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In this thesis an optimization method for nonlinear discrete time systems and periodic operation is presented. The method is particularly suited for engineering problems, as it can obtain an optimal operation point with desired dynamical properties for models with uncertain parameters. In typical applications of the method, technical systems are optimized with respect to economic objectives with nonlinear programming methods, while the desired dynamical properties are ensured with the so-called normal vector constraints. The desired dynamical properties are guaranteed for all operation points in a robustness region around the optimal point.

The normal vector constraints, which are incorporated in the optimization problem, impose the lower bound on the distance between the optimal point and any critical boundary. Typical critical boundaries of interest are stability and feasibility boundaries. The first ones consist of bifurcation points. The second ones involve points at which constraints on output or input variables are violated. Once the locations of the critical points of a system are known, normal vectors on the critical manifolds can be used to measure the distance from the nominal point of operation to stability and feasibility boundaries in the space of the system design parameters. By staying sufficiently far away from all critical manifolds we can guarantee robust stability and feasibility of the system.

Previously the normal vector constraints were applied to the optimization of steady states of continuous-time systems that are modeled by sets of parametrically uncertain differential-algebraic equations. In this thesis the normal vector constraints are developed for fixed points of nonlinear discrete time systems. Such systems frequently arise in engineering applications, either because the model is intrinsically discrete in time, or because the model is the result of a time discretization. Attention is paid to both of these cases. Since stability properties of discrete time systems and periodically operated systems are closely related, the normal vector constraints are considered for the optimization of oscillating models. Note that besides processes, where only oscillating states occur, there exist models that can be operated periodically or at a steady state. The situation where the normal vector constraints for periodic operation are combined with the case of operation at a steady state is discussed.

The concept of the normal vector constraints is successfully applied to the optimization procedures of supply chains which are modeled as discrete time systems, a fermentation process that results from sampling the continuous time model, and examples of oscillating chemical reactions.