip data, slip grouping processing using the proposed method and the travel route derivation processing⁽³⁾ using GA are performed. In addition, the total walking distance is calculated based on the obtained work route.

Fig. 1. Layout design and zone.

Fig. 2. Configuration image of zone layout.

4. Shipping Slip Assignment Method

4.1 Localization

In this paper, we define “localization” as the grouping of slips based on the location information of the received commodity. Accordingly, we developed a process to localize automatically the slips in which the received commodity exists in the same rack and the same zone.

4.2 Proposed Method

In the traveling route derivation method⁽³⁾, the route is derived using a shipping slip. Accordingly, we developed a process to create a shipping slip by automatically localizing the slip. Fig. 3 shows the flow of the proposed method and the specific processes are summarized in (a) to (e). In the proposed method, the shipping slip is created according to the format of the actual shipping order data provided by a partner company. Table 1 shows an example of the order

Fig. 3. Flow of the proposed method.

Table 1. Example of order data.

Order	Sales slip number	Customer code	Commodity code	Shipment quantity
No.1	144805	DAWWAD	1605RS	2
No.2	144805	DAWWAD	00FZ40	5
No.3	144906	WABDAA	611AZ0070	1
No.4	145306	HABAAX	000Z11	4

data.

(a) Generating slip data for each customer

Divide the order data according to customer code. As there is no information on the product location (rack number and zone number) in the order data, the location information is acquired using a database that stores product information in the warehouse. Furthermore, the divided data and the acquired location information are combined and used as the slip data of a customer.

(b) Localization of same rack numbers

In the slip data created in (a), the data including the product stored in the same rack number are searched. If it exists, is put together as the same group. This process is repeated until all the slip data are searched.

(c) Localization of same zone numbers

The zone numbers of the grouped data created by the process in (b) and the slip data that are not grouped are compared. The specific process is the same as that in (b).

(d) Slip group matching process

In this process, the grouped slips are combined to minimize the movement distance between zones, and finally, they are combined into a shipping slip.

First, the logical sum of the zone numbers of all the slip groups is calculated. The logical sum of the calculated zone numbers corresponds to a zone to be circulated in the picking when the target slip group is virtually grouped.

Second, the Euclidean distance is calculated from the coordinate value of the point at the zone entry (zone point) corresponding to the zone number of the logical sum calculated in (a). This is defined as the “distance between zones.” An example of calculation of the distance between zones is shown in Fig. 4 (a) and (b). As shown in Fig. 4 (b), when there are three or more zone numbers of the calculated logical sum, the shortest distance of the path passing through each zone point is set as the distance between the zones. In this study, the shortest path is derived by applying the traveling salesman problem⁽⁶⁾ starting from the zone point closest to the depot entrance and using dynamic programming⁽⁶⁾.

Finally, a weighted matching problem⁽⁷⁾, which is a type of graph theory, is applied to the defined distance between zones as a weight, and a solution with the smallest sum of weights is derived. The slips are grouped based on the derived solution, the inter-partition distance is redefined

(a) In the case of two target zone points.

(b) In the case of 3 or more target zone points.

Fig. 4. An example of distance between zones.

between the grouped slips, and the process is repeated until there is one slip group.

(e) Creation of shipping slip

Based on the customer code, product code, and rack number, the localized data are combined into a list, i.e., the shipping slip.

5. Experiment

5.1 Outline of Experiment

We verified via simulation whether the proposed method is useful for reducing the walking distance in picking work. Specifically, using two slip data (order 1 and 2) differing in received commodities, a shipping slip arranged in order and a shipping slip localized using the proposed method are created. Then, using these shipping slips as input data, a travel route is derived, and the total walking distance of all the workers is compared. In addition, considering the calculation error in the GA, the walking distance for each worker used for the evaluation was an average of five simulations.

In the evaluation of the proposed method, the shortening rate (1) was defined using the average of the total walking distance of all the workers when all the shipping slips were processed, and a comparison was performed. The Twd terms in equation (1) indicate the total walking distances of the proposed method and the method used for comparison.

$$\text{Shortening rate} = \left(1 - \frac{Twd_{\text{proposed}}}{Twd_{\text{comparison}}}\right) \times 100 \quad (1)$$

For the evaluation, we used a method called “multi-picking” in which multiple orders from customers are collected together. The method used for the comparison was developed based on expert knowledge to imitate the slip assignment method currently used.

The proposed method and the method used for comparison are described below.

- Proposed method
Multi-picking with localized issue slips
- Method used for comparison
Multi-picking using commodity shipping slips arranged in order of receipt

5.2 Experiment Condition

(a) Parameter and usage data settings

Tables 2–4 show the GA parameters in the traveling route derivation methods, the order slip data used for the simulation, and the setting values of the warehouse layout,

Table 2. GA parameters.

Population	500
Mutation rate[%]	3.75
Generation	1,000

Table 3. Order slip data and worker data.

Customers	9331
All Orders	10,000
Picking Worker	100 workers setting

Table 4. Warehouse layout of this experiment.

Zone		Lack size	
Total number of zones	20	Width [m]	1
Rows per zone	38	Depth [m]	1
Columns per zone	38		

Fig. 5. Image of the warehouse layout in this experiment.

Fig. 6. Image of picking cart loading.

respectively. Fig. 5 shows an image of the warehouse layout used in the experiment.

In this simulation, based on expert knowledge, the warehouse layout was set assuming an online-shopping-compatible warehouse (total number of racks is approximately 30,000). In addition, in online shopping, one type of order per customer is said to account for 90% of the entire order. Therefore, orders 1 and 2 are set assuming an online shopping order (refer to Table 3).

(b) Loading conditions for picking cart

In the simulation of route derivation, assuming actual work situations, the conditions for cart loading are set. The conditions for picking cart loading are summarized below, and Fig. 6 shows an image of picking cart loading.

- Allows loading of eight customer commodities per picking cart. (refer to Fig. 6)
- If the cart loading capacity is exceeded, move from the point where the worker is currently working to the depot entrance and unload all commodities in the picking cart.

(c) Distribution conditions for shipping slip

As the condition for slip distribution to the workers, the created shipping slips were distributed in order from the top so that the number of customers per worker becomes equal.

5.3 Experiment Result

Table 5 (a) and (b) shows the results of comparison of the total walking distance in order 1 and order 2 of the order slip data. In contrast to the method used for comparison, the proposed method shortens the total walking distance. In the order slip data of order 1, the shortening rate was reduced by about 22.3% with respect to the method used for comparison, and in the order 2, the shortening rate was reduced by about 24.1%.

The results show that the proposed method is useful for reducing the walking distance under the conditions set in this study.

However, it can be observed that the proposed method

Table 5. Comparison result of the total walking distance.

(a) Comparison result of order 1.

Picking Worker	Average walking distance		
	Proposed method [m]	Comparison method [m]	
Worker NO.1	4569.5	14048.4	
Worker NO.2	10559.2	12777.3	
Worker NO.3	10406.3	12981.7	
⋮	⋮	⋮	
Worker NO.10	12816.4	10851.3	
⋮	⋮	⋮	
Worker No.100	10280.8	9094.4	Shortening Rate [%]
Total walking distance	867130.1	1115453.2	22.3

(b) Comparison result of order 2.

Picking Worker	Average walking distance		
	Proposed method [m]	Comparison method [m]	
Worker NO.1	7294.6	10886.3	
Worker NO.2	7443.4	10654.9	
Worker NO.3	7620.5	11682.5	
⋮	⋮	⋮	
Worker NO.10	5897.6	10498.6	
⋮	⋮	⋮	
Worker No.100	11008.9	11809.4	Shortening Rate [%]
Total walking distance	858164.2	1130523.0	24.1

has a large variation in the walking distance of each worker. This is because the slips are equally distributed to the workers without considering the positional relationship between the zone containing the commodity to be collected and the depot entrance. It is necessary to consider an appropriate slip distribution method considering the positional relationship between the depot entrance and the zone.

6. Conclusions

In this paper, we proposed a shipping slip assignment method for reducing the walking distance in picking operation. Moreover, a simulation that assumed the actual work in online shopping was performed, and the usefulness of the proposed method was evaluated. Consequently, it was clarified that the proposed method is useful for reducing the walking distance in picking under the simulation conditions set in this study.

In the future, we will consider a shipping slip distribution method by considering the same walking distance for each worker. In addition, considering the system application of the proposed method, we will study a reduction method for the processing time.

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