Chapter 18
Perspective Directions of Artificial Intelligence Systems in Aircraft Load Optimization Process

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ABSTRACT

The chapter represents an overview of different approaches towards loading process and load planning. The algorithm and specificities of the current cargo loading process force the scientists to search for new methods of optimizing due to the time, weight, and size constraints of the cargo aircraft and consequently to cut the costs for aircraft load planning and handling procedures. These methods are based on different approaches: mix-integer linear programs, three-dimensional bin packing, knapsack loading algorithms, tabu-search approach, rule-based approach, and heuristics. The perspective direction of aircraft loading process improvement is a combination of multicriteria optimization method and heuristic approach using the expert system.

INTRODUCTION

Goods can be delivered anywhere by the following day through air cargo transport. The short delivery time guarantees fast transportation of commodity, emphasizing the value of temperature sensitive cargo by limiting the impact of non-appropriate conditions. Air cargo loading process plays a significant role in the air company’s work and influences the all operations and relationship between air cargo companies, third party organizations and stakeholders. For each flight, air operator, which is responsible for the cargo transportation faces the several challenges simultaneously. The first one is to increase the aircraft’s turnaround time. The second one is to solve the problem of over capacity on the air cargo market, which leads to the average load factor’s decreasing (IATA Economics, 2016). Subsequently air
operators are pushed to cut the handling operation costs, fuel charges and other costs in order to save the business. This situation forces them to face with an aircraft loading problem, which is still the one of the most current explored problems which ties operational research and combinatorial optimization. Load optimizing, indeed leads to an aircraft’s turnaround time reduction and consequently brings a notable economic effect. Thus, current program base and previous scientific works related to our problem doesn’t provide any decision variables, we search for the optimal method of load planning through the prism of multicriteria optimization and heuristic methods. The main aspect in it is the selection of optimal decision among the possible range, which definitely deals with the peculiarity of artificial intelligence systems and neural networks.

BACKGROUND

It splits to different types of loading sub problems, as a The Bin-Packing Problem (BPP), Container Loading Problem (CLP), Knapsack Problem (KP), and Assignment.

The Bin-Packing Problem (BPP) is the loading problem which deals with packing objects of different sizes into a précised number of similar bins, such that the number of used bins is minimized. The problem is well-known as nondeterministic polynomial time problem (NP-hard) and difficult to solve in practice, especially when dealing with the multi-dimensional cases. (Paquay, Schyns, Limbourg, 2011) mention that the BPP can be one, two or three dimensional and with one or several containers. If there are several containers, they can have the same or different shapes (Dyckho, 1990).

Container Loading Problem (CLP) closely correlates with BPP. Authors search the ways how to optimize a space assignment of cargo inside the container, with the objective to maximize the value of the cargo or aircraft’s capacity. The container loading problems can be divided into two types. The first is three-dimensional bin-packing problem. (Bortfeldt & Mack, 2007) note, that the point of the problem, is reducing the number of used containers. The other work (Bortfeldt & Gehring, 2001) defines the second problem as a knapsack problem and its objective is to maximize the capacity of the container while packing to it the cargo which has more value. The CLP focuses on a single container, and has been extended in the literature to handle a variety of different constraints arising from real-world problems. Consider for example the problem of arranging items into an aircraft cargo area such that the barycenter of the loaded plane is as close as possible to an ideal point given by the aircraft’s specifications. The position of the barycenter has an impact on the flight performance in terms of safety and efficiency, and even a minor displacement from the ideal barycenter can lead to a high increase of fuel consumption (Trivella & Pisinger, 2017). The other group of loading challenges is a Knapsack Problem (KP). The single-objective knapsack problem consists of choosing a subset of objects from a defined set, maximizing the overall profit, which results from the sum of the individual benefits of the selected objects where a capacity constraint must be fulfilled, i.e., the sum of the weights of the selected objects, must not surpass a given capacity (Martello, Toth, 1990; Kellerer, Pferschy, Pisinger, 2004).