Investigation of Agent and Task Diversity on Agents' Emergent Behavior in an Open Multi-Agent System Environment

Trevor Fellbaum, Dr. Leen-Kiat Soh
Department of Computer Science and Engineering, University of Nebraska–Lincoln

Background

- An open environment can be described as an environment where there exists both agent openness and task openness.
- Agent openness is the degree at which agents join and exit the system and task openness is the degree at which tasks join and exit the system.
- When exploring diversity, there is both agent diversity and task diversity. Diversity is represented as the distribution of the types of agents and tasks.
- With this study, we can further understand how to optimize task allocation amongst humans in a real-world environment.

Objectives

- Investigate agent and task openness in multi-agent systems (MAS).
- Determine the effect of diversity on agent's behaviors on reward and learning.
- Model human collaboration in MAS.
- Provide insight on optimizing task allocation for human collaboration through multi-agent simulations.

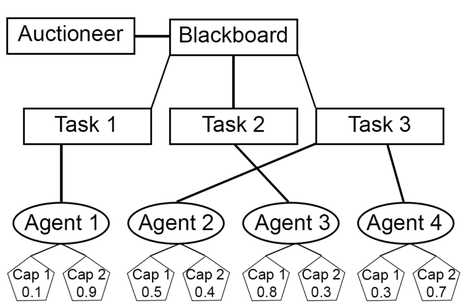

Figure 1. Depiction of Task allocation

Methods

We ran simulations through a Java program on the Holland Computing Center's Supercomputer. The environment was modeled after an auction in which an auctioneer is distributing tasks on a blackboard to the bidding agents for rewards. The tasks are auctioned off based on the agents' bids and capabilities to complete the task. Thus, the environment encompasses the agents, tasks, and auctioneer.

Agent Model

- Agents are the bidders of the auction.
- Each agent has configurable capabilities, to do specific tasks, and a specific bidding strategy assigned before runtime, to acquire tasks.
- There are four bidding strategies: Reward-driven, probabilistic and reward-driven, reward-driven with learning, and probabilistic with reward-driven and learning.
- Agents are classified as either Specialists or Generalists.

Task Model

- Tasks are the items which the agents will bid on.
- Each task is composed of subtasks, number of agents required to complete the task, and the reward gain for completing it.
- Each subtask must be completed to complete a task and contains a required capability level and a learning rate.

Openness

- Agents and Tasks exit and enter the system based on the configurable parameters of agent and task openness. A high rate of openness indicates that the turnover will occur more frequently.

Number of runs	100
Number of simulation ticks per run	1000
Number of configurations per run	4
Total number of runs	400
Number of data files	10,000
Size per data file	10Mb
Total size of data	152 Gb
Simulation time to generate the data files	81 hours
Parsing time to generate statistics from data files	22 hours per run
Computer Specs	121 TeraFLOPS, 64 Gb RAM

Figure 2. Computer Specifications

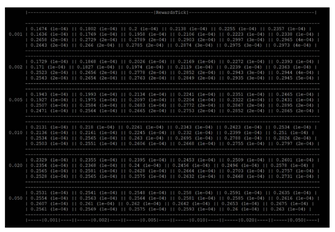

Figure 3. Sample Data

Challenges

- High performance computing can be difficult to debug when processing large amounts of tracked data.
- When working with batch processing, checking the node's memory usage can help find memory allocation errors to improve performance.
- Having a consistent file structure improves memory usage when parsing large amounts of data. This is particularly useful when the simulation environment is dynamic and provides inconsistent data.
- When running simulations with high performance computing, it is best to make them as modular as possible. They can be run in separate batches for quicker results and can later be compiled into a large dataset.

Future Work

- Develop an exit strategy for agents leaving the system.
- Create graphs from simulation data.
- Analyze trends and correlations between agents' rewards, diversity, and openness.
- Investigate the effects of learning with respect to openness.

Acknowledgements

This work was supported by the McNair Scholars Program and under the mentorship of Dr. Leen-Kiat Soh. Special thanks to the staff at the Holland Computing Center.

MCNAIR SCHOLARS PROGRAM