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1. Fusion of MS and PAN Images Preserving Spectral Quality

Image fusion aims at improving spectral information in a fused image as well as adding spatial details to it. Among the existing fusion algorithms, filter-based fusion methods are the most frequently discussed cases in recent publications due to their ability to improve spatial and spectral information of multispectral (MS) and panchromatic (PAN) images. Filter-based approaches extract spatial information from the PAN image and inject it into MS images. Designing an optimal filter that is able to extract relevant and nonredundant information from the PAN image is presented in this letter. The optimal filter coefficients extracted from statistical properties of the images are more consistent with type and texture of the remotely sensed images compared with other kernels such as wavelets. Visual and statistical assessments show that the proposed algorithm clearly improves the fusion quality in terms of correlation coefficient, relative dimensionless global error in synthesis, spectral angle mapper, universal image quality index, and quality without reference, as compared with fusion methods, including improved intensity–hue–saturation, multiscaleKalman filter, Bayesian, improved nonsubsampledcontourlet transform, and sparse fusion of image.
Index Terms—Directional filter, image fusion, optimal filter, pan-sharpening, spectral information.

2. A Pan-Sharpening Based on the Non-Subsampled Contourlet Transform: Application to Worldview-2 Imagery

Two pan-sharpening methods based on the nonsubsampledcontourlet transform (NSCT) are proposed. NSCT is very efficient in representing the directional information and capturing intrinsic geometrical structures of the objects. It has characteristics of high resolution, shift-invariance, and high directionality. In the proposed methods, a given number of decomposition levels are used for multispectral (MS) images while a higher number of decomposition levels are used for Pan images relatively to the ratio of the Pan pixel size to the MS pixel size. This preserves both spectral and spatial qualities while decreasing computation time. Moreover, upsamplingofMSimages is performed afterNSCT and not before. By applying upsampling after NSCT, structures and detail information of the MS images are more likely to be preserved and thus stay more distinguishable. Hence, we propose to exploitthis property in pan-sharpening by fusing it with detail information provided by the Pan image at the same fine level. The proposedmethods are tested on WorldView-2 datasets and compared with the standard pan-sharpening technique. Visual and quantitative results demonstrate the efficiency of the proposed methods. Both spectral and spatial qualities have been improved.

3. Pansharpening Using Regression of Classified MS and Pan Images to Reduce Color Distortion

The synthesis of low-resolution panchromatic (Pan) image is a critical step of ratio enhancement (RE) and component
substitution (CS) pansharpening methods. The two types of methods assume a linear relation between Pan and multispectral (MS)images. However, due to the nonlinear spectral response of satellite sensors, the qualified low-resolution Pan image cannot be wellapproximated by a weighted summation of MS bands. Therefore, in some local areas, significant gray value difference exists between a synthetic Pan image and a high-resolution Pan image. To tackle this problem, the pixels of Pan and MS images are divided into several classes by k-means algorithm, and then multiple

4. A Pansharpening Method Based on the Sparse Representation of Injected Details

The application of sparse representation (SR) theory to the fusion of multispectral (MS) and panchromatic images is giving a large impulse to this topic, which is recast as a signal reconstruction problem from a reduced number of measurements. This letter presents an effective implementation of this technique, in which the application of SR is limited to the estimation of missing details that are injected in the available MS image to
enhance its spatial features. We propose an algorithm exploiting the details self-similarity through the scales and compare it with classical and recent pansharpening methods, both at reduced and full resolution. Two different data

sets, acquired by the WorldView-2 and IKONOS sensors, are employed for validation, achieving remarkable results in terms of spectral and spatial quality of the fused product.

5. Satellite Image Fusion using Fast Discrete Curvelet Transforms

fusion based on the Fourier and wavelet transform methods retain rich multispectral details but less spatial details from source images. Wavelets perform well only at linear features but not at non linear discontinuities because they do not use the geometric properties of structures. Curvelet transforms overcome such difficulties in feature representation. In this paper, we define a novel fusion rule via high pass modulation using Local Magnitude Ratio (LMR) in Fast Discrete Curvelet Transforms (FDCT) domain. For experimental study of this method Indian Remote Sensing (IRS) Resourcesat-1 LISS IV satellite sensor image of spatial resolution of 5.8m is used as low resolution (LR) multispectral image and Cartosat-1 Panchromatic (Pan) of spatial resolution 2.5m is used as high resolution (HR) Pan image. This fusion rule generates HR multispectral image at 2.5m spatial resolution. This method is quantitatively compared with Wavelet, Principal component analysis (PCA), High pass filtering(HPF), Modified Intensity-Hue-Saturation (M.IHS) and Grams-Schmidth fusion methods. Proposed method spatially outperform the other methods and retains rich multispectral details.

6. A New DCT-based Multiresolution Method for Simultaneous Denoising and Fusion of SAR Images

Individual multiresolution techniques for separate image fusion and denoising have been widely researched. We propose a novel multiresolution Discrete Cosine Transform based method for simultaneous image denoising and fusion, demonstrating its efficacy with respect to Discrete Wavelet Transform and Dual- tree complex Wavelet Transform. We incorporate the Laplacian pyramid transform multiresolution analysis and a sliding window Discrete Cosine Transform for simultaneous denoising and fusion of the multiresolution coefficients. The impact of image denoising on the results of fusion is demonstrated and advantages of simultaneous denoising and fusion for SAR images are also presented