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Implementation and Comparison of Spectral and spatial Quality of Pixel-based Satellite Image Fusion Methods

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Extended Abstract

Remote sensing images have become extensively employed due to the fast development of satellite sensors. However, due to sensor technological limits and other variables, current remote sensing sensors must make a basic tradeoff between spatial and spectral resolutions. There are two major restrictions in particular. (1) The radiation energy that enters the sensor. In general, high spatial resolution (HR) panchromatic (PAN) images have a greater bandwidth than low spatial resolution (LR) multispectral (MS) images. To gather more photons while maintaining the signal-to-noise ratio (SNR), the MS detector size should be increased (i.e., a bigger instantaneous field of view (IFOV), followed by a reduced spatial resolution). (2) The amount of data acquired by the sensor. It should be noticed that the HR MS picture has a substantially bigger data volume than the integrated LR MS and HR PAN images. As a result, the restricted on-board storage capacity and data transfer from platform to ground may be overcome. Fortunately, PAN/MS image fusion, also known as "pansharpening," may be used to combine the geometrical detail of the HR PAN image with the spectral information of the LR MS image to produce an HR MS image, overcoming the tradeoff between the spatial and spectral resolutions of satellite sensors. Several reasons influenced the development of pan sharpening methods. For instance, it is prompted by advances in remote sensing sensors. This primarily focuses on the difference in the number of spectral bands and the spectral range between the MS and PAN images. Specifically, this has varied from the previous MS images with only three bands and a PAN image covering only the visible spectrum (such as SPOT-1, SPOT-2, etc.); to MS images with four bands and a PAN image covering the visible and near-infrared (NIR) spectrums (such as IKONOS, QuickBird, etc.); up to MS images with six or more bands and only part of them covered by the PAN image (such as Landsat ETM +, OLI, WorldView-2, etc.). Second, the use of important new developing theories or other hot-spot mathematical discoveries has stimulated the creation of pansharpening methods. Additionally, pansharpening algorithms based on deep learning are gaining popularity. It should be highlighted, however, that if certain new developing theories or hot-spot mathematical research might better answer the challenges of pansharpening, they should be completely evaluated and validated. Third, the demands of practical

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engineering and remote sensing applications drove the development of pansharpening technologies. Effective pansharpening approaches, for example, to produce HR MS images for thematic mapping, visual interpretation, and change detection, are extremely needed. Furthermore, it is worth noting that various applications may have different needs for increased spectral fidelity or spatial improvement. As a result, the development of application-oriented pansharpening algorithms is gaining traction. The purpose of this research is to implement and thoroughly investigate the spectral-spatial outcomes of several image fusion algorithms at the pixel level. Based on this, 15 traditional image fusion methods, including transfer-based methods, computational combination, filter-based methods in the time and frequency domain, and statistical image fusion methods, were developed and compared in four categories. In addition, 10 distinct spectral and spatial quality criteria were assessed in four different modes to assess the quality of the results. In the first situation, each criterion was considered, and the findings show that, with the exception of the RVS and Gramshmit methods, which preserve both spectral and spatial information in the fused images, the rest of the mentioned methods, while preserving spatial information in the integrated images, perform poorly in preserving spectral information. In the second scenario, the average of all seven spectral criteria in the same direction was considered in two categories of minimum and maximum values, with the LMVM, Gramshmit, SVR, and Ehler methods performing best in the maximum spectral criterion and the Ehler, SVR, SFIM, and IHS methods performing best in the minimum spectral criterion, retaining 90% of the spectral information. The spatial criteria exhibited the same trend in the third scenario, with the LMM, ISVR, Brovey, and PCA approaches having the highest performance in keeping spatial information. It was investigated jointly in the fourth mode of study, taking into consideration the average spectral and spatial criteria in both the minimum and maximum dimensions. The findings of this mode demonstrated that the average spectral-spatial quality in the maximum mode, respectively, LMM, LMVM, RVS, Ehler, Gramshmit, and SVR techniques, and in the minimum mode, respectively, Ehler, SVR, SFIM, and IHS methods, maintained spectral and spatial information. They performed the best in fused images. The results of four examination modes revealed that the SVR, Ehler, and Gramshmit algorithms outperformed other methods in maintaining spectral-spatial information in fused images, preserving between 80 and 95% of the information.

Keywords: Image fusion, Remote sensing, Spectral and spatial criteria of image fusion