OA3602

Search Theory and Detection

Spatial Search Models

Objectives:
- From coverage to search, cont.
- Expected time till target found
Search is a *spatio-temporal* problem

*Search requires planning of “where” and “when” to search*

*Let’s use the discrete case to motivate how the “when” \((t,n)\) is tied to the “where” \((x)\)*

**Notation:**

\[
S(n) = \{x_1, x_2, \ldots, x_n\}
\]

\[
x_n \in \{1, 2, \ldots, C_S\}
\]

**Assume:**

1. Searcher using perfect sensor
2. \(S(n)\) contains no revisits
   \[\rightarrow S(C_S)\] is an ideal and complete coverage path
Modeling Detections

The difference between target truly present and searcher “saying” target is present

\[ \Pr[D_c = 1] = \text{Probability of detecting target when searching in location } c \]
Modeling Detections, cont.

Incorporating spatial uncertainty in target location

- By the Law of Total Probability

\[
\Pr[D_c = 1] = \sum_{x=1}^{C_S} \Pr[D_c = 1|X = x] \Pr[X = x]
\]
Expected time till target is found

Effect of target spatial distribution and search path on MOP

- Expected # time steps until the target is found

\[
\mathbb{E}[N] = \sum_{n=1}^{\infty} nf(n) = \sum_{n=1}^{C_s} np(x_n)
\]

(for perfect sensor and ideal, complete search path)
Example

Consider a discrete search environment where

\[
\begin{array}{c|cccc}
 n & 1 & 2 & 3 & 4 \\
\hline
 p(x_n) & 0.1 & 0.15 & 0.3 & 0.45 \\
\end{array}
\]

\[
E[N] = \sum_{n=1}^{\infty} nf(n) = \sum_{n=1}^{C_S} np(x_n) \quad \left( \text{for perfect sensor and ideal, complete search path} \right)
\]

Suppose search trajectory: \(S = \{1, 2, 3, 4\}\)

Suppose search trajectory: \(S = \{4, 3, 2, 1\}\)

Search performance is dependent on search trajectory
- Optimization of search path is active research
Parting shots

• Today we learned...
  – Addressing spatial (target location) uncertainty

• Next time...
  – Glimpse probabilities
  – Addressing imperfect detections

Don’t forget to turn in your mud cards!