

IROS2013

New Horizon

A Visibility Information for Multi-Robot Localization

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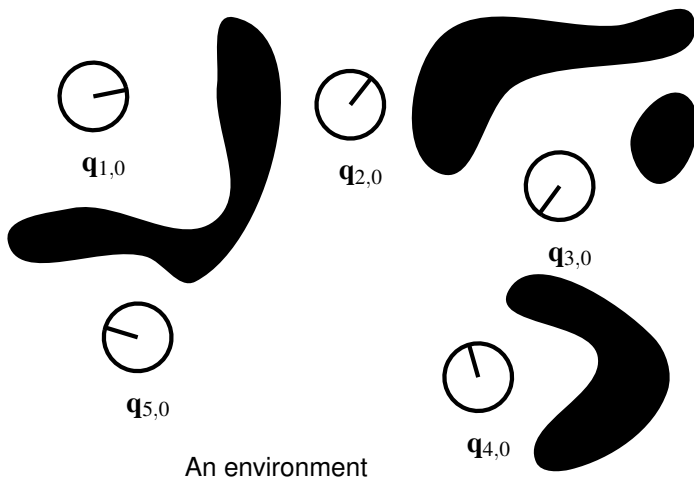


The problem

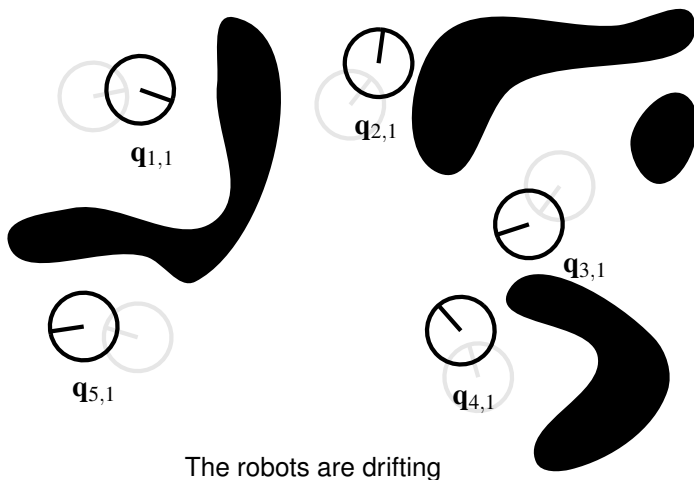
 $q_{1,0}$  $q_{2,0}$  $q_{3,0}$  $q_{5,0}$  $q_{4,0}$

A team of robots

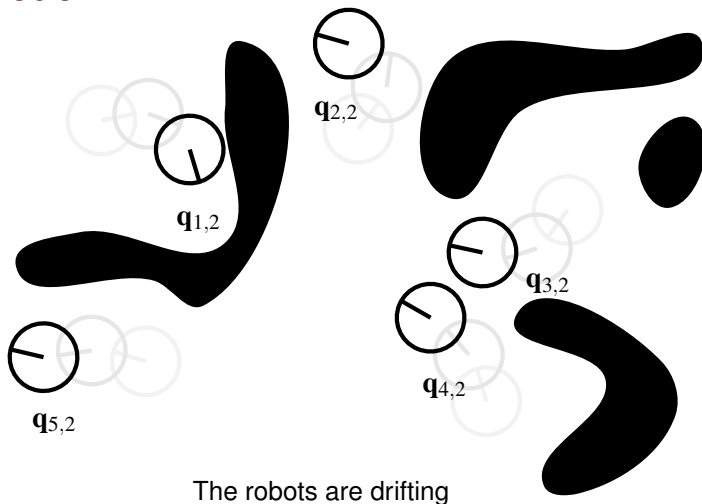
The problem



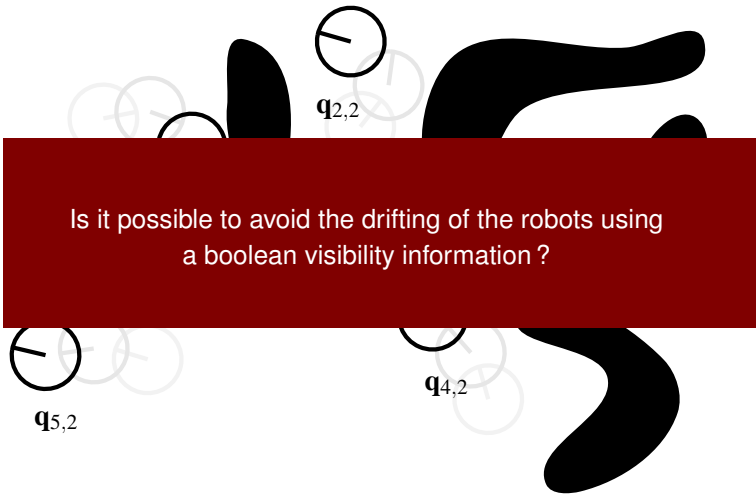
The problem



The problem



The problem



Is it possible to avoid the drifting of the robots using
a boolean visibility information ?

 $q_{5,2}$ $q_{4,2}$ $q_{2,2}$

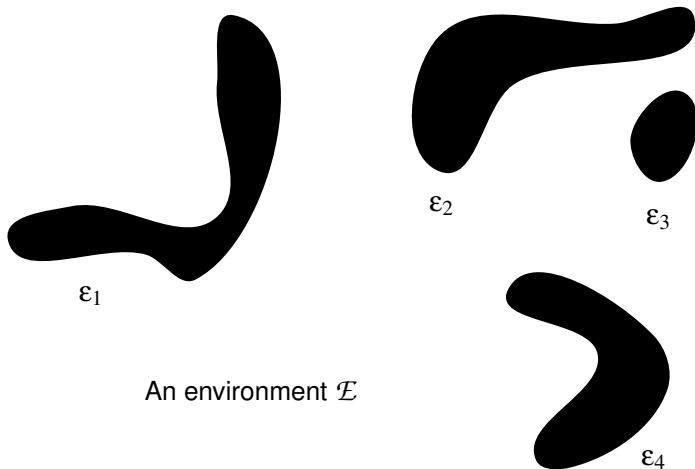
Summary

- 1 Presentation
- 2 The proposed method
- 3 Results

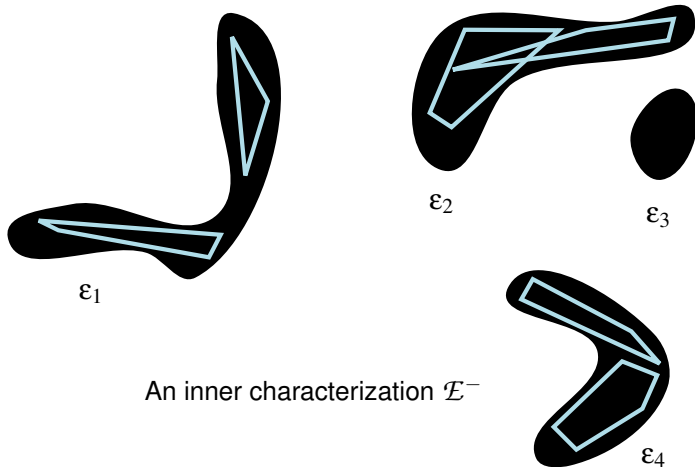
The environment

- An environment \mathcal{E} is a set of m obstacles : $\mathcal{E} = \bigcup_{j=1}^m \varepsilon_j$
- An obstacle ε_j is a connected subset of \mathbb{R}^2
- Inner and outer characterizations : \mathcal{E}^- and \mathcal{E}^+
 - $\mathcal{E}^- \subset \mathcal{E} \subset \mathcal{E}^+$
 - Sets of segments (convex polygons)

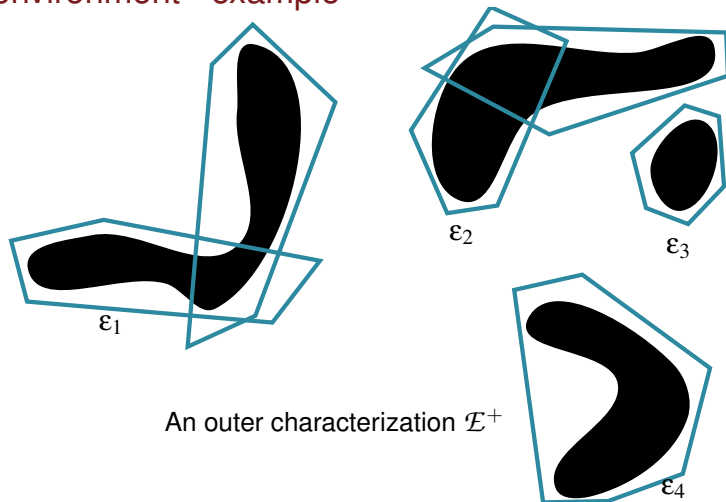
The environment - example



The environment - example



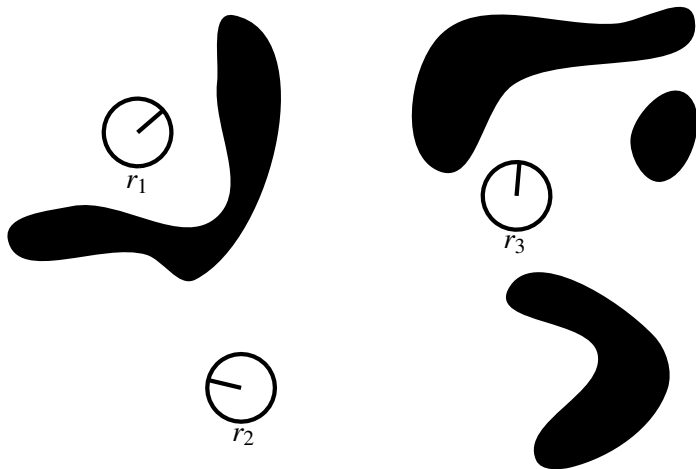
The environment - example



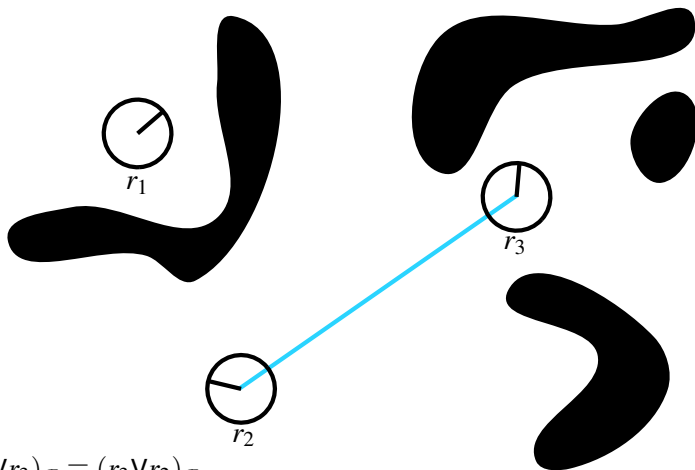
The robots

- A team \mathcal{R} is a set of robots
- A robot r_i is characterized by the discrete time dynamic equation :
$$\mathbf{q}_{i,k+1} = f(\mathbf{q}_{i,k}, \mathbf{u}_{i,k})$$
 - $\mathbf{q}_{i,k} = (\mathbf{x}_{i,k}, \theta_{i,k})$
- Evaluation of $\mathbf{u}_{i,k}$ using odometry
- Evaluation of $\theta_{i,k}$ using a compass
- Measurements : the visibility between the robots

The visibility information

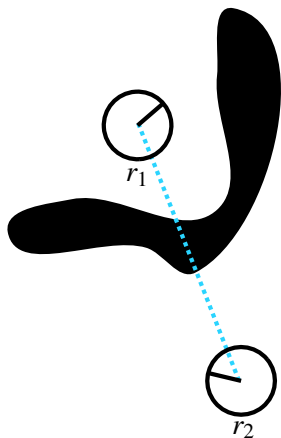


The visibility information

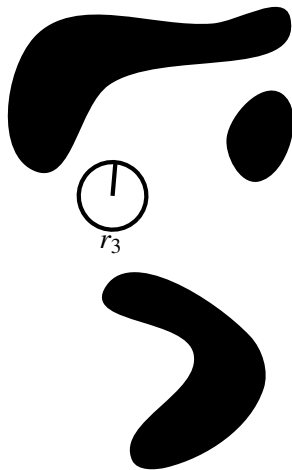


$$(r_2 \mathbf{V} r_3)_{\mathcal{E}} \equiv (r_3 \mathbf{V} r_2)_{\mathcal{E}}$$

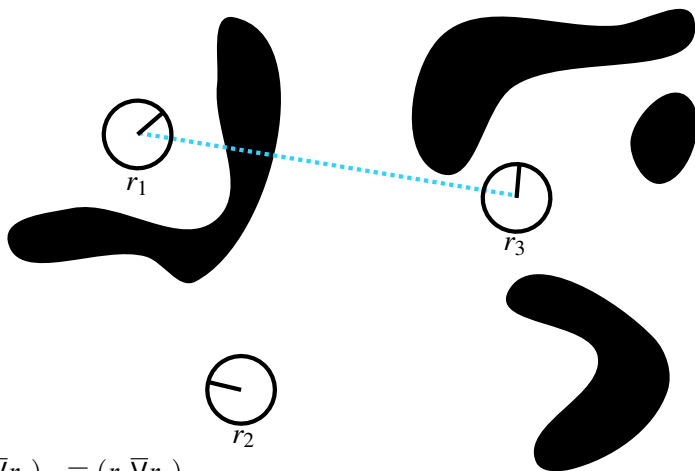
The visibility information



$$(r_1 \bar{V} r_2)_{\mathcal{E}} \equiv (r_2 \bar{V} r_1)_{\mathcal{E}}$$



The visibility information



$$(r_1 \bar{V} r_3)_{\mathcal{E}} \equiv (r_3 \bar{V} r_1)_{\mathcal{E}}$$

The robots

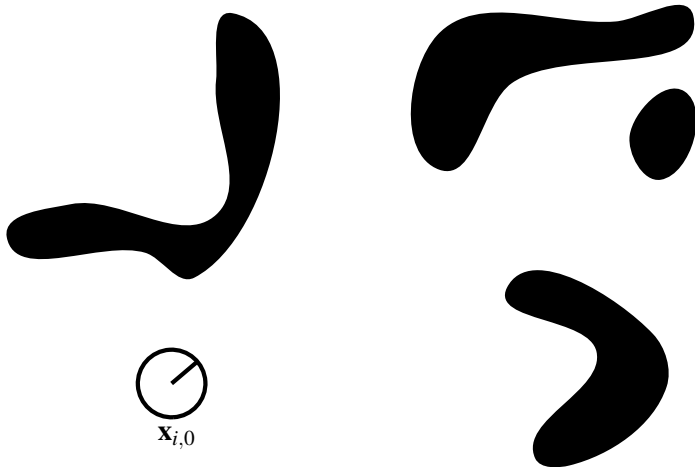
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$$\mathbf{q}_{i,k+1} = f(\mathbf{q}_{i,k}, \mathbf{u}_{i,k})$$
 - $\mathbf{q}_{i,k} = (\mathbf{x}_{i,k}, \theta_{i,k})$
- Evaluation of $\mathbf{u}_{i,k}$ using odometry
- Evaluation of $\theta_{i,k}$ using a compass
- Measurements : the visibility between the robots
 - $\mathbf{z}_{i,t} = \{0, 1, 1, \dots, 0\}$

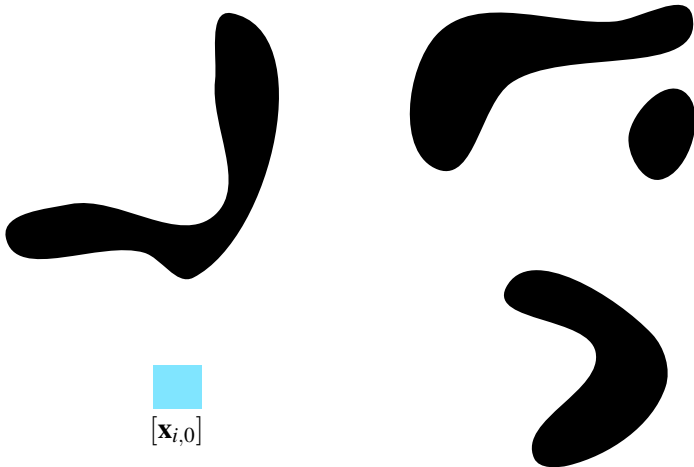
The approach

- Pose tracking problem
 - Robot initial poses are known
- Bounded error context
 - $\mathbf{x}_{i,0} \in [\mathbf{x}_{i,0}]$
 - $\mathbf{u}_{i,0} \in [\mathbf{u}_{i,0}]$
 - $\theta_{i,k} \in [\theta_{i,k}]$

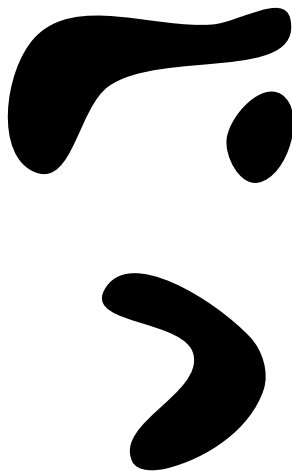
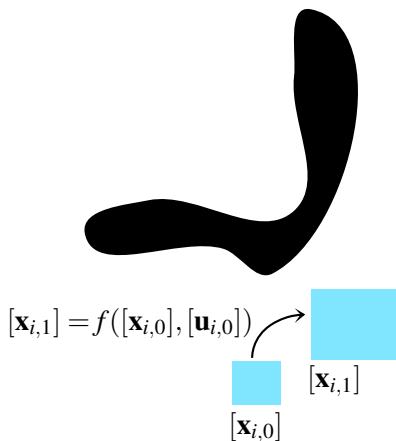
Set-membership drifting



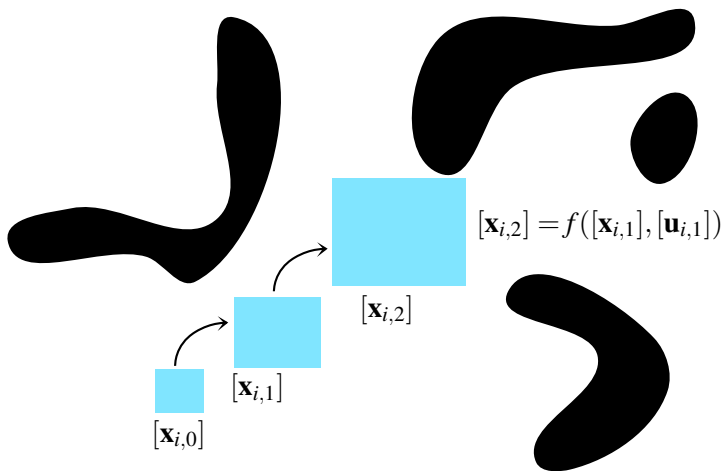
Set-membership drifting



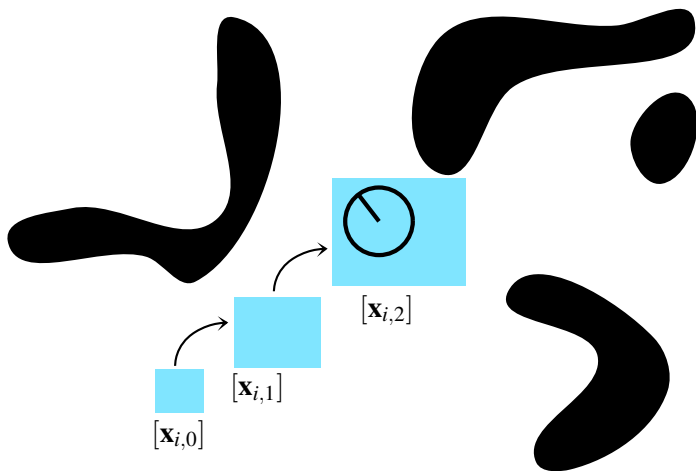
Set-membership drifting



Set-membership drifting



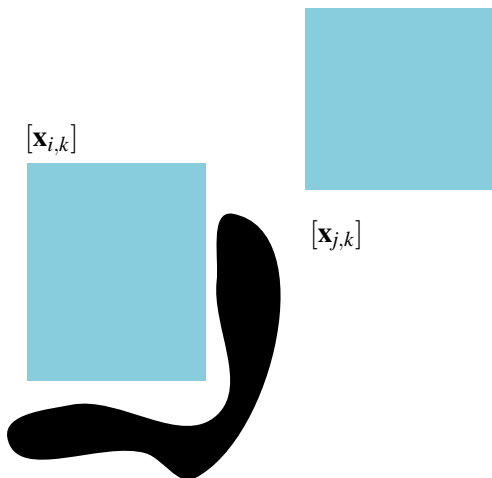
Set-membership drifting



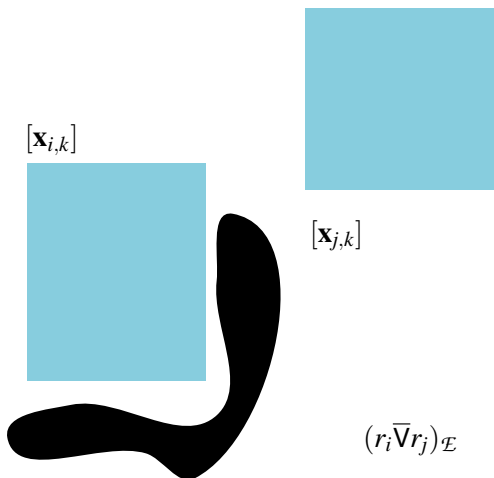
Objective

How to contract a box over a visibility (non-visibility) information ?

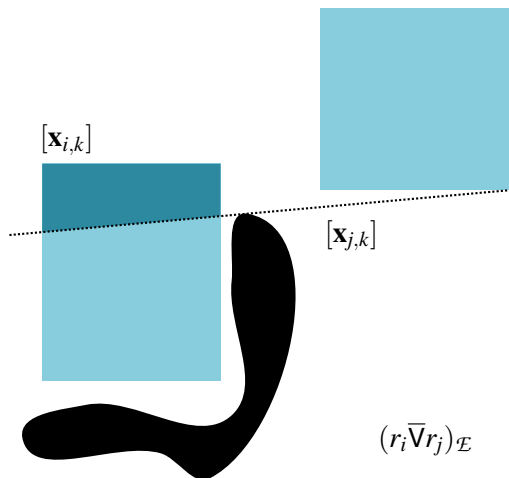
Objective



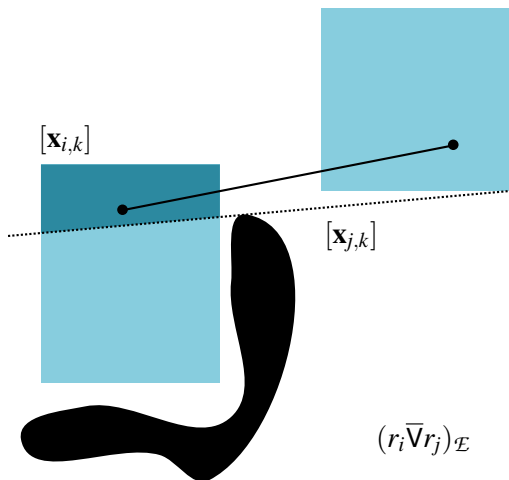
Objective



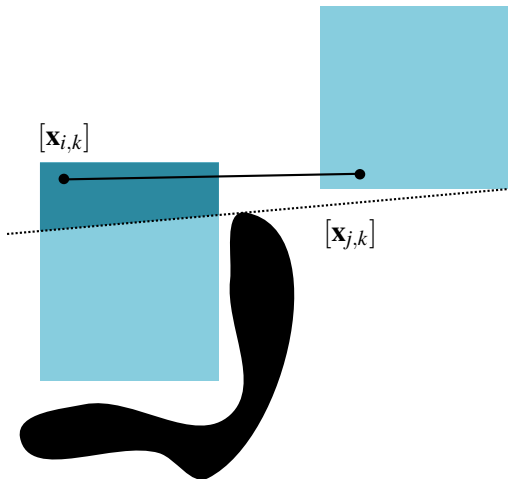
Objective



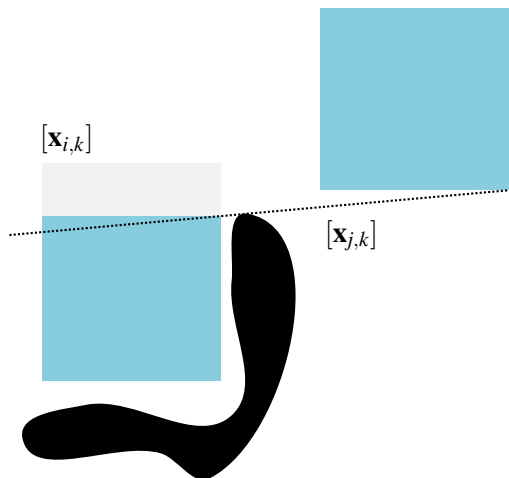
Objective



Objective

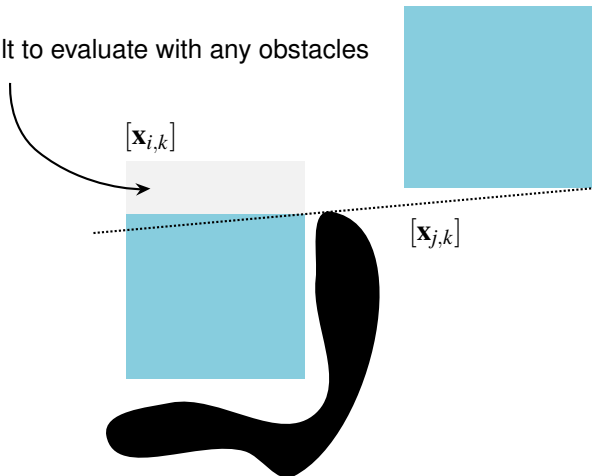


Objective



Objective

Difficult to evaluate with any obstacles



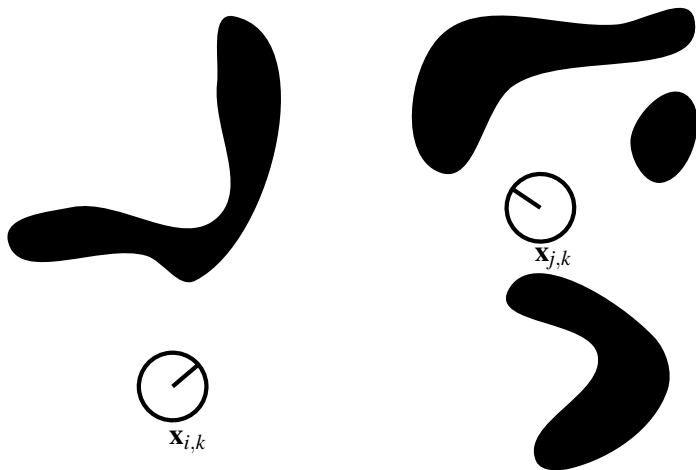
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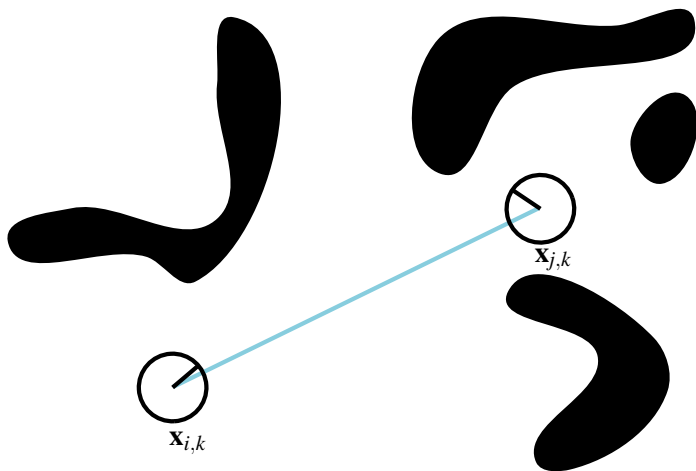
Environment/characterizations

- $(r_i \mathbf{V} r_j)_{\mathcal{E}} \Rightarrow (r_i \mathbf{V} r_j)_{\mathcal{E}^-}$
- $(r_i \bar{\mathbf{V}} r_j)_{\mathcal{E}} \Rightarrow (r_i \bar{\mathbf{V}} r_j)_{\mathcal{E}^+}$

Environment/characterizations - example

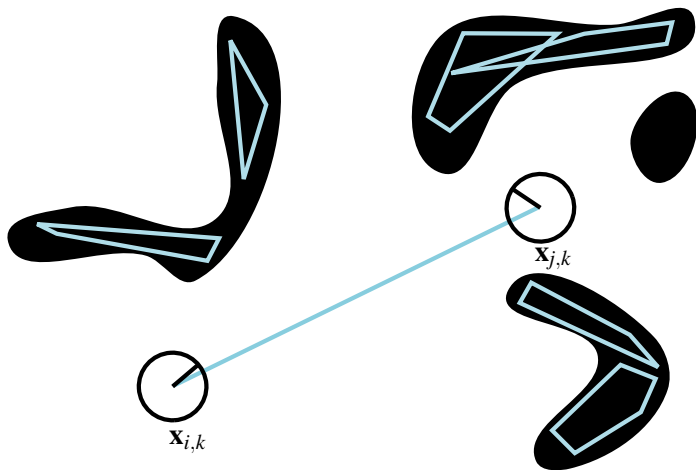


Environment/characterizations - example



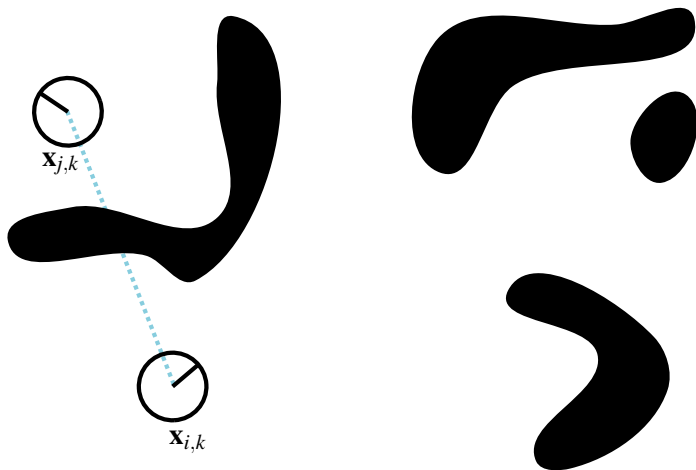
$$(r_i \vee r_j)_{\mathcal{E}}$$

Environment/characterizations - example



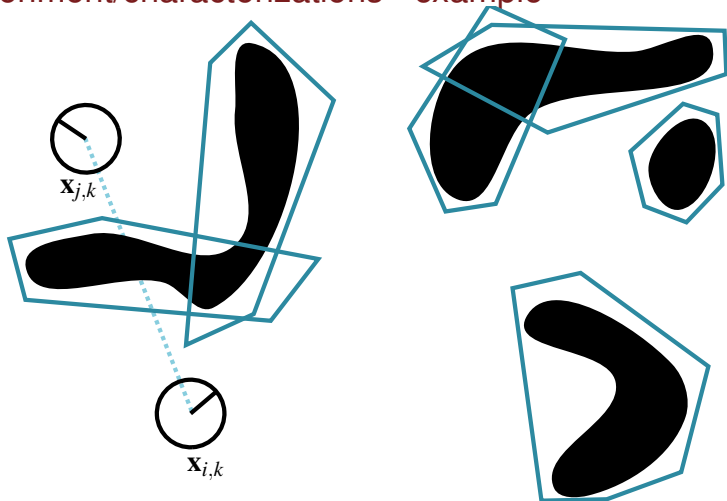
$$(r_i \forall r_j)_{\mathcal{E}} \Rightarrow (r_i \forall r_j)_{\mathcal{E}^-}$$

Environment/characterizations - example



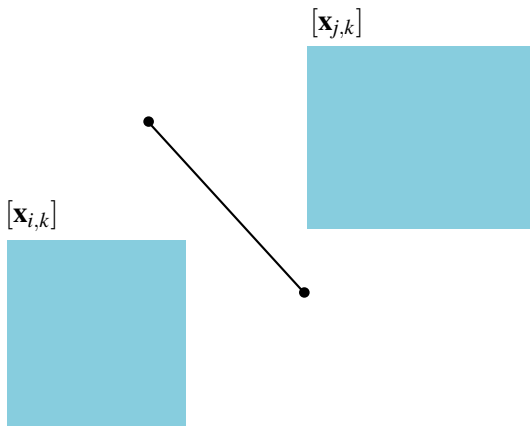
$$(r_i \bar{V} r_j)_{\mathcal{E}}$$

Environment/characterizations - example

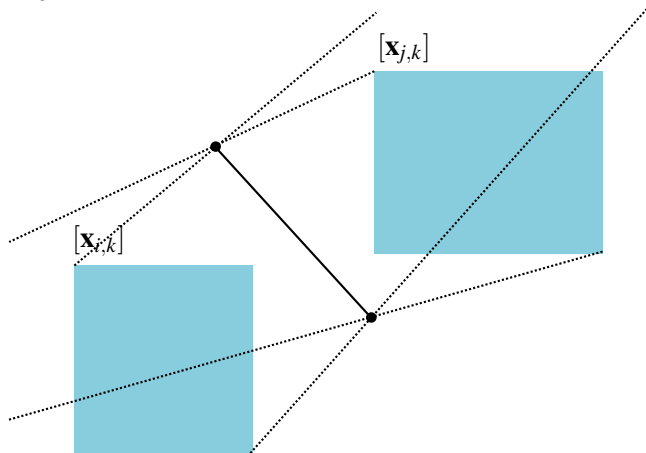


$$(r_i \bar{V} r_j)_{\mathcal{E}} \Rightarrow (r_i \bar{V} r_j)_{\mathcal{E}^+}$$

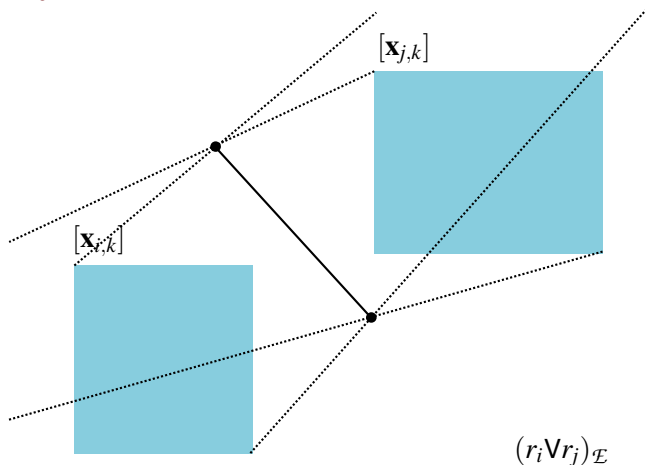
Visibility contractors



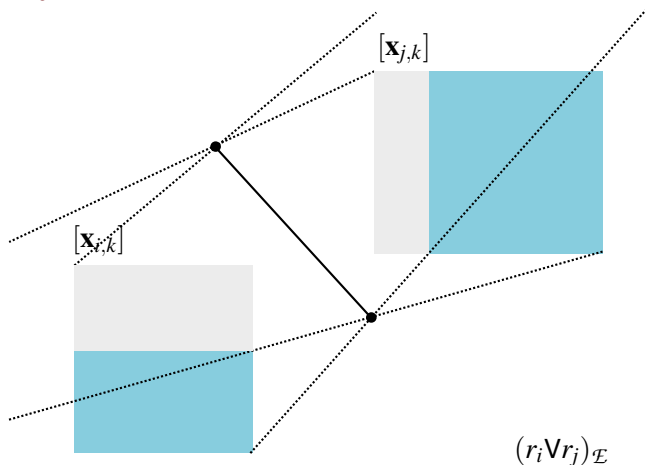
Visibility contractors



Visibility contractors



Visibility contractors



Video

Conclusion

- The visibility information allows to avoid the drifting
- The topology of the environment and the number of robots are important factor for the efficiency of the method
- The visibility can be added to classical methods
- Perspectives :
 - Maximal range for the visibility
 - Restrain the vision field of the robots

Questions

Thank you