Closed-Loop Control of Nonlinear Diffusion Processes Contributing to Spatial Structure Formation

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Abstract: Spatial structure formation occurs in a wide variety of natural phenomena, from protein folding to convection cells in the sun. Experimentally, patterns have been studied in many different systems, and there are currently many different mathematical approaches to the study of patterns, including numerical simulation and bifurcation theory.

The aim of this work is to design an optimization approach to control the pattern formation in an unsteady reaction-diffusion system, and to induce desired patterns into the system. We consider in particular nonlinear diffusion models that describe the self-organization behavior, where the model is supposed to be controlled or externally forced. The mathematical method is based on the Nonlinear Model Predictive Control (NMPC) approach. Main features of the computational approach to obtain closed-loop controls are the direct multiple shooting method for a decomposition of the time domain, and the recently developed real-time iteration scheme, that allow to effectively solve the required optimal control problems.

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