Autonomous Airline Planning

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October 3, 2019

Project Proposal

KTH is starting a new airline in Stockholm and is interested in maximizing its profits by planning an optimal route schedule. The route schedule will take into account flight demand and possible routes between different airports. The amount of flights that can be scheduled on a given day will be determined by the number of planes that are purchased, the capacity and model of each plane, the demand for each route, and the size of each airport among other variables. This plan will have a time constraint of 24 hours and will be limited by KTH's budget for how many planes can be purchased.

This problem can be described as a variation of the classical Vehicle Routing Problem (*VRP*). It can be modeled as a Mixed-fleet (planes with different capacities and technical specifications), Open (planes are not required to return to their original location before completing the next action) Vehicle Routing problem which is partially-observable, multi-agent, and stochastic. The problem is partially-observable as passenger demand will not be provided – it will be estimated based on average route demand across all airlines. The plan will be multi-agent because the planes are acting cooperatively in that they will need to work together to move all the passengers rather than optimize their own individual routes independently. The plan will also be stochastic as it will be a function of uncertain weather patterns, fluctuating passenger demand, and potential mechanical issues.

In order to solve this problem, we will try two different approaches: *PDDL* and Linear Programming. We will break the problem into smaller relaxed sub-problems adding complexity in each step:

- **Problem 0:** Single agent, deterministic, fully-observable.
  - **Initial state:** All passengers at their initial location at time t_0.
  - **Maximize:** People moved.
  - **Constraints:** 1 plane, fixed time, fixed initial state for planes.
- **Problem 1:** Multi-agent, deterministic, fully-observable.
  - **Initial state:** All passengers at their initial location at time t_0.
  - **Maximize:** People moved.
  - **Constraints:** n planes, different planes models (capacity, autonomy) , fixed time, fixed start airport for planes.
- **Problem 2:** Multi-agent, stochastic, partially observable.
  - **Initial state:** Estimation All passengers at their initial location at time t_0.

  - **Maximize:** Profit: sum(over people moved) k x distancetravelled (stochastic demand).
  - **Constraints:** n planes, different planes models (capacity, autonomy, cost), fixed time, random map.

Concepts that we plan to study will be multi-agent PDDLs and Vehicle Routing Problems. We also plan to do research on Multiple-Objective Optimization, Cooperative Vehicle Routing Problems, and flight scheduling modeled in linear programming. Lastly, we will conduct research into different models of airplanes, consumer demand for different routes, and distances between airports in Europe to give the problem real-world context.

By the 50% timeline we expect to be done with the relaxed problem (problem 0) where demand is not stochastic and we are just maximizing how many people we can move. In order to solve this problem we will need to finish the following tasks:

1. Project proposal (All)
2. Research on tools to solve VRP (Federico)
3. Research on VRP theory (Catherine)
4. Solve Problem0: Linear Programming (AMPL/MathProg) (Fernando, Catherine)
5. Solve Problem0: PDDL (Oleguer, Federico)
6. Solve Problem0: Linear programming (Python) (Oleguer, Federico)
7. Solution analysis and validation (All)
8. Choose best approach (All)

At the 100% timeline we expect to finish the final problem (problem 1/2), adding in stochastic demand and potentially other variables. In order to solve this problem we will need to complete the following tasks:

1. Check if we need to redefine Problem1 and Problem2 (All)
2. Problem1: Using best approach (Depends on approach)
3. Problem2: Using best approach (125%) (Depends on approach)
4. Research on real data sets (Catherine, Federico)
5. Solution analysis and validation (Depends on approach)
6. Poster design (Fernando)
7. Write draft (Oleguer, Catherine)
8. Complete paper (All)

References

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