 

Multi-Agent Reinforcement Learning on Trains

Artificial Intelligence Seminar - 2
by
Classical Search Team

Introduction

Aim:

- To make trains coordinate among themselves to minimize delays in large railway networks.

Birth of Flatland:

- The Swiss Federal Railways (SBB) operates the biggest railway network in Switzerland.
- Densest mixed railway traffic system in the world.
- SBB needs to increase the transportation capacity by approximately 30%.
- Collaboration between AI Crowd and SBB, Flatland Challenge was born!

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Introduction

Core Idea:

- There are different rounds evolves in Flatland Challenge:
- Round 0: Single-Agent Navigation
  - GOAL: LEARN TO NAVIGATE
- Round 1: Multi-Agent Navigation
  - GOAL: AVOID CONFLICTS
- Round 2: Traffic Optimization
  - GOAL: ADAPTATION TO CHANGING ENVIRONMENT

Introduction

Environments:

- Global
- Local
- Local Tree

Key features of environments: [1]

- Agents travel at different speeds.
- Agents experience malfunctions
- Agents have to disappear from the environment upon reaching their target.

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Problem Definition

- Many variants of problems exits the following are the few:
    1. Collision
    2. Deadlocks
    3. Dense Sections of Map
    4. Rescheduling

Target:

- To increase the efficacy of challenge aim, and to address the problems defined above, we are going to use the most optimal classical search techniques.

Previous Work

JBR_HSE (2020) [2]

- Reward Function: $r = 0.01 \cdot \Delta D_{\min} + 10 \cdot \text{is\_succeed} - 5 \cdot \text{is\_deadlocked}$
- Domain specific simplification: Agent can make actions only when close to an intersection
- PPO network architecture
- Scheduler – shorter distance first timetable
- Agent’s observations – local tree
- Communication between closest agents – remembering where agent’s ran into a dead end very useful

Previous Work

Old_Driver (2020) [3]

- Initial path – prioritized planning (PP) (sequentially for every agent)
- Improving solution with Large Neighborhood Search (LNS)
  - Select a neighborhood (subset of agents)
  - Re-plan the paths of the agents in the neighborhood
- Neighborhood Selection Methods
  - Station based neighborhood
  - Intersection based neighborhood
  - Agent-based neighborhood
- Minimum Communication Policy (MCP)
- Handling Malfunctions: Partial Re-planning

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Previous Work

Mugurelionut (2019) [4]

- (Re-)generating agent paths
  - Over a time-expanded graph
  - Generate permutations of the N agents
  - Random permutations
  - try to find alternative paths (A* style algorithm)
- Updating agent paths after malfunctions
  - To avoid deadlocks
  - Bringing the system back to a consistent state
- Avoiding most common deadlocks altogether
  - Avoid nested time intervals of agents going to the same cell

Proposed Techniques

- In 2019–2020 winners of the competition who used the classical search techniques have mostly used A* algorithm.
- The process of the A* start by expanding a state and inserting its successors into the open list. Once all the states are expanded they are maintained in a closed list, which causes A* to suffer from the following two major drawbacks [5].
  - The size of the state space
  - The branching factor
- Conflict Based Search (CBS) is an optimal multi-agent path finding algorithm, it is a two-level algorithm, divided into high-level and low-level searches.

Proposed Techniques

- CBS is complete, optimal and in most of the cases it performance is high.
- CBS uses admissible heuristic function to guide its search.
- Even CBS also have the same drawbacks as A* and other search algorithms as the search continues, they all need to store the entire search frontier.
- To overcome the problem of space and as well to make the CBS run longer, we are adopting another approach called Iterative Deepening CBS [6].
- The above mentioned techniques we are going to use to address collision issue discussed in problem definition.

Proposed Techniques

- To address the other scenarios like deadlocks, transportation and scheduling problem we are going to use the technique Large Neighborhood Search (LNS) [7].
- In LNS, an initial solution is gradually improved by alternately destroying and repairing the solution. The LNS heuristic belongs to the class of heuristics known as very large scale neighborhood search (VLSN) algorithms [8]. All VLSN algorithms are based on the observation that searching a large neighborhood results in finding local optima of high quality, and hence overall a VLSN algorithm may return better solutions [9].
- Advantage of LNS are explore further, harder to get stuck, and can handle arbitrary constraints.

Plan of Implementation

- Try to Implement Single Agent on small map using A* with constant speed.
- Try to Implement Single Agent on large map using A* with variation in speed.
- Try to Implement Multi Agent on small map using CBS / IDCBS, LNS and with constant speed.
- Preparation of Final report.
- Project Submission.

References

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Queries???