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Partial Volume Reduction by Interpolation with Reverse Diffusion

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Abstract

Many medical images suffer from the partial volume effect where a boundary between two structures of interest falls in the midst of a voxel giving a signal value that is a mixture of the two. We propose a method to restore the ideal boundary by splitting a voxel into subvoxels and reapportioning the signal into the subvoxels. Each voxel is divided by nearest neighbor interpolation. The gray level of each subvoxel is considered as "material" able to move between subvoxels but not between voxels. A partial differential equation is written to allow the material to flow towards the highest gradient direction, creating a "reverse" diffusion process. Flow is subject to constraints that tend to create step edges. Material is conserved in the process thereby conserving signal. The method proceeds until the flow decreases to a low value. To test the method, synthetic images were downsampled to simulate the partial volume artifact and restored. Corrected images were remarkably closer both visually and quantitatively to the original images than those obtained from common interpolation methods: on simulated data standard deviation of the errors were 3.8%, 6.6%, and 7.1% of the dynamic range for the proposed method, bicubic, and bilinear interpolation, respectively. The method was relatively insensitive to noise. On gray level, scanned text, MRI physical phantom, and brain images, restored images processed with the new method were visually much closer to high-resolution counterparts than those obtained with common interpolation methods.