Second Order Total Generalized Variation for MR Image Reconstruction

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Total Variation (TV) is a well established penalty term for the reconstruction of subsampled MRI data [1]. The advantage of TV is that it preserves edges in the reconstructed images, while at the same time efficiently removing noise and undersampling artifacts. However, the assumption of TV is that images consist of piecewise constant regions, which is often violated in MR data sets, especially due to smooth signal modulations originating from the use of phased array coils. This leads to staircasing artifacts when TV is used, and gives the reconstructed images a cartoon-type appearance. The recently introduced concept of Second Order Total Generalized Variation (TGV_2) [2,3] shares the merits of TV, but as it also allows to integrate higher order derivatives, staircasing effects are reduced.

In this work, we describe the application of TGV_2 to reconstruct subsampled MR data from multiple coils. Examples from radial and spiral data sets are demonstrated with subsampling rates up to 25 below the Nyquist rate. One limitation of nonlinear image reconstruction strategies is the significant increase in computation time, which aggravates their use in daily clinical practice. Therefore we also show that as TGV shares the parallelization potential of all variational methods, it is possible to perform the reconstruction on state of the art graphic processing units (GPUs), which significantly reduces the computation time.

[1] Block et al.: MRM 57:1086–1098, [2] Bredies et al.: SFB-Report 2009-038, [3] Knoll et al.: Proc. ISMRM: 4855.