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Optical flow based optimal control for image registration

Image registration has several applications, amongst others in computer vision and medical imaging. The goal is to align different images, e.g., measured at different times or by different sensors.

By parameterizing the transformations to align the images via velocity fields, we consider image registration as an optimal control problem using an optical flow formulation. More precisely, we aim to solve an optimization problem that is governed by a linear hyperbolic transport equation.

To obtain non-smooth features and ensure bi-Lipschitz continuity of the transformations, we aim for Lipschitz regularity of the velocity fields. We introduce relaxations of the optimization problem involving smoothed maximum and minimum functions and appropriate Orlicz spaces. To derive well-posedness results for the relaxed optimization problems, we revisit and establish new existence and uniqueness results for the linear hyperbolic transport equation.

We further discuss limit considerations with respect to the relaxation parameter and discretization, differentiability, and a numerical implementation of the proposed approach.