Markov Random Fields and Neural Network for Improving Multi-source Data Interpretation

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There is currently a big need for methods aimed at improving the exploitation of multi-source data for earth observation. This is caused by the increasing number of image sources providing different kinds of information about the earth for oceanic, meteorological, terrestrial applications. These sources may be very different in their nature, and consequently also the spatial and spectral resolution of their data sets may be also very different.

In this work we are interested to land cover analysis, especially in urban areas, where the huge spatial variability of the environment requires usually data coming from many sensors to generate a satisfactory and reliable interpretation of the scene. This process, labeled as data fusion, has been performed using various approaches, from statistical methods [1], to Dempster- Shafer theory [2], and also by means of neural networks [3]. Here we propose a basic procedure based on a Markov Random Field but with the aid of neural network for extracting the a priori probability density functions for the land cover classes. Moreover, a comparison with all neural network chains for data fusion in urban areas [4] is provided, in order to understand the advantages and drawbacks of the approach. As a matter of fact, taking into account some simple local interactions at the scale of a single pixel and its neighbors, MRF models show a complex global behavior, which is the principal reason of their popularity among the scientific community. One drawback of MRF is that they may have prohibitive computational costs. To our aim, we found out that ICM (iterated conditional mode) was the most useful algorithm. Still, neural network trained for spatial (re)classification may be equally effective, and maybe more suitable to continuously spatially changing environments. So, this work provides an interesting comparison between the two techniques, both based on a initial pixel-based classification performed by a Fuzzy ARTMAP classifier.

For our tests, the area around the town of Pavia (Northern Italy) has been chosen. The city of Pavia has already been widely analyzed for other purposes and therefore a detailed ground information, together with other results, may be used for analysis and comparison [5]. So, we collected some ERS-1/2, Envisat (ASAR) and Landsat TM and ETM images of the town and performed our classification based on the MRF and NN approaches. The multi-source data have been co-registered one to the others and to the corresponding ground truth. We want to remark here that in defining the MRF classification model, we made some choices as the energy function present in the Gibbs function, the pixel number contained in the neighborhood of each pixel, and the optimization algorithm, which are peculiar to urban areas, and thus were chosen to make the approach more suited to the target area.

REFERENCES

1. Welch, R. and M. Elehers, "Cartographic feature extraction with integrated (SIR-B) and landsat TM images," *Int. J. Remote Sensing*, Vol. 9, 873–880, 1988.
2. Lehrer, N., G. Reynolds, and J. Griffith, "Initial hypothesis formation in image understanding using an automatically generated knowledge base," *Proc. Workshop Image Understanding*, 521–537, Los Angeles, CA, February 1987.
3. Jakubowicz, O., "Autonomous reconfiguration of sensor systems using neural nets," in *Proc. SPIE: Sensor Fusion*, 197–203, Orlando, FL, April 1988.
4. Gamba, P. and B. Houshmand, "An efficient neural classification chain for optical and SAR urban images," *International Journal of Remote Sensing*, Vol. 22, No. 8, 1535–1553, May 2001.
5. Gamba, P., "A collection of data for urban area characterization," *Proc. of IGARSS04*, Vol. 1, 69–72, Anchorage (USA), September 2004.