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Mid-term presentation

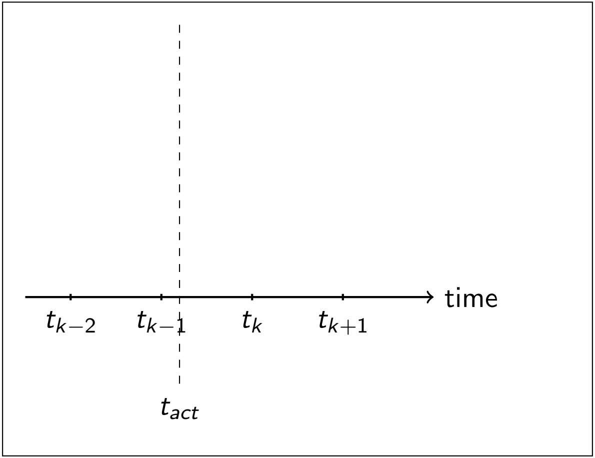
The Quadrocopters

Technische Universität München

26. Mai 2015

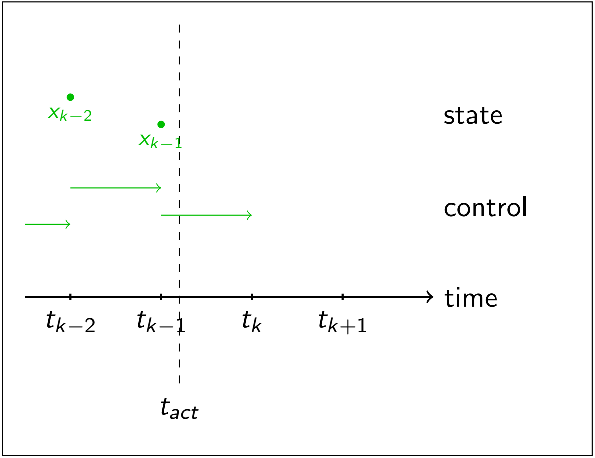
1. Realtime Optimization Approach

Setting



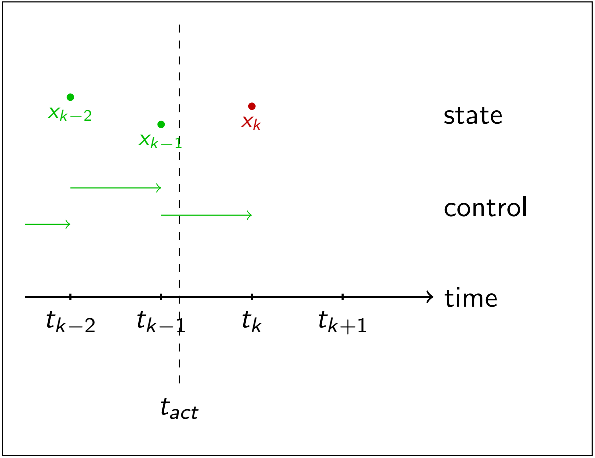
y, s, q erklären

Setting



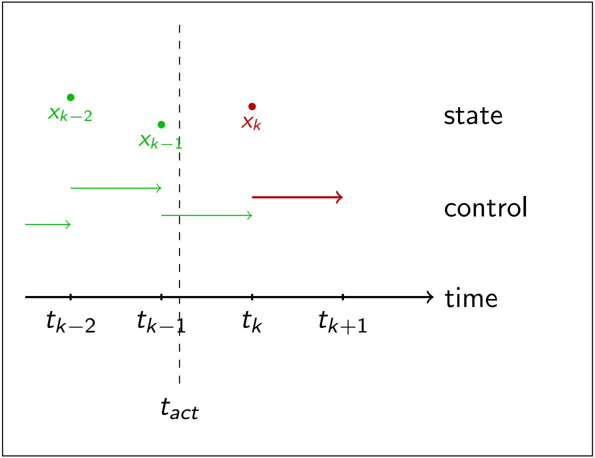
y, s, q erklären

Setting



y, s, q erklären

Setting



y, s, q erklären

Minimization Problem

$$\min_{\substack{s_t, \dots, s_N \\ q_t, \dots, q_{N-1}}} \sum_{i=t}^{N-1} F_i(s_i, q_i) \quad s.t. \left\{ \begin{array}{r} x_t - s_t = 0 \\ h_i(s_i, q_i) - s_{i+1} = 0 \quad \forall i = t, \dots, N-1 \end{array} \right.$$

$F_i(s_i, q_i)$	discretized goal function
$x_t - s_t = 0$	expected state should be the real state at time t
$h_i(s_i, q_i)$	solution of the ODE at time i

The Lagrangian

$$L^t(y) = \sum_{i=t}^{N-1} F_i(s_i, q_i) + \lambda_t^T(x_t - s_t) + \sum_{i=t}^{N-1} \lambda_{i+1}^T(h_i(s_i, q_i) - s_{i+1})$$

We are looking for y^* satisfying the KKT conditions.
$\Rightarrow \nabla_y L^t(y^*) = 0$

The SQP method

How do we find y^*?

$$y_{k+1} = y_k + \alpha_k \Delta y_k$$

$$\Downarrow$$

$$\min_{\Delta y} = \frac{1}{2} \Delta y^T A_k \Delta y + \nabla_y F(y_k)^T \Delta y$$

$$\Downarrow$$

$$A_k := \nabla^2_{y_k} L(y_k).$$

Newton-Raphson

$$y_{t+1} = y_t + \Delta y_t$$
$$\nabla_{y_t} L^t(y_t) + J^t(y_t)\Delta y_t = 0$$

$J^t(y_t)$ Approximated Hessian $\nabla^2_{y_t} L(y_t)$

$\alpha_t = 1$

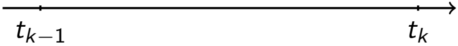
Riccati Recursion

This formulation still depends on x_t ...

$$
J^t(y^t) = \begin{pmatrix}
 & -E & & & & & & & & & \\
-E & Q_t^H & M_t^H & A_t^T & & & & & & & \\
 & (M_t^T)^H & R_t^H & B_t^T & & & & & & & \\
 & A_t & B_t & & -E & & & & & & \\
 & & & -E & Q_{t+1}^H & M_{t+1}^H & A_{t+1}^T & & & & \\
 & & & & (M_{t+1}^T)^H & R_{t+1}^H & B_{t+1}^T & & & & \\
 & & & & A_{t+1} & B_{t+1} & & & & & \\
 & & & & & & & \ddots & & & \\
 & & & & & & \ddots & Q_{N-1}^H & M_{N-1}^H & A_{N-1}^T & \\
 & & & & & & & (M_{N-1}^T)^H & R_{N-1}^H & B_{N-1}^T & \\
 & & & & & & & A_{N-1} & B_{N-1} & & -E \\
 & & & & & & & & & -E & Q_N^H
\end{pmatrix}
$$

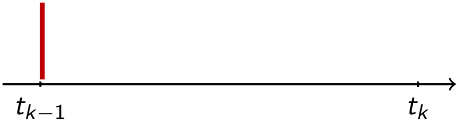
Summary

What happens in interval $[t_{k-1}, t_k]$?



Summary

What happens in interval $[t_{k-1}, t_k]$?



1. Calculate control u_{k-1}

Summary

What happens in interval $[t_{k-1}, t_k]$?

1. Calculate control u_{k-1}
2. Calculate y_k (Riccati Part II)

Summary

What happens in interval $[t_{k-1}, t_k]$?

1. Calculate control u_{k-1}
2. Calculate y_k (Riccati Part II)
3. Prepare u_k (SQP & Riccati Part I)

Finite Horizon

how to choose N?

- $N = t_{end}$ problem gets smaller every time
- $N = t + n$ problem size is constant
- .
- .
- .