Spring 2018

Optimization of Flight Scheduling Problem by MATLAB

Xiang Zhang
xzhang53@wustl.edu

Optimization of Flight Scheduling Problem by MATLAB

Xiang Zhang
Washington University in St. Louis, April 2018

Abstract

This paper discusses the flight scheduling problem by allocating an appropriate airplane for flights between four places using optimization methods. The target of this problem is to maximize the utilization efficiency of seats with distances involved. All the passengers are equally considered as economic class and they must be transported to the destinations directly, which means there can't be any mid-stops. And any airplane must take two or more flights. There are three airplanes for selection with different capacities which is the maximum number of passengers onboard. And there are four cities as well as the distances between any two of them. For the given cities, as a result, the maximum efficiency is found at 85.36%.

Introduction

For the users of transportation airplanes, like airline companies, one of their major demands is reducing the cost of each passenger or unit weight of cargo, to maximize the benefit. For passenger transportation, if there are some empty seats in a flight, the income from this flight may not exceed the cost leading to some finical lost. Or airline companies can sell more tickets than the capacity of the airplane for a flight in case that some passengers may cancel their order just before takeoff. However, if some passengers can't check-in successfully due to lack of available seats, airline companies usually need to make compensation and will lose a bit of reputation. Thus, it is necessary to schedule an appropriate airplane for each flight to make airplanes as fully loaded as possible. Besides fuel consumption can be saved so that less greenhouse gas will be generated (e.g. CO_2 and NO_x)

This problem is close to the travelling salesman problem and the transportation problem.

The purpose of travelling salesman problem is to get the shortest possible route that visits each city and returns to the origin city, given a list of cities and the distances between each pair of cities. Transportation problem focus on finding the minimum cost of transporting a single commodity from a given number of sources to a given number of destinations.

Background

There are some previous works that have been done about both travelling salesman problem and transportation problem. For an On-demand air transportation problem, a time-space multi-commodity network is introduced to derive the mathematical model which is then solved using CPLEX. Another model for transportation problem develops the transportation solution for the North West Corner Rule, Least Cost Method, Vogel's Approximation Method, and Modi method for the transportation problem. And for both problems, genetic algorithm is used widely.

Model

The selected airplanes are as Table 1. And there is only one for each type of airplane.

NO.	Type	Capacity
1	B737-800	189
2	ERJ-195	118
3	A321	236
4	none	0

Table 1. selected airplanes and their capacities, c[n]

The purpose of this problem is to fill Table 2, which is scheduling proper airplanes for each flight. Each location of Table 2 is called n[i,j].

From\to	Chicago	Dallas	Atlanta	Kansas City
Chicago	4			
Dallas		4		
Atlanta			4	
Kansas City				4

Table 2. type of airplane arranged for each flight segment, n[i,j]

The distance between any pairs of cities (i.e. dist[i, j]) which is calculated by GPS locations and the number of passengers(i.e. psg[i, j]) are as Table 3 and 4 respectively.

From\to	**a. Chicago**	**b. Dallas**	**c. Atlanta**	**d. Kansas City**
a. Chicago	none	805	592	415
b. Dallas	805	none	719	452
c. Atlanta	592	719	none	678
d. Kansas City	415	452	678	none

Table 3. distance between each pair of cities, dist[i, j]

From\to	**a. Chicago**	**b. Dallas**	**c. Atlanta**	**d. Kansas City**
a. Chicago	none	79	113	201
b. Dallas	167	none	91	219
c. Atlanta	112	169	none	109
d. Kansas City	216	221	181	none

Table 4. number of passengers for each flight, dist[i, j]

For this flight scheduling problem, there exist two internal constraints: 1. after landing at one city, the airplane must start from this city for its next flight; 2. the airplane can't be arranged for the flight if the maximum number of passengers of the airplane is less than the number of passenger of that flight.

So the what will be optimized is $\frac{\sum dist*psg}{\sum dist*c[n(i,\ \ j)]}\,(i \neq j)$

Table 2 except locations that i equals j is transferred into a vector. Each element of the vector corresponds to a flight. The value of elements in the vector means the selected type of airplane. The value in vector can be 1 or 2 or 3 which corresponds to the type of airplanes in Table 1. Then the vector is optimized by intlinprog function of MATLAB. The search space is discrete and the search technique is heuristic. And search is implemented as branch and bound method.

Result

The result may not be the global answer. But considering that the total number of solution is not large, the result is still quite reliable. The schedule is shown is Table 5.

From\to	Chicago	Dallas	Atlanta	Kansas City
Chicago	4	1	1	2
Dallas	3	4	1	2
Atlanta	1	3	4	3
Kansas City	2	2	3	4

Table 5 scheduled airplane for each flight

This result can be transferred into more than one route of three airplanes. Table 6 is one possible route:

ERJ 195	A321	B737-800
Chicago	Chicago	Atlanta
Dallas	Kansas City	Kansas City
Atlanta	Dallas	Atlanta
Chicago	Kansas City	Dallas
Atlanta	Chicago	Chicago

Table 6 one possible optimized route

Future Work

For the continuing work, on the one hand, more factors could be added into the problem. For example, if flight cost is involved as the optimization object including fuel consumption rate, maintenance cost and crew salary, the result will be more helpful for airline companies to control cost and to improve benefit. On the other hand, this optimization can be extended to larger scale, which means there are more cities, passengers and airplanes. This will also bring some challenge that passengers from city A to city B could need more than one flight.

Reference

[1] On-Demand Air Transportation Flight Scheduling.-- Tanya Lerlin La Foy

[2] SOLVING TRANSPORTATION PROBLEM BY USING MATLAB-- Dr. J. Sengamalaselvi

[3] Genetic Optimization for Transportation Problem-- DIANA BETINA MIRSU, GABRIELA PROSTEAN, RADU MIRSU

[4] Application of Improved Genetic Algorithm in Solving a Type of Connector Transportation Problem Based on MATLAB-- Cheng Xiangyu, Zhang Yan, An Chunyu

[5] A Two-Dimensional Genetic Algorithm and Its Application to Aircraft Scheduling Problem-- Ming-Wen Tsai, Tzung-Pei Hong, and Woo-Tsong Lin

[6] Passenger Transportation Structure Optimization Model Based on User Optimum-- Yanli Maa, Yuee Gao

[7] A Genetic Algorithm for Function Optimization: A Matlab Implementation— Christopher R. Hock, Jeffery A. Joines, Michel G. Kay

[8] Solve the transportation problem with Northwest corner rule-- Warut Boonphakdee: https://www.mathworks.com/matlabcentral/fileexchange/63672-solve-the-transportation-problem-with-northwest-corner-rule

[9] Traveling Salesman Problem: Solver-Based -- https://www.mathworks.com/help/optim/ug/travelling-salesman-problem.html