Cooperation Strategies in a Time-Stepped Simulation of Foraging Robots

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Liam McGuigan

• PhD Researcher at Ulster University
• Researching autonomic robotic swarms
• 11 years software engineering experience
• Interests include AI under real-time constraints
Swarm Robotics

• Large number of cooperating robots

• Cost effective

• Need to be scalable and flexible
Swarm Self-Adaptation

• Research categorised along two lines

• Most research focuses on agent behaviour adaptation

• Swarm-level strategic changes can help with collaboration
Objectives

• Potential for self-adaptation

• Embedded simulation approach
Cooperation in a Foraging Task

• Specialised robots must find and process items

• Three strategies compared:
  • Multiple responders
  • Selective responders
  • One responder
Test Scenarios

• 200 robots, 200 items:
  • Equal balance
  • Robot imbalance
  • Item imbalance

• Two map sizes:
  • 30x30
  • 90x90

• 30 runs per strategy and scenario
Time-Stepped Simulation

• Updates in discrete ticks

• Each tick, a robot may:
  • Move
  • Process an item
  • Participate in selection strategy

• Continues until task ends
Threaded Simulation

• Each robot simulated on a separate CPU thread
• No synchronisation
• Reliance on real-time delays to simulate robot behaviour
Cooperation Strategy Performance

• One Responder strategy best in Equal or Item Imbalance scenarios

• Multiple and Selective Responder strategies perform worse than no cooperation
Cooperation Strategy Performance

• Multiple and Selective Responders work better in Robot Imbalance

• Energy cost of each may need calculated to determine true benefit

• Random exploration is overwhelming factor in 90x90 grid
Items Foraged over Time

• Cooperation not useful until final 10%

• Seen most clearly in Equal and Item Imbalance scenarios
Comparison of Simulations

• Time-stepped simulation is more efficient.

• Threaded sim results in fewer steps to complete task
  • Robots spending more time waiting?
Potential for Autonomic Strategy Selection

- Autonomic Manager on robot
- Make decisions based on known data
- Use knowledge base for selecting strategies
Embedded Simulation

- Time-stepped simulation more suited
- Reduced demands on host
- More simulations can run in same period
Future Work

• Autonomic capability
• Sharing of information
• Adding simulation to MAPE-K loop
• Other factors affecting performance
Summary

• Compared performance of cooperation strategies in a foraging task

• Compared time-stepped and threaded simulations to identify most suitable simulation for embedding within robots

• Identified potential for adjusting behaviour, according to situation, for increased performance

• Aim to develop autonomic capability to consider and select alternative strategies to fit the task and situation at hand
Thank You

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