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Multi-Sensor, Multi-Resolution Image Fusion for Monitoring of Wetlands

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Earth observation satellites provide data covering different portions of the electromagnetic spectrum at different spatial, spectral, temporal and radiometric resolutions giving a more complete view of the observed objects. However, two major factors limit sensor's ability to collect high spatial resolution (HSR), Multispectral (MS) data. First, the incoming radiation energy to sensor is limited by optics size. Second, the data volume to be collected and stored by the sensor increases exponentially with HSR. With physical and technological constraints, some satellite sensors supply the spectral bands needed to distinguish features spectrally but not spatially, while other satellite sensors supply the spatial resolution for distinguishing features spatially but not spectrally. For many applications, combination of data from multiple sensors provide more comprehensive information. Thus, satellites such as QuickBird, IKONOS, IRS bundle a 1:4 ratio while Landsat and SPOT bundle a 1:2 ratio of a HSR Panchromatic (PAN) band and low spatial resolution (LSR) MS bands in order to support both colour and best spatial resolution while 105inimizing on-board data handling needs. A critical consideration is how to integrate spatial information present in the PAN image but missing from the LSR MS data. Therefore, for full exploitation of increasingly sophisticated multi-source data, advanced analytical or numerical image fusion techniques are required.

Image fusion{xe "Image fusion"} refers to combining the geometric detail of a HSR PAN image and the spectral information of a LSR MS image to produce a final image with the highest possible spatial information content while preserving good spectral information quality. It describes a group of methods and approaches using multi-source data of different nature to increase quality of information contained in the data. Fused images provide increased interpretation capabilities, more reliable results as data with different characteristics are combined, reduces ambiguity, improves reliability, improves classification, substitutes missing information and are also used for flood monitoring, ice/snow monitoring, geological applications, etc.

However, for a particular application, it is necessary to have apt spectral and spatial resolution, which is a constrain by availability. Availability depends on the satellite coverage, operational aspects, atmospheric constraints such as cloud cover, economic issues, suitable fusion level, geometric model, ground control points, re-sampling method etc. Considering all these aspects, an attempt has been made to evaluate the performance of five image fusion techniques such as SFIM (Smoothing Filter),

COS (Component Substitution), High Pass Fusion (HPF), High Pass Filter (HPF) and High Pass Modulation (HPM) when applied on different resolution ratios (PAN and MS obtained from different sensors), such as (i) Fusion of 1:4 resolution ratio (IRS PAN 5.8 m + LISS-III MS 23.5 m), (ii) Fusion of 1:2 resolution ratio (Landsat ETM + PAN 15 m + MS 30 m), (iii) Fusion of 1:50 resolution ratio (IRS PAN 5 m + MODIS 250 m), (iv) Fusion of 1:100 resolution ratio (IRS PAN 5 m + MODIS 500 m), (v) Fusion of 1:250 resolution ratio (IKONOS PAN 1 m + MODIS 250 m), and (vi) Fusion of 1:500 resolution ratio (IKONOS PAN 1 m + MODIS 500 m).

The results indicated that HPM is the most suitable technique for merging IRS MS and PAN images. COS is best for fusing 1:2 Landsat ETM+ PAN and MS bands. HP Filter performed best on the fusion of 1:50 and 1:100 resolution ratio data. Visual appearance of fused images (IKONOS PAN and MODIS, 1:250 and 1:500) did not bring any sharpness and one may not see significant improvement in the pixel's appearance before and after image fusion. However, statistical properties of the fused images revealed that HP Filter retained all the properties after fusion. From the above study, it may be concluded that fusion of high and moderate spatial resolution MS band with HSR PAN band retains the spatial and spectral properties of the fused bands. However, as the spatial resolution decreases, fusion of images does not facilitate image quality enhancement for object identification. In such cases, spectral unmixing techniques can be employed on low spatial resolution data.

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