?

Scipy
pyOpt

$\min f(x)$
x_k
x_{k+1}
?

$$(t_{final}, C_0, , C_{d+n_{knot}-2}) \min J = (t_{final} - t_{initial})^2 \quad (1)$$

$\forall k \in \{0, , N_s - 1\}$

$$\begin{cases} \varphi_1(z(t_{initial}), , z^{(l-1)}(t_{initial})) = q_{initial} \\ \varphi_1(z(t_{final}), , z^{(l-1)}(t_{final})) = q_{final} \\ \varphi_2(z(t_{initial}), , z^{(l)}(t_{initial})) = u_{initial} \\ \varphi_2(z(t_{final}), , z^{(l)}(t_{final})) = u_{final} \\ \varphi_2(z(t_k), , z^{(l)}(t_k)) \in \mathcal{U} \\ d_{O_m}(t_k) \geq \rho + r_m, \forall O_m \in \mathcal{Q}_{occupied} \end{cases} \quad (2)$$

$[\dot{v}\dot{\omega}]$
φ_3

$$\varphi_3(z(t_k), , z^{(l)}(t_k)) \in \mathcal{A}$$

$\mathcal{A}$
φ_3

$$\varphi_3(z(t_k), , z^{(3)}(t_k)) = = \begin{bmatrix} \dot{v} \\ \dot{\omega} \end{bmatrix} = \begin{bmatrix} \frac{\partial}{\partial t} \|\dot{z}\| \\ \frac{\partial}{\partial t} \frac{(\dot{z}_1 \ddot{z}_2 - \dot{z}_2 \ddot{z}_1)}{\|\dot{z}\|^2} \end{bmatrix} = \begin{bmatrix} \frac{\dot{z}_1 \ddot{z}_1 + \dot{z}_2 \ddot{z}_2}{\|\dot{z}\|} \\ \frac{(\ddot{z}_1 \ddot{z}_2 + z_2^{(3)} \dot{z}_1 - (\ddot{z}_2 \ddot{z}_1 + z_1^{(3)} \dot{z}_2)) \|\dot{z}\|^2 - 2(\dot{z}_1 \ddot{z}_2 - \dot{z}_2 \ddot{z}_1) \|\dot{z}\| \dot{v}}{\|\dot{z}\|^4} \end{bmatrix}$$

T_c
T_p

$$\tau_k = t_{initial} + k T_c k \in$$

$2m$
$[\tau_{k-1}, \tau_k)(k \in)$
τ_k
$\tau_k + T_p$

$$(C_{(0,\tau_k)}, , C_{(d+n_{knot}-2,\tau_k)}) \min J_{\tau_k} = \|\varphi_1(z(\tau_k + T_p, \tau_k), , z^{(l-1)}(\tau_k + T_p, \tau_k)) - q_{final}\|^2 \quad (3)$$

$\forall t \in [\tau_k, \tau_k + T_p]$

$$\begin{cases} \varphi_1(z(\tau_k, \tau_k), , z^{(l-1)}(\tau_k, \tau_k)) = q_{ref}(\tau_k, \tau_{k-1}) \\ \varphi_2(z(\tau_k, \tau_k), , z^{(l)}(\tau_k, \tau_k)) = u_{ref}(\tau_k, \tau_{k-1}) \\ \varphi_2(z(t, \tau_k), , z^{(l)}(t, \tau_k)) \in \mathcal{U} \\ d_{O_m}(t, \tau_k) \geq \rho + r_m, \forall O_m \in \mathcal{O}(\tau_k) \end{cases} \quad (4)$$

$[\tau_{-1}, \tau_0)$
$q_{ref}(\tau_0, \tau_{-1}) = q_{initial}$

$u_{ref}(\tau_0, \tau_{-1}) = u_{initial}$

$q \in^n$
$u \in^m$
N_s
$n + m$
τ_k
$N_s(m + \text{card}(\mathcal{O}(\tau_k)))$
??
A
B
C
A
$r_{0,1}$
$r_{0,3}$
0
B
s_3
$r_{0,3}$
$r_{3,2}$
C
A
B
C