

Model Predictive Control (MPC) on a Chip (022-106-0044)

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Brief Description on Progress/Achievements:

Model Predictive Control (MPC) outperforms other control strategies through its ability to deal with constraints. This requires on-line optimisation, hence computational complexity can become an issue when applying MPC to complex systems with fast response times. Motivated by the need for a scalable and low-cost embedded MPC algorithm, we proposed a time-multiplexed strategy which solves the MPC problem for each subsystem sequentially, and updates each subsystem as soon as the solution is available, thus distributing the control moves over a complete update cycle. The resulting computational speed-up allows faster response to disturbances, and hence improved performance, despite finding sub-optimal solutions to the original problem. The multiplexed MPC scheme is also closer to industrial practice in many cases. We also obtained initial stability results for two variants of multiplexed MPC. This gives a theoretical foundation for the proposed multiplexed MPC strategy.

We believe that the time multiplexed version of MPC opens up many opportunities to applying MPC to embedded and high bandwidth applications, such as 'Lab-on-chip' devices, precision machines, land and aerial vehicles. Continuing research in this direction to bring the technology to a more matured level is necessary. In addition, we have developed a set of tools which could take a MPC design, simulate it, fine tune the parameters of the MPC algorithm, and encapsulate the final MPC solution as suitable standalone FPGA module for embedded applications.

Publications

- [1] KV Ling, JM Maciejowski and BF Wu, Multiplexed Model Predictive Control, 16th IFAC World Congress, Prague, July 2005.
- [2] MH He and KV Ling, Model Predictive Control on a Chip, The 5th International Conference on Control & Automation, Budapest, Hungary, June 26-29, 2005.
- [3] KV Ling, MH He, BF Wu, Y Zhang, An Augmented Model Predictive Controller for Multirate Cascade Systems, American Control Conference, Boston, USA, pp.1575-1579, 30 June - 2 July 2004.
- [4] Z Ding, KV Ling, and MK Goh, Rapid development of closed-loop control system, International Journal of Software Engineering and Knowledge Engineering, Vol. 15, No. 2 (2005) 325-331, Special Issue: Selected Papers from the 2005 International Conference on Embedded and Hybrid Systems.

Presentations

- [1] "Model Predictive Control (MPC) on a Chip", presented at ASM Technology Singapore Pte Ltd, April 2005.
- [2] "Model Predictive Control (MPC) on a Chip", presented at the National Cheng Kung University, Taiwan, November 2004.
- [3] "Model Predictive Control (MPC) on a Chip", presented at the Regional Symposium on Embedded Hybrid Systems, 12 October 2004, Suntec Singapore International Convention & Exhibition Centre.

Manpower Trained

One Postdoc and one PhD student

Joint Programme

- [1] Algorithm-Centric Embedded Systems, SIMTech in-house project, July – December 2005. Lead by KV Ling