Project Proposal for CS 357

Feeder routing for air-to-air refueling operations

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Introduction

According to the International Civil Aviation Organization, it is expected that the world scheduled passenger traffic will quadruple by 2045. As a result, considerable effort has already been made in order to increase the fuel efficiency of aircraft operations. In this project, we are going to do a brief study on the feeder routing for air to air refueling optimization problem. This is a variant of a vehicle routing problem in which a fleet of feeders are to perform air-to-air refueling operations for a fixed set of cruisers. This is a multi-objective integer problem with both equality and inequality constraints. In the real world, the feeders' scheduling is based on a first-come-first-serve method. We are going to find more efficient way in order to achieve the above goal of fuel efficiency.

Problem Statement

For this problem, we are given a set R of refueling requests of the cruisers. Each request consists of start and end coordinates of the refueling process (given by longitude / latitude pairs), mass of the fuel required and the time when the refueling process should start. The feeders operate from a base b. In order to fulfill a series r1, . . .,rk of requests in R, a feeder departs from the base b, moves to orig(r1), performs a refueling operation at time θ (r1) arriving at dest(r1), moves to orig(r2) and so on, until finally returning to the base b from dest(rk).

Objective

1. The first goal is the reduction in fuel consumption of the feeders which is beneficial in economical as well as environmental perspectives.
2. The second goal is the reduction of the number of feeders required, which is not only beneficial in itself, but may also yield a reduction with respect to the size of the feeder bases.
3. Understanding various concepts related to Air-to-Air Refueling and scheduling optimizing algorithms.

What are we going to do ?

We will divide a refueling operation into several sub-stages and find the minimum amount of required fuel for this operation. After that we will use this result to find an estimate of the minimum fuel consumption for a set of conflicting refueling requests.
For this purpose, we will proceed as :-

1. Formulate our problem in to an Integer Programming (IP problem) equivalent to a set-covering problem
2. A column generation technique in order to find decompositions into subproblems and find new path variables
3. Branch-and-Price framework incorporating an adapted labeling algorithm to solve the pricing subproblem, involving a branch and bound scheme to make branching decisions.
4. Try to use some other competing algorithms to solve the same problem and compare them.

We are going to analyze two different scenarios where in the first scenario the feeder will come back to the base only when it has exhausted its fuel while in the second scenario we bound it by a minimum number of requests served before landing back to the base.

Reason for Topic Selection

With the increasing air traffic it is very important to optimize the fuel consumption in order to minimize carbon footprints and reduce operating costs. Along with the industrial and environmental requirement the problem resembles the more general problem of scheduling which covers a vast set of optimization problems. The topic interested us by the innovative idea of air-to-air refueling in order to reduce the fuel consumption. Moreover the problem is actively being researched and this provides open scope for improvement.

References:

https://www.sciencedirect.com/science/article/pii/S0377221722003149