Development of Runge-Kutta Integrators with continuous output for fast Moving Horizon Estimation

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The principle of automatic generation of optimized code has spread in the world of embedded optimization. An example is the code generation tool of the ACADO Toolkit, which implements the Real-Time Iteration (RTI) scheme [1]. It is based on a shooting discretization of the Optimal Control Problem (OCP), meaning the integration of the system with sensitivity generation forms a major computational step. Until now, this was tackled using code generation of the Explicit Runge-Kutta (ERK) method of order 4. The project which will be presented, consists of three major aspects. The first aspect is to show that auto generation of Implicit Runge-Kutta (IRK) methods with sensitivity generation can also be implemented very efficiently. This greatly improves the support for stiff systems of equations and also allows to handle systems of Differential Algebraic Equations (DAE) instead of only Ordinary Differential Equations (ODE). The second aspect is therefore that the methods can efficiently be extended to DAE systems of index 1.

Collocation methods, which are a special case of IRK methods that can provide a continuous approximation of the solution, are quite promising for Moving Horizon Estimation (MHE) with high frequency measurements. They namely allow the integration step size to be larger than imposed by the measurement frequency, while still being able to use all the high frequency data without any loss of information. The continuous output of these methods could enable many other applications. Translating this into an optional feature of the methods that can efficiently support all of these applications is the third aspect. The final result of the project besides a thesis and a paper is the well documented open source code, made part of the ACADO code generation tool.

References

[1] B. Houska, H.J. Ferreau and M. Diehl, *ACADO Toolkit – An Open Source Framework for Automatic Control and Dynamic Optimization*. Optimal Control Applications and Methods, 32(3):298–312, 2011.

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