Airline Planning Algorithm

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Introduction

The *Vehicle Routing Problem* is a well-known dilemma. It involves combinatorics, optimization methods and integer programming. The goal is to optimize the route of a vehicle fleet to maximize locations reached while minimizing costs, often represented as time.

In this study, this problem was applied in the context of airline route planning. The goal was to identify the optimal route for a network of airplane fleets so that the airline maximizes its income while providing transportation for passengers.

1 Previous work

The Vehicle Routing Problem is a widely studied topic by computer scientists. Much research has been conducted on this topic as the solution is of high value to many different industries. Despite all of this research, it is still a problem without a scalable solution due to its high complexity in many environments.

Route optimization is of high importance to many companies as it has the has the potential to optimize costs and resources in large scale and complex problems.

2 Complexity

This problem has an intrinsically high complexity, making it difficult to be solved when considered at a large scale.

The complexity of this problem is ***Non-deterministic Polynomial Time Complete*** (*NP-Complete*). These kind of problems have no solution that can easily be computed because as the scale increases, the computational complexity increases at a above polynomial rate. Nevertheless, there exist several mechanisms which allow approximations to its solutions. In this project we take a look at some of them.

Fig. 1: Airline Routing

Problem Breakdown

This variation of the problem has been split into three different sub-problems, which vary in complexity. *Problem 0* is the most *relaxed* variation while *Problem 2* is the most complex one. The purpose of these variations is to assess the feasibility of each implementation.

Problem 0

This environment is defined as: single-agent, deterministic and fully-observable.

- At initial state at time t_0, all passengers and the plane are at a fixed location.
- The objective is to maximize the amount of people moved substracting the flight costs (set to one for every flight).
- The problem concludes when either all passengers arrive at their destination or a deadline is reached.

This problem has been solved by means of **Integer Programming**, ***PDDL*** and **Reinforcement Learning**.

Problem 1

This environment is defined as: cooperative multi-agent, deterministic and fully-observable.

- At initial state at time t_0, all passengers and planes are at a fixed location.
- The objective is to maximize the amount of people moved in a specified amount of time, substracting flight costs (set to be equal to flight time).
- Each plane has different capacity.
- The problem concludes when either all passengers arrive at their destination or a deadline is reached.

This problem has been solved by means of ***PDDL*** and **Reinforcement Learning**.

Problem 2

This environment is defined as: cooperative multi-agent, stochastic, and fully-observable.

- At initial state at time t_0, all passengers and planes are at a fixed location.
- The objective is to maximize the amount of people moved in a specified amount of time, substracting flight costs (set to be equal to flight time).
- Each plane has different capacity, and each person has a probability to miss a flight.
- The problem concludes when either all passengers arrive at their destination or the deadline is reached.

This problem has been solved by means of **Reinforcement Learning**.

GitHub repository of the project: `https://github.com/OleguerCanal/vehicle_routing_problem`