Cooperative Control for Pursuit Evasion Game

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June 11th 2008
Cooperative Control for Multi-Vehicle Systems. [Murray:07]

- Cooperative: each vehicle being a dynamic system, and they share a same task without adversarial interference.

- Applications:
  - Military: formation flight, cooperative classification and surveillance, cooperative rendezvous, mixed initiative systems etc.
  - Mobile Sensor Networks: environmental sampling, distributed aperture sampling etc.
  - Transportation Systems: Intelligent highways, air traffic control etc.

Related PEG Systems

- [Demirbas:03]
  - **Evader-Centric**: Sensor nodes near the evader maintain a tracking tree dynamically.
  - Pursuer searches the network until it reaches the tracking tree, and then follows the tree to its root in order to catch the evader.
  - Networked Sensors are tunable for tracking speed or energy efficiency
  - **Pursuer-Centric Extension**: Pursuer sends out agents to find the evader tree, saving energy for locomotion!
  - Small scale experiment: 4 X 4 motes

Related PEG Systems

- [Sharp:05] reports an experiment of 100 nodes in a field of 400 square meter.
- Provides physical design experiences a sensor network for detection (Magnetic), routing (landmark)
- Uses GPS to provide pursuer’s position

Related PEG Systems

- [Oh:07] deployed a sensor network system for target tracking with PIR as binary sensors. The main contribution is data association for multiple target tracking.
- Simulations were used to generate the pursuit process. Pursuer is **not** truly implemented.

Our Current System

- Follows an architecture similar to [Sharp:05]
- As an Indoor test bed, we use a Camera feedback system to take the place of GPS

- We tested two different distributed sensor network coordination method:
  - Group management
  - Cluster-based
Our Current System

Demo One:
- Distributed Group Management.
- HW: MICAz compatible motes, use RSSI to detect evader and calculate the location estimates.
Our Current System

- Demo Two:
  - Single Cluster Management: Nodes are activated only when needed.
  - HW: IRIS motes
    - No longer provides RSSI.
    - Could be used as binary sensors
Where is the **GAME**?

- The Tracking and Pursuit is decoupled by the sensor network!
- It is **unfair** to provide the pursuers with global information and leave the evaders nothing.
- Need more **general settings** that make the game interesting:
  - Tunable information availability for evader/pursuer and tunable moving speed.
  - Task assignment and collision avoidance for pursuers.
  - Consider faulty network transmission with unpredictable latency.
[P. Beling] developed a simulation-based test bed for researchers to compare the performance of PEG strategies.

Formulate the RoboCop problem as a min-cost flow network problem.

PE Game in Sensor Networks

- [Sert] considers chessboard like network (with clustered sensors). Information Available to both pursuer/evader.

- Pursuit considerations
  - Shortest-path pursuit
  - Non-Collaborative Assignment
  - Collaborative Assignment
  - Obstacle Avoidance (not included in the optimization formulation)

- Evader has greedy policy: Maximize the distance between the nearest pursuer at each instance.

Possible Research Directions

- Dynamic Target Assignment
  - Methods: Scheduling, Optimization.

- Pursuers Formation Control (For Multi-On-One)
  - Methods: Flocking (when searching the evader), Rendezvous/Capture (when evader targeted)

- Pursuit-Evasion Strategy
  - Use prediction schemes to counteract different evader mobility models.
  - Take into account network latency.

- All Could Be Categorized into Multi-Robot Cooperative Control Problem
Integration with previous research

- Extend the PEG in Aisle Environment:
  - Utilize indoor positioning technique to detect evaders. [Li:08a]
  - Utilize static sensors to guide pursuers. [Li:08b]

[Li:08a] H. Li et al. INEMO: Distributed RF-based Indoor Location Determination with Confidence Indicator. EURASIP Journal on Advances in Signal Processing, vol. 2008