Individual Progress Report

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Abstract

This report discusses progress on the Automated Warehouse Problem. It explains the scenario and related technical representation in Clingo. A progress summary along with the technical background acquired from course lectures is included. Possible issues encountered and ways to tackle them are discussed. Finally, a list of completed and incomplete tasks is mentioned along with a plan to approach them.

Problem Statement*[[1]](#footnote-1)*

The Automated Warehouse Scenario, as the name suggests, involves a warehouse where robots need to pick up shelves with specific products and deliver them to specified picking station. This scenario is becoming increasingly popular as it is efficient at processing orders and maintaining a better workplace in terms of health and safety (Lowe 2020).

The problem defines the warehouse as a rectangular area with grids. Initially, robots, shelves, and picking stations are allocated to specific grids. Products are assigned to different shelves with different quantities and a set of product orders are defined. The robots must navigate around the warehouse, completing all orders by delivering specified number of products (using the shelves) to a given picking station.

Due to the reality of the situation, there are many physical constraints that come into play in this problem. Some examples include: two robots cannot collide, two shelves cannot be on same grid, two robots carrying shelves cannot collide and many more. Something to note however, is that the robots are considered flat. Thus, they can move under shelves as long as these robots are not carrying a shelf.

The goal of this project is to ensure that the robots complete all orders by performing actions over some period without breaking constraints. Additionally, by using timesteps for the actions, the aim is to find an optimal solution with least number of steps taken.

Progress Summary and Background Work

For this problem, as I will be using Answer Set Programming (ASP) with Clingo, I have made sure to understand the background from weeks 3-5 of CSE 579-Knowledge Representation and Reasoning course. Week 3 introduces ASP using clingo and week 4 shows two important constructs of clingo: choice rules and constraints. Week 5 builds up on weeks 3 and 4 to explain how actions are handled in ASP to solve dynamic world problems. The automated warehouse scenario is a dynamic problem because the solution involves robot actions across multiple time steps. It also needs to find an optimal solution minimizing the number of steps taken to complete all the orders.

To come up with the solution, I am following the strategies taught in week 5. I have identified what the fluents are in this scenario: robots, shelves, products, and orders. Robots will perform the action ‘move’ to change from one grid to another. Shelves may change grids when robots carry them using the ‘pickup’ action and drop down on another location using ‘putdown’ action.

The products and orders are also considered fluent. Every time a ‘deliver’ action occurs, the product quantity in warehouse and the quantity required as per the order decrement by the delivered amount.

In addition to some progress made above, I have come up with some possible constraints (on actions) in English:

• Robot carrying shelf may not be at grid with shelf.

• Robot performs one action per time step.

• No two robots at same grid in all timesteps.

• Robots may not move to grids where these grids were previous positions of the robots i.e. robots may not swap grids.

• No shelves at highway grids.

• Product quantities in orders and on shelves may not be negative.

Issues Encountered and Planning

The number of issues encountered has been minimal as of now. Problems will arise mainly when coming up with more robust constraints. To be able to think of all possible cases, I plan to abstract the general idea of the scenario. A simple example would be in finding the possible cases where robots can have collisions. Robots can move from a start grid to an end grid but only horizontally or vertically. So, the collisions occur either at: start or end grid or at start grid of each other in next time step. The constraint that two robots cannot be on same grid takes care of the first two cases. Thus, only one additional constraint will be needed to avoid robots exchanging grids.

Completed Tasks

Due to a very recent start on this project after completing week 5 learnings I have only completed:

• Understanding background knowledge and completing simple problems in ASP using Clingo.

• Reading through the project description and understanding the requirements for the solution.

• Finding out the fluents in provided scenario and coming up with some constraints in English.

• Coming up with a representation for each object. For example, my program will use the following representation for specifying robot location:

loc(robot, <robotID>, <grid\_x>, <grid\_y>, <timestep>).

Incomplete Tasks and Planning

Following are the incomplete tasks in the order I plan to successfully complete:

• convert the initialized objects into representation used by the main code.

• sort and declare objects, state constraints, effects and preconditions of actions, action constraints and domain independent axioms. (week 5 lectures)

• allow/disallow possible concurrent actions as needed.

• debug constraints trying to include all possible cases.

• optimize on the timesteps taken to complete all orders.

I plan to use week 5 lectures as a guidance to complete most of the tasks above. Also, as I mentioned before, generalizing some concepts is a good plan to find most constraints.

References

Lowe, H. 2020. Warehouse Automation: Leveraging Automated Warehouse Systems. *SelectHub*.

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