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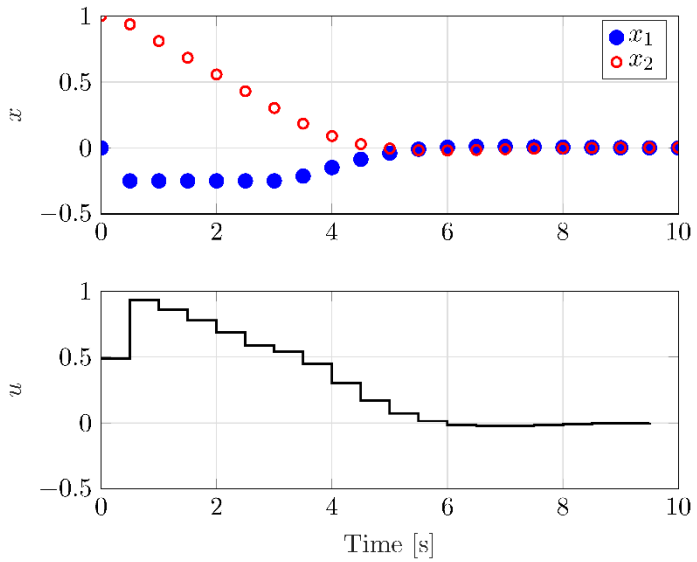
Review PS08

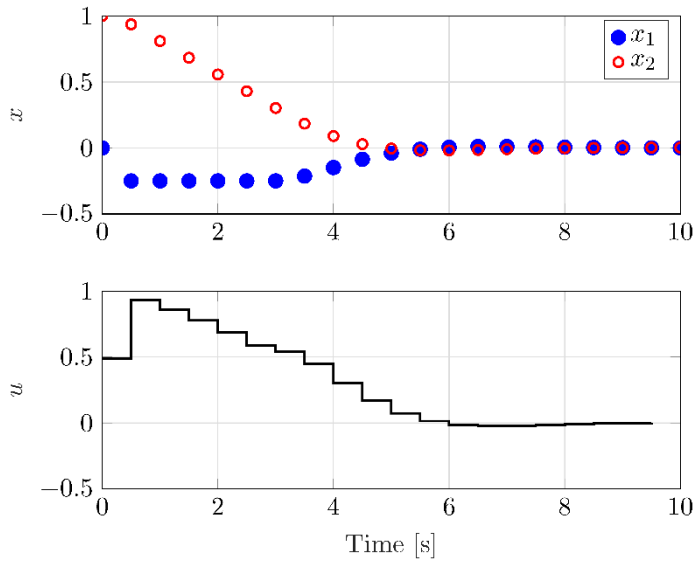
Constrained nonlinear programming



Single shooting

IPOPT

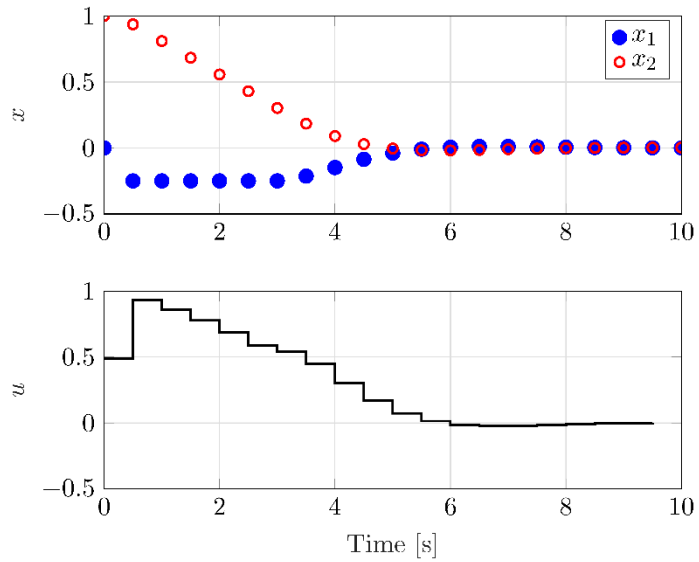
0.71 s



Multiple shooting

IPOPT

0.15 s

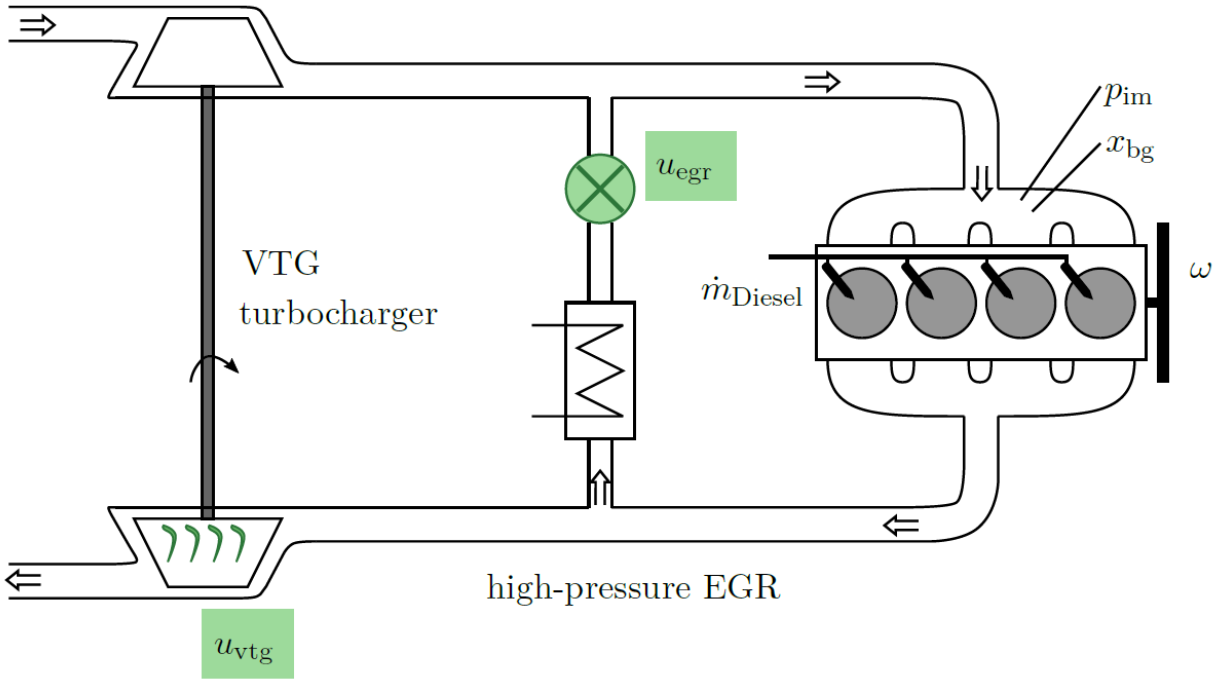


SQP using multiple shooting

qpOASES

0.06 s

Group Work
Control task



Input variables

u_{vtg} Guide vane position

u_{egr} EGR valve position

Control variables

p_{im} Intake manifold pressure

x_{bg} Burnt gas ratio

Challenges

MIMO, non-minimal phase, non-linear, input constraints

Group Work

Optimal control problem

$$
\begin{aligned}
\min_{\boldsymbol{x}(\cdot|k),\, \boldsymbol{u}(\cdot|k)} \quad & J(\boldsymbol{x}(\cdot|k), \boldsymbol{u}(\cdot|k)) \\
\text{s.t.} \quad & \boldsymbol{x}(k+i+1|k) = f_{\text{ROM}}(\boldsymbol{x}(k+i|k), \boldsymbol{u}(k+i|k)) \\
& 0 \leq u_{\text{vtg}}(\cdot|k) \leq 1 \\
& 0 \leq u_{\text{egr}}(\cdot|k) \leq 1 \\
& \boldsymbol{x}_0 = \boldsymbol{x}(k|k)
\end{aligned}
$$

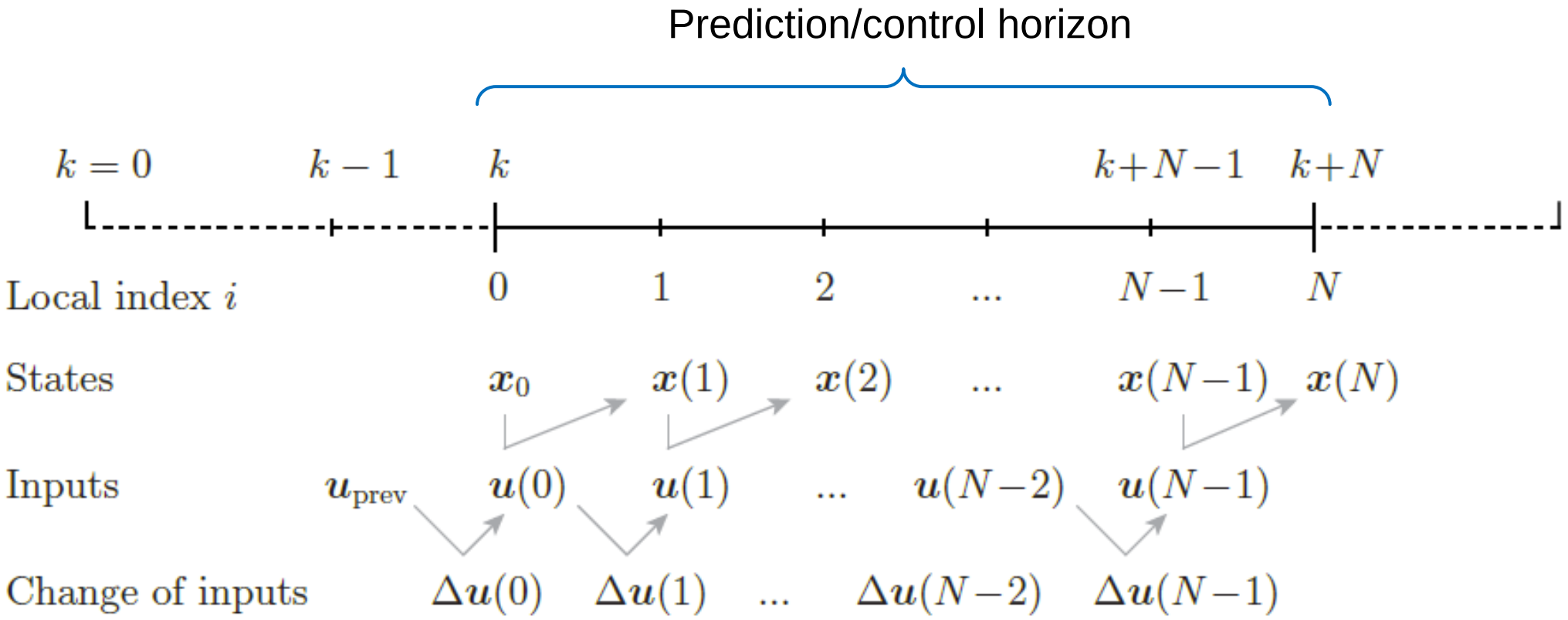
- Track references for p_{im} and x_{bg}
- Penalize changes in control action
- Use ROM as internal model
- Several design parameters: N, T_s, $Q_{..}$, $R_{..}$, n_{SQP}, etc.

with

$$
\begin{aligned}
J(\boldsymbol{x}(\cdot|k), \Delta\boldsymbol{u}(\cdot|k)) = {} & Q_1 \cdot \sum_{i=1}^{N} \left(p_{\text{im}}(k+i\,|k) - p_{\text{im,ref}}(k) \right)^2 + Q_2 \cdot \sum_{i=1}^{N} \left(x_{\text{bg}}(k+i\,|k) - x_{\text{bg,ref}}(k) \right)^2 + \\
& R_1 \cdot \sum_{i=0}^{N-1} \left(\Delta u_{\text{vtg}}(k+i\,|k) \right)^2 + R_2 \cdot \sum_{i=0}^{N-1} \left(\Delta u_{\text{egr}}(k+i\,|k) \right)^2
\end{aligned}
$$

Group Work

Timeline definitions



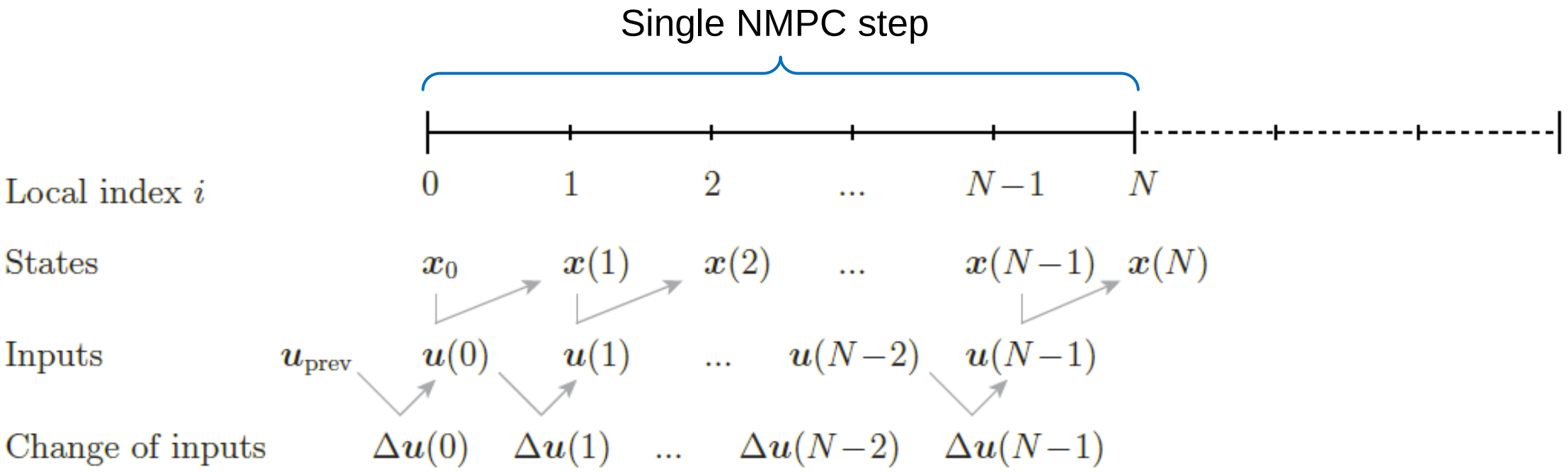
Shorthand notation: $\boldsymbol{x}(i) = \boldsymbol{x}(k+i|k)$

Group Work
Planning

GW	Date	Content	Comments
01	08.05.2020	Single NMPC step in MATLAB and Simulink	
02	15.05.2020	Offset-free NMPC in Simulink and parameter tuning	Hand in your NMPC #1 for review by TAs until 20.05.2020 (23:59)
03	22.05.2020	Code optimization and advanced formulations	Hand in **two** final NMPCs until 27.05.20 (23:59). One NMPC is allowed to be non-causal
	29.05.2020	“Competition”	Controller design and performance will be presented and discussed in exercise session

- Instructions how and which files to hand in will follow

GW01
Goal



For first MPC step (as in this group work): $k = 0$

GW01
Steps

1. Generate NLP from OCP using CasADi and create functions
   Solution from PS08 exercise 1 is a good starting point
2. Solve the NLP using qpOASES in MATLAB
   Solution from PS08 exercise 2 is a good starting point
3. Analyze performance when changing some tuning parameters
4. Implement single NMPC step in Simulink
5. Compare implementations and correct bug(s) if present

GW01

Files

For group work:

- **MATLAB 2017b**
- **Windows only**

!

Provided:

- **main_GW01.m** – Defines options and parameters, compiles C code, triggers simulations, plots results
- **NMPC.slx** – Template Simulink implementation of NMPC
- **providedCode/SfunctionGeneration** folder – Generates C code for Simulink

To be created by you:

- **createCasadiFunctions.m** – Formulate NLP using CasADi and create functions
- **NMPC_Matlab_singlestep.m** – Solve NLP using qpOASES in MATLAB