Application of the Gradient Vector Flow Method for Treating Satellite Image

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Abstract

In this work we propose a new approach to delineate regions in Satellite Image. This method is particularly applicable to the limitation of insoluble habitats. We are interested in detecting the boundaries of the villages near Marrakech from their satellite images, as a study case: Ouahat Sidi Brahim. Our approach has three stages: The first, using k nearest neighbour method for classification of the satellite image. The second, using a mean filter to regularize this classification. In the last we use the Gradient Vector Flow to detect the edge of the village. Our method gives satisfactory and encouraging results to detect the edge of the village and can be used as a tool to control the spread of slums.

Keywords: *Classification, Satellite Image, k-Nearest Neighbour (k-NN), median filter, active contour, Gradient Vector Flow.*

1. Introduction

Mathematics is heavily involved in developing science. These interactions revitalize and strengthen the field. The field of image analysis is clearly the future, therefore, mathematicians should be involved in image processing as the most important and exciting scientific discoveries of all time are in the field of computer vision. Research in image processing is useful and interesting, and the results are usually relevant. The image processing is the set of methods and techniques operating on them in order to make this operation possible, simpler, more efficient and more enjoyable, improve the visual image and extract information deemed relevant. The reader interested in this vast subject may consult the following references for more details [1], [2], [3], [4], [8].

Here we focus particularly on edge detection of the village from their satellite image to limit the spread of slums which is a district precarious illegal building formed by a poor suburb in or near a big city. This form of urban sprawl is growing almost always occupied government land without authorization, and therefore these parts become places of crime by excellence.

We are interested in the region of Marrakech is the first tourist destination in Morocco, appreciated for its quality of life and its landscapes, its rich heritage and historical conditions of easy access. It is perceived as a destination of confidence.

In this paper we propose a method based on remote sensing and Gradient Vector Flow to control the spread of slums in the regions of Marrakech. We took as an example Ouahat Sidi Brahim village located 20Km from the center of Marrakech.

This article is organized as follows: first time we discussed the classification method and more specifically the method of k-NN, then to regulate our classification we apply a median filter followed by a thresholding to eliminate isolated points. Edge detection of the village is obtained by applying the GVF method, this is the subject of Section 3. In the last section we present experimental results and discussion

2. Classification and treatment of satellite image

2.1 Principle of k-NN method

The classification is a method of data analysis that aims to separate the image into several classes of interest, ie to aggregate data in homogeneous subsets [1], [6], [7], which share common features. It may be supervised or automatic (ie unsupervised). In the supervised case, it requires a subset of data with known classes, called learning base in order to classify new data. Concerning our problem, we must determine two classes, the class of pixels buildings and the fields. For this we adopted the method of k-NN [1], [5], which is a supervised learning algorithm where the result of new instance query is classified based on majority of k-NN category. The purpose of this algorithm is to classify a new object based on attributes and training samples. The classifiers do not use any model to fit and only based on memory. Given a query point, we find k number of gold objects (training points) closest to the query point. The classification is using majority vote among the classification of the k objects. Any ties can be broken at random. The k-NN algorithm use the neighborhood classification as the prediction value of the new query instance. The algorithm of k-NN is as follows [1], [5]:

For each pixel (x,y) in the image:

- Calculate distances between every pixel and vector based B_{i} of the database: d ((x,y), B_{i})

- Search the k vectors of the training set closest to the pixel, ie, those with the k smallest distances.

- Assigns the pixel to the class most represented among these k vectors.

2.2 Post treatment

After classification, usually we get isolated pixels, poorly sorted and contains areas of small discontinuities. To improve the mapping, we must rectify by reallocating these isolated pixels. In our case to regularize the classification we used a mean filter followed by an adaptive thresholding.

The principle of the filter medium is very simple: a pixel is replaced by the average of itself and its neighbors. In the definition of neighborhood that the filters will vary.

Because of the variety of image content filtering (size M x N) we apply an adaptive thresholding to free ourselves of local contrast and allow good detection of edges in all regions of the image. We choose a threshold of the form:

t=m+ßs

$$m = \sum u(x,y) / MN$$

$$s = \sqrt{\sum (u(x,y) - m)^2 / MN}$$

m and s are respectively the mean and standard deviation of the image u obtained in first step and we set β equal to 0.6. The thresholding is to compare the gray level of each pixel (x,y) of the image with a global fixed threshold t. In our case we use the new value of pixel thresholding given by the following expression:

$$U(x,y) = 255 \text{ if } u(x,y) \geq t \text{ and } U(x,y) = 0 \text{ if } u(x,y) < t$$

Where U is a new image obtained after post treatment.

3. THE DETECTION OF THE CONTOUR BY THE GVF METHOD

3.1 Gradient Vector Flow Field

In [9], [10] Xu and Prince proposed the gradient vector flow to resolve the problem of initialization and poor convergence of the classical model of snakes [y]. The energy function to be minimized by a snake can be described as follows:

$$E = \int_0^1 \left(\alpha \left| \frac{d}{ds} \mathrm{v}(s) \right|^2 + \beta \left| \frac{d^2}{ds^2} \mathrm{v}(s) \right|^2 + \nabla f(\mathrm{v}(s)) \right) ds \qquad (1)$$

Where, $\{\mathrm{v}(s) = (x(s), y(s)),\ \mathrm{s} \in (0,1)\}$ is a snake curve, and α and β are two parameters which satisfy $\alpha + \beta = 1$. The first two terms in (1) are internal energies. The latter term represents an external energy in this case f is a function of rising edge detector, which depends on the image. If a snake realizes the minimum of the energy E then the Euler equation is satisfied:

$$\alpha \frac{d^2 v}{ds^2}(s) - \beta \frac{d^4 v}{ds^4}(s) - \nabla E_{ext} = 0 \qquad (2)$$

where, $\frac{d^2 v}{ds^2}(s)$ and $\frac{d^4 v}{ds^4}(s)$ are the second and fourth derivatives of $\mathrm{v}(s)$ with respect to s, respectively, and $E_{ext} = -f$.

The gradient vector flow is defined as the vector field $\mathrm{v}(x,y)=\left[u(x,y),v(x,y)\right]$ which minimizes the energy function:

$$E_{gvf}=\iint\left(\mu(u_x^2+u_y^2+v_x^2+v_y^2)+\left|\nabla f\right|^2\left|\mathrm{v}-\nabla f\right|^2\right) \quad (3)$$

where, u_x and u_y are the first order partial derivatives of u(x,y), and v_x and v_y are the first order partial derivatives of v(x,y), respectively. It is easily shown that if if ∇f is small. The function of the energy used to get all the minimum value when $\mathrm{v}=\nabla f$. The solution to (3), which is the GVF field, can be found by solving the following Euler equations:

$$\mu\nabla^2 u-(u-f_x)(f_x^2+f_y^2)=0 \qquad (4)$$

$$\mu\nabla^2 v-(v-f_x)(f_x^2+f_y^2)=0 \qquad (5)$$

3.2 Numerical Implementation

Equations (4) and (5) can be solved by treating and as functions of time and solving

$$\frac{\partial u}{\partial t}-\mu\nabla^2 u+(u-f_x)(f_x^2+f_y^2)=0 \qquad (6)$$

$$\frac{\partial v}{\partial t}-\mu\nabla^2 v+(v-f_x)(f_x^2+f_y^2)=0 \qquad (7)$$

for the numerical implementation we use the following discretization

$$u_{i,j}^{t+dt}=u_{i,j}^t+\frac{\mu dt}{\left|N_r\right|}\sum_{(k,l)\in N_r}(u_{k,l}^t-u_{i,j}^t)\ + \\ +dt(u_{i,j}^t-dxf_{i,j})(dxf_{i,j}{}^2+dyf_{i,j}{}^2) \qquad (8)$$

$$v_{i,j}^{t+dt}=v_{i,j}^t+\frac{\mu dt}{\left|N_r\right|}\sum_{(k,l)\in N_r}(v_{k,l}^t-v_{i,j}^t) \\ +dt(v_{i,j}^t-dxf_{i,j})(dxf_{i,j}{}^2+dyf_{i,j}{}^2) \qquad (9)$$

When Sobel gradient operator is used to calculate (f_x, f_y) .

4 Application

Images used are of size (512 ×512) pixels obtained from google maps, with a scale equal to (1/(20000)). The algorithm of k-NN is tested on these images and the parameter k is set at 3. Figure (2) shows the obtained results. The calculation time is proportional to the size of the training set, which is logical since the algorithm calculates the distance between each new object and each element of the training set. To improve the classification obtained by taking into account the spatial information provided by neighboring pixels in the image, thresholding on the average yields good results as shown in Figure (3). We apply the method of GVF to each separate region in our image, taking the initial contour is a circle outline that surrounds this region, will evolve until it reaches the edge of the village as it is represented in Figure (4).

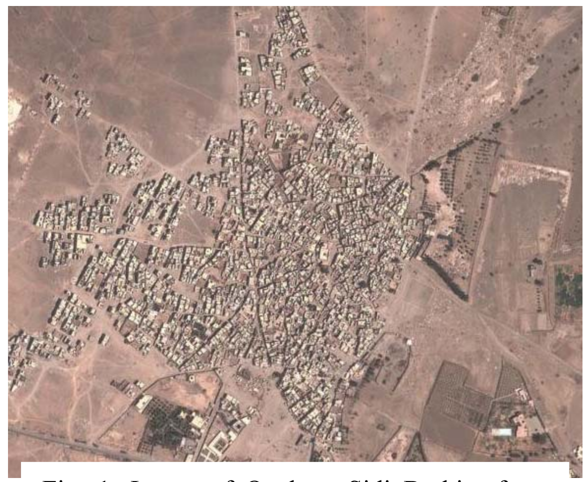

Fig. 1. Image of Ouahat Sidi Brahim from

5 Conclusion

In this article, we are concerned with the problem of slums in limited regions of Marrakech from satellite images of high resolution. Our approach has two steps: the first is the classification of satellite images by the technique of k-NN, the second . Our method gives satisfactory results and encouraging, and this, by comparing the contours detected at different times which are intended to confirm the spread of slums around. For detection of the contour we applied the method of GVF, the initial contour is a circle, will evolve until it reaches the edge of the village as it is represented in Figures (4).

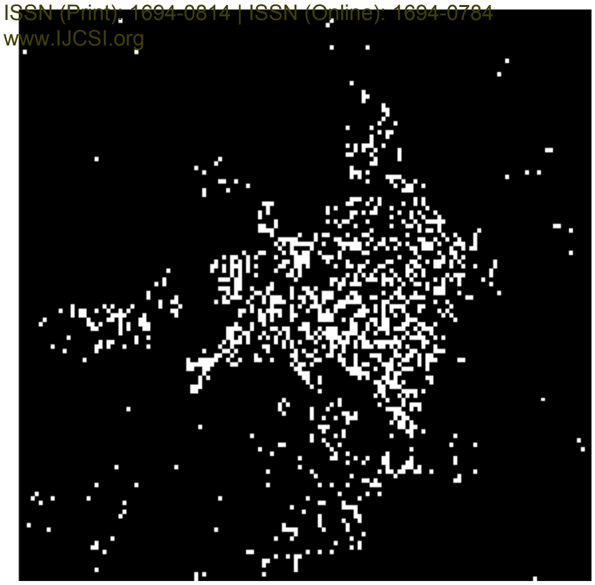

Fig. 2. Image after classification by k-NN

Fig. 3 Image after post treatment

Fig. 4 Final contour of the village Ouahat Sidi Brahim

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