Set-Membership Approach to the Kidnapped Robot Problem

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IROS 2015, Hamburg.
Presentation available at https://youtu.be/oFvl0__NQpuc
1 OMNE
We consider the bounded-error estimation problem

\[ f_i(p) \in [y_i] \]

where

\[ [y_i] \subset \mathbb{R} \] is the \( i \)th collected interval data,
\[ p \in \mathbb{R}^n \] is the parameter vector to be estimated,
\[ p^* \] is the true value for \( p \).
The set of all $p$ consistent with the $i$th measurement $y_i$ is

$$\mathbb{P}_i = f_i^{-1}([y_i]).$$
Inlier or outlier?

$[y_i]$ is an inlier if $p^* \in \mathbb{P}_i$.
It is an outlier if $p^* \notin \mathbb{P}_i$. 
OMNE (Outlier Minimal Number Estimator) [Walter and Lahanier, 1987]

\[
\lambda(p) = \text{card} \{ i \mid p \notin \mathbb{P}_i \}
\]

\[
q^* = \min_p \lambda(p)
\]

\[
\mathbb{P} = \lambda^{-1}(q^*).
\]
2 Set formulation
q-relaxed intersection
OMNE corresponds to

\[ P_i = f_i^{-1}([y_i]) \]
\[ P\{q\} = \bigcap P_i \]
\[ q^* = \min\{q \mid P\{q\} \neq \emptyset\} \]
\[ P = P\{q^*\}. \]

Outer GOMNE solves the problem with intervals and a local search.
3 Illustrative example
Range only localization with 3 landmarks using interval analysis.
\( \mathcal{P}_0, \mathcal{P}_1, \mathcal{P}_2 \)
4 \hspace{1em} \textbf{DEM}

The map is described by $M = (x_i, y_i, z_i), i \geq 1$.
Example of digital map
Aerial orthoimage built from UAV
Velodyne Lidar
Original range data
Down sampling
Extraction of vertical shapes
5 Localization
\[ \mathbf{p} = (x, y, \psi) \]
\[ \mathbb{P}_i = f_i^{-1}(M) \]
\[ \mathbb{P}\{q\} = \bigcap \mathbb{P}_i \]
\[ q^* = \min \{q \mid \mathbb{P}\{q\} \neq \emptyset\} \]
\[ \mathbb{P} = \mathbb{P}\{q^*\}. \]
Contribution of the paper: We are able to compute the global minimum $q^*$. We used a Monte Carlo search to speed up the calculus.
Question?