**Course Project Progress Report**

Introduction

Briefly reintroduce the project, emphasizing the automated warehouse scenario and the goal of optimizing order fulfillment using logic programming.

Objective Recap

Reiterate the project's objective of demonstrating automated reasoning about actions using KR tools, emphasizing the optimization of order fulfillment within the warehouse scenario.

Milestones Overview

Recap the project milestones and their significance:

* **Milestone 1:** Understanding the problem description and input/output requirements.
* **Milestone 2:** Initial implementation of logic programming constraints.
* **Milestone 3:** Midterm progress check, refining constraints and optimizing solution.
* **Milestone 4:** Finalizing project report and solution implementation.
* **Milestone 5 (Optional):** Portfolio inclusion request.

Accomplishments

Detail what has been achieved up to this point:

* **Milestone 1:** Successfully understood and analyzed the problem description, input/output requirements, and provided example.
* **Milestone 2:** Implemented initial logic programming constraints to represent the warehouse scenario, including grid representation, robot actions, shelf movements, and order fulfillment conditions.
* **Milestone 3:** Further refined constraints and optimized solution approach, ensuring collision-free robot movements and efficient order fulfillment.
* **Milestone 4:** Progressing towards finalizing the project report, with a comprehensive understanding of the problem and significant implementation progress.

Remaining Work

Outline the tasks that remain to be completed:

* Finalize implementation details and optimize solution further if possible.
* Complete the final project report, detailing the solution approach, implementation steps, and results analysis.
* Review and refine the solution to ensure adherence to project requirements and constraints.

Challenges and Solutions

Discuss any challenges encountered and how they were addressed:

* Challenges included understanding the intricacies of the warehouse scenario and formulating logic programming constraints to represent various actions and conditions accurately.
* Solutions involved thorough analysis of the problem description, iterative implementation and testing of constraints, and seeking clarification or assistance when necessary.

Support and Resources

Acknowledge any support or resources utilized during the project:

* Utilized the provided project description and example instances as a foundation for understanding and implementing the problem scenario.
* Leveraged online resources and discussion forums to address specific questions and challenges encountered during implementation.

Conclusion

Conclude with a summary of the current progress and outlook:

* Progressing steadily towards the completion of the project, with significant achievements in understanding the problem and implementing logic programming constraints.
* Remain focused on finalizing the solution and project report, ensuring a comprehensive and well-documented submission by the project deadline.

**Additional Notes:**

* Ensure the report aligns with the provided project requirements and expectations.
* Provide clear and concise descriptions of accomplishments, challenges, and remaining tasks.
* Maintain a professional tone and format throughout the report.

Top of Form

Bottom of Form

**ABSTRACT**

In the evolving landscape of e-commerce and logistics, the integration of automation and robotics into warehouse operations significantly enhances efficiency and productivity. Automation applies technology to perform tasks with minimal human intervention, while robotics focuses on designing and operating robots to undertake hazardous or repetitive tasks. This combination is crucial in warehouse management, optimizing processes like inventory handling and order picking, thereby reducing labor strain and costs. This project implements an automated warehouse scenario where robots intelligently coordinate to retrieve shelves containing required products and deliver them to designated picking stations for order fulfillment.

**PROBLEM STATEMENT**

The project implements an automated warehouse scenario where robots are tasked with intelligently coordinating to retrieve shelves containing required products and delivering them to designated picking stations in order to fulfill customer orders. The warehouse environment is represented as a rectangular grid layout consisting of shelves placed in certain grid cells to store products in specified quantities. Additionally, some grid cells are designated as picking stations where products for orders need to be delivered. The layout also includes restricted highway cells that robots can traverse but cannot be obstructed by shelves. The robots can move horizontally or vertically between adjacent non-highway grid cells.

The robots are designed with two key capabilities. Firstly, they are flat and can move underneath shelves when not carrying one. Secondly, they can pick up shelves by moving under them. However, once carrying a shelf, a robot cannot move underneath any other shelves.

The overall objective is to develop an algorithm that generates optimal plans of robot actions to complete all given orders while satisfying the following constraints: Avoid collisions between robots at all times. Never place shelves on restricted highway cells. Ensure all product units for each order are fully delivered to the correct picking station. Minimize the makespan - the total number of parallel time steps until the last order is completely fulfilled.

**PROGRESS MADE**

The foundational step in this project involved setting up the necessary tools and understanding the key concepts essential for our automation endeavor. Initially, I installed and configured CLINGO on my local machine, which is pivotal for our project's development. Following this, I delved into learning the foundations of Answer Set Programming (ASP) and mastered how to effectively translate the facts written in ASP to CLINGO using the correct syntax. This knowledge was crucial for laying the groundwork for our project's technical framework.

The subsequent step focused on decomposing the problem statement into actionable segments. The first significant milestone achieved was the construction of the warehouse layout represented as grids. This grid system was established as the primary environment for our scenario, providing a structured space within which our automated processes could be conceptualized and tested.

Once the grid was established, I proceeded to encode the properties of various objects within this grid, including shelves, picking stations, and robots. This encoding was essential for defining the interaction and functionality of these elements within our automated system.

Following the object property encoding, I strategically positioned the picking stations within the grid. Part of this process involved designating specific grid cells as "highway cells" - exclusive pathways where only robots are permitted to move, thereby optimizing the flow of robotic movement and ensuring that shelves and picking stations remain fixed.

The next phase of progress entailed assigning initial positions to the robots and shelves within this grid environment, effectively hardcoding their starting locations into our system for preliminary testing and simulation. This step was crucial for visualizing the interaction between robots and other elements within the warehouse environment.

The figure below illustrates the currently established environment, showcasing the grid layout with designated positions for robots, shelves, and picking stations, alongside the specified highway cells. This visual representation marks a significant milestone in our project, providing a concrete foundation upon which further development and optimization can be built.

[Figure not shown]

This phase of the project has laid the groundwork for subsequent steps, which will involve fine-tuning the interaction between robots and the warehouse environment, optimizing the efficiency of item retrieval and delivery, and integrating advanced decision-making algorithms for dynamic task allocation among the robots.

**CHALLENGES ENCOUNTERED**

The major challenge currently being faced is effectively managing robot collisions within the warehouse environment. With multiple robots operating simultaneously, ensuring collision avoidance becomes paramount to maintain operational efficiency and safety. The constraint limiting robot movement to only vertical or horizontal paths complicates collision avoidance strategies, leading to increased traversal times as robots must navigate around each other's paths. Additionally, the optimization of code execution remains a significant challenge, with current implementations exhibiting longer-than-desired execution times. Addressing these challenges requires the development of sophisticated collision detection and avoidance algorithms, as well as the optimization of code efficiency to enhance overall system performance and responsiveness.

Top of Form

**PLAN TO RESOLVE ISSUES**

To address the challenge of robot collisions, I will implement additional constraints within the algorithm to account for the positions of other robots. By introducing prioritization of orders, I can ensure that robots handling high-priority tasks are assigned the most optimal paths, while others select the next most optimal paths. In cases where multiple robots have tasks of equal priority, they will prioritize fairness in task completion time over individual efficiency, opting for their second most optimal paths.

Furthermore, to mitigate the issue of longer code execution times, I will conduct research to identify simpler and more efficient methods for transforming and executing ASP facts in CLINGO. This may involve optimizing the encoding of warehouse layout and robot behaviors, as well as exploring potential enhancements to the underlying algorithms. By streamlining the execution process, I aim to improve overall system performance and responsiveness, thereby enhancing the efficiency of warehouse operations.

**TASKS COMPLETED**

1. **Learning ASP Fundamentals**: I learned the basics of Answer Set Programming (ASP), understanding how it works and its syntax.
2. **CLINGO Setup and Configuration**: Installed and set up CLINGO on my computer, which is a crucial tool for our project.
3. **CLINGO Syntax Mastery**: I practiced solving various problems using CLINGO to become familiar with its syntax.
4. **ASP Fact Generation**: Created facts in ASP to describe the initial state of our warehouse environment.
5. **ASP to CLINGO Translation**: Converted ASP facts into CLINGO format to make them compatible with CLINGO.
6. **Constraint Implementation**: Defined constraints necessary for solving our warehouse automation problem.
7. **Constraint Conversion to CLINGO**: Translated these constraints into CLINGO syntax for implementation.
8. **Environment Setup**: Created a grid layout representing our warehouse, including shelves, picking stations, and robots.
9. **Initial Object Positioning**: Assigned starting positions to robots and shelves in the warehouse grid.

**TASK TO BE COMPLETED**

1. **Implement Additional Constraints**: I'll create extra constraints to prevent robot collisions by considering the positions of other robots in the algorithm.
2. **Prioritize Task Assignments**: I'll research and implement task prioritization, ensuring high-priority tasks get the best paths while maintaining fairness for equal-priority tasks.
3. **Optimize Pathfinding Logic**: I'll develop logic to find the best paths for each robot, considering task priorities and obstacles.
4. **Optimize Code Execution Time**: I'll explore and apply efficient algorithms to reduce code execution time, improving system performance.
5. **Ensure Program Correctness**: I'll validate the program's correctness to ensure it works well with CLINGO, fixing any errors or inconsistencies.
6. **Validation Set Testing**: I'll evaluate the program's performance using the provided validation sets, ensuring that it meets the required standards and accurately handles various scenarios.

Top of Form

Bottom of Form

Bottom of Form