Optimal control with finite control set and applications in Model Predictive Control

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Model Predictive Control (MPC) has gained huge popularity in the last decades and is nowadays considered as a main mathematical tool for industrial process control. The MPC method can be viewed as a method for constructing feedback solutions of long/infinite horizon Optimal Control Problems (OCPs), where the underlying controlled dynamics is described either in continuous or in discrete time. The feedback control, obtained by the method, has the advantage (as all feedback controls) to adapt to disturbances and measurement inaccuracies, but has the disadvantage (compared with other methods for feedback control design) that it has to be computed in real time. This leads to the necessity to utilize efficient computational methods, especially if the process to be controlled is fast, which requires high frequency of measurement and of resolving the OCPs involved.

The project aims at developing certain theoretical and numerical aspects of the MPC framework, which are especially important in the case of fast processes. Such typically arise in power electronics – the area that provides one of the main motivations for the project. Moreover, in this area the control inputs are implemented by “switch on – switch off” devices, which, due to the finiteness of the feasible control set, brings combinatorial features into the problem. In addition, the OCPs involved are lacking the property called “coercivity”, which plays a very important role in both the theoretical analysis and the numerical solution of OCPs. The main goal of the project is to develop a new numerical approximation scheme that directly deals with non-coercive problems (without preliminary “regularization”) and directly produces switch on/off type controls (in contrast to the presently used methods). Such a method was recently proposed for restricted classes of problems by the author of the project with co-authors. However, the enhancement of this approximation approach and its embedding into the Newton-type iteration processes for differential variational inequalities that will be employed, requires to build a solid regularity theory for non-coercive OCPs, substantially extending the recently developed one.

Apart from the MPC applications, the theoretical and computational tools created within the project will be useful for many other OCPs engineering and biomedicine, which are either non-coercive or such with finite control sets.