Multispectral image pansharpening based on the contourlet transform

Israa Amro and Javier Mateos

Departamento de Ciencias de la Computación e I.A. , Universidad de Granada, 18071 Granada, Spain

E-mail: iamro@correo.ugr.es, jmd@decsai.ugr.es

Abstract. Pansharpening is a technique that fuses the information of a low resolution multispectral image (MS) and a high resolution panchromatic image (PAN), usually remote sensing images, to provide a high resolution multispectral image. In the literature, this task has been addressed from different points of view being one of the most popular the wavelets based algorithms. Recently, the contourlet transform has been proposed. This transform combines the advantages of the wavelets transform with a more efficient directional information representation. In this paper we propose a new pansharpening method based on contourlets, compare with its wavelet counterpart and assess its performance numerically and visually.

1. Wavelet and Contourlet-based pansharpening

In the literature many pansharpening methods have been proposed for combining PAN with MS image, see [1, 2] for a detailed review. It was found that multi-sensor image fusion is a trade-off between the spectral information from an MS sensor and the spatial information from an PAN sensor that is easily controlated with the wavelet transform fusion methods. However, wavelets fail to capture the smoothness along the contours [3]. The contourlet transform, an alternative multiresolution approach, provides an efficient directional representation and also efficient in capturing intrinsic geometrical structures of the natural image along the smooth contours [4]. A wide amount of methods had been proposed both for wavelets and contourlets. See [5, 6] for a detailled comparison of wavelet based fusion methods. Contourlets methods based on those wavelets methods has been also proposed in the literature. Also, the WiSpeR method can be understood as a generalization of different wavelet-based image fusion methods [7]. It uses a modification of the non-subsampled additive wavelet algorithm where the contribution from the PAN image to each of fused bands depends on a factor generated both from the sensor spectral response and physical properties of the observed object. We proposed a new contourlet panshapening method, named CiSpeR, that, similarly to WiSpeR, depends of a spectral factor to determine the amount of spatial detail of the PAN image that has to be injected into each MS band but it uses the non-subsampling contourlet transform with necessary filters, and n resolution levels and m directions in each level.

2. Experimental Results

The contourlet-based and wavelet-based methods mentioned in section 1 are evaluated on the dataset acquired by SPOT5 satellite shown in Fig. 1. The pansharpened images resulted from

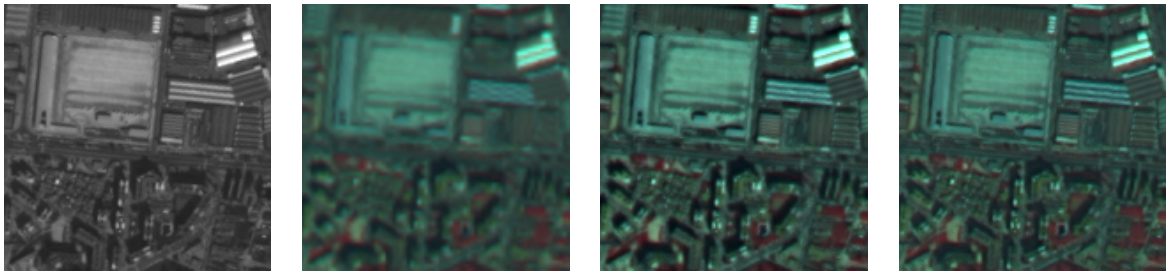

Figure 1. From left to right: SPOT-5 PAN image, low resolution image formed from the G-R-NIR bands of the MS SPOT image and pansharpened images using WiSPeR and CiSPer.

	COR (Ideal Value: 1)				UIQI (Ideal Value: 1)				ERGAS
	band 1	band 2	band 3	band 4	band 1	band 2	band 3	band 4	
WiSpeR	0.90	0.92	0.93	0.88	0.79	0.89	0.85	0.85	7.29
CiSpeR	**0.92**	**0.94**	**0.95**	**0.92**	**0.91**	**0.97**	**0.95**	**0.94**	**2.86**

Table 1. SPOT 5 Quantative Analysis

using the wavelet and contourlet methods under study are presented in Fig. 1. From the pansharpened images we observe that the proposed method, CiSpeR, enhances the images spatially while accurately preserves the spectral information. Numerical results in Table 1 agree with visual inspection. The highlighted values in the table present the highest (close to ideal ideal) values for each measure. It is clear that the contourlet-based method has better results than wavelet one. This result is expected since the contourlet is known to have a better representation for directional information.

3. Conclusions

In this paper, wavelet and contourlet based pansharpening approaches have been compared and their efficiency to merge SPOT images has been evaluated visual and quantitatively. The contourlet-based pansharpened images present, visually and numerically, better results than those obtained by wavelet, extracting spatial information from the PAN image missing in the MS image, without modifying its spectral information content.

Acknowledgments

This work has been supported by the Consejería de Innovación, Ciencia y Empresa of the Junta de Andalucía under contract P07-TIC-02698.

References

[1] Pohl C and Genderen J L V 1998 *Int. J. Remote Sens.* **19** 823–854

[2] Alparone L, Wald L, Chanussot J, Gamba P and Bruce L M 2007 *IEEETrans. Geosci. Remote Sens.* **45** 3012–3021

[3] Shah V P, Younan N H and King R 2007 *Proc. IEEE Int. Geosci. Remote Sens. Symp. IGARSS 2007* pp 310–313

[4] Do M N and Vetterli M 2005 *IEEE Trans. Image Process.* **14** 2091–2106

[5] González-Audícana M and Otazu X 2005 *Int. J. Remote Sens.* **26** 595–614

[6] Nuñez J, Otazu X, Fors O, Prades A, Pala V and Arbiol R 1999 *IEEE Trans. Geosci. Remote Sens.* **37** 1204–1211

[7] Otazu X, Gonzlez-Audcana M, Fors O and Núñez J 2005 *IEEE Trans. Geosci. Remote Sens.* **43** 2376–2385