

Distributed autonomous encirclement of a wheeled robot formation with collision avoidance

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Intelligent Distributed Systems
DD December 2023



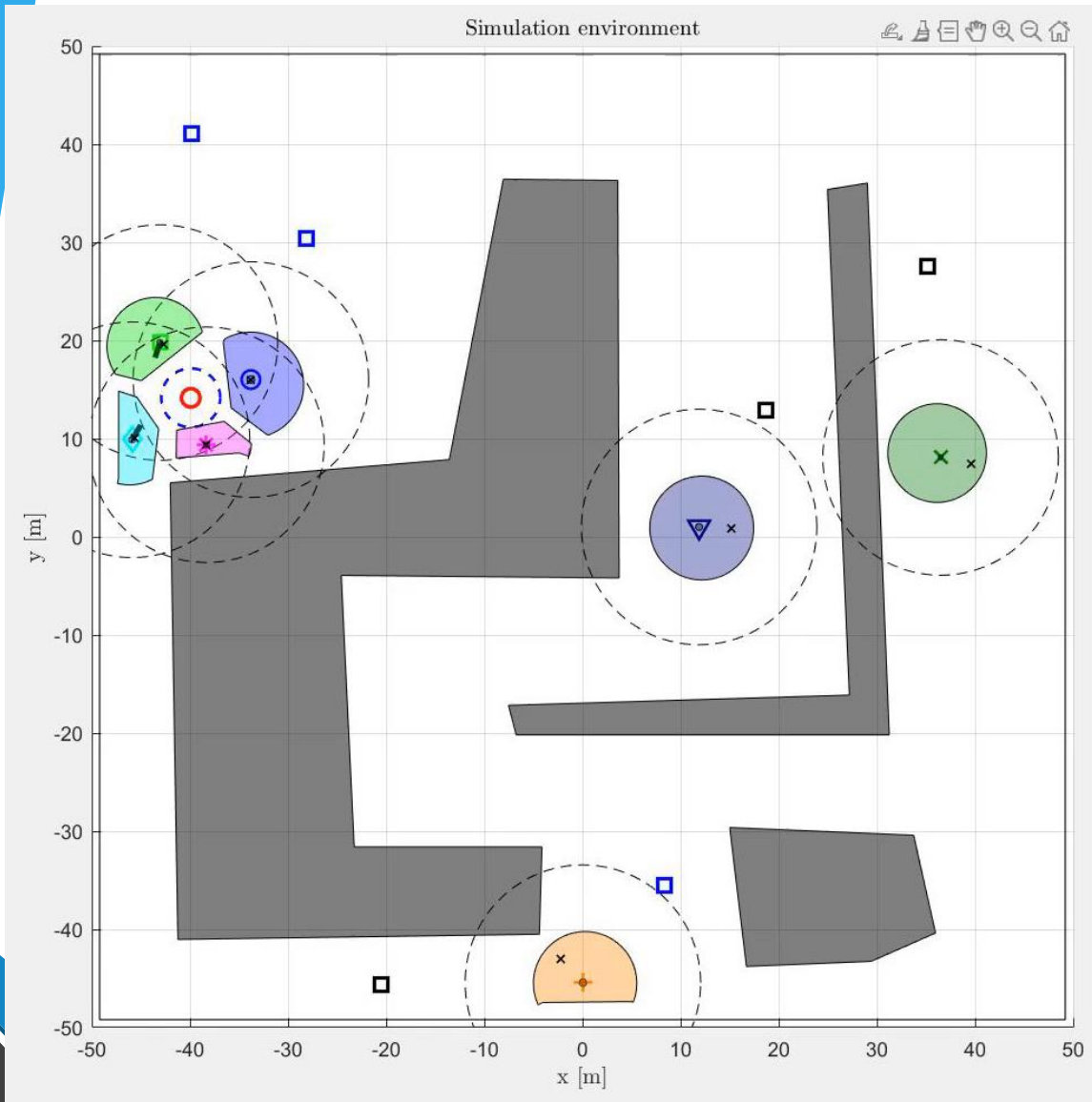
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Ingegneria Industriale



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Context and goal explanation



- Goal: Moving target encirclement
- Solution:
 - Localization
 - Exchange information
 - Motion control

Robot equipment

- Robot: moving circular entity with encumbrance δ

- Dynamics:

- Linear
$$\bar{x}_{R,i+1} = \bar{x}_{R,i} + \bar{u}_i + \bar{v}_i$$

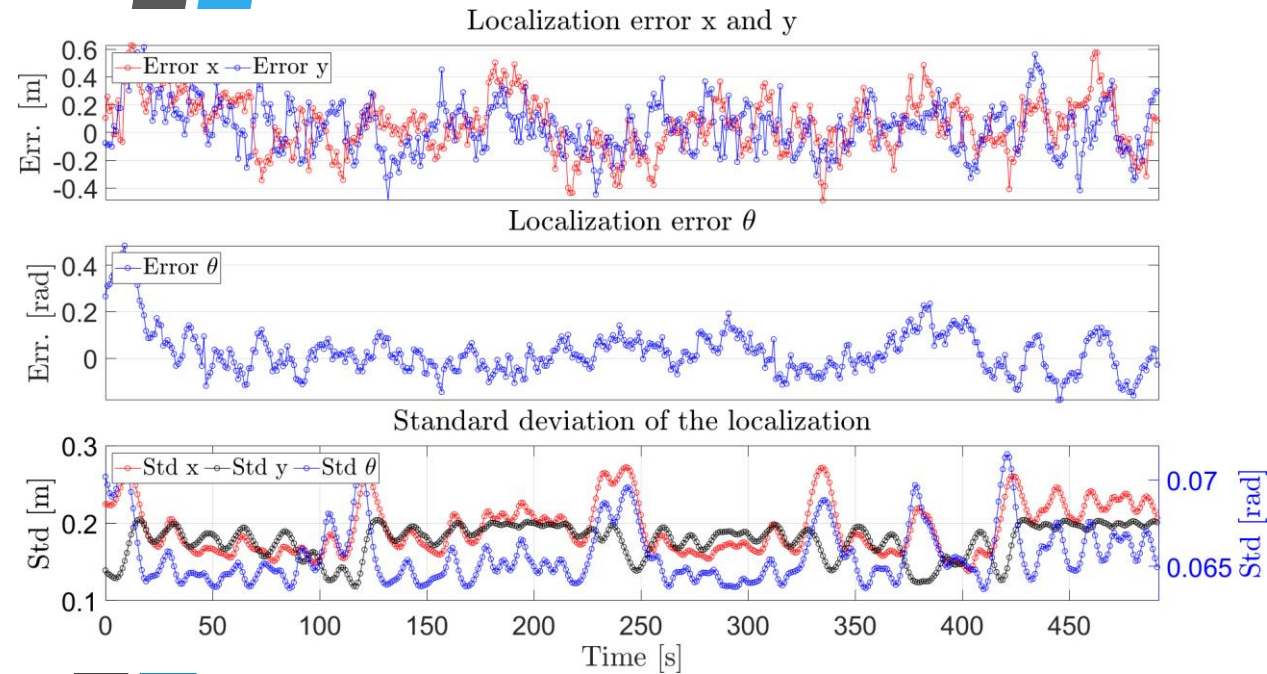
- Unicycle
$$\begin{bmatrix} \bar{x}_R \\ \theta_R \end{bmatrix}_{i+1} = \begin{bmatrix} \bar{x}_R \\ \theta_R \end{bmatrix}_i + \begin{bmatrix} \cos(\theta_R) & 0 \\ \sin(\theta_R) & 0 \\ 0 & 1 \end{bmatrix}_i \bar{u}_i + \bar{v}_i$$

- Sensors:

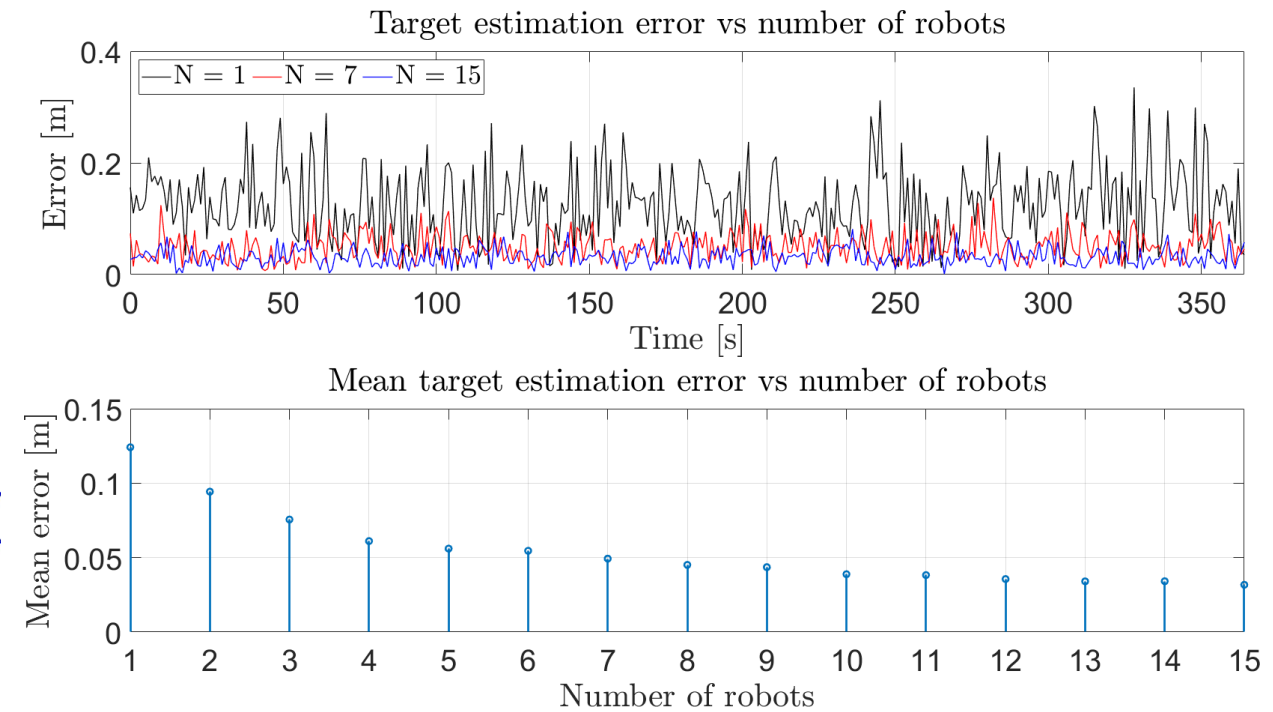
- GPS: $\sigma = 3 [m]$
 - Stereo camera / Relative distance sensor: $\sigma = 0.3 [m]$
 - $R_{\text{com}} = R_{\text{cam}} = 12 [m]$

Robot localization

Extended Kalman filter



Distributed WLS

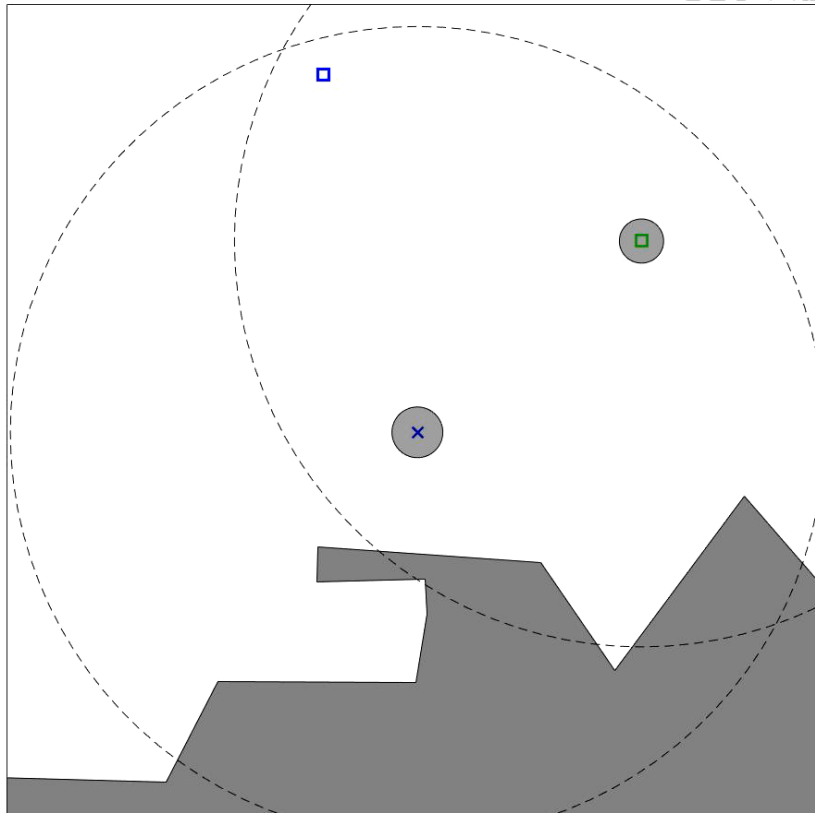


Voronoi tessellation

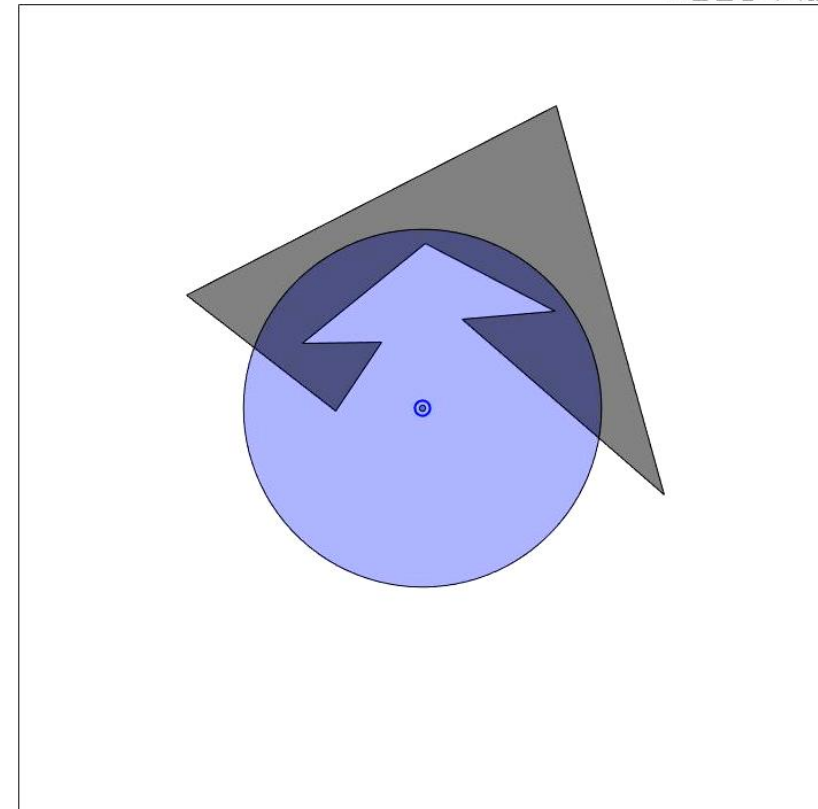
The voronoi cell considers:

- Uncertainty on robot localization (self and reciprocal)
- Robot encumbrance

Voronoi explanation

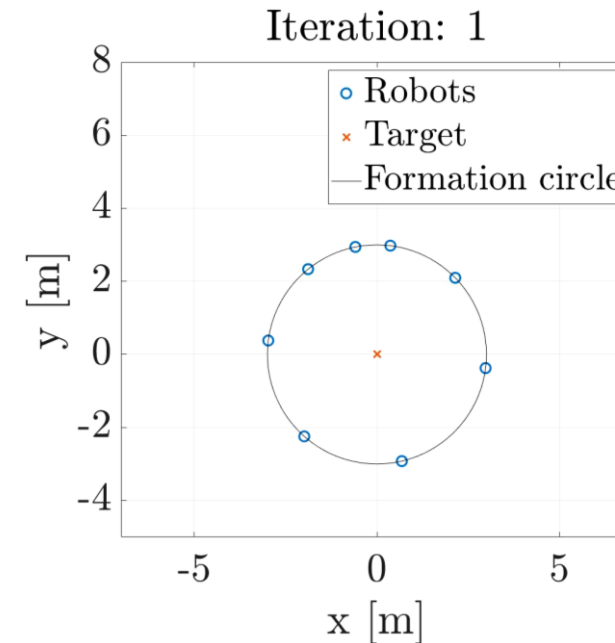
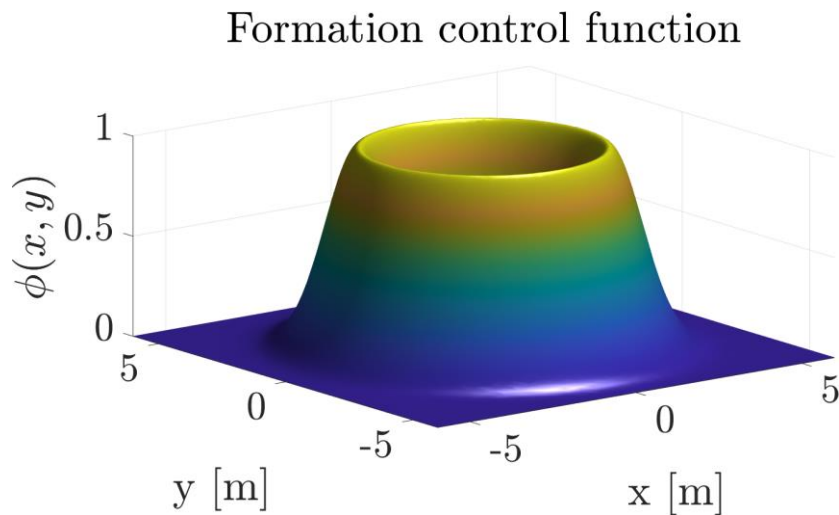


Initial scenario

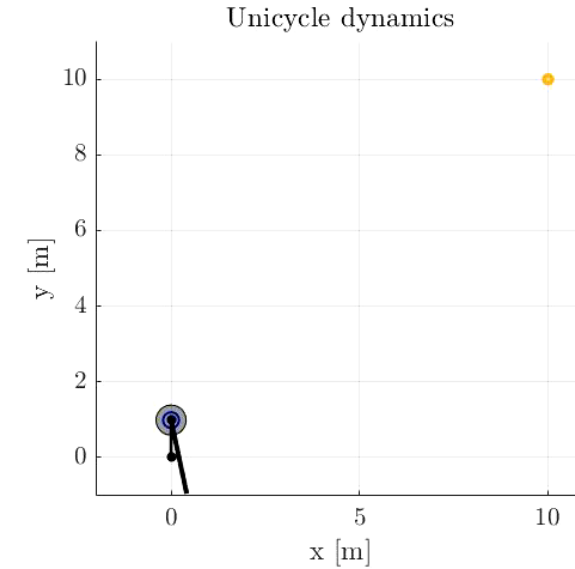
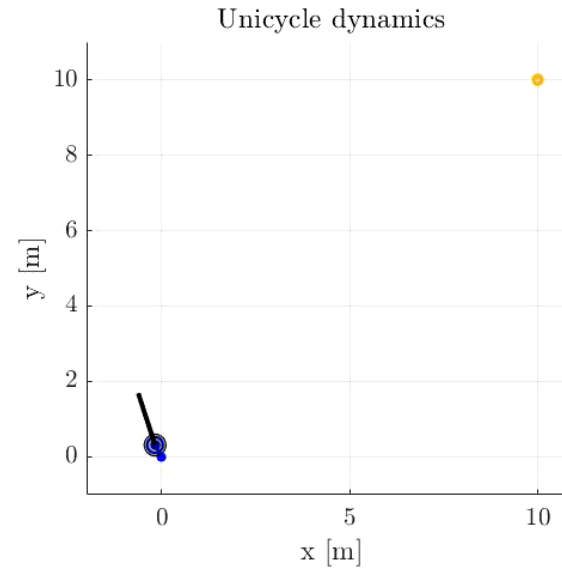
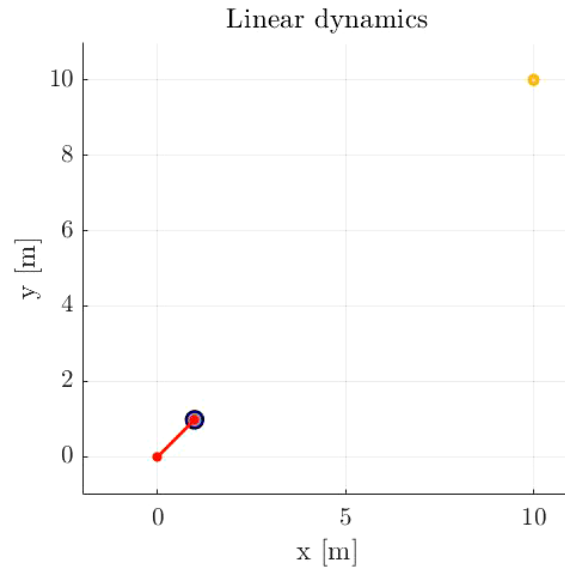


Motion control – High level

- It defines a goal position for the low level control
- Target search: random search of the target
- Target reaching
- Keeping equidistance



Motion control – Low level



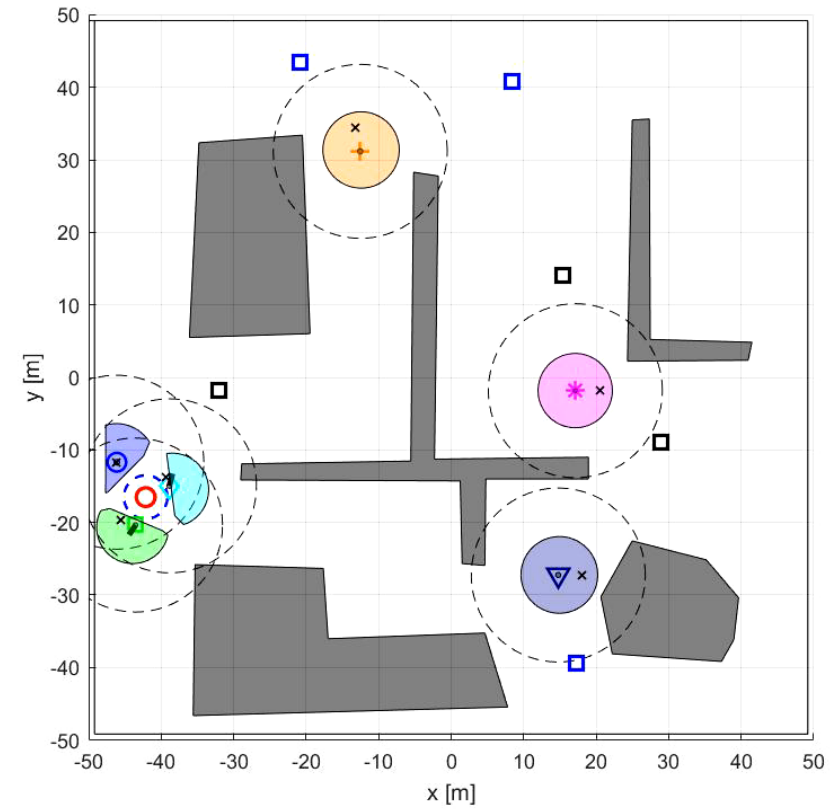
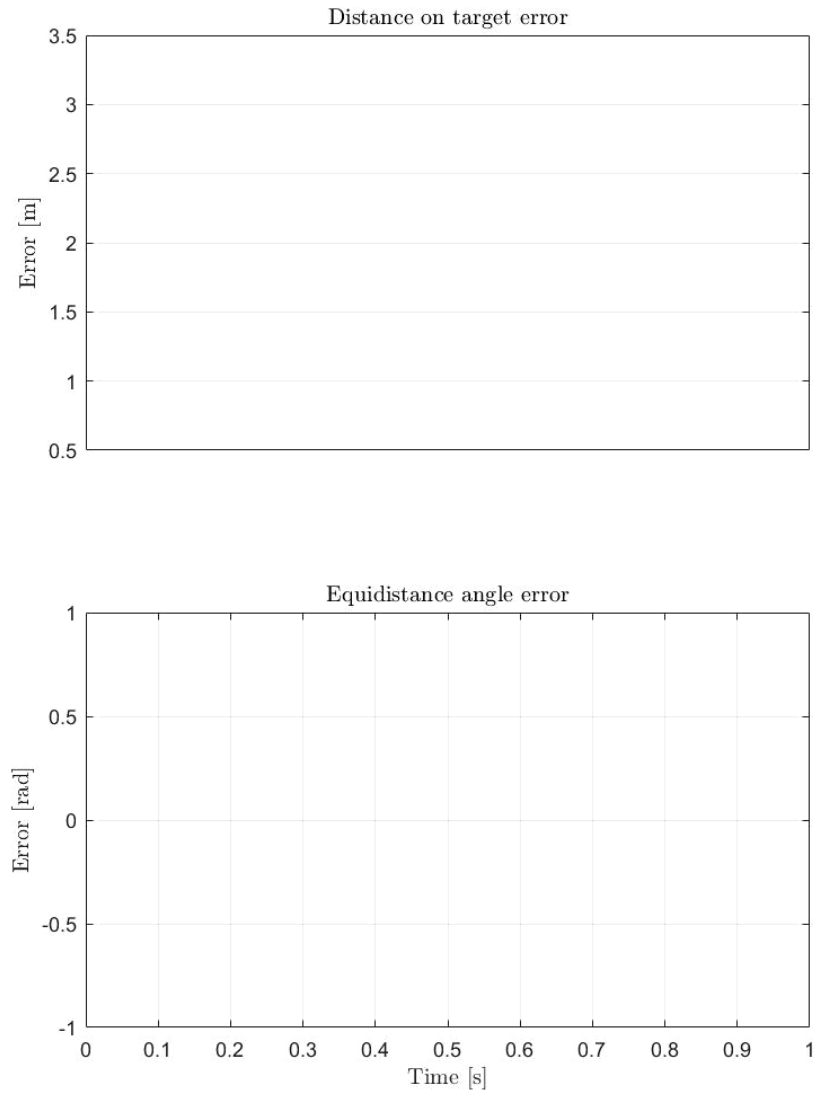
Linear Dynamics

$$\bar{x}_{R,i+1} = \bar{x}_{R,i} + \min(k_p (\bar{x}_{R,i} - \bar{x}_D), v_{MAX}) \Delta t$$

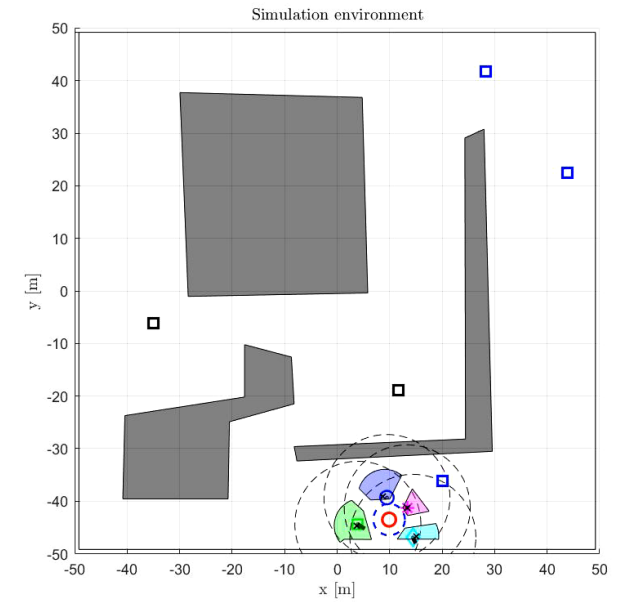
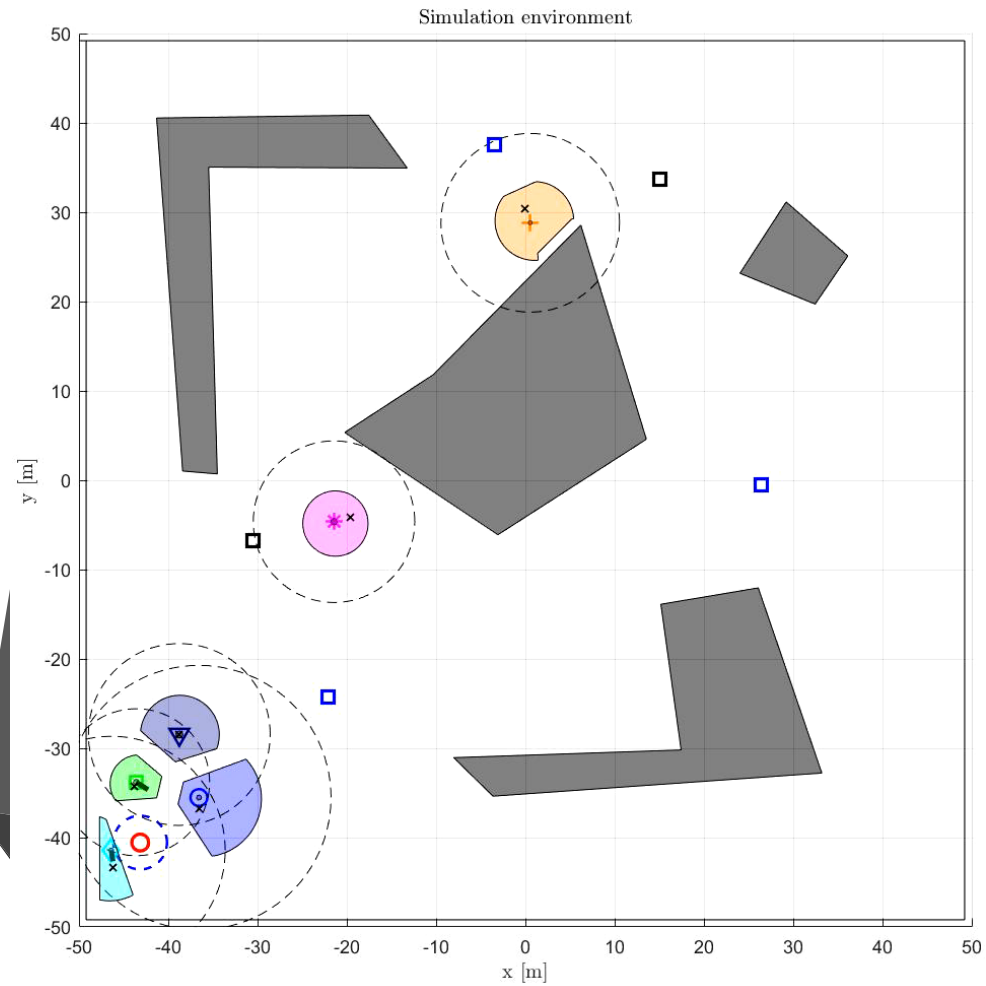
Unicycle Dynamics

$$v = \min(k_p \|\bar{x}_R - \bar{x}_D\|, v_{MAX}) \cos(\gamma_m)$$

$$\omega = \min(k_p |\gamma_M|, \omega_{MAX}) \cdot \begin{cases} 1 & (\alpha_D \geq \theta_R \wedge \gamma_M < \pi) \\ -1 & (\alpha_D < \theta_R \wedge \gamma_M > \pi) \\ \text{otherwise} & \end{cases} \vee$$



Extra results



Conclusions

- Performed tasks:
 - Localization
 - Information distribution
 - Voronoi tessellation and Motion control
- Improvements:
 - Increase localization accuracy with distributed SLAM
 - Model Predictive Control to enhance the non linear trajectory
 - Environment - adaptive formation function