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Models and algorithms for off-the-grid point tracking in dynamic inverse problems

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We present and discuss strategies for the solution of dynamic inverse problems in spaces of measures where for each time point, a time-dependent linear forward operator mapping measures to time-dependent Hilbert-space data has to be inverted. These problems are regularized with dynamic optimal-transport energies that base on the continuity equation as well as convex functionals of Benamou—Brenier and Hellinger–Kantorovich type [ESAIM:M2AN 54(6):2351—2382, 2020]. Sparsity results then give rise to the study of the extremal points of the Benamou—Brenier/Hellinger–Kantorovich energy subject to the continuity equation. For the latter, it is proven that the extremal points are realized by point masses moving along curves with Sobolev regularity [Bull. LMS 53(5):1436—1452, 2021] [CPDE 47(10):2023–2069, 2022]. This result will be employed to develop numerical optimization algorithms of generalized conditional gradient type for off-the-grid point tracking. We present instances of this algorithm that are tailored towards this task in the context of dynamic inverse problems. Finally, the application and numerical performance of the method is demonstrated for sparse dynamic superresolution [FOCM 23(3):833–898, 2023].

Auteur principal: BREDIES, Kristian (University of Graz)

Orateur: BREDIES, Kristian (University of Graz)