Active perception using POMDPs

Matthijs Spaan

Institute for Systems and Robotics

Instituto Superior Técnico

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Introduction

- Active perception: control your sensors.
- Context: URUS project.
  - Network of cameras and robots.
  - Outdoor, cameras won’t cover everything.
  - Cameras detect events.
- Issues to tackle: modeling and solving.

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Cooperative Perception Framework

- Static and mobile sensors.
- Using probabilistic feature models.
- Bayesian strategies to fuse uncertain information from spatially distributed sensors.
- Handling disagreement.

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Active Perception

- Active perception will improve cooperative perception performance.
- Models interaction of active sensor with environment:
  - ► Point pan-and-tilt camera.
  - ► Choose more informative robot trajectory.
  - ► Ask robot to investigate area.
  - ► Execute expensive vision algorithm.

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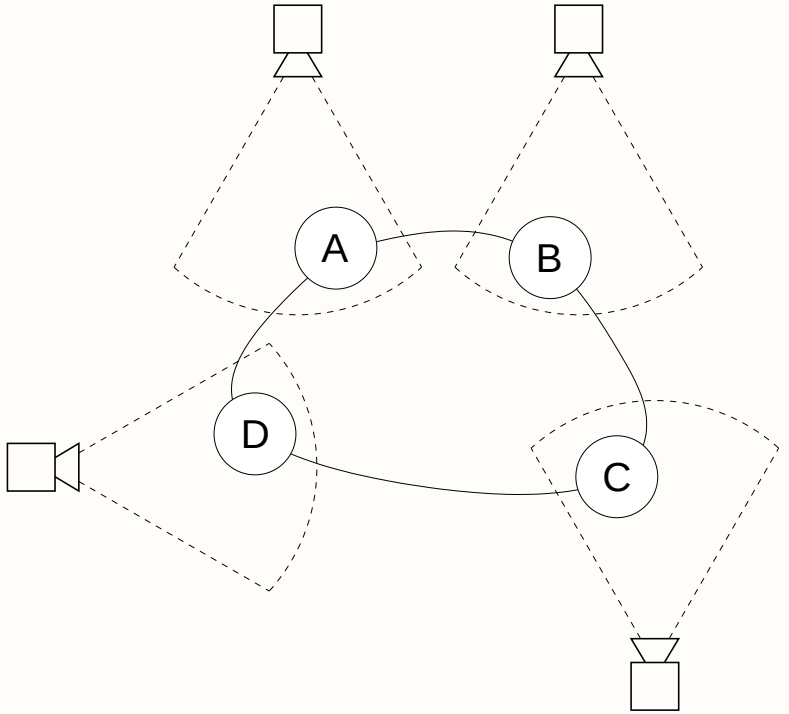
URUS scenarios

- Navigation
  - Adjust robot's trajectory to improve perception.
  - Tradeoff information gain vs task execution.
- Guiding
  - Actively keep track of human.
  - Check whether human is still following.
- Event detection
  - Fixed camera detects possible event.
  - Ask robot to investigate.

Example scenario

- High level example scenario.
- Cameras detect fires and persons, noisy sensors.
- Robot moves to investigate.
- Fire occurs less, but are more valuable if detected correctly.
- Robot successfully reports events: trades off persons and fires.



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POMDPs

- Partially Observable Markov Decision Processes (POMDPs).
- Models interaction with stochastic, partially observable environments.
- Probabilistic action and sensor models.
- Task: maximize long-term reward.
  - ► Allows prioritization of objectives.
  - ► Allows for actively reducing uncertainty.
- Solving is intractable: approximate methods.
- Decentralized POMDPs.

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Beliefs

- Beliefs: probability distribution over states.
- Can be used to define quality of information.
- Common measure: entropy.
- POMDPs allow for trading off entropy minimization and task performance.

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Solution methods

- Off-line vs. on-line (approximate) methods.
- Off-line methods such as “classic” POMDP solvers:
  - ► Rapid execution.
  - ► Off-line computation can be expensive.
- On-line methods, e.g., search the belief tree
  - ► Easily integrate belief-based rewards.
  - ► Require computation each decision moment.
- Are the POMDP models changing?

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Discussion

- Level of abstraction.
- Static or dynamic models.
- Solution method design.
- Communication issues.
- URUS integration.