| Citation            | Xin Wang, Julian Stoev, Jan Swevers (2014)  
|                    | Pre-stabilized Energy-optimal Model Predictive Control  
|                    | for Point-to-Point Motions  
|                    | Benelux Meeting on Systems and Control 2014 |
| Archived version   | Author manuscript: the content is identical to the content of the published paper, but without the final typesetting by the publisher |
| Published version  | |
| Journal homepage   | |
| Author contact     | xin.wang@mech.kuleuven.be  
|                    | phone number + 32 (0)16 322222 |
| IR                 | url in Lirias https://lirias.kuleuven.be/handle/123456789/442766 |
Pre-stabilized Energy-optimal Model Predictive Control for Point-to-Point Motions

Xin Wang
Department of Mechanical Engineering, KU Leuven
xin.wang@mech.kuleuven.be

Julian Stoev
Flanders’ Mechatronics Technology Centre, Belgium
julian.stoev@fmtc.be

Jan Swevers
Department of Mechanical Engineering, KU Leuven
Jan.Swevers@mech.kuleuven.be

1 Abstract
This presentation proposes Pre-stabilized Energy-optimal Model Predictive Control (Pre-stabilized EOMPC) which is an extension of our previous research - Energy-Optimal Model Predictive Control (EOMPC) approach. In the Pre-stabilized EOMPC, a ‘pre-stabilization’ strategy is utilized to reduce the computational load of the EOMPC. Pre-stabilization uses deadbeat state feedback to modify the system models employed in the formulation of MPC and yields a sparse optimization problem. The computational efficiency and performance of EOMPC with pre-stabilization is validated through numerical simulations.

2 Pre-stabilized EOMPC
EOMPC [1] is a control method to realize energy-optimal point-to-point motions within a required motion time. It determines the control signal by solving on-line, at every sampling time, an optimal control problem, based on the current state of the open-loop system model as shown in Fig 1.

![Figure 1: The EOMPC approach is based on an open-loop model](image)

Pre-stabilized EOMPC is developed based on EOMPC. The pre-stabilized EOMPC approach calculates the optimal control sequence based on a closed-loop system model as illustrated on Fig. 2.

![Figure 2: Control scheme of pre-stabilized EOMPC](image)

Constructing the closed-loop system model is called pre-stabilization. The dead-beat state-feedback controller $K$ is calculated using the pole placement approach such that all poles of this closed-loop system model are located at zero, the origin of the $z$-plane. It is the key to yield sparse MPC optimization problems.

3 Numerical validation
The considered system is the linear motor of a badminton robot setup developed at Flanders’ Mechatronics Technology Centre (FMTC). This linear motor is used to position the badminton robot across the field and is the main energy consumer of this setup. The dynamics of this linear motor relating the motor current and position are modelled as a double integrator. The considered limits on position, velocity, and acceleration are: $\pm 1.9[m]$, $\pm 3[m/s]$, $\pm 30[m/s^2]$ respectively.

Figure 3 shows the simulation result for a motion of $1[m]$. The required motion time is $0.5[s]$, requested at time $0.1[s]$. Using pre-stabilized EOMPC and EOMPC, both implementations yield exactly the same motion. However, the CPU time is quite different. Since the pre-stabilization results in sparse MPC optimization problem, the resulting CPU time has one peak ($8.6[ms]$) at $t = 0.1[s]$. The worst CPU time of EOMPC is 4 times larger than that of the pre-stabilized EOMPC which is $32.54[ms]$.

![Figure 3: Performance of the system and CPU time](image)

References

Acknowledgement
This work has been carried out within the framework of projects IWT-SBO 80032 (LeCoPro) of the Institute for the promotion of Innovation through Science and Technology in Flanders (IWT-Vlaanderen). This work also benefits from KU Leuven-BOF PFV/10/002 Center-of-Excellence Optimization in Engineering (OPTEC), the Belgian Federal Science Policy Office (DYSKO), and KU Leuven’s Concerted Research Action GOA/10/11.