LASSO-MPC: Model Predictive Control for Over-actuated Systems

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Over-actuated systems
Introduction

- Potential of over-actuation
  - *High performance (despite constraints)*
  - *Reliability - Fault tolerance*

- Control design must exploit this potential!

- Common solution: control allocation block

What happens here?
Closed-loop stability? Performance?
**LASSO-MPC**

- **L1-regularisation in MPC**

\[
V_N(x, u) = F(x_N) + \sum_{j=0}^{N-1} x_j^T Q x_j + u_j^T R u_j + \lambda \| S u_j \|_1
\]

- **1-norm penalty gives “sparse” control signals**
  - Some inputs are zero for most of the time
LTI example

\[
A = \begin{bmatrix} 0.15 & 0.1 \\ 0 & 1.1 \end{bmatrix} \quad B = \begin{bmatrix} 1 & 1 \\ 0 & 1 \end{bmatrix}
\]

\[
Q = \begin{bmatrix} 20 & 0 \\ 0 & 60 \end{bmatrix} \quad R = \begin{bmatrix} 0.1 & 0 \\ 0 & 0.1 \end{bmatrix}
\]

\[|x_j| \leq 20, \quad |u_j| \leq 5.\]

Input 1 is never used

Sharp control allocation for a finite \( \lambda \) (300)
Conclusions

- **LASSO-MPC**: regulation plus control allocation
  - For over-actuated systems or expensive control

- **Research status**
  - *Stabilising formulation: ad-hoc Terminal cost and Terminal constraint*
    - Quasi-infinite horizon, maximal DOA
  - *Offline tuning for extra actuators*
    - Improve pre-existing controllers

- **Future directions**
  - *Setpoint tracking*
  - *Robustness*