SEVENTH FRAMEWORK PROGRAMME
THEME – ICT
[Information and Communication Technologies]

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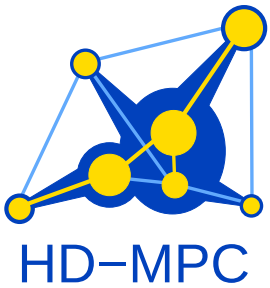

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Executive Summary

In this deliverable we report on the activities carried out by the project partners to transfer knowledge on methods for hierarchical and distributed control of large-scale systems to industry and practitioners. We shall report on the following courses/lectures:

- Industrial course on "Embedded Optimization for Nonlinear Model Predictive Control" which will be held on February 10-11, 2011 in Leuven, Belgium.
- The "DISC Summer School on Distributed Control and Estimation", which has been organized on June 2-5, 2009 in Noordwijkerhout, The Netherlands.
- A lecture on "Advanced traffic control: Model-based predictive control" on September 30, 2009 in Delft, The Netherlands.

Chapter 1

Industrial course on "Embedded Optimization for Nonlinear Model Predictive Control"

Moritz Diehl, Boris Houska, and Hans Joachim Ferreau will organize an industrial course on "Embedded Optimization for Nonlinear Model Predictive Control" on February 10-11, 2011 in Leuven, Belgium.

1.1 Course Description

The course is an intensive and quite interactive course with the aim of providing the participants with a strong working knowledge about the methods and applications of nonlinear dynamic optimization in control engineering. Particular emphasis is put on the methods of convex, nonlinear and embedded optimization and how they are useful for Nonlinear Model Predictive Control (NMPC) and moving horizon state estimation. Applications are described by nonlinear ordinary differential equations and range from chemical reactors, power plants, renewable energy systems, to fast mechatronic systems such as combustion engines and machine tools with control sampling times in the range of milliseconds and microseconds. At the end of the course, each participant shall be able to understand the basic numerical tricks employed in state-of-the-art algorithms, able to set up his / her own problem in the software package ACADO (which comes under LGPL[1]), and to use ACADO's latest developments such as automatic C-code export which allows us to solve medium-size NMPC problems with sampling frequencies of 10 kHz.

Participant prerequisites. Strong background in analysis and linear algebra corresponding to the first two years of a science or engineering degree with good grades. Knowledge of numerical mathematics is very helpful, but not mandatory. Programming skills in the languages C / C++ are helpful.

1.2 Course topics

The course will cover the following topics:

- Convex optimization problems and interior point algorithms;

[1] LGPL: GNU Lesser General Public License

- Theory of nonlinear programming and optimal control;
- Dynamic system modeling for optimization;
- Nonlinear Model Predictive Control;
- Gauss-Newton Algorithms;
- Real-Time Iterations;
- Real-time optimization using the open-source optimal control software package ACADO Toolkit – a toolkit for automatic control and dynamic optimization;
- Automatic C-Code Generation for Nonlinear MPC applications in the microsecond scale.

1.3 Further information

More information will be made available on the course website:
`http://www.kuleuven.be/optec/EONMPC2011`

Chapter 2

DISC Summer School on Distributed Control and Estimation

In addition to the short industrial course mentioned in Chapter 1, the HD-MPC project also contributed to the DISC[1] Summer School on Distributed Control and Estimation, Noordwijkerhout, The Netherlands, June 2-5, 2009. In particular, HD-MPC researcher Tamás Keviczky was a co-organizer of this summer school, in cooperation with Siep Weiland and Mircea Lazar, both from Eindhoven University of Technology (The Netherlands). The summer school gave an introduction to the area of distributed control and estimation, two areas that are also part of the HD-MPC project.

The DISC Summer School on Distributed Control and Estimation was primarily aimed at PhD students and researchers, but it was also open to participants from industry. The summer school focused on distributed control and estimation both from a fundamental point of view (distributed decision-making and optimization) and an engineering perspective (applications). This was reflected in the list of speakers, which includes expert researchers, educators, and engineers from leading groups around the world.

The summer school program included the following lectures:

- "The Structure of Optimal Distributed Controllers" Bassam Bamieh (UC Santa Barbara, USA);
- "Flocking Theory: Distributed Control of Networked Multi-Robot Systems" Reza Olfati-Saber (Dartmouth College, USA);
- "Distributed Kalman Filtering in Sensor Networks" Reza Olfati-Saber (Dartmouth College, USA);
- "Computational and Communication Complexity in Distributed Control" Cedric Langbort (University of Illinois at Urbana-Champaign, USA);
- "On Control of Discrete-time Nonlinear Systems under Artitrary Information Constraints" Andrej Jokic (Eindhoven University of Technology, The Netherlands);
- "Randomness and Performance in Large Controlled Networks" Bassam Bamieh (UC Santa Barbara, USA);
- "Event-based Control for Distributed Systems" Karl H. Johansson (Royal Institute of Technology, Sweden);

[1] DISC: Dutch Institute for Systems and Control, www.disc.tudelft.nl

- "Consensus with Random Link Failures" Bassam Bamieh (UC Santa Barbara, USA);
- "On Distributed Optimization Methods in Control and Estimation" Tamás Keviczky (Delft University of Technology, The Netherlands);
- "State Estimation with Different Sampling Methodologies" Joris Sijs (TNO Science and Industry, The Netherlands);
- "Rigidity Graph Theory and Formation Control of Teams of Autonomous Agents" Ming Cao (University of Groningen, The Netherlands);
- "When is a Linear Controller Optimal" Michael Rotkowitz (University of Melbourne, Australia);
- "Tractable Problems in Optimal Decentralized Control" Michael Rotkowitz (University of Melbourne, Australia).

There were about 60 participants in this summer school.

Chapter 3

Lecture on “Advanced traffic control: Model-based predictive control”

From the application side, Bart De Schutter also gave a 1-hour lecture on “Advanced traffic control: Model-based predictive control” on September 30, 2009 in Delft, The Netherlands. In this lecture several HD-MPC related topics were discussed, in particular, multi-agent model predictive control of large-scale traffic networks.

This lecture was part of the course on “Dynamic traffic management” organized by the Stichting Postacademisch Onderwijs (PAO), which is a foundation that organizes postgraduate courses on various civil engineering topics, including traffic and transport technology. This PAO course was explicitly aimed at practitioners and participants from industry.

There were about 30 participants in this course.