FULLY AUTOMATED, HIGH-RESOLUTION CLASSIFICATION OF REMOTELY SENSED DIGITAL MULTISPECTRAL RECORDINGS

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ABSTRACT

The working program pre-set by the chairmen of WG III/3 has been worked on further rigorously as regards topic 1 (Analysis of Multispectral Digital Recordings). The results obtained have been condensed in a method of automatic classification. Thus, e.g. multispectral homogeneity and normal distribution of grey values within so-called training areas ensure that theoretical preconditions of the Maximum Likelihood Method (MLM), which was used for their discrimination, are met. From this a method for searching training areas automatically has been developed. Reliability of classification results depends decisively on that statistically equal training areas are grouped before classification, and that statistically not equal but neither significantly different training areas are grouped only after classification. The statistical test parameters needed for this purpose are presented and their effects described, whereby confusion matrices and classification results serve as examples.

Keywords: Classification, Feature Extraction, Landsat

1. INTRODUCTION

Expectations placed by the different users in remote sensing focus mainly on aspects such as accuracy of content and geometry as well as on the fine structured variety of land use classifications.

The confusion matrice still serves as a source of information on the reliability of assignment of re-classified training areas as well as - inadmissibly - a criterion of discrimination in the case of larger, classified areas. The achievable accuracies documented in this way give no rise to much confidence as to the reliability of results. A hit rate of 60-70 % must be considered as a poor result unworthy of discussion and should be sufficient reason for thinking about the causes. Item 1 of the working programme of WG III/3 served that purpose.

1. Analysis of multispectral digital recordings
1.1 Analysis of data with regard to systematic and random errors and their effect on classification
1.2 Possibilities of data preprocessing and compression without loss of informtion
1.3 Statistical requirements on training areas and their statistical analysis
1.4 Statistical analysis of clusters with regard to separability of objects, admissibility of their integration before classification, and necessity for their integration after classification.
1.5 Analysis of mainly used or self-developed classifiers with regard to their separation capability
1.6 Analysis and valuation of classification algorithms and procedures as well as of spectral resolution of different remote sensing systems
1.7 Possibilities and limits of unsupervised classification

1. FIRST RESULTS OBTAINED BY A NEW PROCEDURE

The causes of poor discriminations in the classification as well as first results of new methodological developments have been published (Schulz, 1990). Considering that the acquisition of objects and land uses can mainly be performed indirectly via spectra, the spectral homogeneity and normal distribution constitute important factors, that means that, among others, neither a variance to be pre-set may be exceeded nor may there exist more than one frequency maximum. This comparatively simple requirement is in most cases very difficult to be met if one pre-defines training areas externally, particularly in instances where they are obviously inhomogeneous in land use and hence also spectrally inhomogeneous, as e.g. in cases of sparsely built-up areas, mixed forest, etc.

2. AUTOMATIC SEARCH AND GROUPING OF TRAINING AREAS

The problem of training area definition inadmissible in the sense as outlined above may be solved by scanning the data without training area-related à priori definitions, that means automatically without operator or intepreter, for those image sections which fulfill the a.m. distribution criteria in all n spectral bands within the range of a pre-set gliding working matrice. In these instances of a successful search for training areas their substitutional parameters, i.e. mean value vector and covarance matrice, are stored.

The training areas found in this way do not at all contain à priori significantly different spectral qualities of land uses. For this reason it is important to check in the following every training area by comparing it to each other one for whether

- it is statistically equal to another one and can thus be combined with it into a training area already before classification

- it is significantly different from the other one and must hence enter into classification as representing a completely new type of land use or

- whether it is, in the sense as defined above, neither equal with any other area nor significantly different from it and must therefore first be formally introduced into

classification as a new class in order to be subsequently grouped with a class of approximate characteristics.

These comparative computations and aggregation processes requiring considerable computation expenditure can formally be placed on a simple level of decision. The value of distance to be computed between 2 training area clusters is

$$t^2 = (u-v)^T * (A+B)^{-1} * (u-v).$$

Here, u and v represent the mean value vectors of the cluster samples to be compared, A and B their covariance matrices.

The introduction of threshold values allows a very simple decision: if, e.g.,

t < 1, then the two testing areas are statistically equal and may be grouped before classification. If. e.g.

t > 3, then the two testing areas are significantly different and stand for 2 classes. If, e.g.,

1 < t < 3, then it is for a clear delimination of clusters concerned from others necessary to first introduce each testing area as independent into classification and to group it with the comparable ones afterwards.

This approach prevents inadmissible grouping of training areas which are classified as identical by the interpreter, while actually being different. Thus, an unnecessary overexpansion of the clusters causing a decrease of the discrimination capacity can be avoided. Beyond that, controlled grouping of statistically equal, nearly normally distributed training areas freed from outliers can lead to larger and statistically better substantiated units. It is to be expected that there is hardly any operator capable of such a performance. The clusters whose distance t is between 1 and 3 can be grouped and assigned after classification when being interpreted.

These are - all in all - the essential reasons for the lateral diagonals of the confusion matrices being occupied by zero and the main diagonal by values between 90% and 100%. The lateral diagonal elements occupied by zero mean that ambiguous classification results can be avoided. Deviations of 100 % in the case of main diagonal elements indicate an incomplete though free of conflicts training area classification.

3. FURTHER PROCESSING OF THE CLASSIFICATION RESULTS

Classification running automatically as depicted above provides very differentiated and safe but not yet interpreted results. Interpretation, which takes place together with the selection of training areas when proceeding interactively, is transferred to the end of the operational treatment in the case of automatic classification. Interpretation is performed by experts of the various disciplines concerned.

4. CONCLUSION AND OUTLOOK

Automatic search for and grouping of training areas according to spectral and statistical aspects provides a substancial benefit as to:

- objective, i.e. only spectrally proven training area selection

- separation capability and thus secured variety of land uses as well as

- free availability of the workstations which would otherwise be strongly occupied by these tasks.

Excessive loading of the data with other background knowledge which is not represented in the data does in this way not occur, hence reducing the risk of ambiguity normally caused by such overloading. Inclusion of multitemporal and multisensoral data in a simultaneous evaluation presupposes rectification accurate to the pixel in each image site, which is particularly difficult in moved terrain and has not been possible as yet.

Inclusion of further data and additional knowledge, e.g. via the interpretation process, will provide in the long run orientation towards artificial intelligence. This is the path we will follow.

LITERATURE

Schulz, B.-S., 1990. Analysis of the Statistical Prerequisites for Classification of Multispectral Data. Proceedings of the Symposium "Progress in Data Analysis", Comm. III of ISPRS, May 20-25, 1990, Wuhan, China