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"Novel methods for panchromatic sharpening of multi/hyper-spectral image data"

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Abstract

In the first part of the paper we address six problems we have encountered when sharpening multi-spectral imagery (MSI) using panchromatic (PAN) images from current commercial satellites such as QuickBird and Ikonos, and describe methods we have developed to solve them. In the second part of the paper, we describe a PAN-sharpening method that can be used for hyper-spectral data where the PAN band does not cover all spectral bands.

The first problem that is often encountered in sharpening four-band multi-spectral imagery is that the satellite imagery looks too dark when displayed on computer monitors, we find that a non-linear compression similar to the one used for digital cameras needs to be applied to satellite data to render the intensity values correctly. The second problem is that PAN bands often cover the visible and near infrared (NIR) region and that this results in severe color distortions for targets such as vegetation when current PAN-sharpening methods are used. To solve this problem we have developed method to create a new synthetic PAN band PAN(RGB) for the visible bands and one PAN(NIR) for the NIR band [1]. The third problem is that output from current PAN-sharpening methods is often in 8-bit format and looses radiometric information. We have solved this problem by creating a floating-point version of histogram matching and also floating-point versions of RGB to HSV conversion routines. The fourth problem we found is that the imagery from current sensors is blurred by the optical system point spread function and thus the resolution is not optimal. We apply a variety of image restoration algorithms: (1) inverse filtering, (2) iterative Wiener filtering and (3) Richardson-Lucy filtering to the PAN and MSI data. The fifth

problem is how to co-register the MSI data to the Pan image so that the color bleeding is reduced. The sixth problem is how to interpolate the MSI bands to the PAN band resolution without introducing artifacts, *e.g*. nearest-neighborhood sampling will introduce blocky artifacts, bi-linear interpolation creates blurring, cubic interpolation produces over and under-shoots and Fourier Transform interpolation can create artifacts near the image boundaries.

Our new PAN-sharpening algorithm fuses the low-resolution MSI data with the synthetic PAN(RGB) and PAN(NIR) optionally using four different data fusion methods. In this paper we compare a number of currently used PAN-sharpening methods (Multi-resolution Wavelet Transform, Principal Components Analysis, Gram-Schmidt, and Intensity-Hue-Saturation, [2]) with our new algorithm.

Hyper-spectral imagery (HSI) typically covers the visible through the shortwave infrared and may have a PAN band to give more detailed imagery, which covers the visible and part of the NIR. The current consensus in the data fusion community seems that it is impossible to PAN-sharpen bands not spectrally covered by the PAN band. In this paper we describe a method that attempts to create synthetic PAN bands PAN(i) for each band (i) by a four-step process. The first step is to cluster the HSI data using a Spectral Angle Mapper (SAM) algorithm, which assigns a spectral class and magnitude to each pixel. In the second step, we determine the regression coefficients to relate the magnitude image to a synthetic PAN image created by weighting the HSI bands. In the third step, we create a synthetic PAN band for each band by using the class spectra multiplied with the linearly transformed magnitude. In the fourth step, the synthetic PAN band image PAN(i) is fused with the interpolated HSI band to create the PAN-sharpened HSI cube. To measure the performance of the PAN-sharpened HSI data we use simulated data. We create a simulated high-resolution data cube and then derive a lower resolution HSI and high-resolution PAN band. The simulated data are then processed with the proposed HSI PAN-sharpening algorithm and the performance is measured using the Wang-Bovik quality index.

[1] Aiazzi, B.; Baronti, S.; Selva, M., "Improving Component Substitution Pansharpening Through Multivariate Regression of MS +Pan Data," Geoscience and Remote Sensing, IEEE Transactions on , vol.45, no.10, pp.3230-3239, Oct. 2007.
[2] Alparone, L..; Wald, L..; Chanussot, J..; Thomas, C..; Gamba, P..; Bruce, L. M., "Comparison of Pansharpening Algorithms: Outcome of the 2006 GRS-S Data-Fusion Contest," IEEE Transactions on Geoscience and Remote Sensing, vol. 45, issue 10, pp. 3012-3021,2007.