Embedded Optimization for Resource Constrained Platforms EMBOCON NR. 248940

There is enormous economic potential for the application of *embedded optimization technologies* in embedded systems design. Recent advances in the performance of *embedded hardware platforms*, in combination with fundamental improvements in optimization theory and algorithms, have opened the door to widespread applications over the next decade. *Embedded optimization* will enable huge energy and resource savings, increased safety, and improved fault detection across a wide a range of industrial applications in the mechatronic, automotive, process control and aerospace sectors. In order to realize the full potential of optimization in embedded systems, their design must also be supported by a focused set of tools enabling the rapid transfer of novel high-performance algorithms to practical applications.

The EMBOCON consortium enabled widespread application of real-time optimization in embedded systems through:

- Tailoring of customized numerical algorithms to increase their robustness and efficiency on embedded systems,
- Enabling real-time optimization on cheap industry-standard hardware platforms,
- Defining a common user interface for optimization technologies to facilitate technology transfer to industry
- Performing challenging case studies in cooperation with industrial partners to demonstrate technological maturity.

There has been created a strengthened a network of world-leading academic and industrial partners with complementary expertise in control, optimization and embedded systems in a range of industrial applications. Particular emphasis has been placed on close collaboration between mathematical algorithm developers, control theorists, hardware specialists and industrial application engineers. The network consolidated and extended Europe's position as the world research leader in these areas and foster strong collaborative links between European academia and industry.

The EMBOCON consortium included the following members:
1. Imperial College London
2. Katholieke Universiteit Leuven
3. Otto-von-Guericke-Universität Magdeburg
4. Eidgenössische Technische Hochschule Zürich
5. **University Politehnica Bucharest**
6. Technische Universität Dortmund
7. Universität Heidelberg
8. BASF SE
9. IPCOS NV

10. LMS International
11. National Instruments Ltd

For many practical applications the embedded optimization algorithms usually require too much computing time compared to the real-time requirements, which may be due to the complexity of the problem or communication restrictions. A powerful paradigm in computing is the distribution of calculations. The University "Politehnica" of Bucharest has been concerned with the tasks regarding the distributed optimization and the efficient parallelization of state-of-the-art methods that are the basis for the other EMBOCON workpackages. The main objective of the work package directed by UPB has been the development of new distributed optimization algorithms for embedded (possibly distributed) systems that will result in an efficient and reliable operation of the overall complex system as well as reliable operation of these algorithms on computationally constrained hardware.

The EMBOCON research team from UPB has been composed by: Ion Necoara (project director), Dragos Clipici (research assistant), Valentin Nedelcu (research assistant), Andrei Patrascu (research assistant), Alexandru Dumitrascu (post-doctoral student), Prof. Cristian Oara, Prof. Ioan Dumitrache, Prof. Nicolae Constantin.

The practical results of the project are defined by the following software: ACADO Code Generation, FORCES, **POPT (I. Necoara - UPB)**, MPT, qpOASES, IPOPT / CasADi. The theoretical results are materialized in over 170 publications in ISI journal and proceedings (**over 20 ISI publications by UPB team**).

The EMBOCON project has represented an opportunity for the collaboration of UPB with many high-level research groups from very well ranked universities of Europe. The collaboration has been materialized in *project meetings*, *conferences* and *short research stages*, which facilitated experience exchange and marked foundations for possible future collaborations as there remains strong scientific relationship with the TU Delft group. Also, this integration opportunity in high-level research environment of universities such as ETH Zurich and Katholieke Universiteit de Louvain brought a great amount of motivation and scientific stimulation, which could be very helpful for the future research of the Romanian team from UPB.