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Swiss Federal Institute of Technology Zurich

Institute for Dynamic Systems and Control
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Institut für Dynamische Systeme und Regelungstechnik

151-0310-00 **Problem Set 4 - Solution**

Topic: **Unconstrained Linear MPC**

March 16, 2022

You can run the Matlab script `ps04_sol_main.m` in order to execute all exercises of this problem set.

Exercise 1 (System Response Trajectory Matrices)

Have a look at the m-files `setupPredictionMatrices.m` and `ps04_sol_main.m` to compare your code with the solution.

a) An example of how to implement the prediction matrices is given in the function `[Gamma,Psi,Upsilon,Theta] = setupPredictionMatrices(A,B,C,N)`, which can be found in the `providedCode` folder.

b) Find the continuous-time system by running `[sysC, linearizationPt] = getLinearModel(0.5, 0.5)`.

c) Find the dixcrete-time system by running `sysD = c2d(sysC, 0.05, 'zoh')`.

d) Use the function developed in Task a).

```
N = 50;
[Gamma, Psi, Upsilon, Theta] = ...
setupPredictionMatrices(sysD.A, sysD.B, sysD.C, N);
```

You will find the code with a matrix dimension check in the provided Matlab solution script.

Exercise 2 (MPC Control Law)

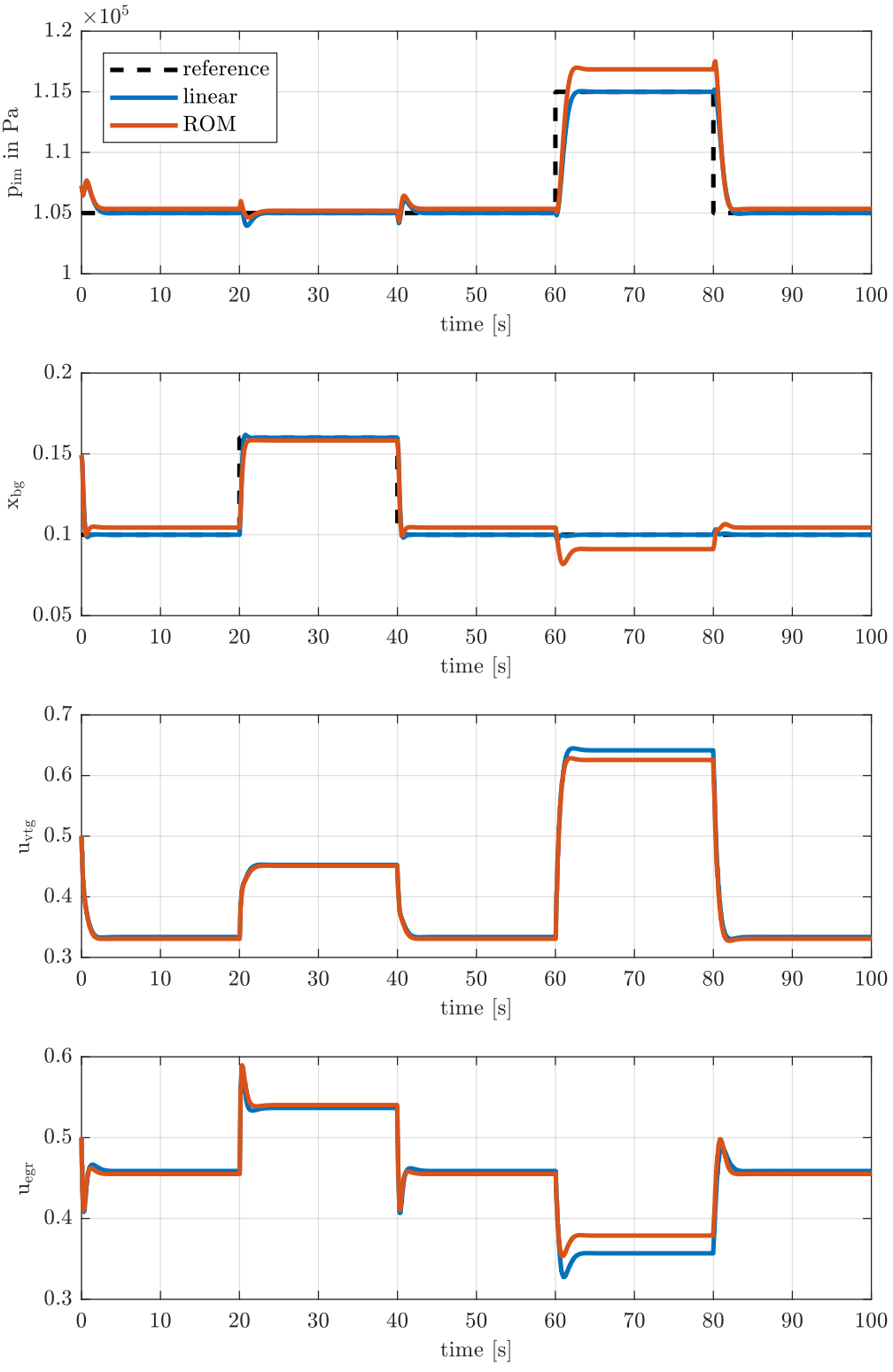
See the Matlab solution script.

Exercise 3 (MPC Implementation in Simulink)

a) You will find the implemented model predictive controller in the Simulink model `ps04_ex3_LinearModel.slx`. The resulting controller performance when evaluated using the linearized model is shown in the figure below (blue).

b) Add the unconstained linear model predictive controller to the Simulink model `ps04_ex3_ROM.slx`. Run the Matlab script `ps04_sol_main.m` in order to load all the necessary data to the Matlab workspace, simulate the two models, and plot the results.

The comparison of the controller performance when evaluated on the linearized model and on the ROM is shown in the figure below. The nonlinear ROM and the linearized model coincide only at the linearization point. Everywhere else there will be a model mismatch, resulting in a steady-state error. The further away from the linearization point you get, the bigger the error of the linearized model becomes. This deviation leads to an error in the prediction matrices of the model predictive controller, which calculates its optimal control trajectory based on these matrices. Without any information regarding the model mismatch (disturbance), the MPC scheme cannot compensate for this effect.


×10^5
1.2
1.15
1.1
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1
p_im in Pa
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0
10
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u_vtg
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