Fast Optimization of RF Excitation

M. Bödenler[1], **C.S. Aigner**[1], **A. Rund**[2], **C. Clason**[3] and **R. Stollberger**[1,4]

[1]Institute of Medical Engineering, Graz University of Technology, Austria
[2]Institute of Mathematics and Scientific Computing, University of Graz, Austria
[3]Faculty of Mathematics, University of Duisburg-Essen, Germany
[4]Biotechmed Graz, Graz, Austria

RF pulse design via optimal control (OC) allows the generation of RF pulses with very flexible properties close to ideal templates. However, OC approaches usually suffer from high computational effort resulting in long optimization times. With improved optimization algorithms using second-order information and adjoint-based derivatives, it is possible to increase the convergence rate and to reduce the optimization time, but real-time optimization is still not feasible. In a second step, we have now investigated the acceleration of the optimization by means of parallel computing.

The inherent spatial parallelism of the Bloch equation is exploited to accelerate the optimization. Different application interfaces (C++, OpenMP and CUDA) are applied to generate Matlab executable (MEX) files of the computational demanding functions in the existing Matlab framework. The implementations have been tested for simultaneous multi-slice excitation with constant and sharp slice profiles.

The presented implementations of the OC RF pulse design framework lead to a significant reduction in computing time while maintaining all the advantages of the Matlab environment. In particular, the CUDA implementation allows optimization times in the order of a few seconds making on-site design feasible. The acceleration can even be increased by changing the underlying floating-point format, without significant loss of accuracy. This allows efficient and fast generation of accurate slice profiles for arbitrary flip angles as well as refocusing or inversion pulses.