Materials Packing Integration Platform Based on Spatial Planning Algorithm

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Abstract. In view of the modern logistics transportation in the number of materials, miscellaneous types of the situation, the integrated material packing optimization platform of "front-end scanning data--algorithm optimization scheme--terminal output results" is proposed, which the spatial planning algorithm is used to generate and optimize the binning scheme, and the corresponding technical implementation means are given. The packing platform proposed in this paper can effectively save manpower, reduce space cost and improve loading efficiency, which has strong feasibility and reference.

Keywords: Material packing · Integrated platform · Spatial planning · Method optimization

1 Introduction

With the development of national economy, the development of logistics industry has also entered the fast lane. But there are also increasing challenges, mainly including: First, the loading variety of materials, the order is complex, in the unloading of specific materials are not easy to find, there is no effective means to find the lost tools, can only spend a lot of manpower, time slowly search, efficiency is very low [1, 2]; Second, the material label cannot meet the existing material positioning and control. Material labels are easy to damage, drop and pollute; material information cannot be transmitted in a narrow space, preventing relevant personnel to effectively locate and collect; Third, the material management work cannot be responsible to the people. When the materials are lost, it is easy for the operators to shirk the responsibility to each other. The imperfect material management responsibility system directly leads to the low utilization rate of material loading and unloading, resulting in asset loss, tool loss and potential safety problems [3, 4].

In the face of high intensity, high difficulty, variety and large number of carrying materials, how to conduct a fast and reasonable loading design of materials, so that the loading scheme is quickly generated and the transport personnel can clearly understand the different positions of different materials [5], meanwhile, it can also efficiently use the space of the loading platform (train cars, trucks, containers, etc.), often becoming a big problem in front of the logistics staff.

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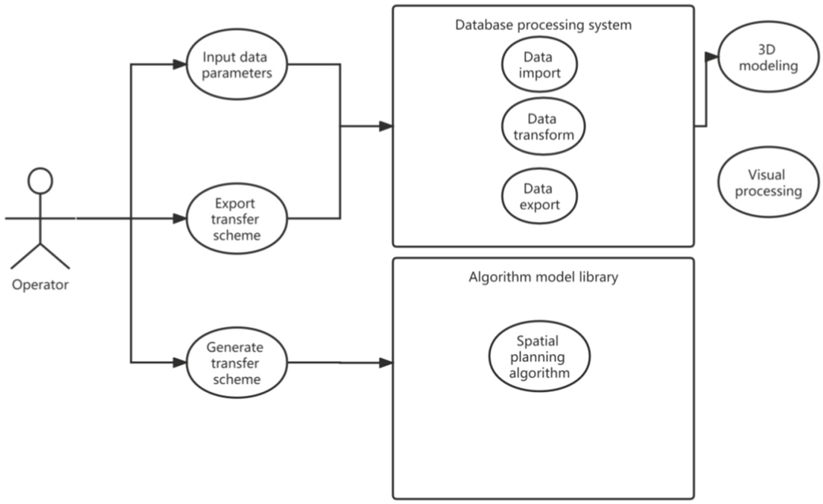

Fig. 1. Integrated operation system of material packing.

In view of this problem, an integrated material packing optimization platform of "front-end scanning data-algorithm optimization scheme-terminal output results" is proposed. In Fig. 1, according to the characteristics and importance of material size, as well as the characteristics of loading tools, the spatial planning algorithm is proposed to ensure the least space, load more materials, save space cost, meanwhile, avoid manual spatial layout, using the powerful computing power of the computer algorithm, calculate the effective loading scheme of large-scale materials.

2 Design Framework of the Material Transfer Scheme

2.1 Front-End Input Design

This paper proposes a kind of based on intelligent scanning front end, supplemented by manual input data material information input method, namely through the 3D scanning equipment, extract the material information data, and the data information, as the input part of the transport scheme generation algorithm, provide data basis for the subsequent material transfer scheme generation. The input data information shall include:

(1) Material information setting:

It is mainly used to input cargo information, such as name, number, size, quantity, weight, destination, number of stacking layers and placement requirements. The module should be able to draw a variety of common 3D entities, such as cuboids, cylinders, and keep the common 3D shape in memory for any time in the future. At the same time, the geometric model can also be color-edited, with different colors to represent different kinds of goods, so that users can see the packing situation at a glance.

(2) Carrier information setting:
It is mainly used to input the information of the container container, such as name, number, length, width, height, load capacity, etc. At the same time, the size of the container should be customized according to the actual situation to meet the needs of more occasions.

2.2 Scheme Generation Design

The generation system of material packing scheme proposed in this paper mainly takes spatial planning algorithm as the core algorithm, supplemented by 3D modeling and data visualization technology, and through interface design to facilitate users to carry out relevant operations. In the algorithm design, attention should be paid to the setting of constraints and optimization objectives. The constraints are mainly the design of assembly rules. The factors considered in this paper are: The constraints on the total volume and weight of the container, the direction and bearing capacity of the cargo, loading and unloading sequence, and priority; Optimization goal of the algorithm is: after input goods and container information, the system according to the user input information, in the case of various given loading constraints, treat loading items intelligent stacking arrangement, in fixed container as much as possible, namely seeking a filling rate as big as possible stacking way [6, 7].

2.3 Scheme Export Design

The graphical visualization technology is used to simulate the actual cargo loading situation in the container container by computer, so that the system can 3D display the cargo loading effect diagram in the container, and can view the cargo loading situation [8, 9] from different angles through the front view, top view, side view, left front view. Allow further manual editing on the basis of the optimization scheme, using the mouse to adjust the goods in the container, such as moving and rotating operations, as well as adding and deleting goods in the container container to meet the personalized needs. Meanwhile, the system can generate reports for the loading of goods, illustrated to show the display of the goods in each packing container, including 3D display loading effect, step display packing steps, and packing report can be saved and exported to EXCEL, convenient for users to view the packing information and guide the packing work in the actual packing process.

3 Spatial Planning Algorithm Design

3.1 The Hypothesis of the Algorithm

(1) Suppose that all containers and materials are standard cuboids;
(2) The space of the transport vehicle consists of a standard geometric splicing;
(3) The mass of the container is evenly distributed, and the center of gravity is in its geometric center;
(4) The volume changes due to extrusion from each other are negligible;

3.2 Algorithm Steps

The expected goal of the spatial planning algorithm is to determine a feasible loading method according to the specifications of the container and the shape, size, quantity, weight of the cargo. To satisfy the volume constraints, the weight capacity, the loading order, the total volume of the container is as large as possible, so as to use the space of the transport container and reduce the transportation cost. The overall design process of the spatial planning algorithm is shown in Fig. 2:

First of all, the space dimension of the imported means of transport (unit: meters), the length of a unit is x, the width is y and the height is h. Enter the dimensions of n materials (unit: meters) in turn, and the length, width and height are recorded as:

$$x_1 x_2 x_3 \ldots\ldots x_n$$
$$y_1 y_2 y_3 \ldots\ldots y_n$$
$$h_1 h_2 h_3 \ldots\ldots h_n$$

Take the maximum of the three groups:

$$X = max(x_1 x_2 x_3 \ldots\ldots x_n) \tag{1}$$

$$Y = max(y_1 y_2 y_3 \ldots\ldots y_n) \tag{2}$$

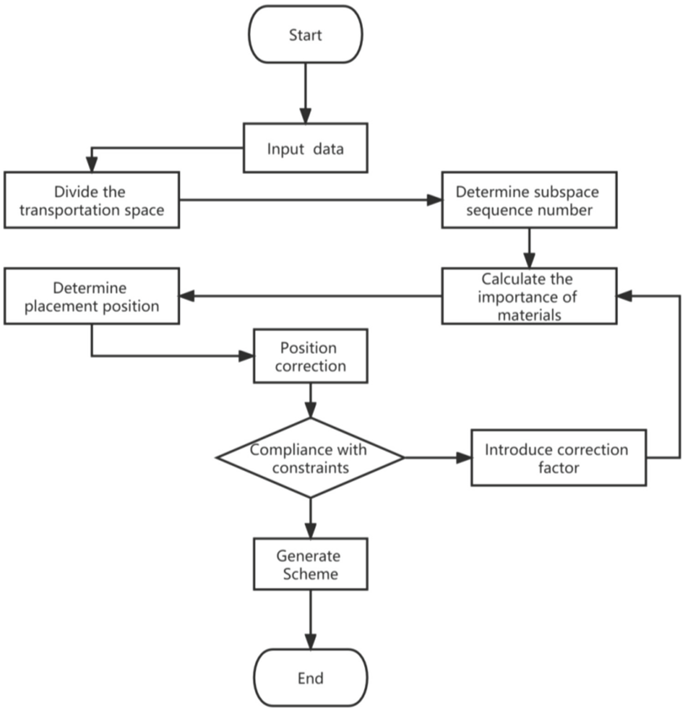

Fig. 2. A Schematic diagram of the overall flow of the spatial planning algorithm.

$$Z = max(z_1 z_2 z_3 \ldots\ldots z_n) \tag{3}$$

A three-dimensional rectangular coordinate system composed of x, y and h axis is established to divide the transportation platform space into:

Space of $(x/X) \times (y/Y) \times (h/H)$, and with the marking, marking order principle is:

From the origin, the grid space coordinates are (0,0,0) to (x/X,y/Y,h /H), and the sequence number of each grid is:

$$(\text{n}) = 3\text{hi} + 2\text{yi} + \text{xi} \tag{4}$$

The sequence number of each grid is arranged from large to small. It stipulates that the larger the grid space of the sequence number, the greater the importance of the items placed.

Calculate the importance of each material *W* the importance of the material has the following indicators:

Material attributes. The importance of different materials is given by the expert scoring method according to the material attributes. Take the transfer of aviation materials as an example, see the Table 1 (Common importance assessment table of aviation materials) for details:

Location of the center of gravity, the equivalent center of gravity of different materials is different, resulting in different order will change the overall position of the center of gravity, which will have a significant impact on the take-off safety of the aircraft.

Load leveling to ensure that the center of gravity of the total material is near the center of the aircraft cabin. The calculation method of the center of gravity of the total material can be obtained from the center of gravity of each material (the center of gravity of each material is the geometry of the material) through the center of gravity calculation formula. The difference between the center of gravity of the total material and the center of the cabin should not exceed 1 m;

The greater the weight of the material, the weight, the closer the position of the material, that is, the smaller the serial number of the corresponding space position;

After calculating the W value of each material, place the corresponding position of the material according to the W value. The larger W, the larger the serial number of the corresponding spatial position. In conclusion, the function of calculating the importance of materials is:

$$\text{W} = 0.6\text{w} - 0.4\text{m} + \text{z} \tag{5}$$

Table 1. Common importance assessment table of aviation materials

Material attributes	Scores
Precision mechanism	5
Aviation equipment	4
Portable supplies	3
Hock rack	2

z is the modified regulation coefficient [10], and its assignment rule is:

For any item, the initial value is 0; If the material scheme generated for the first time does not meet the following constraints, the z-value was introduced: for materials with the greatest importance of materials, the corresponding z value is 1, and for the second importance of materials, the z value is 2, and the z value is the ranking number of the importance of materials.

Constraints are:

$$\sqrt{(x - X)^2 + (y - Y)^2 + (h - H)^2} \leq 0.5 \tag{6}$$

where $x\ y\ z$ is the center of gravity of the total material, and $X\ Y\ Z$ represents the position of the center of the cabin.

After calculating the space where each material is located, there may be cases that the material is in a volley position, which does not conform to the actual situation. Therefore, correcting the above calculation process is needed. The correction process is as shown in Fig. 3:

After the correction, determine the location of each material and generate the plan. If the scheme does not meet the constraints, the modified regulation coefficient z is introduced, the importance value of the material is recalculated, and the loading scheme is regenerated until the loading scheme meeting the conditions appears.

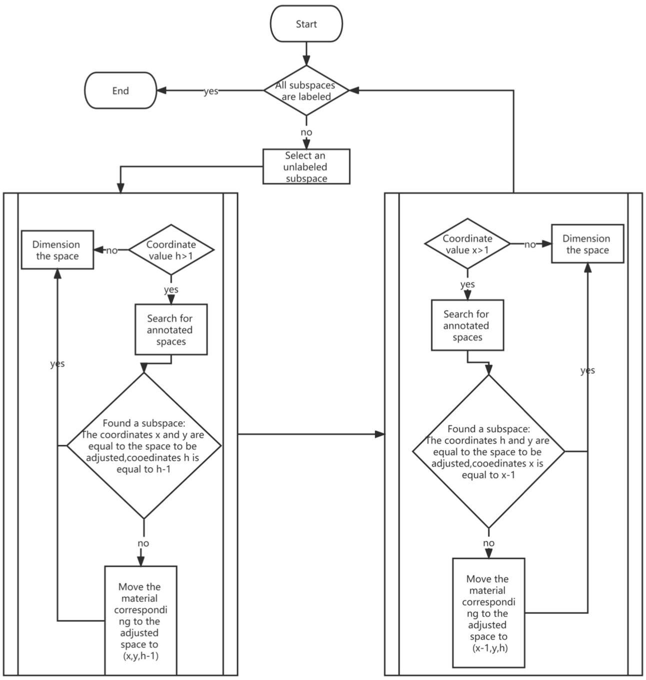

Fig. 3. Schematic diagram of the correction process of the material packing position.

3.3 Algorithm Implementation

According to the algorithm flow chart, using the VC++ 6.0 corresponding code program, data processing process and the specified transport materials database link, using standard data communication interface, connecting database and the system development platform front-end uni-app, appropriately introduce computer-aided design system, the calculation results to operators in the form of 3D visualization.

4 Summary

In view of the modern logistics system, and the problem of large-scale centralized material packing and transfer, this paper puts forward a material packing scheme based on front-end intelligent input, spatial planning algorithm processing, terminal intelligent output and specific technical implementation plan. This scheme can effectively improve the fine management level of the usual transfer scheme design, reduce the busy, chaos, legacy, forgetting, error and leakage in the transfer process; adapt to the requirements of fast and accurate transfer of modern logistics, realize the rapid inventory, inspection and positioning of various transfer materials; and solve the bottleneck problems such as difficult material arrangement, positioning, scheme design, chaotic design process, and poor effect display.

In the future, the big data technology of the Internet of Things can also be used to realize the perception of material status and wholly-owned visualization, analyze the associated data, and put forward the problems and solutions that should be focused on in the decision and evaluation of material transfer. The scheme proposed in this paper has a complete and mature technical system, which has high feasibility and reference for the upgrading of cross-regional material transfer system.

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