

EXPANSIVE WAVELET-BASED APPROACHES FOR SATELLITE IMAGE FUSION

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ABSTRACT

A useful technique in various applications of remote sensing involves the fusion of panchromatic and multispectral satellite images. Recently, some studies showed that a wavelet-based image fusion method provides high quality spectral content in fused images. However, most decimated wavelet-based methods yield fused results with spatial resolution that is less than that obtained via the intensity-hue-saturation (IHS) fusion technique. In this paper, we introduce three types of the expansive wavelet-based image fusion - the undecimated wavelet-based image fusion, the dual-tree complex wavelet-based image fusion, and the framelet-based image fusion - to increase the spatial resolution of fused result. These methods provide a fused result with both high spatial and spectral resolution. I have been used to merge IKONOS and Landsat ETM+ panchromatic and multispectral images.

INTRODUCTION

The fusion of a panchromatic (Pan) image with a high-spatial and low-spectral resolution and multispectral (MS) images with a low-spatial and high-spectral resolution is an important issue in many remote sensing applications, especially for GIS based applications.

A well-fused image by an effective fusion technique is a useful tool not only for increasing the interpretability of human observers but also for improving the accuracy of the classification. In addition, a well-fused image gives a visually beautiful color image only for visualization purposes [1].

Corresponding to the purpose of a given applications, many image fusion techniques and software tools for fusing images have been developed. Among the hundreds of variations of image fusion techniques, the wavelet-based fusion method is widely used as an image fusion technique which is based on the principle of extracting from a Pan image the detailed spatial information not present in an MS images; this information is later injected into the MS image.

The wavelet approach preserves the spectral characteristics of the MS image better than the intensity-hue-saturation (IHS) method. But, in general, images fused by wavelets have much less spatial information than that fused by the IHS method. However, recent studies showed that if an expansive discrete wavelet transform (DWT) is used instead of the usual DWT (proposed by Mallat [2]), the spatial resolution of the fused images can be as good as those of these images obtained applying IHS fusion method [3],[4]. An example of an expansive DWT is an undecimated DWT which is implemented by removing the down-sampling operations in the usual DWT implementation [5]. The undecimated DWT is a shift-invariant form of the

DWT and avoids some of the artifacts that arise when the critically-sampled DWT is used for image fusion.

In this work, the author introduces other examples of an expansive DWT. First is the dual-tree complex wavelet transform (CWT) which is implemented by performing two DWTs in parallel on the same data [6]. Second is the fast framelet transform proposed by Daubechies et al. [7]. In order to validate these approaches, it has been used to merge IKONOS as well as Landsat Enhanced Thematic Mapper Plus (ETM+) Pan and MS images. The spatial and spectral quality of the resulting images has been analyzed and it has been compared with the quality of those images obtained applying IHS fusion method.

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