FINITE HORIZON MODEL PREDICTIVE CONTROL OF ELECTROWETTING ON DIELECTRIC WITH PINNING

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ABSTRACT. A time-discrete spatially-continuous electrowetting on dielectric (EWOD) model with contact line pinning is considered as the state system in an optimal control framework. The pinning model is based on a complementarity condition. In addition to the physical variables describing velocity, pressure, and voltage, the solid-liquid-air interface, i.e., the contact line, arises as a geometric variable that evolves in time. Due to the complementarity condition, the resulting optimal control of a free boundary problem is thus a mathematical program with equilibrium constraints (MPEC) in function space. In order to cope with the geometric variable, a finite horizon model predictive control approach is proposed. Dual stationarity conditions are derived by applying a regularization procedure, exploiting techniques from PDE-constrained optimization, and then passing to the limit in the regularization parameters. Moreover, a function-space-based numerical procedure is developed by following the theoretical limit argument used in the derivation of the dual stationarity conditions. The performance of the algorithm is demonstrated by several examples; including barycenter matching and trajectory tracking.

Keywords: Electrowetting on dielectric, EWOD, contact line pinning, surface tension, sharp interface, optimal control of free boundary problems, mathematical program with equilibrium constraints, MPEC, PDE-constrained optimization, barycenter matching, trajectory tracking.

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