Bounty Hunting and Multi-Robot Task Allocation

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Outline

● Introduction
● Auction Based Task Allocation
● Bounty Hunting based Task Allocation
  ○ Dynamic Tasks Results
  ○ Task Abandonment Results
● Future Work
  ○ Multi-robot task allocation
  ○ Cooperative tasks
  ○ Large scale
Decentralized Dynamic Task Allocation

- *Agents* are mapped to *tasks* which they must complete
- Agents decide *collectively* how to map the tasks
- New tasks appear dynamically while agents are working on other tasks

**Real Life Applications**
Disaster and Emergency Tasks
Robot Soccer
Pickup and Delivery problems

**Common Methods**
Auctions
Markets
Contract Networks

Taxonomy of Task Allocation

- Single-Task Robots vs Multi-Task Robots
- Single Robot Tasks vs Multi-Robot Tasks
- Instantaneous Assignment vs Time Extended

Auctions (MURDOCH)

- Bid valuation (or fitness score) for each task
- Auctioneer determines winner after some clearing time
- Auctioneer monitors winners and reassigns if insufficient progress

Auctions are generally exclusive, assume infinite money supply and altruistic, non-strategic agents, require accurate valuation, and commonly assume sequential task arrival or some kind of task queue. This is an unwieldy and unreasonable set of constraints for many dynamic task allocation problems.
An alternative: Bounty Hunting!

Bounty hunter and Bail bondsman

Task Classes, and task commitment

Advantage: no bidding!

Disadvantage: Not exclusive

Problem Description

Corners = “home bases”
Black circle = Agent
Red circle = Ball/Task

For this field:
20 Tasks
4 Agents
60x40 grid

Bondsman:
Bounty rate
Initial Bounty
Experiments

- Static Environment
- Dynamic Agents - agents are removed
- Dynamic Tasks - task distribution changes
- Unreliable Collaborators - two slow agents are added, pick tasks randomly.
- Unexpectedly Bad Tasks - randomly selected tasks become difficult for some agents

Evaluated by measuring the total bounty available.
Bounty Hunters

- Bounty hunters learn which task classes to go after
  - Simple - learns time to task and probability of success
  - Complex - learns time to task and probability of success given that certain other agents have committed to the task.

- Bounty “Auction”
  - Similar to an Auction, but incorporates the Bounty
Results

- Adaptive bounties converge to divvying tasks up despite not being exclusive
- Adaptive Bounties can successfully adapt to dynamically changing environments
- Adaptive Bounties can perform comparably to, and in some cases much better than, exclusive methods
- “Complex” is generally more effective
Task Abandonment

- Bounty hunters may abandon tasks, or *Jumpship*.
- Improves performance significantly in all but the Dynamic Agents and Dynamic Tasks experiments.
- Does statistically significantly the best in two new experiments.

Multi-robot Bounty Hunting

- Current assumptions
  - Teleportation to home base after task completion
  - Home Base
  - Simultaneous occupation of space
  - Grid movement (manhattan distance)
- Instead
  - Full pickup and delivery
  - Obstacle avoidance
  - Continuous space (cartesian distance)
  - Incorporate cost and battery life
Future Work

● Implement Bounty Hunting system in a multi-robot system using GMU’s FlockBots.
● Important to show that the system works in real life, not just in simulation.
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Questions