
TO-CBF-MPC:

$$\arg \min_{u \in \mathcal{U}, x \in \mathcal{X}, \Delta t} J = \lambda_1 T_1^2 + \lambda_2 \epsilon^2 \quad (1a)$$

$$s.t. \ T_1 = N \cdot \Delta t \quad (1b)$$

$$x_{i+1} = f(x_i) + g(x_i)u_i\Delta t, \ i \in [0, N-1] \quad (1c)$$

$$u_{min} < u < u_{max} \quad (1d)$$

$$v_{min} < v < v_{max} \quad (1e)$$

$$\Delta t \leq t_{max} \quad (1f)$$

$$x_N - x_g \geq \epsilon \text{ or } (x_N - x'_g \leq -\epsilon) \quad (1g)$$

$$y_N > w/2 \quad (1h)$$

$$\dot{h}_{ef}(\mathbf{x}, u) \geq -\alpha h_{ef}(\mathbf{x}), \quad (1i)$$
