Optimization Problems in Visual Surveillance

M.Sc. Thesis Proposal
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Introduction

Camera

Target
Two Variants

1-on-1
Both Mobile

Many-to-Many
Both Static
Agenda

● Introduction
● **Problem(1) Pursuit-Evasion**
● Problem(2) Camera Assignment
● Study Plan
Agenda

● Introduction
● Problem(1) Pursuit-Evasion
  ○ Definition
  ○ Background
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Visibility-Based Pursuit-Evasion

- Keep evader in sight!
- Omnidirectional vision
- Bounded speed
- Holonomic motion
- General obstacles
- Move in turns
- Complete information
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Background - Pursuit-Evasion

- **Continuous - Differential Games**
  - Isaacs conditions ~ Pontryagin’s principle [1]
    Characterize the Hamiltonian of the system along optimal trajectories
    
    $$H(x, \nabla J, u, v) = \nabla J \cdot f(x, u, v) + L(x, u, v)$$
    $$\left(u^*_e, \theta^*_e, u^*_p, \theta^*_p\right) = \min_{u_e, \theta_e} \max_{u_p, \theta_p} H(x, \nabla J, u, v)$$
    $$H(x, \nabla J, u^*, v^*) = 0.$$  

- **Discrete - Graph Search**
  - Cops and Robbers [2]
    
    $$\ell(c_{xy}) := 1 + \min \{ \ell(r_{x'y}) : x' \in N^+(x) \}$$
    $$\ell(r_{xy}) := \max \{ \ell(c_{xy'}) : y' \in N^+(y) \}$$

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Camera-Target Assignment

- Cover max. no. of targets!
- Cameras rotate freely
- Fixed field of view
- General obstacles
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Background - Camera Assignment

- Assignment Problems [3]
  - Bipartite Matching

- Geometric Set Cover
  - Coverage by unit disks, NP-hard [4]

Background - Camera Assignment

- **Greedy Heuristics**
  - Approximation of Set Cover
  - $\Omega(\log n)$ - *unless NP has quasi-polynomial time algorithms* [5]


- **Game Theory**
  - Welfare Games [6]
  - Nash Equilibrium
  - Price of Anarchy

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Study Plan - Pursuit-Evasion

- Theoretical foundations
  - Escape conditions
  - Graph models

- Solution methods
  - Star regions
  - Recurrences

- Practical considerations
  - Feasible computation
  - Motion continuity
  - Online planning
Study Plan - Camera Assignment

● Theoretical foundations
  ○ Assignment models
  ○ Linear programming relaxation
  ○ Geometric set cover
  ○ Game theory

● Solution methods
  ○ Greedy heuristics
  ○ Approximation algorithms

● Practical considerations
  ○ Quality of coverage e.g. zooming
  ○ Target mobility
Thank You

Questions?

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