A STRUCTURAL APPROACH TO THE EXTRACTION OF TEXTURE FEATURES FROM SPOT AND CIR PHOTOGRAPHS.

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ABSTRACT

A structural approach to the quantification of texture is demonstrated. Texture is treated as a state of an area between pure pattern and pure noise. As topological relations play an important role in our method the derived features are relatively insensitive to changes in radiometry or geometry. Progress in the separation of texturally defined classes in urban areas and in vegetation canopies are reported.

INTRODUCTION

The classification of areas based on textural features is usually approached using a statistical method such as auto correlation, local variance or value transition frequency tables. As these methods are inherently based on a noise model we decided to approach the extraction of textural features from the structural pattern recognition side. We start with the analysis of structured patterns which can then become less structured by the addition of noise or less discernable because of low resolution.

In order to evaluate the performance of our method we applied it to low resolution SPOT data (10m and 20m scene elements) and to vegetation canopies in high resolution (0.25m) Colour Infrared Photographic data.

As one of the research aims is to design an optical texture channel ,the similation of a set of optical spatial filters on the basis of the Hadamard- and principal component transforms is reported first .The data used are the high resolution CIR data. The simulated operator size is 4 x 4 elements.

We review the approach of correspondence analysis, next we report results on a limited number of test areas and test data.

CLASSIFICATION BASED ON TEXTURAL FEATURES.

Texture is a feature of an extended area . The area shows a variation in observable attributes (features) which are characteristic for the class the area belongs to.

Correspondence analyses [Mulder,Radwan ISPRS88] is applied to subarea (segment) patterns. Subarea spectral or structural features define local feature vectors. Within a limiting search neighbourhood other subareas with maximum correspondence and minimum distance in feature space are found. The network of corresponding subareas has topologocal and distance properties which are typical for the pattern or texture under observation. Completely random data will have random, nonorganised network features. Stuctured data such as generated by images of modern suburbs will generate a network reflecting the structure of blocks of housing and the surrounding roads.

Areas of constant texture are outlined by merging segments of the previous level (of merging) based on correspondance analysis applied to these segments.

THE STRUCTURE OF PATTERNS

The problem of classification of areas on the basis of pattern which may degenerate to almost pure noise can be approached from two extreme sides. One is to assume the data is generated by a noise source with peculiar parameters. The other model is that the objects in the data are basically forming a structured pattern but there is insufficient resolution or noise which distorts or hides the pattern.

In order to describe pattern in an area, structure units have to be defined. Structure units follow from low order image segmentation (over-segmentation, fine grained segmentation). Each small segment has a list of attributes (segment features). Correspondence analysis is applied first to the adjoining neighbours. As often patterns are generated by objects against a background corresponence analysis has also to be applied to objects which are a "distance" apart.

In some applications the distinction of objects and background must be solved before the correspondence analysis is applied. A reason for this could be that the network pattern of corresponding segments in the foreground is not at all related to the network pattern of the background.

In any structural approach the use of knowledge is critical. Therefore the classification process must be preceeded by some sort of supervised training and explicit formulation of pattern models.

Our research on DEM generation from "stereo" SPOT data indicates that a measure of self-correspondence (texture) must be available at the time when cross-correspondence is evaluated. This is equivalent to the application of cross correspondence analysis to left and right images which have already been segmented to the level including textural features.

In the poster session we will show the result of a number of experiments

EXPERIMENTS :

A) In {Gorte, Mulder, 1987] examples are given on the discrimination of artificial texture and texture occuring in SPOT images using the density of structure-class symbols. This approach was as successful or slightly better than the approach as followed by Granlund using the GOP (Context Vision) machine. A good discrimination was achieved between build-up areas and other. This discrimination was not possible on spectral features only. The addition of the textural feature was essential.

A recent improvement is the availability of the distance transform on the GOP (Context Vision) and a fast density transform implemented on the GOP (Gorte,1988).

B) Design of an optical texture channel. Data :digitised CIR, application :vegetation canopies, tree stand and species discrimination.

BACKGROUND :

In the "green" tropics spectral discrimination of vegetation types is not well possible. To improve spaceborn RS systems Mulder proposed in 1983 to add on optical texture channel for the discrimination of vegetation canopies and landuse classes. The design criteria were to have a ground resolution of 1 to 2 m and a texure element matrix of 4 x 4 to 8 x 8 elements. The optical texture masks would be generated either from Hadamard matrices or derived from an other set of orthogonal filters (spatial principal components).

Image 1 shows the original IR band at a resolution of 0.25 m and 16 Hadamard components (data +127) derived from 4 x 4 Hadamard matrices in pseudo greyscale.

Image 2 shows the 16 principal components of 4 x 4 subimages (data + 127) represented as greyscale images.

In order to contrast the structural method with the statistical method ,image 3 shows the local variance applied to the same 4 x 4 subimages.

The next step is to select a subset of textural features and use them as input for the segmentation programme. The segmentation programme produces a segment property list and a region (segment) adjacency graph which is the required input for the structural texture analysis procedures.

C) Texture analysis based on using the segment property list and the region adjacency graph. Presently the property list includes : (x,y)first-scan-intersect,

(x1,y1,x2,y2)bounding-rectangle

segment-area

nr-of-adjacent-regions.

Correspondence analysis is implemented as a search for adjacent neighbours which have less than a threshold distance in feature (property) space.

As segment area and number of neighbours are both related to the density of segments they are used as first candidates for further segmentation (merging). The average density and average number of neighbours over the new (texture) segments form part of the new properties of segments at the present level.

Examples will be shown during the poster presentation.

CONCLUSIONS

- with high resolution data it is recommendable to preceede structural texture detection by low order pattern detection filters. The prospects for an optical texture channel are encouraging further R&D and more effort in marketting the concept.
- using correspondence analysis for directing the high-order merging of segments works well in the absence of background.
- the interaction of foreground connection nets and background connection nets has to be studied further.
- the selection of segment properties (features) and subsequent decision parameters has to become more knowledge driven. At present good results are mostly obtained by manual " fine tuning" by the researcher.
- there are indications that the structural approach is better suited for interfacing with knowledge engineering systems than the statistical approaches to texture feature extraction.

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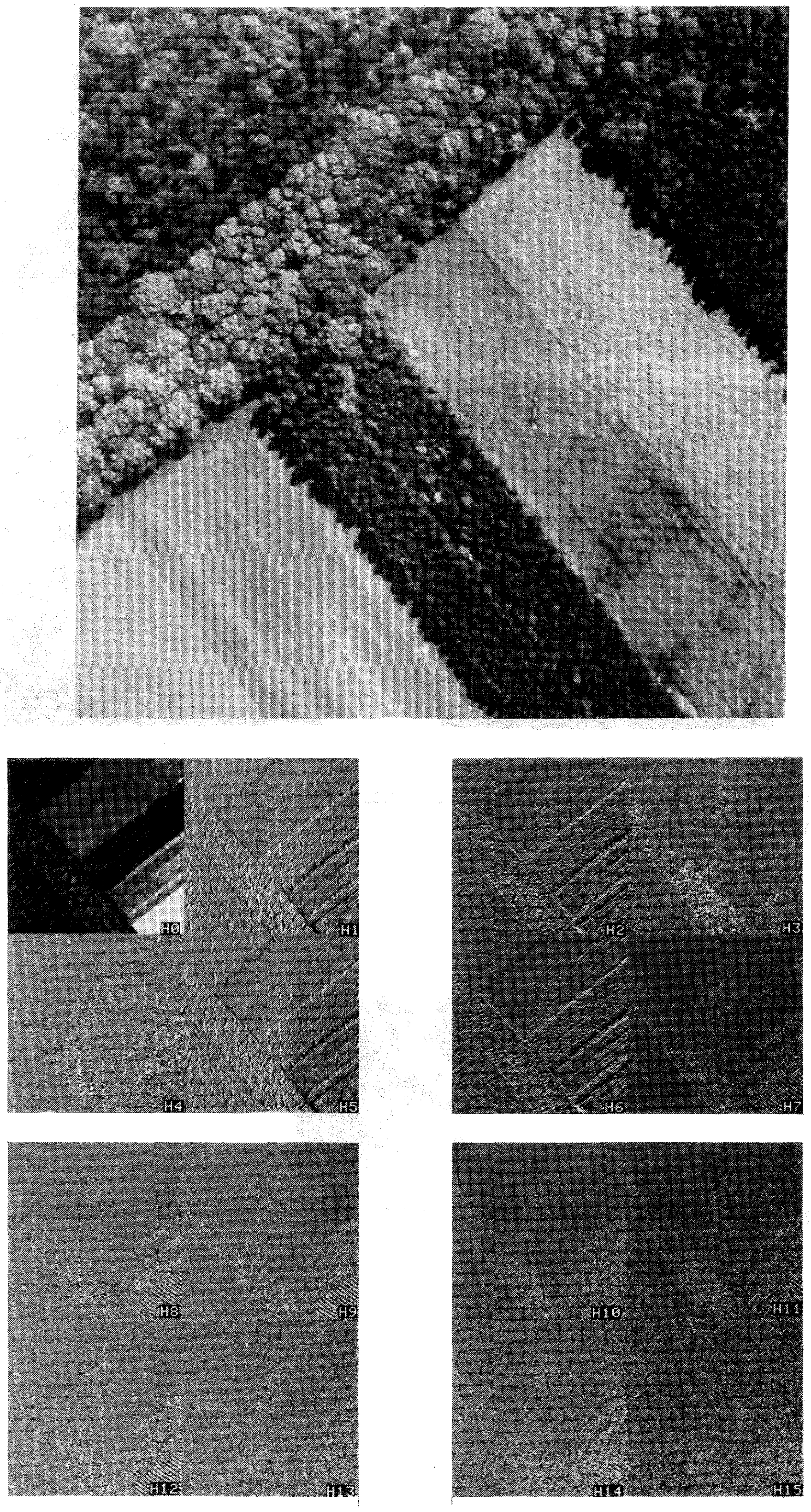

Image 1: IR band (0.25 m) digitized form a CIR aerial photogragh (1:2500) and Hadamard components

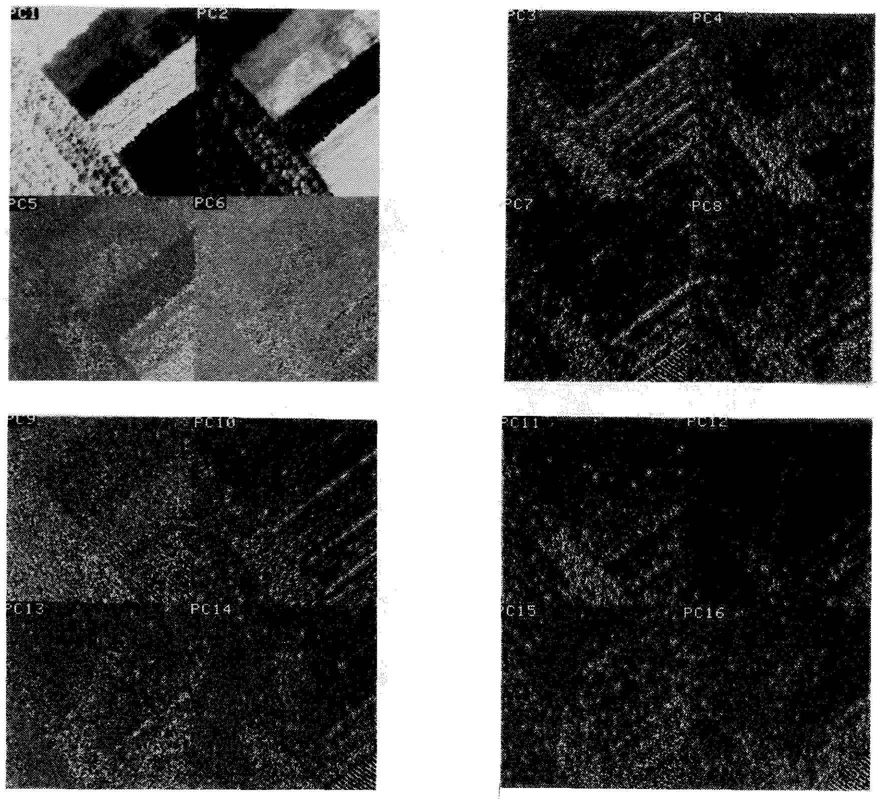

Image 2: Spatial principal components (derived from 4*4 subimages).

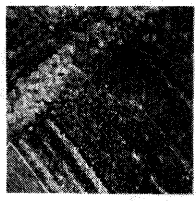

Image 3: Local variance (derived from 4*4 subimages).