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Developing insight into the optimization element in a nonlinear model predictive control context

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Abstract

Optimization is one of the fundamental components in Model Predictive Control (MPC) and Nonlinear Model Predictive Control (NMPC). In NMPC the optimization problem that is to be solved can be non-convex which is a challenging problem to solve. Having insight into the optimization component of the NMPC algorithm will offer value to the control engineers designing and using NMPC controlled systems. This study presents an approach, referred to as the Optimization Roadmap, that graphically provides insight or transparency into the optimization element within NMPC. The methodology was applied to several examples to ratify the insights gained. Two optimization algorithms, the gradient based Sequential Quadratic Programming (SQP) algorithm and the meta-heuristic Particle Swarm Optimization (PSO), were employed within the NMPC algorithm and their characteristics contrasted. The application of the methodology to the examples revealed that the Optimization Roadmap provides useful insights into the optimization problem to the user. These insights include the convexity or non-convexity of the problem and additionally regions of local minima, if present. The Optimization Roadmap additionally provides insights into areas in which initial conditions, for local optimization methods, could be chosen for the best results. Furthermore, the results show that the local optimization algorithm, SQP, performs much faster than the PSO algorithm. More importantly, by using the Optimization Roadmap to select favourable initial conditions for the SQP algorithm led to it producing results in the vicinity of, if not equal to, those obtained by the PSO algorithm.