Model Predictive Control for Drones Navigating Dynamic Obstacles

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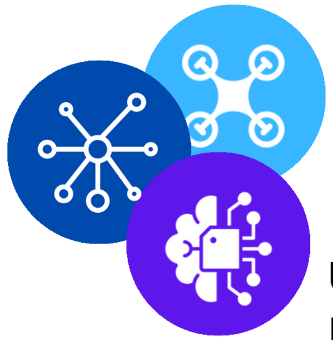
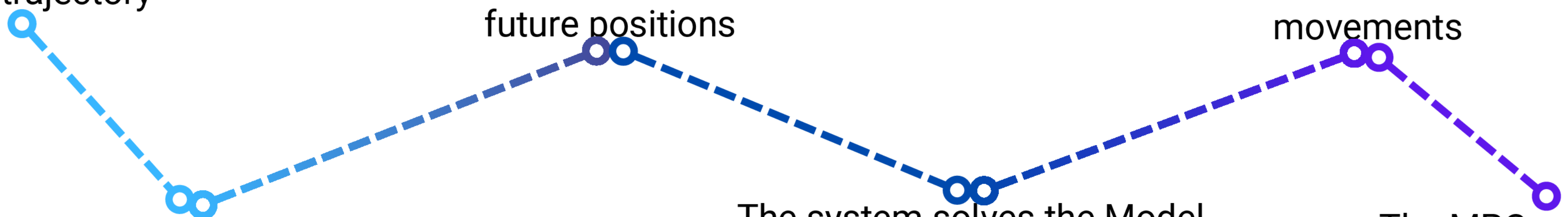
1. Context and Goal

- Rescue situation with specific trajectory to be followed;
- Civil construction inspection;
- Secure and vigilance.



2. Proposed Scenario



3. The Projet

3.1 Problem Formulation & Considered Theoretical Approach

Turtlebot Control

$$\mathbf{r}(t) = \begin{bmatrix} r\cos(\omega t) & r\sin(\omega t) \\ r\cos(\omega t + \frac{2\pi}{3}) & r\sin(\omega t + \frac{2\pi}{3}) \\ r\cos(\omega t - \frac{2\pi}{3}) & r\sin(\omega t - \frac{2\pi}{3}) \end{bmatrix}$$

$$u_i(t) = k_p(\mathbf{r}(t) - \mathbf{x}_i(t)) + k_d(\dot{\mathbf{r}}(t))$$

MPC

$$\mathcal{L}_{\text{gate-follow}} = \sum_{h=1}^{H-1} (\mathbf{x}_h^q - \mathbf{x}_{t_i}^g)^T \mathbf{Q}_f (\mathbf{x}_h^q - \mathbf{x}_{t_i}^g) \cdot w_h \cdot (1 - p_h)$$

$$\mathcal{L}_{\text{terminal}} = (\mathbf{x}_H^q - \mathbf{x}^{\text{goal}})^T \mathbf{Q}_{\text{goal}} (\mathbf{x}_H^q - \mathbf{x}^{\text{goal}})$$

$$\mathcal{L}_{\text{u}} = \sum_{h=1}^{H-1} (\mathbf{u}_h^q - \mathbf{u}_r)^T \mathbf{Q}_{\text{u}} (\mathbf{u}_h^q - \mathbf{u}_r)$$

CasADi

Quadrotor Dynamics

$$\mathbf{p}_{WB}^q = [p_x^q, p_y^q, p_z^q]^T$$

$$\mathbf{v}_{WB}^q = [v_x^q, v_y^q, v_z^q]^T$$

$$\mathbf{q}_{WB} = [q_w, q_x, q_y, q_z]^T$$

$$\mathbf{x}^q = [\mathbf{p}^q, \mathbf{q}^q, \mathbf{v}^q]$$

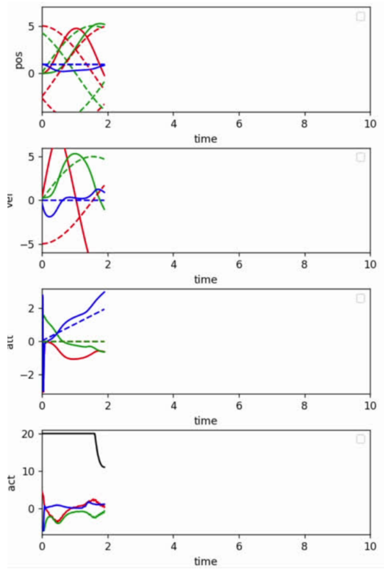
$$\dot{\mathbf{p}}_{WB} = \mathbf{v}_{WB} \qquad \dot{\mathbf{q}}_{WB} = \frac{1}{2}\mathbf{\Lambda}(\boldsymbol{\omega}_B) \cdot \mathbf{q}_{WB}$$

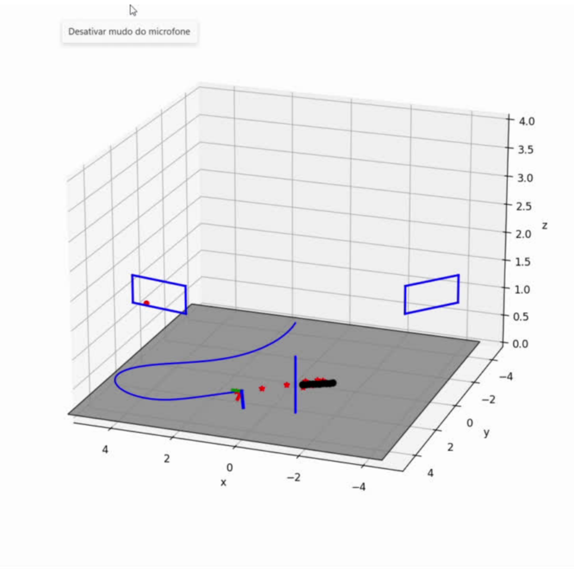
$$\dot{\mathbf{v}}_{WB} = \mathbf{q}_{WB} \odot \mathbf{c} - \mathbf{g} \qquad \dot{\boldsymbol{\omega}}_B = \mathbf{J}^{-1}(\boldsymbol{\eta} - \boldsymbol{\omega}_B \times \mathbf{J}\boldsymbol{\omega}_B)$$

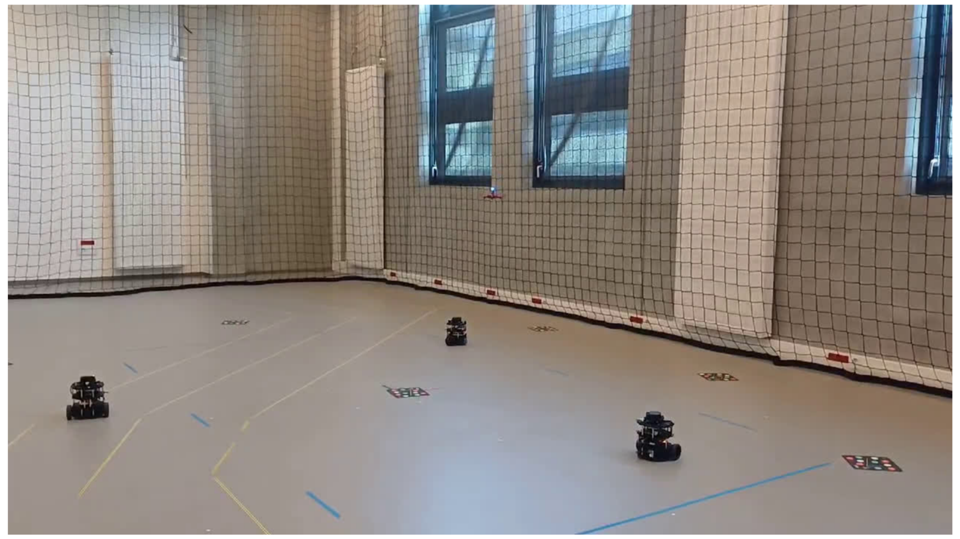
CentraleSupélec

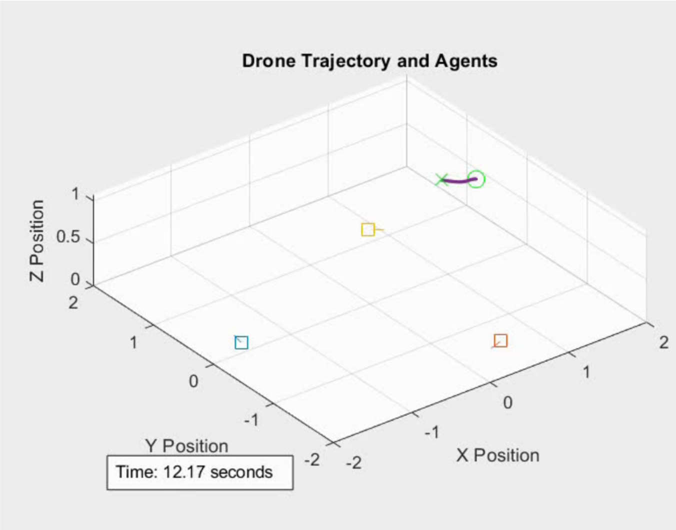
3.2 Results Analysis

Simulation in Python well succeded. After, real tests in the volière with stable results, but needing calibration of parameters.









[1] Benedetto Piccoli. Control of multi-agent systems: results, open problems, and applications, 2023

[2] Y. Song and D. Scaramuzza, "Policy Search for Model Predictive Control with Application to Agile Drone Flight," IEEE Transaction on Robotics (T-RO), 2021