Determining Pallet Counts using a 3D Bin Packing Problem Heuristic

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April 30, 2025

J.B. Hunt DCS

J.B. Hunt Transport Services (J.B. Hunt) is an industry leader in transportation and logistics with a mission to create the most efficient transportation network in North America. Our project involves the Dedicated Contract Services (DCS) business unit, which provides long-term, customized transportation solutions for businesses. DCS allows companies to outsource their transportation needs by offering dedicated fleets—trucks, drivers, and equipment—tailored to their specific operations.

Specifications and Preferences Met

To address the challenge of accurately determining pallet counts, J.B. Hunt asked us to develop an internal decision support system to determine pallet counts using optimization, based on their belief that the workers pack using close to the minimum number of pallets necessary. Our provided solution ultimately met every required specification provided by J.B. Hunt and one important preference.

Specifications

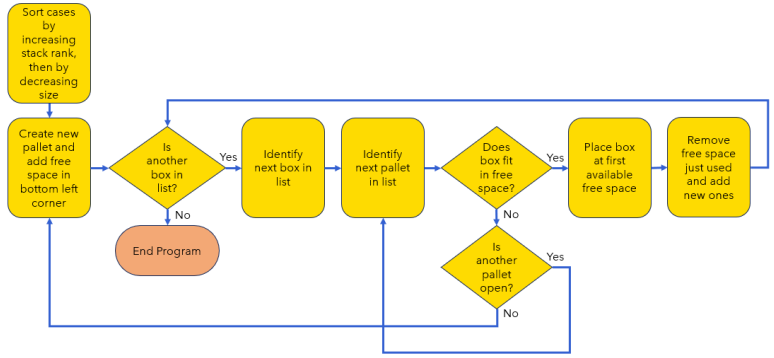
- ☑ Determines the pallet count for a given set of orders (packing in a way that is humanly feasible and expected)
- ☑ Satisfies stacking priority constraint
- ☑ Packs pallets in a way that is physically feasible
- ☑ Implements the C# coding language
- ☑ Incurs no additional licensing costs
- ☑ Uses code to determine pallet count that is separate from code for input or outputting data

Preferences

- ☑ Creates a 3D visual mapping of how the pallets are packed

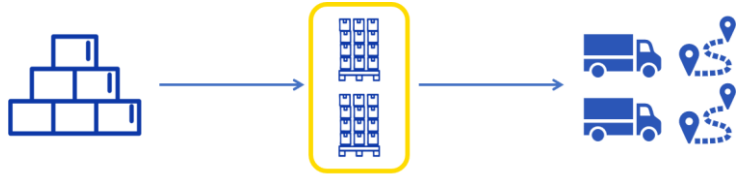
Creating a Heuristic Solution

To address the computational challenges associated with the first two models, an algorithm to solve the 3D Bin Packing Problem using a First Fit Decreasing (FFD) heuristic is used. The heuristic considers three corners of the previous box as "free spaces" for the bottom left corner of the bottom face of the next box. It tests the feasibility of placing the box first along the x axis, then y axis, then z axis.



Determining Pallet Counts

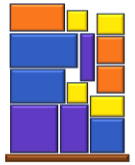
Operations logistics engineers plan the details associated with customer orders, such as the number of trucks and routes needed. One current customer requests that the pallet count, the number of pallets required to pack a given set of orders, be estimated as part of this planning. Currently, the operations team simply assumes a constant number of cases per pallet and divides the total number of cases by that assumed number. This method often results in inaccurate estimates, resulting in unnecessary transportation costs and other logistical issues. Because of the nature of DCS, J.B. Hunt does not have access to historical packing data or control over their customers' warehouse operations.



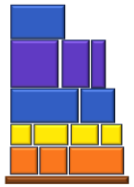
Exploring Optimization Models

First, we developed a 3D-bin-packing optimization model using case and pallet dimensions to determine the minimum number of pallets necessary for a given order. Second, to more accurately reflect a typical worker's packing methods, and attempt to reduce the solving time, we developed a model based on the Distributor's Pallet Loading Problem. Both models were unable to solve within a reasonable amount of time at the scale required by J.B. Hunt.

3D Bin Packing Problem



Distributor's Pallet Loading Problem



Visualizing Pallet Layouts

Finally, we used Python based code to create two versions of a 3D visualization of the packed pallets. One version loads quickly and displays all pallets at once, while the other allows interactive inspection. The code dynamically generates individual pallet layouts based on input data given in a csv file. Types of boxes are color coded according to unique sets of width and length.