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A well-posed shape optimization flow arising from an inverse geometry problem

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Inverse geometry problems arise in many applications, including non-destructive testing, medical imaging, and material characterization. A common approach to solving such problems is to reformulate them as shape optimization problems and then employ gradient-based numerical methods to identify unknown geometries.

In this talk, we revisit a classical inverse geometry problem and its shape optimization formulation. Motivated by a simple and efficient numerical reconstruction algorithm, we derive a Hele–Shaw-like moving boundary problem that describes the continuous evolution of the unknown shape. The resulting free-boundary system can be interpreted as a shape optimization flow driven by boundary measurement data.

The main focus of the talk is the mathematical analysis of this evolution problem. We establish the local-in-time existence, uniqueness, and continuous dependence of classical solutions, thereby providing a rigorous well-posedness result for a class of shape optimization flows arising from inverse problems. The analysis is based on a transformation of the moving-boundary problem to a fixed domain and on classical techniques developed for quasi-stationary free-boundary problems.

Numerical examples illustrating the proposed reconstruction method and the associated shape evolution will also be presented. The results demonstrate that the proposed flow provides both an effective computational framework for shape identification and an interesting mathematical model connecting inverse problems, shape optimization, and free-boundary dynamics.

This is a joint work with Julius Fergy T. Rabago (Kanazawa University).

Keywords: Inverse geometry problems, shape optimization, free-boundary problems, Hele–Shaw flow, well-posedness

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References