



Using Controller Knowledge in Predictive Control

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Outline

- Motivation
- System Setup
- Controller Designs
- Simulation Results
- Conclusions



Motivation

Control with constraints – windup phenomenon

- Anti-windup schemes
- MPC



System Setup

Process:

$$Ay = Bu, \quad y = Gu + f$$

Controller

$$Fu = \tilde{u}, \quad P\tilde{u} = Rw - Qy$$

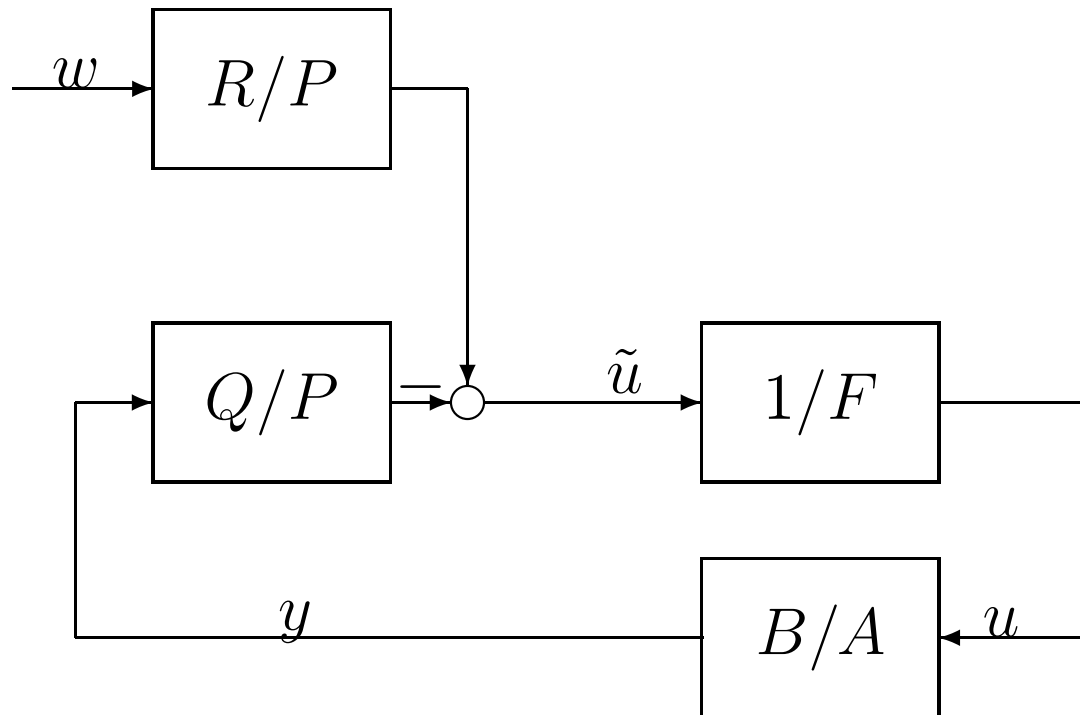
Closed-loop poles

$$AFP + BQ = M$$



Closed-loop Block-scheme

$$Ay = Bu + d, \quad P\tilde{u} = Rw - Qy, \quad \tilde{u} = Fu$$

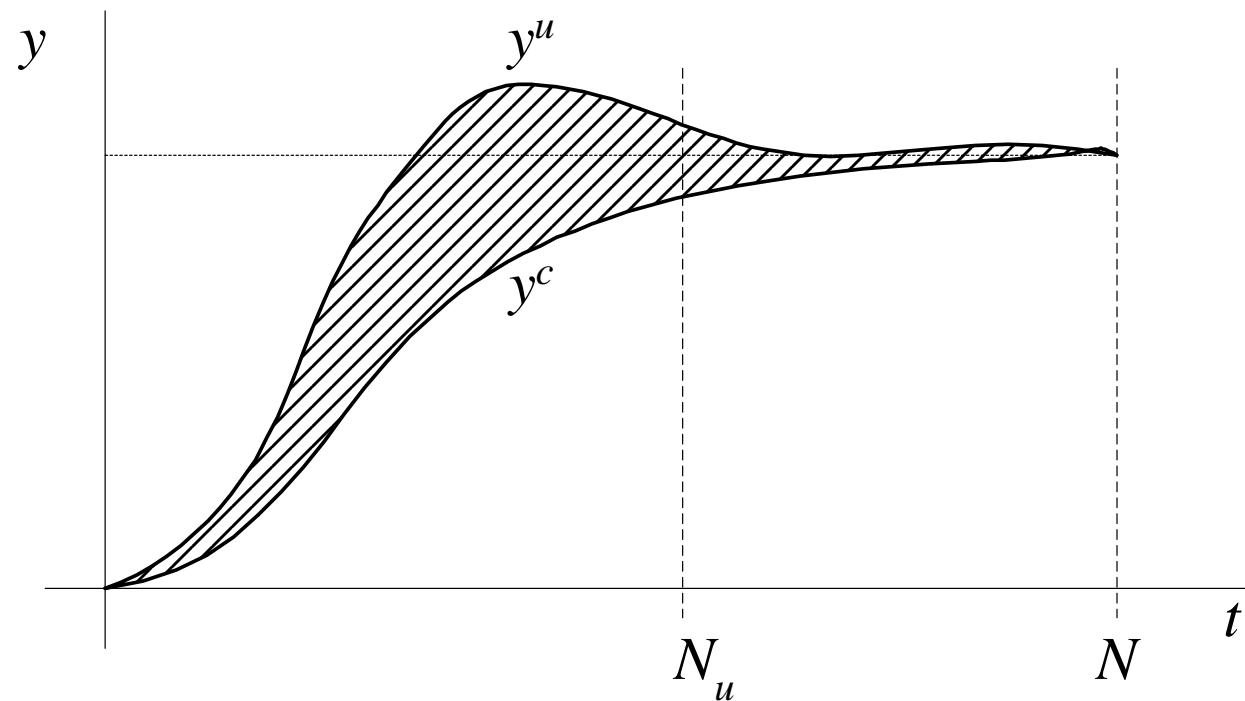




Controller Design #1

Minimise the output trajectory deterioration due to constraints

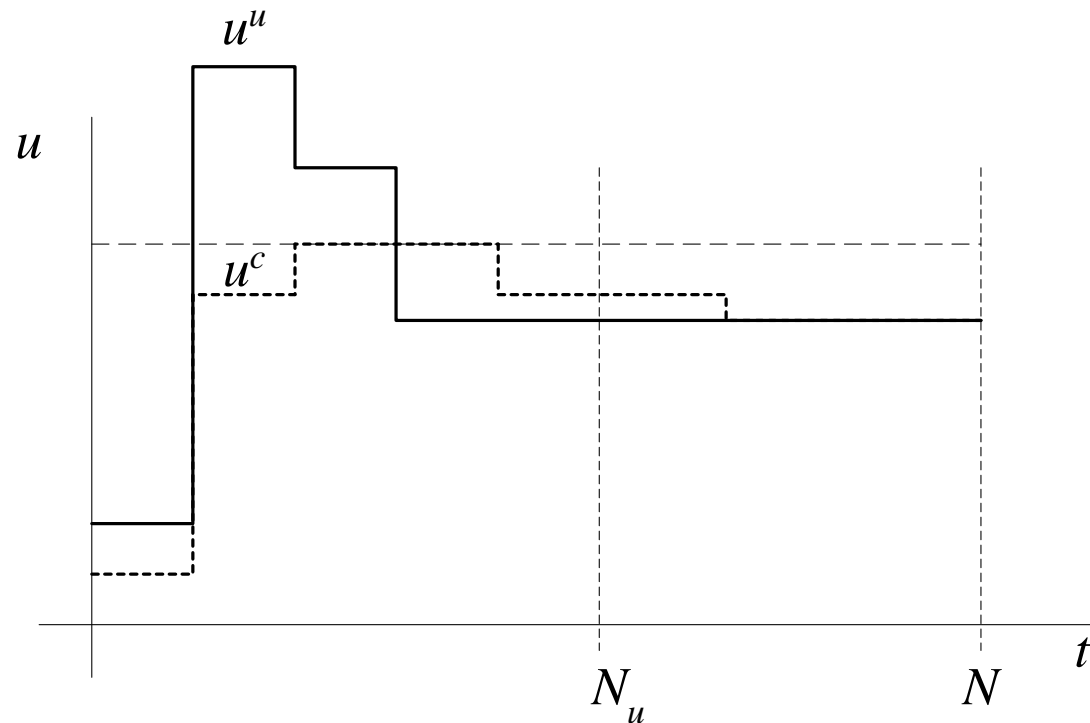
$$J = ||y^u - y^c||$$





Controller Design #1

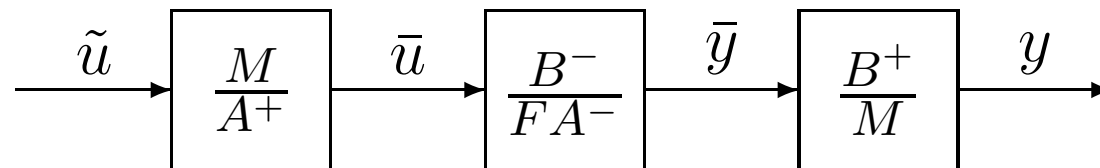
- Part N_u is optimised
- Part $N - N_u$ is linear based on the controller P, Q, R





Controller Design #2

System decomposition: $G = G_1 G_2 G_3 = B/AF$



1. Construct an unconstrained stable predictive controller without any degrees of freedom equivalent to a given pole-placement controller.
2. Introduce n degrees of freedom by enlarging $N_u \rightarrow N_u + n, N \rightarrow N + n$ to be able to handle constraints.



Simulation Results

System:

$$G = \frac{z^{-2}}{(1 + 3z^{-1})^2}$$

Dead-beat controller:

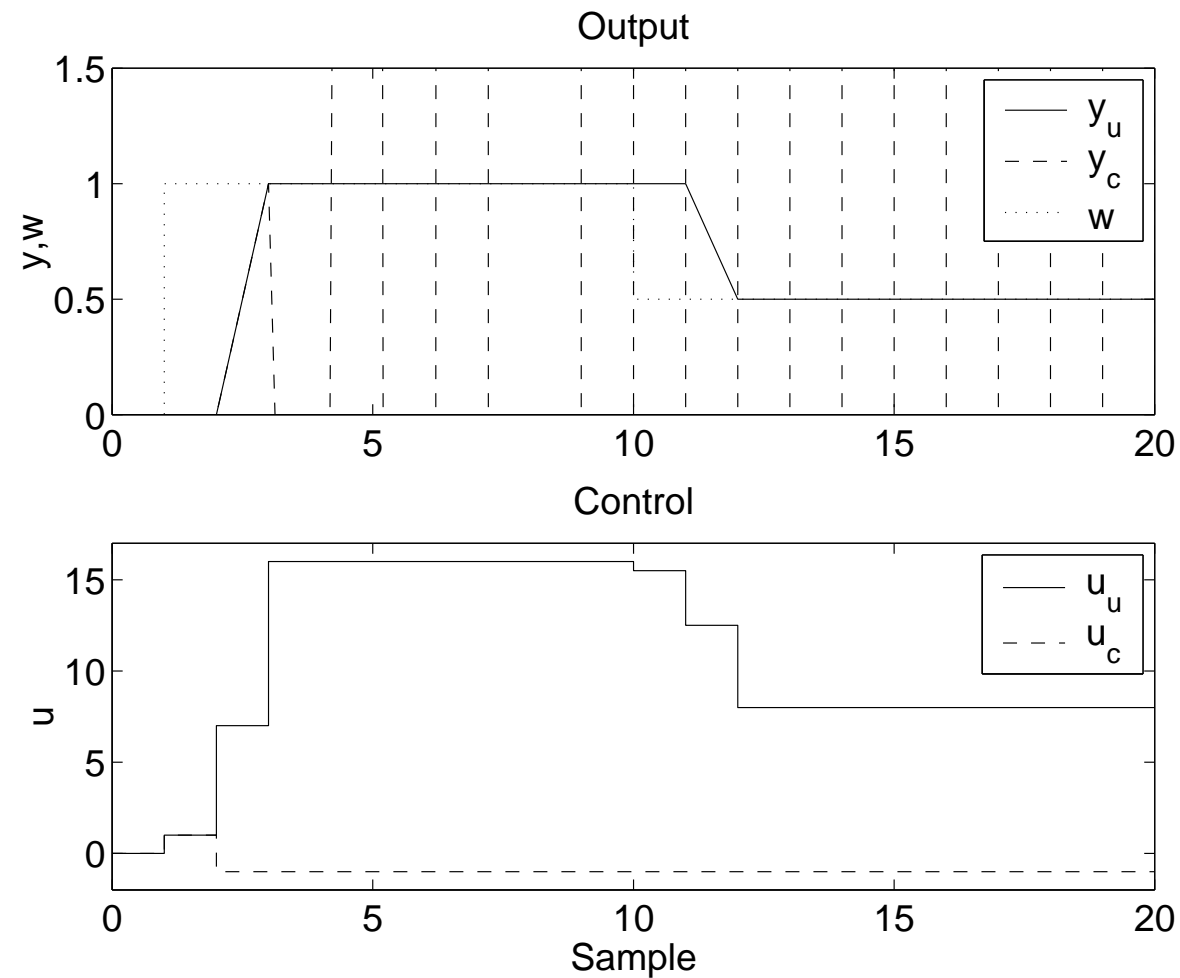
$$u_t = 6u_{t-1} - 5u_{t-2} + w_t - 22y_t - 24y_{t-1} + 45y_{t-2}$$

Constraints:

$$\Delta u \leq 5, \quad u \geq -1$$

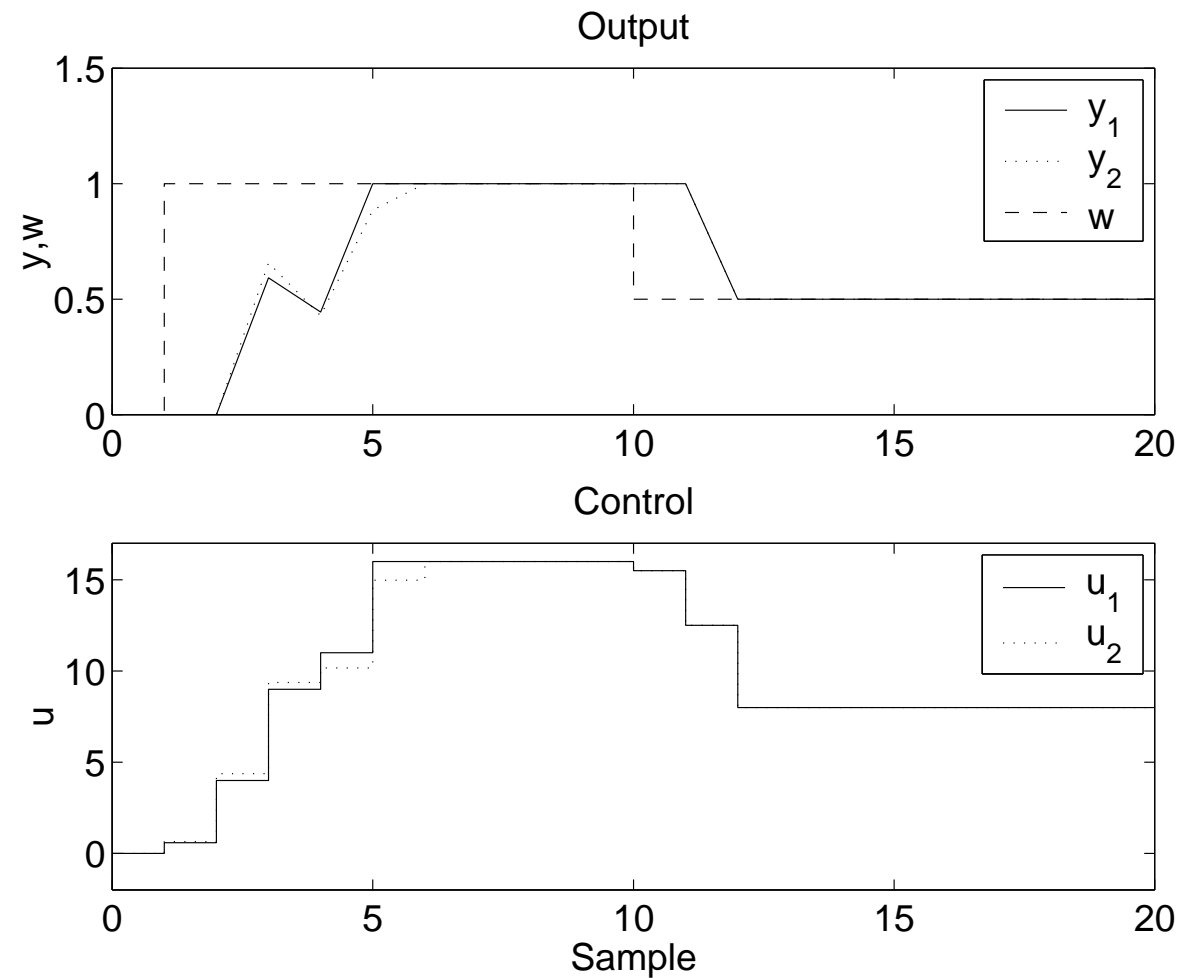


Nominal Controller





Proposed Controllers





Conclusions

- Advantage of MPC over AW strategies
- Two approaches to MPC design based on controller knowledge
- Slightly different performance of both controllers