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Efficient numerical schemes for Beltrami color image filtering

Abstract

The Beltrami flow is an efficient nonlinear filter, that was shown to be effective for color image processing. It is closely related to the median, total variation and bilateral filters. The corresponding anisotropic diffusion operator strongly couples the spectral components. Usually, this flow is implemented by explicit schemes, that are stable only for very small time steps and therefore require many iterations. We introduce a semi-implicit Crank-Nicolson scheme based on locally one-dimensional (LOD)/additive operator splitting (AOS) for implementing the anisotropic Beltrami operator. In case of constant coefficients, the LOD splitting scheme is proven to be unconditionally stable. Numerical experiments indicate that the proposed scheme is also stable in more general settings. Stability, accuracy, and efficiency of the splitting schemes are tested in different applications such as the Beltrami-based scale-space, Beltrami denoising and Beltrami deblurring. In order to further accelerate the convergence of the numerical scheme, the reduced rank extrapolation (RRE) vector extrapolation technique is employed.

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