<u>CS5446 AI PLANNING & DECISION MAKING</u>

Group P12 Proposed Topic: AI Planning and Decision Making in simulated robot arm manipulation

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1. Background & motivation – While there is an advent of artificial intelligence technologies through implementation of machine learning and language models, realized benefits have remained largely confined within digital applications. A next frontier of realizing meaningful human interaction through physical systems is a critical inflection point. Towards this goal, this project aims to explore possibilities of implementing theoretical frameworks learnt in this module onto **robotic arm manipulation**.

2. Scope & Approach – Robotic arm manipulation has traditionally relied on either classical planning or reinforcement learning (RL). While sole reliance on classical planning within a perfect simulated environment can be done, such learning frameworks will underperform given uncertainties (e.g., object misplacement, etc.). On the flip side, the sole reliance on RL can be computational expensive, due to complex reward functions and large search space spanning across both task planning and task execution stages.

This project aims to integrate both techniques to harness their complementary strengths, by proposing a hybrid technique, for a robotic arm to perform a manipulation task autonomously. The **integration of classical planning (through using PDDL) and RL** will be the main exploration component of this project. RL will ideally not be overly complex from the multi stage action, since each agent will be focused on 1 atomic action defined during classical planning, while remaining sufficiently robust for any stochastic adjustments in environment.

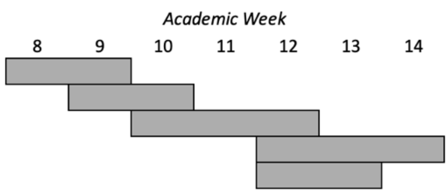
3. Methods – Robosuite for robot learning will be utilized to simulate the environment and robotic arm. PDDL will be utilized to define states and actions on a hierarchical level, where high-level tasks are specified and subsequently broken down into more detailed components. Reinforcement learning will then be used to learn and execute each atomic action as defined in the tasks and component.

The manipulation task defined is for the robotic arm to move a disk from 1 peg to another peg (i.e., resembling a simplified 1-disk Tower of Hanoi puzzle). While this task may be easily managed for humans in general, the same is hardly trivial for a robotic arm. Primarily, the arm will be required to learn to (i) navigate towards disk, (ii) pick up disk from 1st peg, and (iii) move disk from 1st peg to 2nd peg, and (iv) place disk within 2nd peg. Should this be successful, this task is a demonstration of the hybrid approach's applicability, and a likely indication on this approach being likely generalizable to other tasks.

4. Limitations – The exploration of the hybrid approach occurs in a deterministic, fully observable simulated environment. Such simulations, no matter the complexity, is hardly a full representation of reality, and results in a limited confidence for such approach to be fully applicable in reality. Such transferring of learnt policies from simulation into reality will hence require further extensions in the future, but currently out-of-scope.

5. Responsibilities & Milestones

Milestones	Responsibilities
Set up of environment & simulations	LAI EN HAN
Definition & implementation of hierachical tasks in PDDL	TOH HOON CHEW & PHANG DAO YI JOSEPH
Definition & implementation of RL for atomic tasks	LAI EN HAN & XIAO YICONG
Results consolidation and Report	ALL
Presentation deck	ALL



6. ***Risk Assessment –*** Since robotic arm manipulation is an ambitious target which comprises a myriad of tasks involved within the limited timeframe, the team undeniably undertakes the risk of non-completion. However, each successful stage (e.g., successful picking up of disk) can already serve as good reference point to evaluate on the adequacy of the hybrid method, even without the eventual successful placing of disk into 2nd peg.