?

Scipy

pyOpt

$\min f(x)$

x_k

x_{k+1}

?

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

$\forall k \in$

$\{0, , N_s -$

$1\}$

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

$[\dot{v} \dot{\omega}]$

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

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

$\forall t \in$

$[\tau_k, \tau_k +$

$T_p]$

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

$[\tau_{-1}, \tau_0)$

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

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

$q \in^n$

$u \in^m$

N_s

$n +$

m

r_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

algorithm related optimization solver related

N_s
n_{knots}
T_p
T_c
$MAXIT_{first}$
T_c
N_s
N_{knots}
v_{max} 1.00m/s
ω_{max} 5.00rad/s
q_{inital} $[-0.050.00\pi/2]^T$
q_{final} $[0.107.00\pi/2]^T$
u_{final} $[0.000.00]^T$
u_{final} $[0.000.00]^T$
O_0 [0.551.910.31]
O_1 [−0.083.650.32]
O_2 [0.384.650.16]
$_{0_{N}knots_4/uni.eps}Fournon - nullknotsintervals.$ $_{0_{N}knots_5/uni.eps}Fivenon - nullknotsintervals.$
$_{0_{N}knots_6/uni.eps}Sixnon - nullknotsintervals.$
T_p
T_c
N_s
N_{knots}
v_{max} 1.00m/s
ω_{max} 5.00rad/s
q_{inital} $[-0.050.00\pi/2]^T$
q_{final} $[0.107.00\pi/2]^T$
u_{final} $[0.000.00]^T$
u_{final} $[0.000.00]^T$
O_0 [0.551.910.31]
O_1 [−0.083.650.32]
O_2 [0.384.650.16]
T_c
$_{r}esults/p_{30}.48_2.4_11_{40}.001_15_40_20_5.0_0.1_3.0_0.5_1.0_10.0/multirobot-path.png Robot's path.$
$_{r}esults/p_{30}.48_2.4_11_{40}.001_15_40_20_5.0_0.1_3.0_0.5_1.0_10.0/multirobot-vw.png Robot's input.$
$_{3_{N}knots_4/uni.eps}Fournon - nullknotsintervals.$
$_{3_{N}knots_5/uni.eps}Fivenon - nullknotsintervals.$
$_{3_{N}knots_6/uni.eps}Sixnon - nullknotsintervals.$
T_p
T_c
N_s
N_{knots}
v_{max} 1.00m/s
ω_{max} 5.00rad/s
q_{inital} $[-0.050.00\pi/2]^T$
q_{final} $[0.107.00\pi/2]^T$
u_{final} $[0.000.00]^T$
u_{final} $[0.000.00]^T$
O_0 [0.551.910.31]
O_1 [−0.083.650.32]
O_2 [0.384.650.16]
T_c
$_{r}esults/p_{30}.48_2.4_11_{40}.001_15_40_20_5.0_0.1_3.0_0.5_1.0_10.0/multirobot-path.png Robot's path.$
$_{r}esults/p_{30}.48_2.4_11_{40}.001_15_40_20_5.0_0.1_3.0_0.5_1.0_10.0/multirobot-vw.png Robot's input.$
$_{6_{N}knots_4/uni.eps}Fournon - nullknotsintervals.$
$_{6_{N}knots_5/uni.eps}Fivenon - nullknotsintervals.$
$_{6_{N}knots_6/uni.eps}Sixnon - nullknotsintervals.$
T_p
T_c
N_s
N_{knots}
v_{max} 1.00m/s
ω_{max} 5.00rad/s
q_{inital} $[-0.050.00\pi/2]^T$
q_{final} $[0.107.00\pi/2]^T$
u_{final} $[0.000.00]^T$