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Evolution-Operator-Based Single-Step Method for Image Processing

Yuhui Sun,[1] Peiru Wu,[1] G. W. Wei,[1,2] and Ge Wang[3]

[1]Department of Mathematics, College of Natural Science, Michigan State University, 48824, MI, USA
[2]Department of Electrical and Computer Engineering, College of Engineering, Michigan State University, 48824-1226, MI, USA
[3]Department of Radiology and Department of Biomedical Engineering, University of Iowa, Iowa City 52242, IA, USA

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Abstract

This work proposes an evolution-operator-based single-time-step method for image and signal processing. The key component of the proposed method is a local spectral evolution kernel (LSEK) that analytically integrates a class of evolution partial differential equations (PDEs). From the point of view PDEs, the LSEK provides the analytical solution in a single time step, and is of spectral accuracy, free of instability constraint. From the point of image/signal processing, the LSEK gives rise to a family of lowpass filters. These filters contain controllable time delay and amplitude scaling. The new evolution operator-based method is constructed by pointwise adaptation of anisotropy to the coefficients of the LSEK. The Perona-Malik-type of anisotropic diffusion schemes is incorporated in the LSEK for image denoising. A forward-backward diffusion process is adopted to the LSEK for image deblurring or sharpening. A coupled PDE system is modified for image edge detection. The resulting image edge is utilized for image enhancement. Extensive computer experiments are carried out to demonstrate the performance of the proposed method. The major advantages of the proposed method are its single-step solution and readiness for multidimensional data analysis.