A Fourier Transform-based Method to Fusion IKONOS Data

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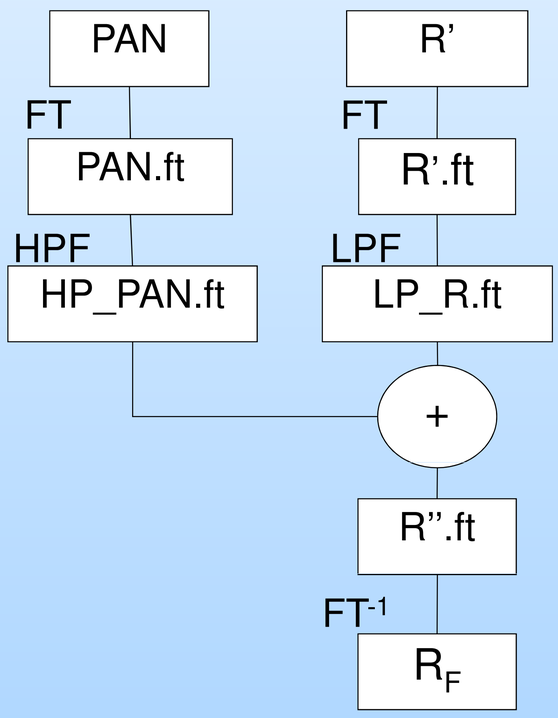
Introduction: IKONOS satellite produces panchromatic band (PAN) with one meter spatial resolution and multiespectral bands (MS) with four meters. Spectral information from MS is useful to differentiate land cover classes, like vegetation, bare soil, water, roads and buildings. On the other hand, the spatial information from PAN is necessary for an accurate description of image details, such as shape, contours and features. Image fusion is used to combine both PAN and MS to obtain high-resolution multispectral bands.

Existing Fusion Methods: The traditional IHS fusion method has the disadvantage of distort the spectral characteristics of the original MS bands. Image fusion methods using frequency domain processing like wavelet transform (WT), preserve good spectral information, but their spatial visual results are not satisfactory. IHS fusion methods enhanced by Fourier transform have been very suitable in preserving both spectral and spatial information, but they are limited to red (R), green (G) and blue (B) bands, excluding the near-infrared (NIR) band.

Proposed FT-based Image Fusion Method: The proposed method consists in obtain the spectral information from MS band by applying a low pass filter in the frequency domain, and obtain the spatial information from PAN by applying a high pass filter. The steps to fusion R and PAN bands are illustrated in figure 1. The same steps must be applied to G, B and NIR bands.

Figure 1 - Schematic diagram for FT-based fusion of PAN and R



For the filters, the optimum cutoff frequency must be measured accordingly to the spatial resolution, which depends on the image sampling interval, following the Nyquist sampling criterion: the sampling interval is in inverse proportion to the sampling frequency. The maximum frequency of an image is $1/2\Delta x$ (where Δx is its pixel size in meters). IKONOS PAN has one meter spatial resolution, so the maximum frequency is 0.5 cycles per meter. The MS maximum frequency is 1/4 of PAN maximum frequency, so the cutoff frequency for an IKONOS image is 0.125 cycles per meters.

Some filters like Gaussian, Butterworth and Hanning were tested to smooth the results. The more suitable was Hanning.

Figure 1 show that the result (c) of the proposed method has high spatial resolution (compare it to PAN in figure (a)), while maintaining the original colors (compare it to RGB composition in figure (b)).

Figure 2 – (a) PAN, (b) MS, (c) result of the proposed fusion method using Hanning filter.

Table 1 compares the proposed method with other fusion methods by applying correlation coefficient between the fused bands and their corresponding original. The MS bands are expected to be as similar to the original bands as possible.

Method	R	G	B	NIR
IHS	0.34	0.24	0.27	----
WT	0.64	0.61	0.53	0.77
IHS+FT	0.77	0.70	<u>0.75</u>	----
FT (proposed)	<u>0.84</u>	<u>0.78</u>	0.74	<u>0.86</u>

Conclusions: A method based on filter in the frequency domain was proposed to the fusion of IKONOS bands. It can be observed that high information from PAN was added to MS information without distorting the original colors. The proposed method attains more spectral information when compared with IHS, WT and IHS+FT methods. Another advantage is that the proposed method can use the NIR band.

Acknowledgments: The authors thanks CNPq for financial support.