Multi-spectral Image Classification Using Wavelets

Jun Yu
Department of Forest Resource Management and Geomatics
Swedish University of Agricultural Sciences
Umeå, Sweden
jun.yu@resgeom.slu.se

Magnus Ekström
Department of Forest Resource Management and Geomatics
Swedish University of Agricultural Sciences
Umeå, Sweden
magnus.ekstrom@resgeom.slu.se

Supervised classification of remote-sensing images has been widely used as a powerful means to extract various kinds of information concerning the earth environment. The objective of supervised classification in remote sensing is to identify and partition the pixels comprising the noisy image of an area according to its class (e.g. forest and non-forest), with the parameters in the model for pixel values estimated from training samples (ground truths). Usually, the spectral signature is the main aspect of the classes used to classify the pixels.

Among early classification rules to be used were parametric methods such as linear and quadratic discriminant analysis (LDA and QDA) and nonparametric methods like the k-nearest neighbour (k-NN) classifier. In these rules, each pixel is classified solely on its spectral intensities and it does not account for spatial dependence. These approaches effectively assume the spectral intensities in neighbouring pixels to be independent, therefore important information from neighbouring pixels is neglected. They might be reasonable if the pixel-sizes are large or when the densities of the spectral intensities are well separated for different classes. In the classification of the states of forests, for example, the densities of the spectral intensities are seldom well separated. Also spatial dependency grows more important as the spatial resolution increases. Therefore, various methods for contextual classification of multi-spectral scanner data have been developed in order to take the neighbouring pixel information into account. See Flygare (1997) and references therein. They tend, however, to be computationally intensive, and also have special requirements on the ground truths such as homogeneous crosses of pixels, which may not be easily available in practice.

Recently, the wavelet transform has been attracting attention in diverse areas such as medical imaging, pattern recognition, data compression, numerical analysis, and signal processing, especially for non-stationary signal analysis applications, since it provides information in both spatial and frequency domains due to its inherent nature of space-frequency analysis. In wavelet representations, the images are decomposed using basis functions localised in spatial position, orientation, and spatial frequency (scale). Because satellite images consist of thousands of pixels pertaining to the energy of light reflected from the ground, it displays non-stationary signal characteristics. This specific characteristics of satellite images and the characteristics of the wavelet transform motivate the investigation of use of the wavelet transform in target classification of scenes.

"Pixels" in wavelet transformed sub-images (i.e., wavelet coefficients) represent the characteristics in sub-frequency bands, which also represent the characteristics of the pixels in the original image. Since these new "pixels" bear information also on the neighbouring pixels, a repeated wavelet transform to a specific image may serve to classification of targets efficiently. This is an advantage compared to contextual methods which require extensive computation time on correlation between adjacent pixels.

The aim of the present simulation study is to compare some conventional classification methods with wavelet based methods on different types of scenes (ground truths) together with multi-spectral remotely sensed data with correlated frequency bands. The observed vectors of spectral reflectances in pixels, given the classes, have varying degrees of spatial dependency, from independence to strong autocorrelation. The data are generated from binormal class distributions, according to the model used in Mohn et al. (1987). The results of our study indicate that the wavelet based method usually reduces the misclassification rates considerably and performs best among the methods under study, which agrees with our previous study (Yu et al. (2000)) of wavelet classification for remotely sensed data with single frequency band.

REFERENCES

Flygare, A-M. (1997). A comparison of contextual classification methods using Landsat TM. *Int. J. Remote Sensing*, **18**, 3835-3842.

Mohn, E., Hjort, N.L. and Storvik, G.O. (1987). A simulation study of some contextual classification methods for remotely sensed data. *IEEE Trans. Geosci. Remote Sensing*, **GE-25**, 796-804.

Yu, J., Ekström, M. and Nilsson, M. (2000). Image classification using wavelets with application to forestry. *Proceedings of the 4th International Conference on Methodological Issues in Official Statistics, Stockholm.* (http://www.scb.se/omscb/proceedingspdf/Jun.pdf)