تحديد المساحات المزروعة بالاشجار في صور الاقمار الصناعية

Tree Farms Detection in Satellite Images

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Abstract

Satellite images are now playing an active and important role in several areas, including the areas of military, industrial and agricultural. In the agricultural field, determining wooded green space is important in the process of future planning. This paper presents two approaches to detect farms with trees, the first approach based on the color and second on the trees texture. Within the work of this research, the two algorithms are using a set of images and the comparison between the proposed algorithms is stated.

الخلاصة

صور الاقمار الصناعية تلعب اليوم دورا مهما وفاعلا في عدة مجالات ومنها المجالات العسكرية، الصناعية والزراعية. ففي المجال الزراعي فان تحديد المساحات الخضراء المشجرة مهم في عملية التخطيط المستقبلي. يقدم هذا البحث خوارزميتين لتحديد المساحات المزروعة بالاشجار تعتمد الاولى على اللون والثانية تعتمد البنية التركيبية لمجموعة الاشجار . في اطار هذا البحث تم فحص الخوارزميتين باستخدام مجموعة من الصور والمفاضلة بين الخوارزميتين المقترحة في هذا العمل.

1. Introduction

Automatic extraction of geographical information from satellite images about the earth surface from them has been one of the most important research theme in the remote sensing field [1][2]. Important applications include industrial and biomedical surface inspection, for example of defects or disease, and ground classification and segmentation of satellite (See Rao [3] and Haralick and Shapiro [4]).

In a satellite image, identifying trees is done using segmentation. Image segmentation involves subdividing an image into constituent parts, or isolating certain aspects of an image**.**

Automatic texture detection can play an important role in many image analysis tasks, such as image segmentation or object recognition.

One of the most fundamental properties appearing in many textures is the presence of some regularity in a contiguous image region, which may manifest itself as a spatially repeating color pattern or shape. It is however not possible to find a strict regularity criterion which would discriminate between textures and non-textures. Several segmentation algorithms, either automatic or semi-automatic, aim at dividing an image into uniform color and/or texture regions [5].

Since the early days of texture analysis, second-order statistics derived from the co-occurrence matrix of a texture image has been proven to be the most successfully approach to many kinds of texture processing (especially the detection of texture faults, and the texture segmentation) [6].

Recently, Tavakoli Targhi and coworkers proposed the *SVD-transform* [7]and *Eigen-transform* [8]. These texture descriptors are derived from matrix decompositions.

We shall investigate two very important topics: color thresholding and texture based segmentation using Gabor filter.

Gabor filters have been demonstrated to achieve high recognition rates in traditional 2D face recognition tasks [9][10]. They have also found favour in many image processing fields due to their desirable characteristics of spatial locality and orientation selectivity.

2. Background

2.1 Color Thresholding

Colors are defined in some standard way, usually as a subset of a three dimensional coordinate system; such a subset is called a color model. There are in fact a number of different methods for describing color, but for image display and storage a standard model is RGB, for which we may imagine all the colors sitting inside a color cube as shown in figure 1. The colors along the black-white diagonal, shown in the diagram as a dotted line, are the points of the space where all the R, G, B values are equal. They are the different intensities of gray. We may also think of the axes of the color cube as being discretized to integers in the range 0-255.

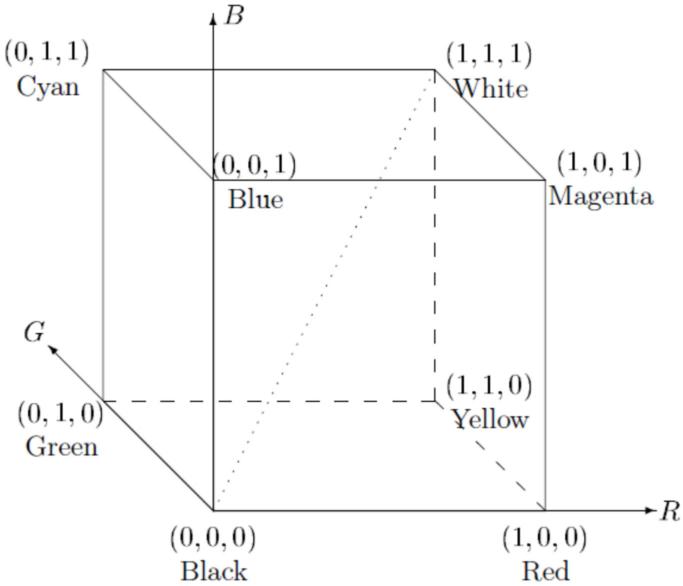


Figure 1 The color cube for the RGB color model

The thresholding can be useful in the following situations:

- When we want to remove unnecessary detail from an image, to concentrate on essentials.
- To bring out hidden detail.

Two thresholding methods are applied in image processing:

- Single thresholding

A grayscale image is turned into a binary (black and white) image by first choosing a gray level T in the original image, and then turning every pixel black or white according to whether its grey value is greater than or less than T :

$$\text{A pixel becomes} \begin{cases} \text{white if its grey level is} > T, \\ \text{black if its grey level is} \leq T. \end{cases}$$

- Double thresholding

Here we choose two values T1 and T2 and apply a thresholding operation as:

$$\text{A pixel becomes} \begin{cases} \text{white if its grey level is between } T_1 \text{ and } T_2, \\ \text{black if its grey level is otherwise.} \end{cases}$$

2.2 Texture Based Segmentation

Texture is an important cue in many applications of computer vision such as image segmentation, the classification of objects or materials and texture synthesis for computer graphics.

One way of describing texture is "things arranged in a pattern." Textures are a function of things and patterns mathematically, texture =f(thing, pattern). The thing is a grouping of pixels such as a dot or line. The pattern is the arrangement of the things such as a random or regular cluster of dots and horizontal or vertical lines. Regular patterns are usually man made while random patterns are natural. These ideas about texture all make sense, but a commonly used model of texture is lacking.

Figure 2 shows an image containing four. These textures are (clockwise starting in the upper left) a fuzzy carpet, a tightly woven straw mat, random grass, and straw.

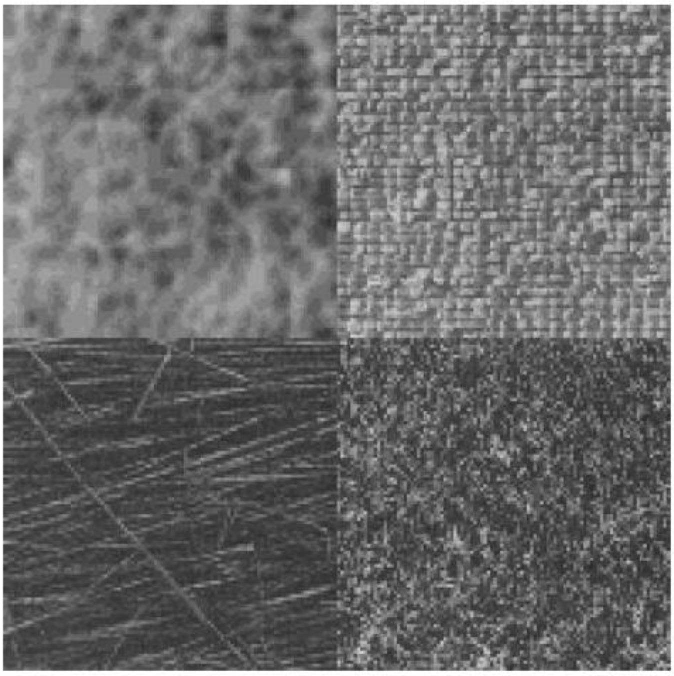


Figure 2 Four textures

In order to *segment* an image according to its texture, we can measure the texture in a chosen region and then classify it.

Texture understanding methods are divided into three major groups:

- Spatial Methods a texture is modeled as a *surface,* from which spatially compact and visually perceptual features like lines, edges, orientation, etc., are extracted over a larger area. These methods look for such repetitive perceptual features, and create a vector of these perceptual features in the texture. Various orthonormal transforms/filters may be employed to characterize these features.
- Structural methods a texture is viewed as made up of many primitive textural elements, called *texel*, arranged according to some specific placement rules.
- Statistical methods a texture is modeled as a random field and a statistical probability density function model is fitted to the spatial distribution of intensities in the texture.

2.3 Gabor Filter

Gabor filters optimally capture both local orientation and frequency information from an image. By tuning a Gabor filter to specific frequency and direction, the local frequency and orientation information can be obtained [11][12]. Thus, they are suited for extracting texture information from images [13]. An even symmetric Gabor filter has the following general form in the spatial domain:

$$\psi_{f,\theta}(x,y) = \exp\left[-\frac{1}{2}\left\{\frac{x_{\theta_n}^2}{\sigma_x^2} + \frac{y_{\theta_n}^2}{\sigma_x^2}\right\}\right]\exp(2\pi f x_{\theta_n}),$$

$$\text{where, } \begin{bmatrix} x_{\theta_n} \\ y_{\theta_n} \end{bmatrix} = \begin{bmatrix} \sin\theta_n & \cos\theta_n \\ -\cos\theta_n & \sin\theta_n \end{bmatrix} \cdot \begin{bmatrix} x \\ y \end{bmatrix}$$

where *f* is the frequency of the sinusoidal plane wave along the direction θ from the *x*-axis, and δ*x* and δ*y* are the space constants of the Gaussian envelope along *x* and *y* axes, respectively.

The Gabor representation of an image is computed by convolving the face image with the Gabor filters. Let f(x, y) the intensity at the coordinate (x, y) in a gray scale image, its convolution with a Gabor filter is defined as

$$g_{f,\theta}(x,y) = f(x,y) \otimes \psi_{f,\theta}(x,y)$$

Where $\otimes$ denotes the convolution operator.

2.4 Mathematical Morphology

Mathematical morphology is a collection of non-linear processes which can be applied to an image to remove details smaller than a certain reference shape, which is called structuring element. Mathematical morphology relies on two simple operations: dilation and erosion. Other operations may be defined in terms of them. Matlab has many tools for binary morphology in the image processing toolbox; most of which can be used for grayscale morphology as well.

- **Dilation**

Dilation is the process by which we "dilate" the objects in the image by placing the centre of the structuring element on every object pixel and marking every pixel covered by the structuring element as an object pixel.

- **Erosion**

Erosion is the process by which we "erode" an object by placing the centre of the structuring element on every object pixel and keeping only those pixels that allow the structuring element to fit fully inside the object.

3. Methodology

3.1 Color Thresholding Algorithm

The first proposed algorithm is color thresholding in which segmentation is implemented according the following steps:

Step 1: Read satellite image in the RGB model.

Step2: Threshold the image according the following rule:

Pixel become white if $40<R<50$ *and* $55<G<65$ *and* $30<B<35$*, otherwise it become black.*

Step 3: dilate the separated thresholded pixels by using the dilation morphology operation with the 3x3 square structuring element.

Step4: Show the final result.

Note that, the threshold values are specified by testing manually the histogram of 100 different satellite images that includes tree farms (the tested images not included in this paper).

3.2 Texture Based Segmentation

The Gabor filter is chosen in the second algorithm to measure the frequency components in the spatial domain (the filter parameters are tuned manually to δ_x=2, δ_y=4, f=8,and θ=60^o) , then threshold the result of the filter at specific values (again these values are selected form the same test images used in the previous algorithm).

The following steps are the road map to implement the texture based segmentation:

Step 1: Read satellite image in the RGB model.

Step 2: Select the G component to be the reference.

Step 3: Convolve the G component with the Gabor filter with δ_x=2, δ_y=4, f=8,and θ=60^o(the 2D Gabor filter is shown in figure 3).

Step 4: Threshold the result of filtering according the following rule:

Result pixel become white if 100<filtered G pixel<550, otherwise it become black.

Step 5: Show the final result.

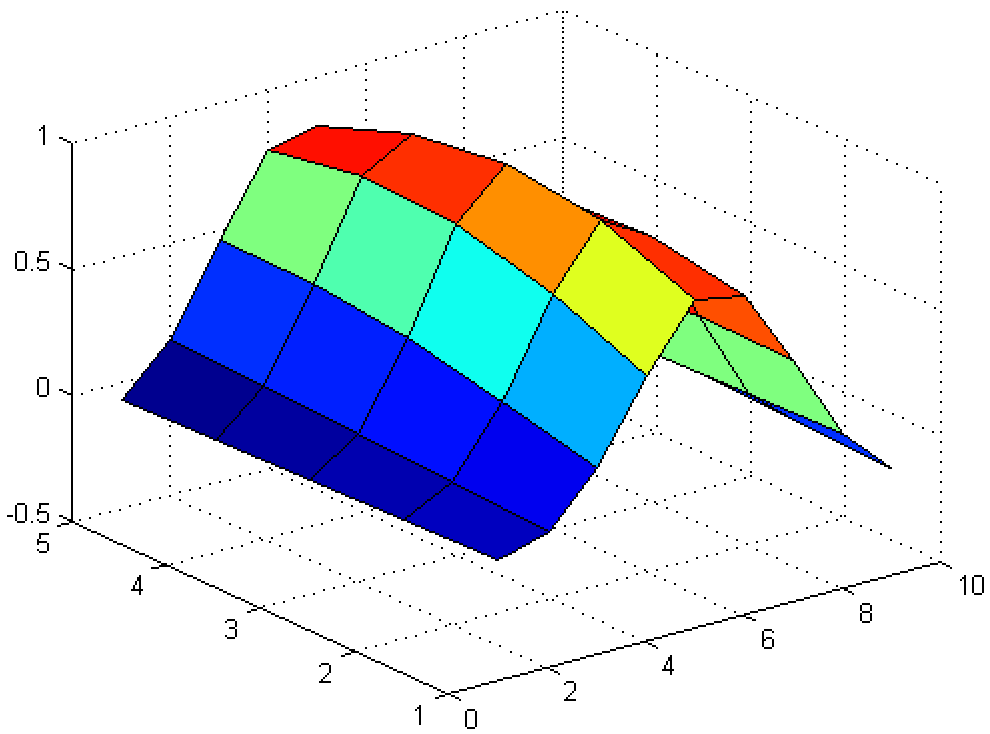


Figure 3 the tuned 2D Gabor filter

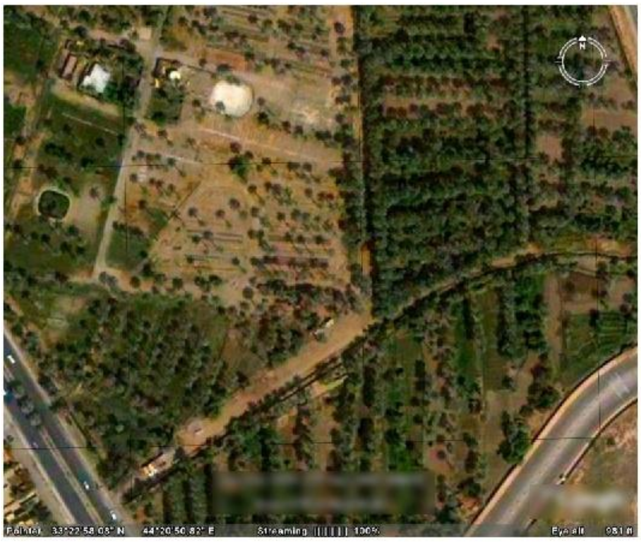
4. Results

The two proposed algorithms are tested using four satellite images shown in the figure below (figure 4)

(a)

(b)

Figure 4 (792X665) pixel satellite images used to test the proposed algorithms



(c)

(d)

Figure 4 (cont.) (792X665) pixel satellite images used to test the proposed algorithms

4.1 Results of Color Thresholding Algorithm

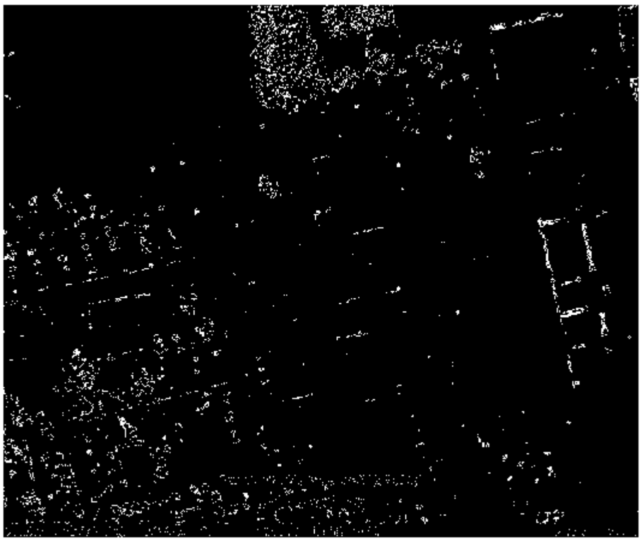
The results of applying the color thresholding algorithm stated previously are shown in figure 5 and 6:

(a)

(b)

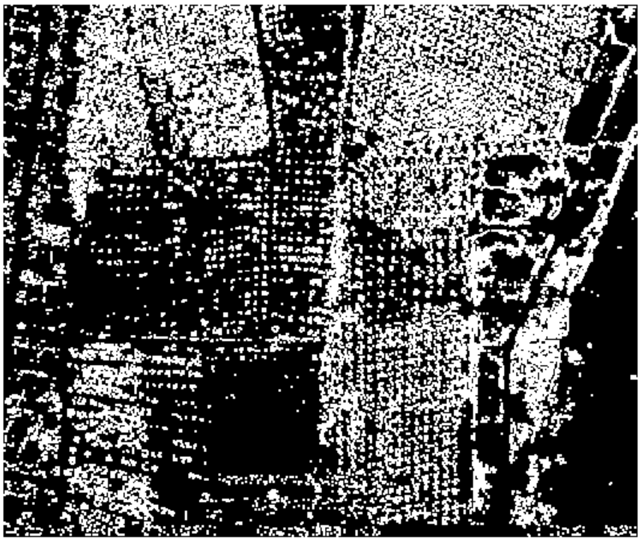
Figure 5 Results after color thresholding

(c)



(d)

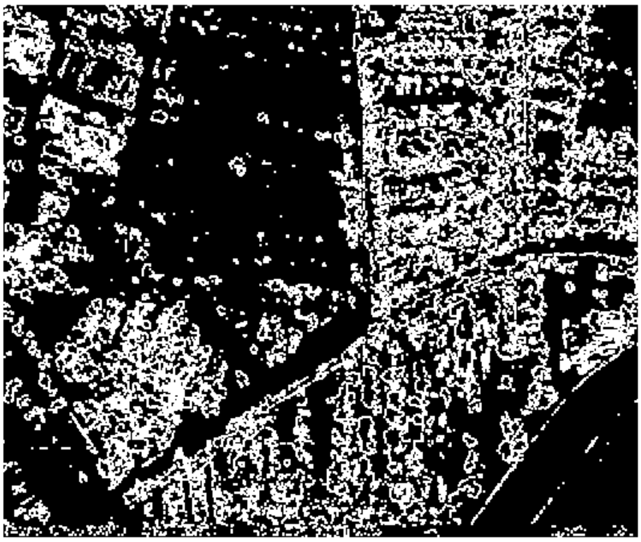
Figure 5 (cont.) Results after color thresholding



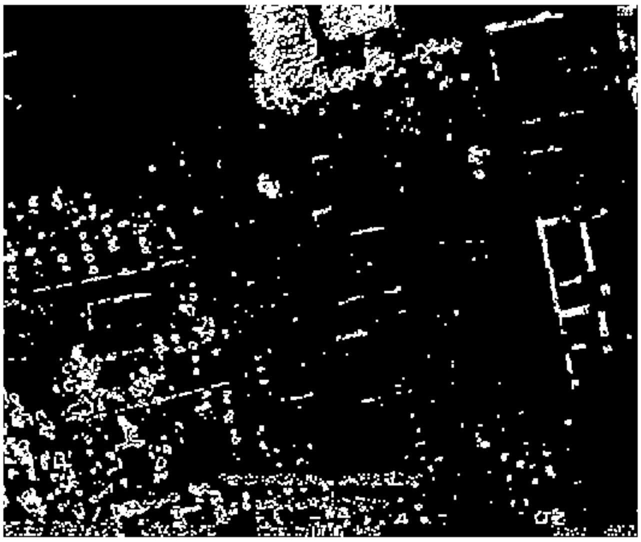
(a)

(b)

Figure 6 Results after color thresholding and using the dilation morphology operation



(c)

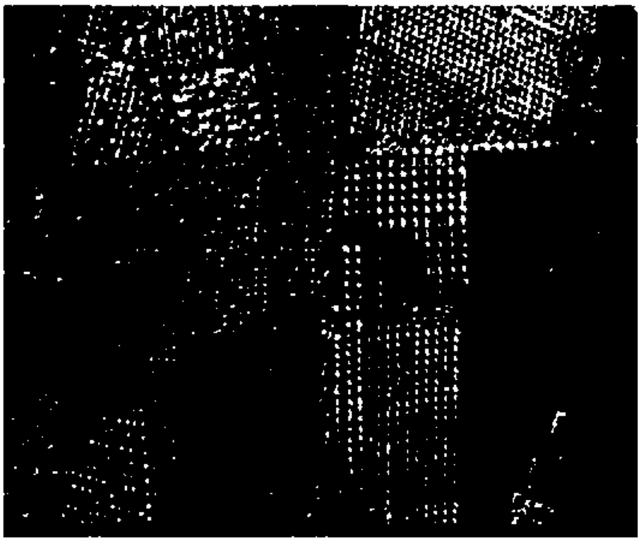


(d)

Figure 6 (cont.) Results after color thresholding and using the dilation morphology operation

4.1 Results of Texture Based Algorithm

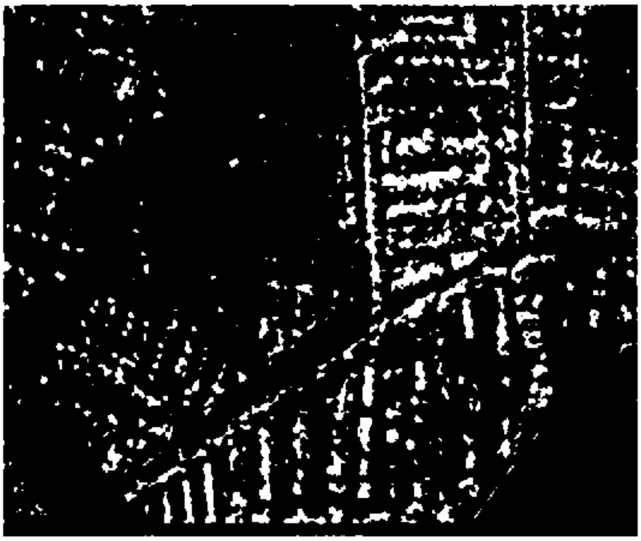
The results of applying the texture based algorithm stated in the previous section are shown in figure 7:



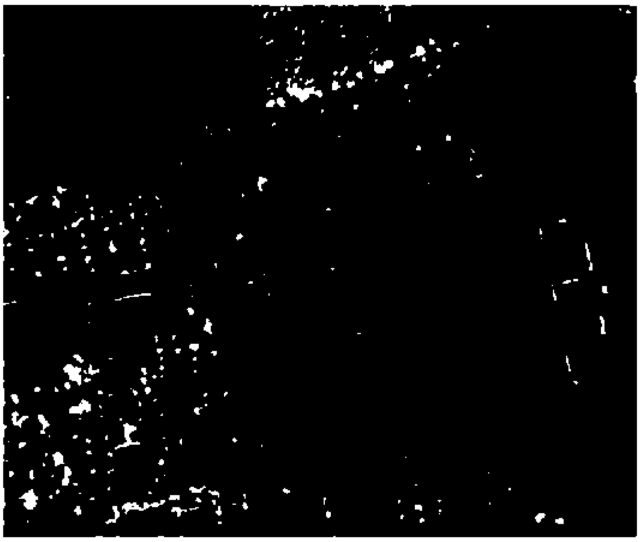
(a)

(b)

Figure 7 Results of texture based approach applied to the selected satellite images



(c)



(d)

Figure 7 (cont.) Results of texture based approach applied to the selected satellite images

5. Conclusions

After the result of the proposed algorithms was shown, the following conclusions are appears:

- In case of color thresholding algorithms, part of the non-tree farm regions are classified as tree farm regions, for example see right hand side of figure 6(a).
- The uncrowned regions are classified as the non-tree farm regions after applying the texture based algorithm(see center of figure 7d).

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