ON THE EFFECTS OF PAN-SHARPENING TO TARGET DETECTION

Andrea Garzelli, Luca Capobianco, Filippo Nencini

University of Siena
Department of Information Engineering
Via Roma, 56, I-53100 Siena, Italy, e-mail: garzelli@dii.unisi.it

1. ABSTRACT

The last generation of multispectral sensors (e.g., Quickbird, Ikonos, SPOT-5) can acquire a panchromatic image characterized by a very high geometrical resolution and a set of multispectral images that have lower spatial resolution. In order to merge the properties of these two kinds of data, i.e. to achieve a set of MS images with an enhanced geometrical resolution, it is possible to use proper multiresolution fusion (merging) techniques, usually called pan-sharpening.

The goal of this paper is to analyze the effects of multiresolution fusion on multi-spectral (MS) and panchromatic images for applications of target detection. The rationale of the analysis consists in understanding in what conditions and to which extent the merging process can improve the results of standard or advanced methods of target detection. In order to properly analyze and study this problem, different multiresolution fusion algorithms are tested to compare the detection results obtained from original MS and Pan data and from spatially-enhanced MS data. To this aim, both consolidated widely-used algorithms and more recent advanced methods of pan-sharpening are considered.

The following techniques are selected and compared: the GIHS method [1], the algorithm based on the à-trous wavelet proposed in [2], and the pan-sharpening method based on a minimum mean squared error approach described in [3]. In this way, different methodological approaches to pan-sharpening are taken into account: component-substitution methods, multiresolution analysis (MRA) methods, and hybrid methods. From a theoretical point of view, the algorithms strictly based on standard component substitution locally introduce spectral/radiometric distortions during the fusion process which may negatively affect the performances of target detection methods. On the other hand, MRA-based methods performing a highpass detail injection may produce spatial distortions, typically ringing or aliasing effects, originating shifts or blur of contours and textures. These drawbacks, which may be as much annoying as spectral distortions for detection applications, are emphasized by misregistration between MS and Pan data, especially (but not exclusively) if the MRA underlying detail injection is not shift-invariant. Efficient hybrid methods should represent a good trade-off between component-substitution and MRA-based pan-sharpening approaches.

Results are firstly assessed by using a linear distance method such as (Maximum Likelihood or) Minimum Distance, in order to properly understand the impact of pan-sharpening on the target detection process. However, in the last years linear methods have been demonstrated to be not appropriate for describing the class variability in the framework of classification and target detection in multi/hyperspectral images; the use of kernel instead, among others advantages, provides flexible non-linear mappings with controlled complexity and may *catch* (describe) quite easily the non-linearities in the data. Hence, the effects of pan-sharpening are evaluated also by using a kernel algorithm, such as Kernel Orthogonal Subspace Projection [4, 5]. In addition, the well-performing one-class SVM algorithm is used as well in its kernel version.

Several experiments are carried out by applying the aforementioned techniques to QuickBird and Ikonos datasets. From these experiments it is possible to derive interesting conclusions on the effectiveness and the appropriateness of the different investigated multiresolution fusion techniques with respect to the selected target detection algorithms. The experimental results are shown in terms of pixel-based ROC curves evaluated on user-built ground truth. Results obtained at full and at degraded scale on well-defined targets (e.g. airplanes and ships) substantially confirm the theoretical considerations. Comparisons with resampled MS images are also performed.

2. REFERENCES

[1] T.M. Tu, S.C. Su, H.C. Shyu, and P.S. Huang, "A new look at IHS-like image fusion methods," *Information Fusion*, vol. 2, no. 3, pp. 177–186, 2001.

[2] J. Nuñez, X. Otazu, O. Fors, A. Prades, V. Pala, and R. Arbiol, "Multiresolution-based image fusion with additive wavelet decomposition," *IEEE Transactions on Geoscience and Remote Sensing*, vol. 37, no. 3, pp. 1204–1211, 1999.

[3] A. Garzelli, F. Nencini, and L. Capobianco, "Optimal MMSE Pan Sharpening of Very High Resolution Multispectral Images," *IEEE Transactions on Geoscience and Remote Sensing*, vol. 46, no. 1, pp. 228–236, January 2008.

[4] H. Kwon and N.M. Nasrabadi, "Kernel matched signal detectors for hyperspectral target detection," in *Proceedings of the 2005 IEEE Computer Society Conference on Computer Vision and Pattern Recognition (CVPR'05)-Workshops-Volume 03*. IEEE Computer Society Washington, DC, USA, 2005.

[5] L. Capobianco, G. Camps-Valls, and A. Garzelli, "Semi-supervised kernel orthogonal subspace projection," in *Proc. IEEE IGARSS 2008*, 2008.