Set-Membership Approach to the Kidnapped Robot Problem

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Presentation available at *https://youtu.be/oFvl0_NQpuc*

1 OMNE

We consider the bounded-error estimation problem

$$f_i(\mathbf{p}) \in [y_i]$$

where

$[y_i] \subset \mathbb{R}$ is the ith collected interval data,

$\mathbf{p} \in \mathbb{R}^n$ is the parameter vector to be estimated,

$\mathbf{p}^*$ is the true value for $\mathbf{p}$.

The set of all $\mathbf{p}$ consistent with the ith measurement y_i is

$$\mathbb{P}_i = f_i^{-1}\left([y_i]\right).$$

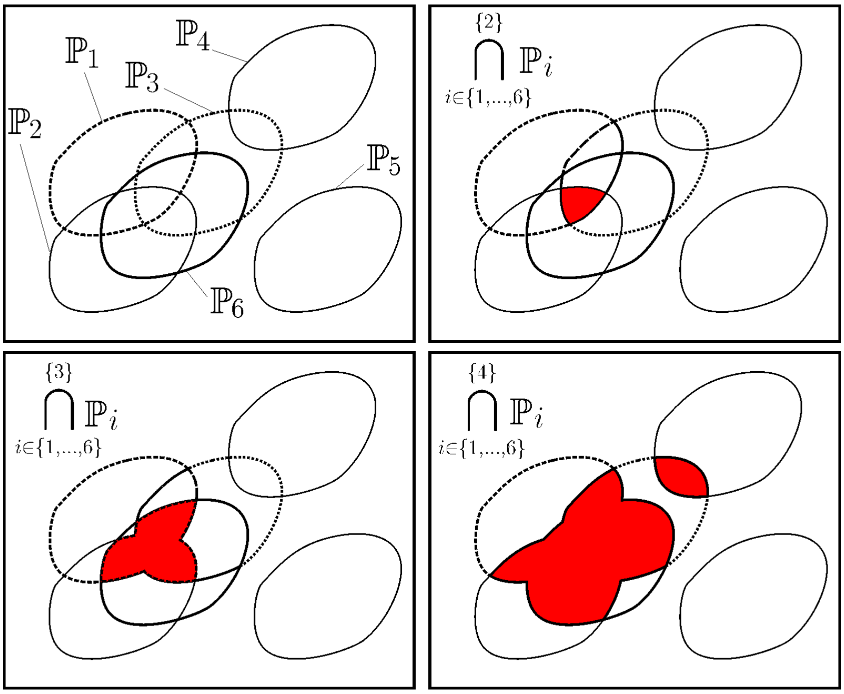
Inlier or outlier ?

$[y_i]$ is an inlier if $\mathbf{p}^* \in \mathbb{P}_i$.
It is an outlier if $\mathbf{p}^* \notin \mathbb{P}_i$.

OMNE (Outlier Minimal Number Estimator) [Walter and Lahanier, 1987]

$$
\begin{aligned}
\lambda(\mathbf{p}) &= \mathsf{card}\{i \mid \mathbf{p} \notin \mathbb{P}_i\} \\
q^* &= \min_{\mathbf{p}} \lambda(\mathbf{p}) \\
\mathbb{P} &= \lambda^{-1}(q^*) .
\end{aligned}
$$

2 Set formulation



q-relaxed intersection

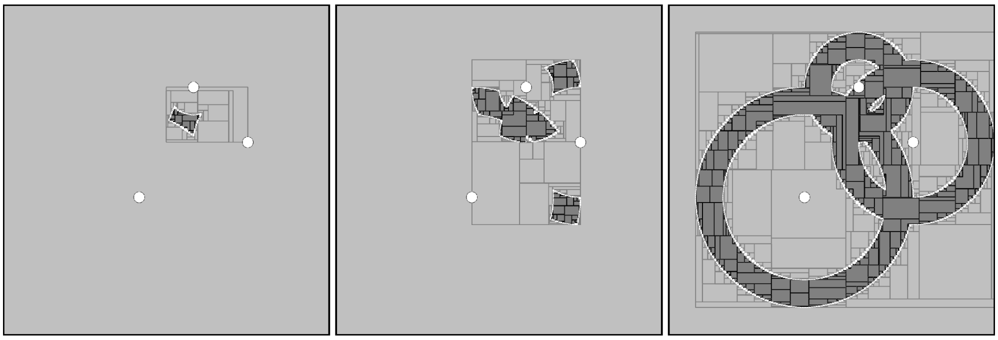
OMNE corresponds to

$$
\begin{aligned}
\mathbb{P}_i &= f_i^{-1}([y_i]) \\
\mathbb{P}^{\{q\}} &= \bigcap^{\{q\}} \mathbb{P}_i \\
q^* &= \min\left\{q \mid \mathbb{P}^{\{q\}} \neq \emptyset\right\} \\
\mathbb{P} &= \mathbb{P}^{\{q^*\}}.
\end{aligned}
$$

Outer GOMNE solves the problem with intervals and a local search.

3 Illustrative example

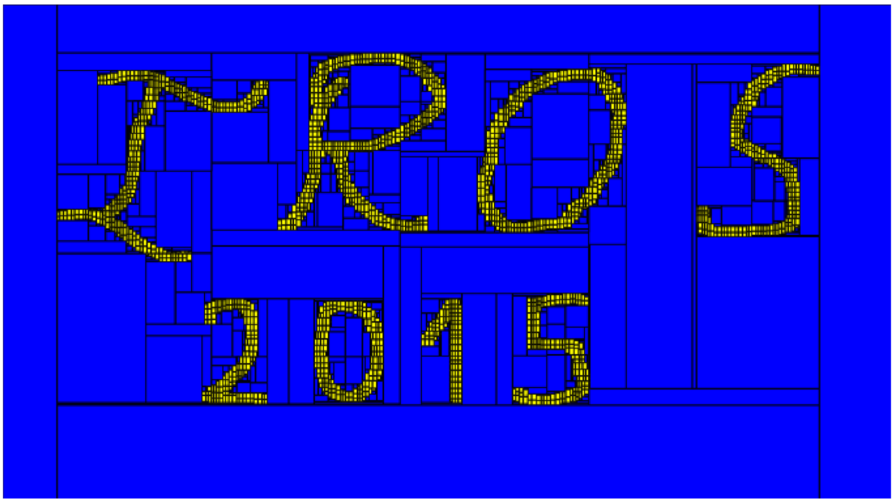
Range only localization with 3 landmarks using interval analysis.



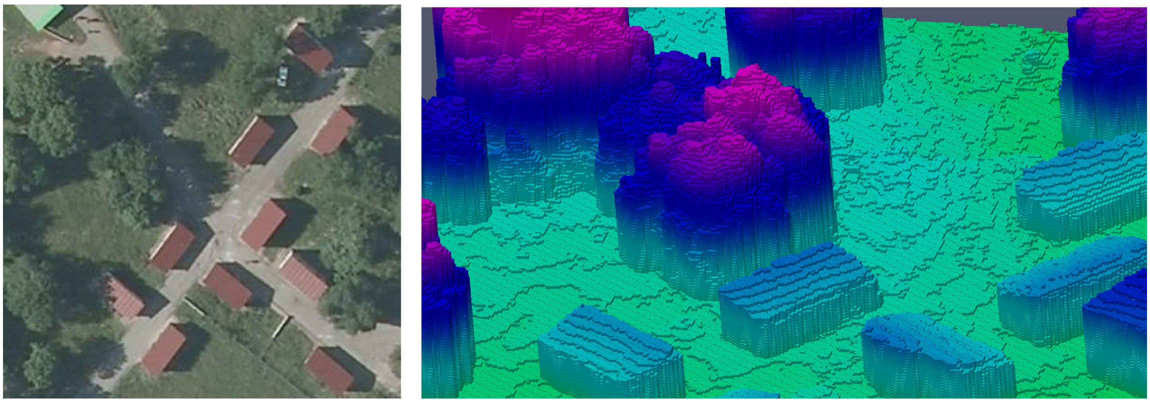
$\mathbb{P}^{\{0\}}, \mathbb{P}^{\{1\}}, \mathbb{P}^{\{2\}}$

4 DEM

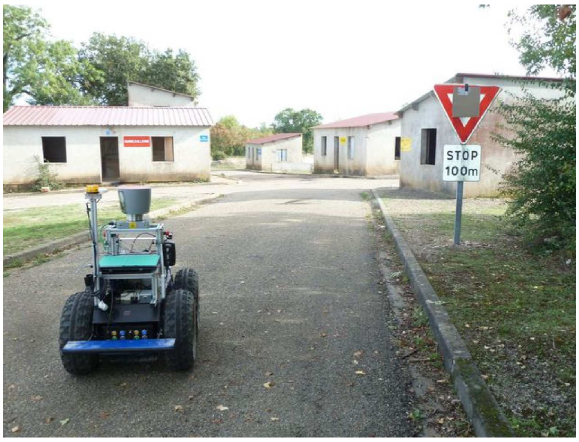
The map is described by $\mathbb{M} = \left(x_i, y_i, z_i\right), i \geq 1$.

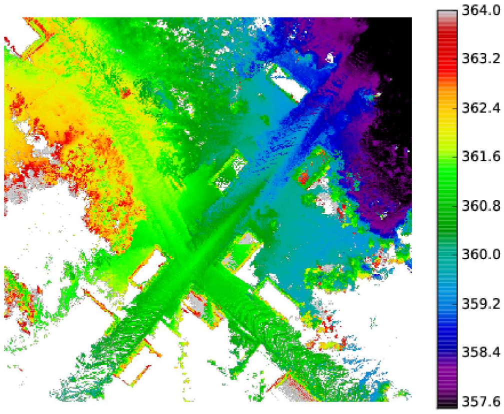


Example of digital map

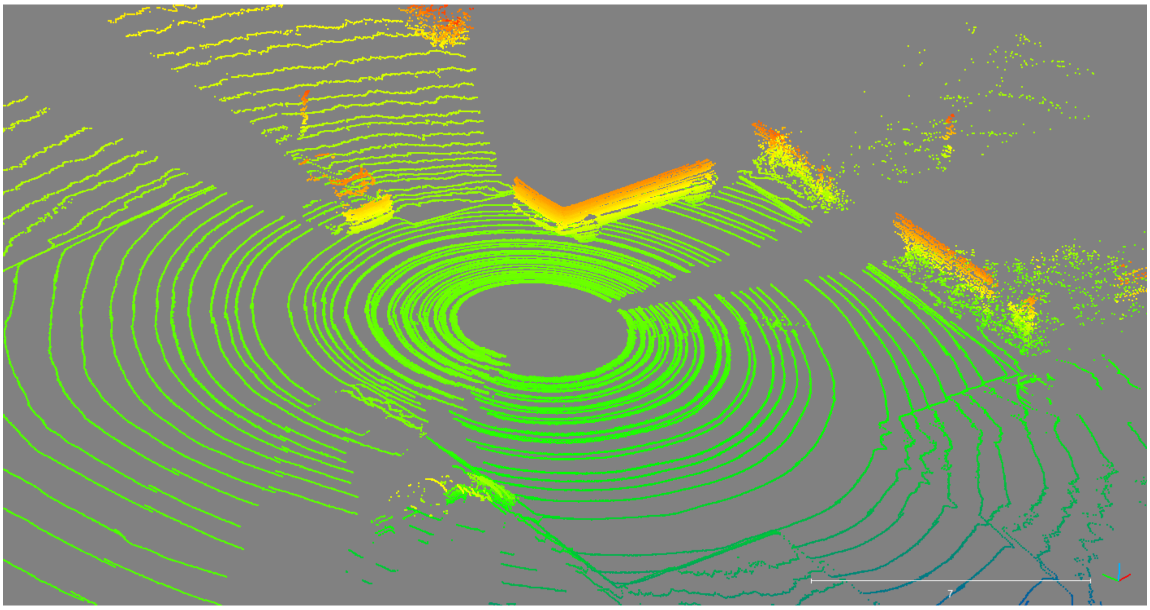


Aerial orthoimage built from UAV

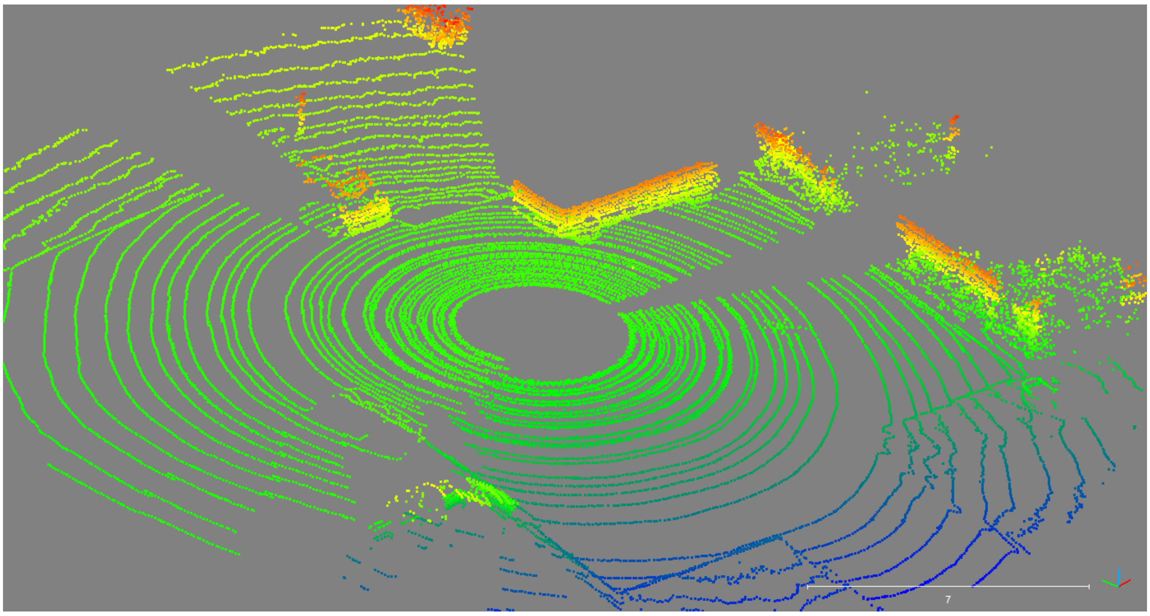




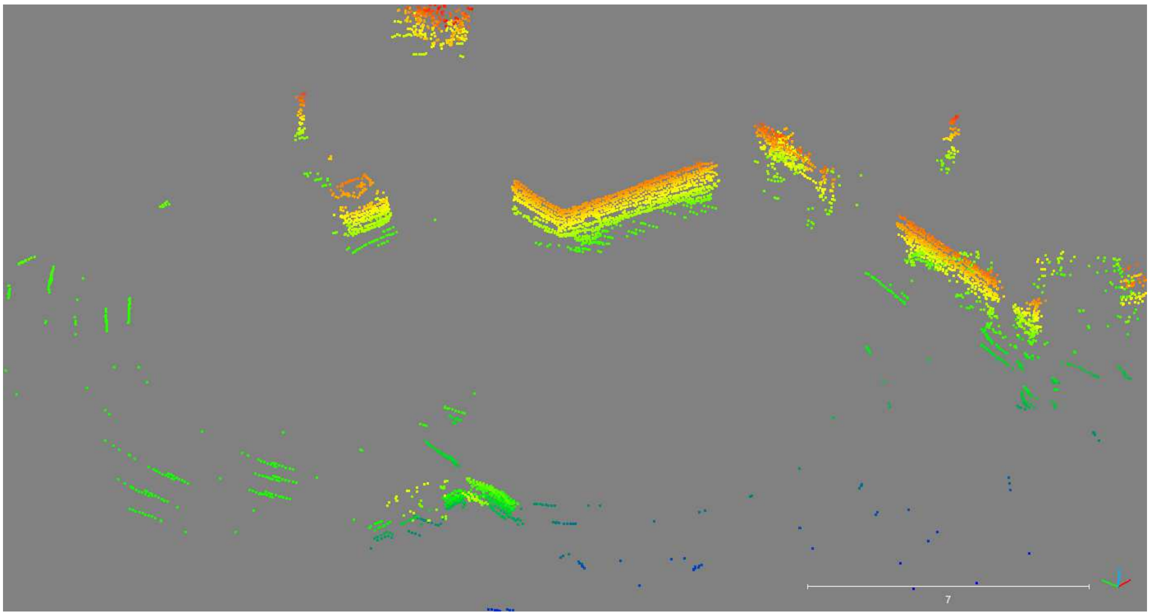
Velodyne Lidar



Original range data



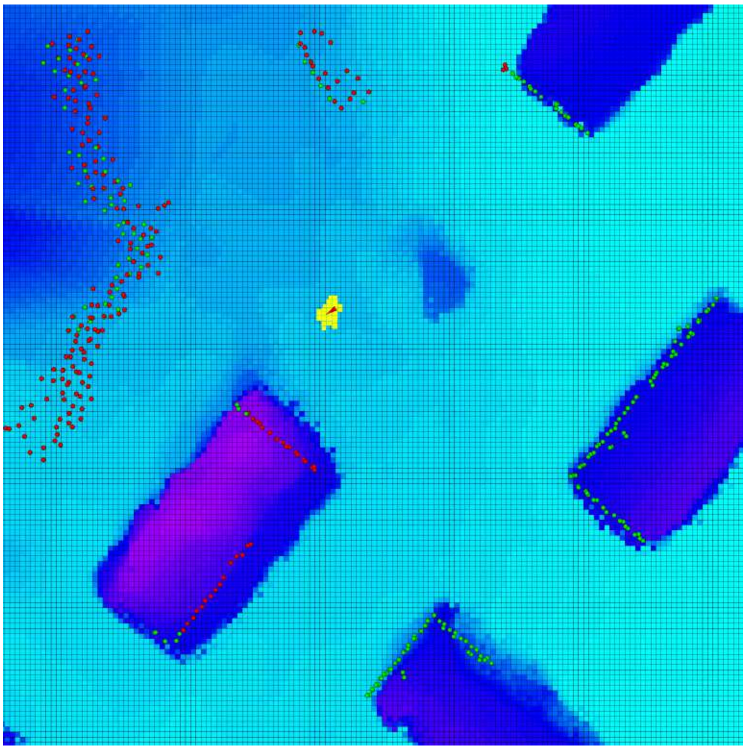
Down sampling



Extraction of vertical shapes

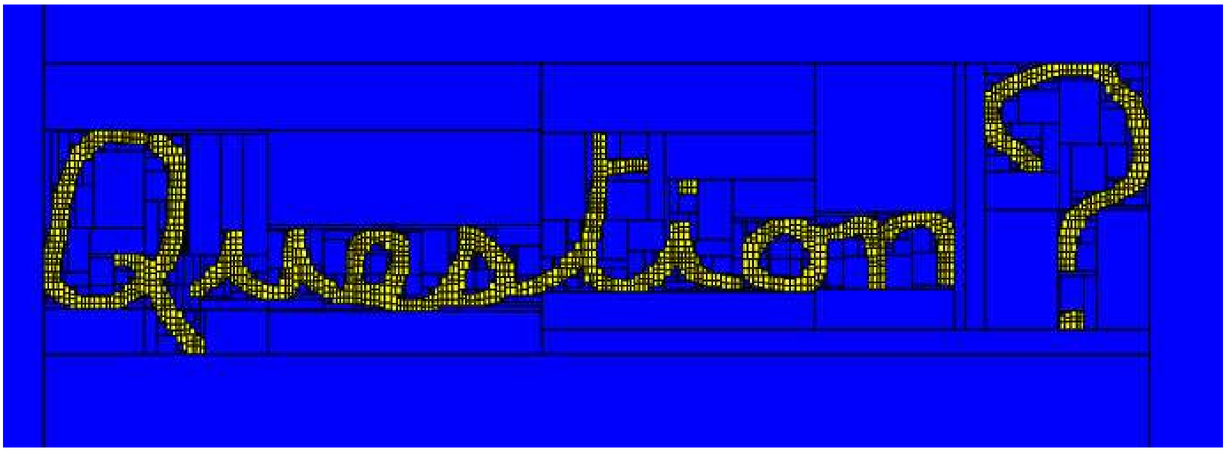
5 Localization

$$
\begin{aligned}
\mathbf{p} &= (x, y, \psi) \\
\mathbb{P}_i &= f_i^{-1}(\mathbb{M}) \\
\mathbb{P}^{\{q\}} &= \bigcap^{\{q\}} \mathbb{P}_i \\
q^* &= \mathsf{min}\left\{q \mid \mathbb{P}^{\{q\}} \neq \emptyset\right\} \\
\mathbb{P} &= \mathbb{P}^{\{q^*\}}.
\end{aligned}
$$



Contribution of the paper: We are able to compute the global minimum q^*.

We used a MonteCarlo search to speed up the calculus.


Question?