# **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.

Multi-agents control and application

**Drone with** dynamic obstacles

**Use of Model Predictive Control** 

## 2. Proposed Scenario

Two or more robots follow a circular trajectory

The drone has access to the robots' previous, current, and future positions

This approach can be extended to various robot formations and movements



Each robot has a gate on top for the drone to pass through

The system solves the Model Predictive Control (MPC) problem for a single gate

The MPC problem can also be solved for multiple gates

# -3. The Projet

#### 3.1 Problem Formulation & Considered Theoretical Approach

#### **Turtlebot Control**

$$\mathbf{r}(t) = egin{bmatrix} r\cos(\omega t) & r\sin(\omega t) \ r\cos\left(\omega t + rac{2\pi}{3}
ight) & r\sin\left(\omega t + rac{2\pi}{3}
ight) \ r\cos\left(\omega t - rac{2\pi}{3}
ight) & r\sin\left(\omega t - rac{2\pi}{3}
ight) \end{bmatrix}$$

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

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

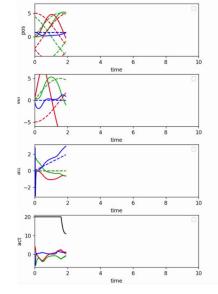
$$\mathcal{L}_{ ext{terminal}} = (\mathbf{x}_H^q - \mathbf{x}^{ ext{goal}})^T \mathbf{Q}_{ ext{goal}} (\mathbf{x}_H^q - \mathbf{x}^{ ext{goal}})$$

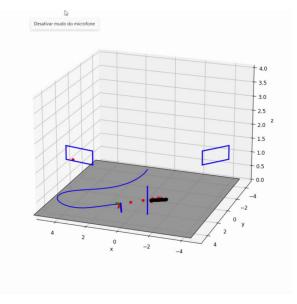
$$\mathcal{L}_{ ext{u}} = \sum_{h=1}^{H-1} (\mathbf{u}_h^q - \mathbf{u}_r)^T \mathbf{Q}_{ ext{u}} (\mathbf{u}_h^q - \mathbf{u}_r)$$



### 3.2 Results Analysis

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





#### **Quadrotor Dynamics**

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

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

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

$$\mathbf{\dot{p}}_{WB}$$

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

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

$$\dot{\mathbf{y}}_{WB} = \mathbf{q}_{WB} \odot \mathbf{c} - \mathbf{g}$$

$$\dot{\omega}_{\mathbf{p}} = \mathbf{J}^{-1}(\mathbf{p} - \omega_{\mathbf{p}} \times \mathbf{J}\omega_{\mathbf{p}})$$

$$\mathbf{g}$$
  $\dot{\boldsymbol{\omega}}$ 

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

- [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

