



SMARTNC

Real-time multi-axis motion interpolator for an open **C**omputerized **N**umerical **C**ontrol

Project Summary

The manufacturers of swiss machine tools and production machines are using today mostly proprietary and unextendable blackbox CNC equipments from a few global suppliers as FANUC, SIEMENS, etc. This creates an undesirable supplier retention because the machine manufacturers cannot freely purchase the motor drives they want. Moreover, existing CNC controls don't offer the possibility to implement new customer specific control algorithms e.g. for handling external sensors or other trade-specific requirements. This impedes mechatronics innovation and reduces the competitiveness of machine manufacturers.

The core of a CNC control consists of feedrate planning algorithms enabling nearly time optimal execution of multi-axis motion complying with various mechatronic constraints as speed, acceleration and jerk limitations. In the present project "SmartNC", new real-time algorithms for feedrate planning have been developed and tested enabling the development of open architecture CNC controls.

Feedrate planning is related to a classical variational optimization problem in the field of optimal control. Most of these problems do not have analytical solutions. Therefore, numerical methods must be utilized. Many approaches have already been published (e.g. dynamic programming, "shooting" methods for solving a boundary value problem, switching point search methods, etc.). Very few of these methods are sufficiently fast and numerically reliable for real time applications. The most promising solution used in this project exploits the following properties and methods:

- convexity through a nonlinear change of variables
- interior point methods using barrier terms in order to incorporate optimization constraints
- sparsity of the second derivatives (Hessian matrix) enabling fast Newton steps
- recursive reformulation using moving horizon optimization (fast model predictive control)

The algorithm has been coded and prototyped using Matlab for a 5-axis machine tool with nonlinear kinematics. Different parameters of the algorithm have been optimized. The algorithm has been recoded in C++. Implementation and validation on a real machine is ongoing.

Valorisation

The feedrate planning algorithms partially have been used in the CTI project "SoftCAM", SageX n° 32632. The real time algorithms developed in this project are now being integrated in the software platform "Concept" of the spinoff company Objectis SA (www.objectis.ch). A five-axis machine tool with pivotable table has been purchased as a demonstrator. The CNC of this machine is being retrofitted with the CNC solution of Objectis. The acquisition of launching customer projects is ongoing.