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PAPER

Adaptive convolutional sparsity with sub-band correlation in the NSCT domain for MRI image fusion

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Abstract

Objective. Multimodal medical image fusion (MMIF) technologies merges diverse medical images with rich information, boosting diagnostic efficiency and accuracy. Due to global optimization and single-valued nature, convolutional sparse representation (CSR) outshines the standard sparse representation (SR) in significance. By addressing the challenges of sensitivity to highly redundant dictionaries and robustness to misregistration, an adaptive convolutional sparsity scheme with measurement of the *sub-band correlation* in the non-subsampled contourlet transform (NSCT) domain is proposed for MMIF. *Approach.* The fusion scheme incorporates four main components: image decomposition into two scales, fusion of detail layers, fusion of base layers, and reconstruction of the two scales. We solved a Tikhonov regularization optimization problem with source images to obtain the base and detail layers. Then, after CSR processing, detail layers were sparsely decomposed using pre-trained dictionary filters for initial coefficient maps. NSCT domain's *sub-band correlation* was used to refine fusion coefficient maps, and sparse reconstruction produced the fused detail layer. Meanwhile, base layers were fused using averaging. The final fused image was obtained via two-scale reconstruction. *Main results.* Experimental validation of clinical image sets revealed that the proposed fusion scheme can not only effectively eliminate the interference of partial misregistration, but also outperform the representative state-of-the-art fusion schemes in the preservation of structural and textural details according to subjective visual evaluations and objective quality evaluations. *Significance.* The proposed fusion scheme is competitive due to its low-redundancy dictionary, robustness to misregistration, and better fusion performance. This is achieved by training the dictionary with minimal samples through CSR to adaptively preserve overcompleteness for detail layers, and constructing fusion activity level with *sub-band correlation* in the NSCT domain to maintain CSR attributes. Additionally, ordering the NSCT for reverse sparse representation further enhances *sub-band correlation* to promote the preservation of structural and textural details.

1. Introduction

The diversity of imaging mechanisms in modern clinical practice of medicine is essential and extensively utilized in disease diagnosis and radiation therapy (Du *et al* 2016). Considering that a single form of imaging tends to be unable to effectively characterize the symptoms of different diseases, doctors generally need to diagnose a patient's condition by comprehensively analyzing different categories of organ/tissue information at the same