Soft Computing and Neural Adaptive Techniques for High Accuracy Data Classification

E. Binaghi and I. Gallo
Università degli Studi dell'Insubria, Italy

In this present work we intend to survey the recent salient experiences and main results obtained by our group in the field of Soft Computing and Neural Learning for Pattern Recognition.

To document our first significant research activity, we present a supervised classification model integrating fuzzy reasoning and Dempster-Shafer propagation of evidence; the model is built on top of connectionist techniques to address classification tasks in which vagueness and ambiguity coexist. The salient aspect of the approach is the integration within a neuro-fuzzy system of knowledge structures and inferences for evidential reasoning based on Dempster-Shafer theory. In this context the learning task can be formulated as the search for the most adequate "ingredients" of the fuzzy and Dempster-Shafer frameworks such as the fuzzy aggregation operators, for fusing data from different sources and focal elements, and basic probability assignments, describing the contributions of evidence in the inference scheme. The new neural model allows us to establish a complete correspondence between connectionist elements and fuzzy and Dempster-Shafer ingredients, ensuring both a high level of interpretability and high performance in classification.

A second salient experimental work developed by our group concerns contextual classification of remote sensing images. Many cases of remote sensing classification present complicated patterns that cannot be identified on the basis of spectral data alone, but require contextual methods which base class discrimination on the spatial relationships between the individual pixel and local and global configurations of neighboring pixels. However, the use of contextual classification is still limited by critical issues, such as complexity and problem dependency. We present a contextual classification strategy for object recognition in remote sensing images in an attempt to solve recognition tasks operatively. The salient characteristics of the strategy are the definition of a multiresolution feature extraction procedure exploiting human perception and the use of soft neural classification based on the Multi-Layer Perceptron model. Three experiments were conducted to evaluate the performance of the method-ology, one in an easily controlled domain using synthetic images, the other two in real domains involving built-up pattern recognition in panchromatic aerial photographs and high resolution satellite images.

The last work presented is representative of recent research interest focusing on 3D image analysis. In particular the work investigates the potential of neural adaptive learning to solve the correspondence problem within a two-frame adaptive area match-ing approach. A novel method is proposed based on the use of the Zero Mean Normalized Cross Correlation Coefficient integrated within a neural network model which uses a least-mean-square delta rule for training.

Two experiments were conducted for evaluating the neural model proposed. The first aimed to produce dense disparity maps based on the analysis of standard test images. The second experiment, conducted in the biomedical field, aimed to model 3D surfaces from a varied set of SEM (Scanning Electron Microscope) stereoscopic image pairs.