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REFERENTIAL CLASSIFICATION – A NEW INTELLIGENCE BASED CLASSIFICATION ALGORITHM

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Abstract

This paper describes a recently developed method which can be used in the classification of pixels in satellite images. The new method named 'Referential Classification' is a concept in which the spectral contents of the pixels are not considered alone; but instead they are correlated with a kind of ancillary data that involves the coordinates of corresponding pixels and their possible variations of spectral data base. The referential classification process is carried out in two subsequent stages. The application of this method in classifying remotely-sensed images resulted in higher accuracy and less demand for the user intervention during the classification course which implies higher degree of automating the classification process without decreasing its accuracy.

Keywords: image, classification, intelligence, algorithm.

Introduction

Classification of remotely sensed images collected by multispectral scanners onboard different kinds of satellites has been performed by conventional methods depending mainly on the spectral content of the pixels while ignoring other kinds of information related to the pixels, depending only on one factor which is the spectral content of the pixel and discarding the role of other information about the pixel is a serious pitfall in the classification procedure. However, there is a clear evidence that if one likes to have an efficient classification then the classification concept must simulate the human being high ability of perception and analyzing (BAXES, 1985). The role of the human beings in the interpretation of image data is of unique and great value for two reasons: First is the human being's ability to efficiently acquire and maintain an awareness of a universal nature; an awareness not only of the complete remote sensing data but also of the associated reference data and the relationship between the reference and spectral data.

Second is the ability of the human beings to draw and assemble data making considerable use of previous training and experience to make critical decisions (HUNT, 1984). Referential classification is a concept in which the spectral contents of the pixels are not considered alone; but instead they are correlated with the coordinates of the corresponding pixels and their possible variations of spectral database so enhancing the probability of having correct classification of image pixels (ALHUSAIN, 1992).

Referential Classification

The algorithm implemented within this method proceeds first towards assigning Cartesian coordinates (x, y) to each pixel. *Fig. 1* shows the flowchart of the referential classification method. This might be done lo cally where the coordinates of each pixel are valid only within the image where the assignation process has been defined, or globally where the coordinates of each pixel are related to national or even international grid coordinations. The pixel data base is used for archiving all previously measured and/or expected information about each pixel along with its coordinates within the image. The most significant factor in the pixel data base design is its ability to include multitemporal information about pixels and indices to their trends of possible change in the future, because any analysis process done on pixels depends not only on the present measurements but also on measurements from the past. Coordinates assignation should be in compliance with the resolution of the imaging sensor of the satellite system; that means an image of 30 m resolution should be based on a coordinate grid of 30 m or smaller steps but not larger. The referential classification process is carried out in two subsequent stages. In the first stage a supervised classification algorithm is implemented according to the maximum likelihood rule which is presented and discussed in details in image processing literature (SWAIN, 1978; RICHARDS, 1986). In this algorithm suppose that the training data of an image is available for each groundcover type, this data can be used to estimate a probability $p(x/w_i)$ distribution for a cover type that describes the chance of finding a pixel belonging to a class ω_i at a specific position x. This could be expressed by the term $p(x/w_i)$.

The number of the $p(x/w_i)$ will be equal to the number of the ground cover classes. This means, for a pixel at a position x in multispectral space a set of probabilities can be computed for each class. The required $p(w_i/x)$ of the class and the available $p(x/w_i)$ of training data are related by the Bay's Theorem as follows:

$$p(w_i/x) = p(x/w_i)p(w_i)/p(x) \ ,$$

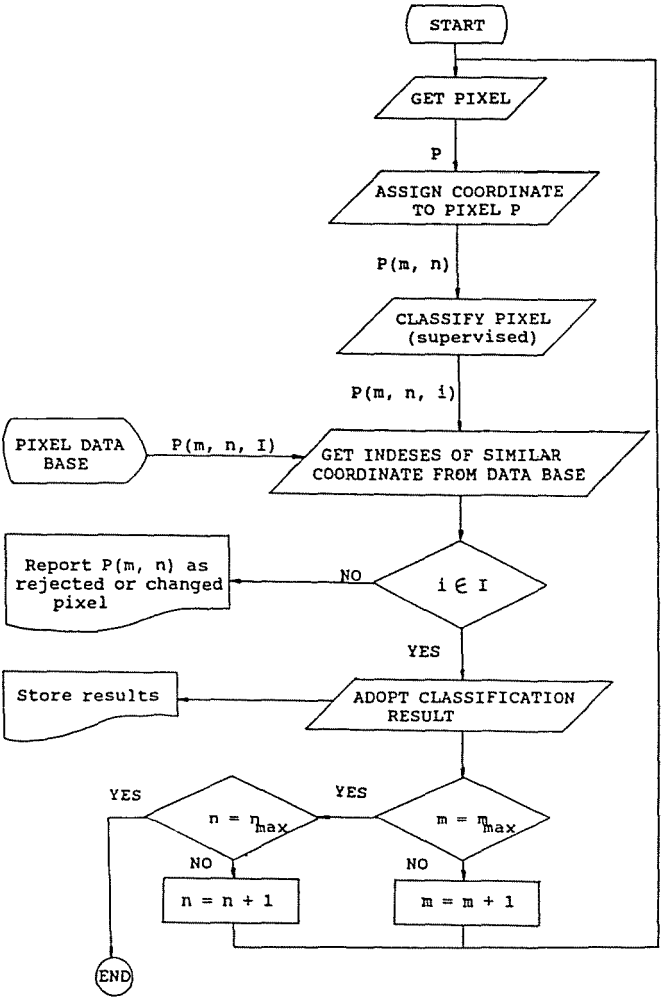

Fig. 1. Flowchart of the referential classification algorithm

where $p(w_i)$ is the probability that class w_i occurs in the image. The rule in classifying a pixel at a position x will be:

$$x \ni w_i \quad \text{if} \quad p(x/w_i)\ p(w_i) > p(x/w_i)\ p(w_i), \quad \text{for all} \quad j \neq i\ .$$

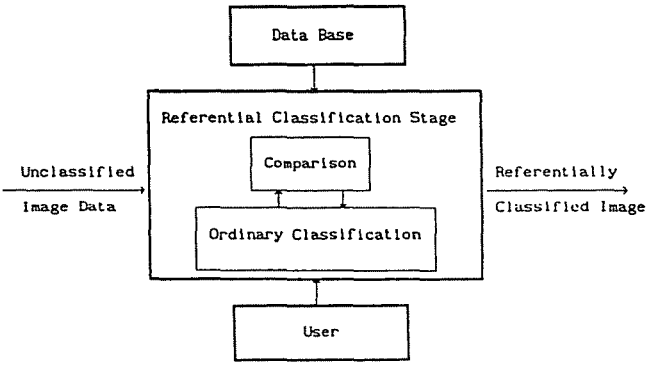

Fig. 2. Block diagram of the referential classification

Table 1
Accuracies of supervised and referential classification

Class	Pixels	Accuracy(%)		
		Supervised	Referential	Improvement
Poplar	800	81	81	0
W. Chestnut	1612	89	96	7
Forest	3791	74	88	13
Grass	2718	81	97	16
W. Bodies	2126	78	94	16
S. Beet	2521	60	85	25
Total	13568	75.6	92.8	17.2

As we mentioned above this method is carried out in two stages, *Fig. 2*, in the first stage and as a result to applying the maximum likelihood classification mentioned above, an index related to the measured spectral content is assigned to each pixel. Then in the second stage each pixel at a time is taken along with its coordinate and the spectral index which was derived in the first stage, then this index is led to the pixel data base and checked against the indices of a pixel with the same coordinates there. If the check result is true this means that the index derived in the first stage is the real spectral content of the classified pixel and classification decision will be confirmed. On the other hand if the check result is false this points to conflicting pixels and means one of two things: the characters of the conflicting pixel have been changed after constructing the data base, or the criterion established for the classification in the first stage is not as

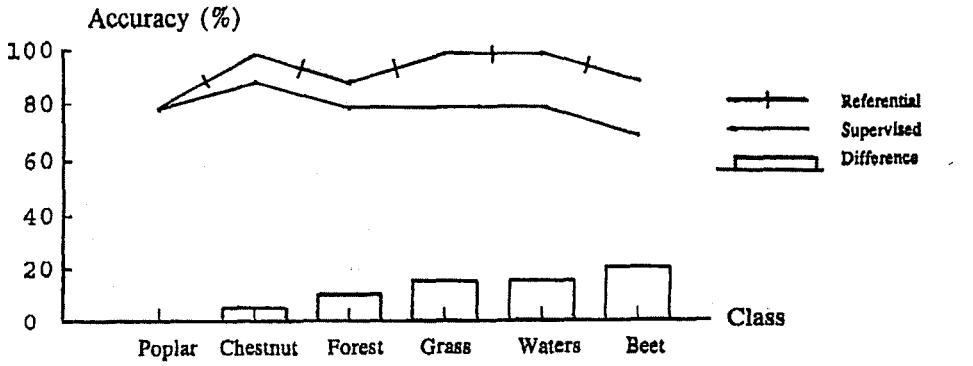

Fig. 3. Graphical comparison of supervised and referential classification accuracies

accurate as required. In both cases the final decision on classifying such pixels is given to the user where he can adopt the classification results though they are not in line with the information from the data base or he can change the classification criteria. The result of applying this method on classifying a test site image resulted in a good improvement in the image quality and its general appearance. The comparison of the accuracy results between the ordinary and referential classification (*Table 1*) shows that there is 0%, 7%, 13%, 16% and 25% when classifying poplar, water, chestnut, forest, grass, water bodies and sugar beet, respectively, and the average accuracy in classifying all the studied classes has been improved by 17.2%. Further comparison between the accuracies of both classification procedures in *Fig. 3* shows that the accuracy of the referential classification is always higher than that of ordinary classification (supervised), the worst case of the referential classification accuracy happens when the data base does not contain any pre-collected information about pixels required to be classified, even in this worst case the referential classification is just as accurate as ordinary classification and is never less as in the poplar class case.

Conclusions

Referential classification of image data is a vital step toward automating the classification process which is an important step in automating the whole image processing and analysis process. This can be achieved by cancelling the role of the user in classifying the conflicting pixels where the spectral data allocated to them in the ordinary classification stage can be adopted, changing their classification to ordinary and not referential or

they can be rejected and reported as unknown pixels; a multifold process which involves three steps that reflect high level of expert and artificial intelligent behaviour. Reporting about rejected and unknown pixels could be a highly advantageous feature of this method especially when using multitemporal images in constructing the data base about one area and using another image of later time about the same area in the referential classification. Then all rejected pixels in the referential classification could denote possible change in the area between the time of constructing the data base and the present date of classification. However, the referential classification method has slightly disadvantageous features such as the fact that constructing a really indicative data base about individual pixels is not an easy task, though not impossible; also the algorithm for performing this method is more complicated and needs more time and more efficient hardware to be executed.

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