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A Blending Stabilization Method of Discrete Mechanics and Nonlinear Optimization for 2-dimensional Nonlinear Films

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Summary

In general, it is well known that control of distributed parameter systems is more difficult in comparison with concentrated constant systems. We have developed a numerical approach to control of distributed mechanical parameter systems based on "discrete mechanics," which is one of the discretizing methods for nonlinear systems and derived by calculation of discrete variations with discrete Hamilton's principle (Marsden, et. al., 1998; Junge, et. al., 2005; Kai et. al., 2018 ∼). The purpose of this research is to derive a stabilization control method for a 2-dimensional nonlinear film via a blending method of discrete mechanics and nonlinear optimization.

We formulate the stabilization control problem for a 2D nonlinear film modeled by discrete mechanics with an evaluation function on the displacements of the films and control inputs generated by actuators installed at the film. It is represented as a finite dimensional constrained nonlinear optimization problem, and we can efficiently solve it by using "the sequential quadratic programming (SQP) method." In addition, we apply "model predictive control (MPC)" that repeatedly solves optimization problems for short time interval in order to reduce computation amount.

Then, a numerical simulation is carried out in order to confirm the validity of the proposed control method. The control purpose is that control inputs are added to a vibrating nonlinear film and the vibration of the film is suppressed. Fig. 1 illustrates snapshots of the nonlinear film in the simulation, and we can see that vibration of the nonlinear film is gradually suppressed, and the whole of the film is finally stabilized. Fig. 2 shows the absolute average of the displacement of the nonlinear film, and it turns out the value converges to zero as time goes by, that is, the nonlinear film is stabilized. Consequently, it can be confirmed that the proposed method has the effectiveness via the numerical simulation.

Our future work related this research are as follows; theoretical analysis of discrete mechanics for general distributed mechanical parameter systems, experimental evaluation of the proposed control method, trajectory tracking control of nonlinear films (generation of characters).

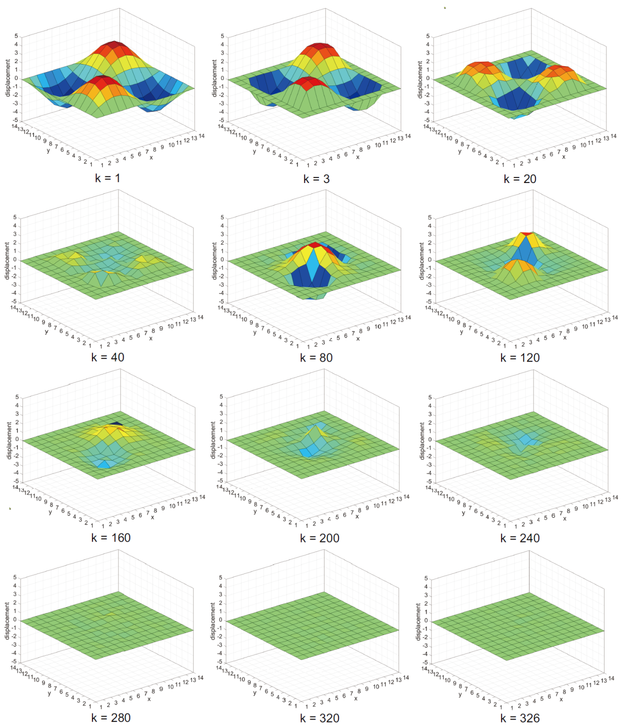

Figure 1: Snapshot of Nonlinear Film

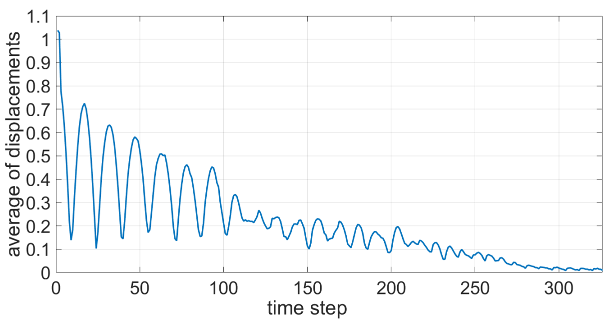

Figure 2: Snapshot of Nonlinear Film