REMOTE SENSING SEGMENTATION THROUGH A FILTER BANK BASED ON GABOR FUNCTIONS

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ABSTRACT

One of the most critical activities of remote sensing consists of the identification of different coverages (types of crops) on land surface. This task is complicated when the entire plot is not covered by the crop (e.g. almond and olive fields, vineyards, etc.). In this paper, the segregation of these crops is accomplished by using a multi-channel (Gabor functions) filtering approach in remote sensing imagery, in this case applied to aerial photograph.

1. INTRODUCTION

The remote sensing imagery supervised and non-supervised classification methods [2][4] are accurate when dealing with intense crops say, the whole region of the image covered by this crop has some similar characteristics. But their accuracy is decreased when the crop presents a textured distribution (Fig. 1), as is the case of the almond-tree, olive grove, vineyards, etc..

The almond-tree, olive grove, vineyards, etc. segmentation is a difficult and very important task in remote sensing imagery classification. One of the main research lines [5][7][8] considers the pixel as a mixture pixel in a low resolution multi-spectral image say, its digital level is obtained as the weighted sum of the crops present in the area covered by the pixel. This approach is useful for low image resolution, when a pixel covers several independent trees. Conversely, when image resolution is high enough to show the trees as independent units, it is not suitable for classification purposes thus giving way to other segmentation techniques.

Texture segmentation involves partitioning a digital image into a finite set of regions with homogeneous textures. To design an effective algorithm for texture segmentation, it is essential to find a set of texture features with good discriminating power. Most textural features are generally obtained from the application of a local operator, statistical analysis, or measurement in a transformed domain. Common features are estimated from co-occurrence matrices, Law's texture energy measures, Fourier transform domains, multi-channel filtering (MCF) approach, Markov random field models, local linear transforms, etc.

Among the various approaches, the MCF approach appears to be one of the most successful approaches for texture segmentation. Recent physiological and psychophysical findings on human visual perception point to a "spatial frequency channels" model of early human vision, in which raw images are processed to extract their constituent spatial frequencies at a variety of orientations. Although the precise specifications of such spatial frequency channels remain unclear, evidence [10][9] suggests that the "spatial frequency channels" suitable being to approach the aforementioned model of early human vision are similar to a class of functions known as Gabor functions.

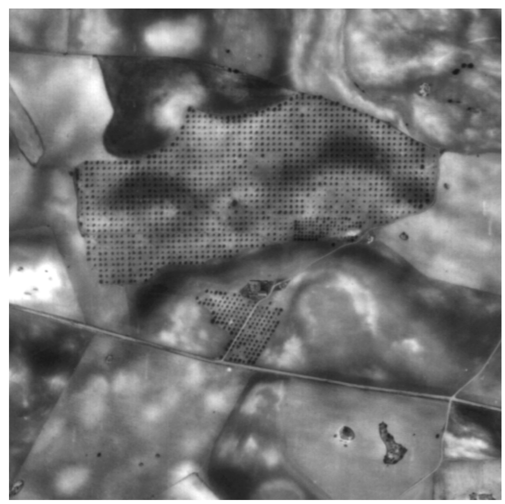


Fig.1: Air photograph of the studied zone

2. METHODOLOGY

In this paper, a system as shown in Fig. 2 is used to demonstrate the multi-channel filtering technique applicability to the segmentation of the aforementioned crop regions. In such a system, a bank of Gabor filters [1] , with 4 orientations (0º, 45º, 90º and 135º) and 4 frequencies (1/4,1/8, 1/16 and 1/32 cycles/pixel), to characterize the channels is used. To accomplish the segmentation a previous bounded nonlinear transformation and local energy computation [3] was made to each (selected) filtered image. The segmentation stage is achieved through multiresolution processing [6].

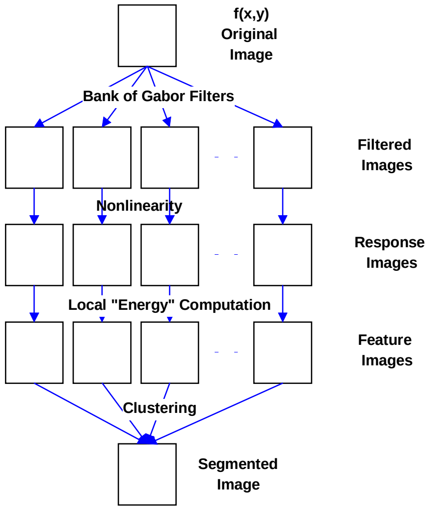


Fig. 2: An overview of the texture segmentation algorithm

3. DATA AND RESULTS

The chosen image, with the interest zones (Fig. 1), is an air photograph taken to scale of 1:30,000. This choice was made because the zone edges are easily distinguished by a photo-interpreter, as well as because of its low cost and high availability. The photographed area is found in the province of Albacete (Spain) and contains most of the crops of interest in the community of Castilla-La Mancha. Plots were determined by field work.

The main characteristic of the almond and olive fields, vineyards (the most extended in such a community and with greater social impact) consists of their cultivation in the form of diamond (see Fig. 3), which in air photographs will be appreciated as textured zones which are simulated in Fig. 4. Each tree (or vine) can be considered as the individual texture element (texton) that is repeated in a structured way in each region.

The distances D, H and w (and consequently d and h) vary in function of the different crops, which presumably would permit their discrimination among similar structured crops, using only their characteristics in the frequency domain (amplitude and phase).

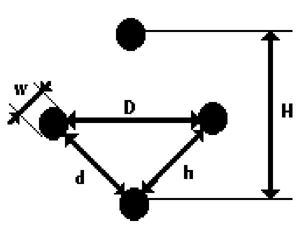


Fig. 3: Almond tree, olive grove, vineyards, etc. are cultivated in diamond- like form. Where w is the LAI (Leaf Area Index), and d, h, D and H represent the distance between nearest trees in four directions.

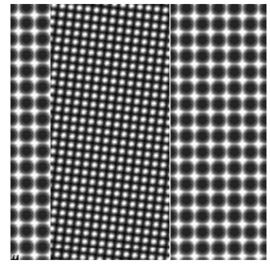
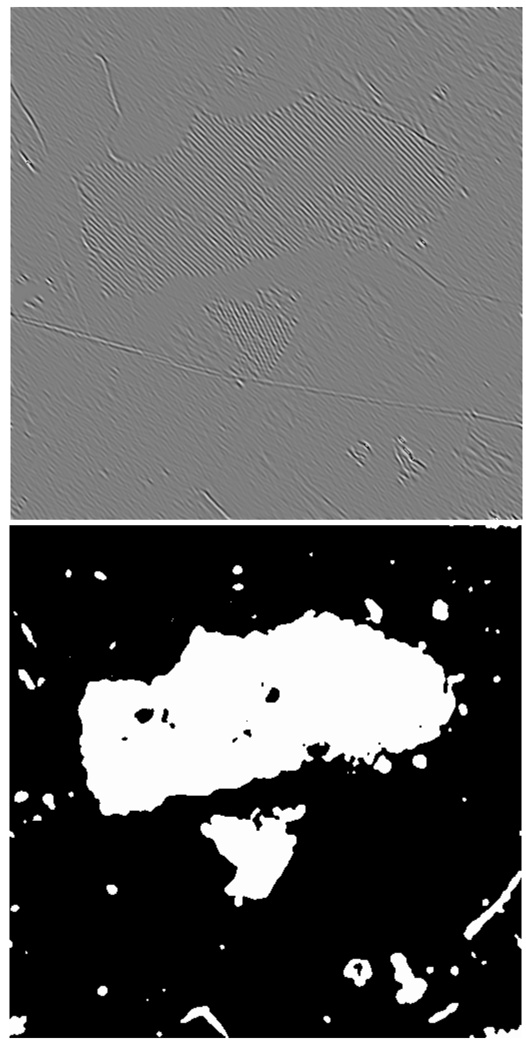


Fig. 4: Synthetic image with simulated textures which can be found in aerial photograph.

We have applied our texture segmentation algorithm to the detection of several almond-tree plots using aerial photograph (Fig. 1), in order to demonstrate its performance.



a)

b)

Fig. 5: a) Feature image obtained at 1/4 cycles/pixel and orientation 45º and b) Segmented image.

Fig. 5 b) shows the image obtained from the application of the segmentation algorithm. In this figure, a good segmentation of the three fundamental plots can be observed. In the first plot, small untextured areas appear, this being due to small clearings present in the plot. The other two plots appear segmented as an only plot, which is produced fundamentally by the incorporation of the road section that limits them due to its same orientation. The remainder of the detected zones are motivated by the presence of noise or groves.

Undesired small regions could appear (see Fig. 5 b)), caused by either nonuniformity of the texture elements, or noise in the input image, or even intrinsic being to the algorithm. A postprocessing could be used to remove such artifacts.

4. CONCLUSIONS

The almond-tree, olive grove, vineyards, etc. segmentation is a difficult and crutial task in remote sensing imagery classification. Research lines based on mixtured pixels are not suitable when image resolution is high enough to show trees as independent units.

Here, we present an alternative way based on a multi-channel filtering (MCF) approach. This process has been widely used in computer vision systems. Our algorithm shows good performance when used in aerial photograph. But also, the main critical stages were identified: choice of parameters of the bank filter, the nonlinear transform, and the segmentation process.

Discontinuities in texture phase, possibly arising from surface discontinuities, can be located by detecting large variations in the phase envelopes. So, texture segmentation is modeled as a process whereby textured image regions are segregated by localizing spatial changes in the frequency, orientation, or phase of the textures.

Arriving in this point, it is important to remark that this paper is not aiming to optimise the segmentation of the crops shown in Fig. 1, but validating the multi-channel filtering (MCF) approach based on Gabor functions, as a useful tool to be used in such segmentation process.

5. REFERENCES

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