1. Introduction

Early remotely sensed data analysis in the 70’s and 80’s, opened the eyes of the world on the problem of tropical deforestation. Today, land-cover mapping using data from satellite borne sensors has become a fundamental tool in countless research, development and policy applications. The need of information has also grown considerably. Simple forest / non-forest mapping is no longer sufficient for most applications. Fortunately, the remote-sensing technology is progressing fast, providing data of increased spatial, spectral, radiometric and temporal resolution, and so have data analysis methods.

Despite recent improvements in technology and methods, classifying a landscape in meaningful land-cover strata from the perspective of the biological, hydrological, mineralogical, socio-economical or climatic sciences is still difficult. Considerable research efforts are being made to improve multi-spectra data analysis algorithms and to develop methods for integrating ancillary spatial data in the classification procedure.

Neural networks classifiers are becoming increasingly popular among the remote sensing community. They also have become a standard tool of most remote-sensing software packages. An advantage of neural network classifiers is that they can use ancillary spatial data in the classification.

The *Università degli Studi di Trieste* (UST) and CATIE classified independently the same satellite image using two different methods: a neural network (UST, Micheli 2003) and an in-house developed Bayesian method (CATIE, Pedroni 2003), the latter having produced the more accurate classification results.

2. Methods

The dataset used for the classifications included:
- A Landsat TM image from March 1996 (path 15, row 53)
- A digital elevation model of the same study region
- A model of access time from each pixel location to the closest road
- A distance model from each pixel to the Atlantic shoreline

Because of its spatial coarseness, the thermal band was eliminated from the multi-spectral dataset, while NDVI and three Tasseled Cap indexes were added. For training and classification accuracy assessment, geo-referenced information was made available from 979 field sites inspected during 1997-1998.

The objective of the Bayesian classification was the identification of 33 land-cover categories. These were grouped in 16 categories for the neural network classification, making a formal comparison of the two methods impossible. Nevertheless, each classification result was compared with that obtained from a traditional maximum likelihood classification.

As neural network classifier, UST used the *Back Propagation* algorithm of the software *Idrisi Kilimanjaro*. CATIE’s Bayesian classification procedure involved more steps, since adequate tools are still lacking in standard remote-sensing software:
- Stratification of the study region in homogeneous strata using the three ancillary variables
- Maximum likelihood classification using *Erdas Imagine* software
- Estimation of class prior probabilities through sampling of best classified pixels on each stratum using a Mahalanobis Distance threshold
- Modification of the prior probability of each land cover category in each strata
- Stratified Bayesian maximum likelihood classification using *Erdas Imagine* software and a Visual Basic routine written in-house.

3. Results

The overall accuracy of the Bayesian classification was tested in 252 control sites, in which 24 of the 33 land cover categories...
of the map legend were found. With a value of 89%, the accuracy was 20.3% above that obtained with the traditional maximum likelihood classification. The overall accuracy of the neural network classifier (tested on a 16 land-cover categories map) was assessed on 160 control sites. It was almost 10% above the accuracy of the maximum likelihood classification. The results suggest that modifying the class prior probabilities using the procedures developed at CATIE is very effective for improving the accuracy of the classification.

The use of spatially variant prior probabilities eliminates from the results those land cover classes that are unlikely to exist in a given stratum, such as urban areas around clouds above the ocean. It also reduces considerably the so called "salt and pepper" effect. The Bayesian procedures developed at CATIE makes abundant use of the information contained in the ancillary spatial data set, which can be almost as detailed as the spectral data set. The information is used probabilistically (in contrast to deterministically), thus avoiding artifacts in the classified output dataset. The procedures makes it possible to estimate the class probability at each pixel location, e.g. at each elevation.

4. Discussion and conclusion

The Bayesian classification, as developed at CATIE, and the neural network classification made at the Università degli Studi di Trieste were not designed to be compared. Nevertheless, both studies compared their results with those of the traditional maximum likelihood classification. These comparisons suggest that the Bayesian classification, as implemented at CATIE, can produce more accurate results than neural network classifiers. Neural networks are becoming increasingly popular among the remote-sensing community.

Future experimental research should test the accuracy and cost of these methods in comparable conditions, meaning that the training and control data set should be the same, as well as the definition of land-cover categories, the multi-spectral and ancillary spatial data.

Bayesian classifiers exist since a few decades, but they have been rarely used because the estimation of prior probabilities has been difficult. The procedure developed at CATIE addresses this difficulty, but there is no software tool facilitating its implementation in current remote-sensing software packages. Such a software tool should be designed; otherwise, the procedure will hardly be implemented, despite its potential of producing accurate land-cover information.

References


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