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LINEAR FEATURE EXTRACTION FOR SATELLITE IMAGES USING CNLS (CONTEXTUAL NONLINEAR SMOOTHING) ALGORITHM

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Abstract- The satellite images present a great variety of features due to the trouble what returns their treatment is little delicate. The automated extraction of linear features from remotely sensed imagery has been the subject of extensive research over several decades. Recent studies show promise for extraction of feature information for applications such as updating geographic information systems (GIS). Research has been stimulated by the increase in available imagery in recent years following the launch of several airborne and satellite sensors. All the satellite images, which are going to be used in the present work, are going to be processed in the computer vision, for which the existing researchers are interested to analyze the synthetic images by feature extraction. These images contain many types of features. Indeed, the features are classified in 1-D feature such as step, roof and 2-D features such as corners, edges, and blocks. The satellite images present a great variety of features due to the trouble what returns their treatment is little delicate. In this we present a method for edge segmentation of satellite images based on 2-D Phase Congruency (PC) model. The proposed approach is composed by two steps: The contextual nonlinear smoothing algorithm (CNLS) is used to smooth the input images. Then, the 2D stretched Gabor filter (S-G filter) based on proposed angular variation is developed in order to avoid the multiple responses.

***Keywords**: Satellite images, feature extraction, phase congruency, S-G filter, image processing, image interpretation, gray value substitution, wavelet substitution.*

I. INTRODUCTION

The objective of this paper is to provide an effective segmentation and classification. In order to better explain the structure of this work, the preliminary information about the Satellite Image and Remote Sensing is discussed [1,2].Satellite image is defined as a picture of the earth taken from an earth orbital satellite. This image is a remotely sensed image. Remote sensing is a science of obtaining information about an object, area or phenomenon through the analysis of data acquired by a device that is not in contact with the object [1, 2]. Commonly remote sensing is referred to the collection and analysis of data regarding the earth using electromagnetic sensors, which are operated from the space borne platform. Satellite image classification includes two steps: a) Segmentation step b) classification step. In this paper, the satellite image segmentation & classification are done by using nonlinear smoothing algorithms (phase congruency model). In the current work, we present a new application of the phase Congruency model for satellite images edge segmentation. Then, stretched Gabor filter, based on novel angular variation, to compute the PC map of satellite images.

II. 2D PHASE CONGRUENCY MEASURE

The phase congruency model has also been implemented using banks of filters. This model was further modified by Kovesi in [3], [4]. An apparent problem of PC model it is a rather difficult quantity to calculate and is very sensitive to noise. In this paper, we use the measure of phase congruency in expressed by [5]

$$PC(\mathrm{x,y}) = \frac{\sum_o \sum_s w(\mathrm{x})[\mathrm{A}_{so}(\mathrm{x,y})\Delta\Phi_{so}(\mathrm{x,y}) - \mathrm{T}]}{\sum_o \sum_s A_{so}(\mathrm{x,y}) + \varepsilon}$$

(1)

Where o and s denotes the index over orientations and scales respectively, the symbols $\lceil \ \rceil$ denote the enclosed quantity is equal to itself when its value is positive, and zero otherwise. W (x) is the sigmoid function used to weight a phase congruency. Using the same notation in [5] let M_{so}^{even} and M_{so}^{odd} denotes the even-symmetric and odd-symmetric filter at scale s and orientation o respectively.

We define the response vector given by

$$[\mathrm{e}_{so}(\mathrm{x,y}), \mathrm{o}_{so}(\mathrm{x,y})] = [\mathrm{I(x,y)} * \mathrm{M}_{so}^{even}, \mathrm{I(x,y)} * \mathrm{M}_{so}^{odd}]$$

(2)

The amplitude of the response at a given scale and orientation can be expressed by

$$A_{so}(x,y) = \sqrt{e_{so}(x,y)^2 + o_{so}(x,y)^2}$$

(3)

And the phase angle is defined by

$$\Phi_{so}(x,y) = a\tan(e_{so}(x,y)/o_{so}(x,y))$$

(4)

Denote o (,) φ x y the mean phase angle at orientation o , a more sensitive phase deviation measure is given by

$$\Delta\Phi_{so}(x,y)=\cos(\Phi_{so}(x,y)-\overline{\Phi}_o(x,y)) - \left|\sin(\Phi_{so}(x,y)-\overline{\Phi}_o(x,y))\right| \quad (5)$$

According to Kovesi [3], using the magnitude of dot and cross products between the weighted mean filter response vector and the individual filter response vectors at each scale, the phase deviation can be calculated directly from the filter outputs, as [5].

$$A_{so}(x,y)\Delta\Phi_{so}(x,y)=\left(e_{so}(x,y)\overline{\Phi}_o^{even}(x,y)+o_{so}(x,y)\overline{\Phi}_o^{odd}(x,y)\right) - \left|e_{so}(x,y)\overline{\Phi}_o^{odd}(x,y)+o_{so}(x,y)\overline{\Phi}_o^{even}(x,y)\right| \quad (6)$$

A. The Phase Congruency Computation Scheme

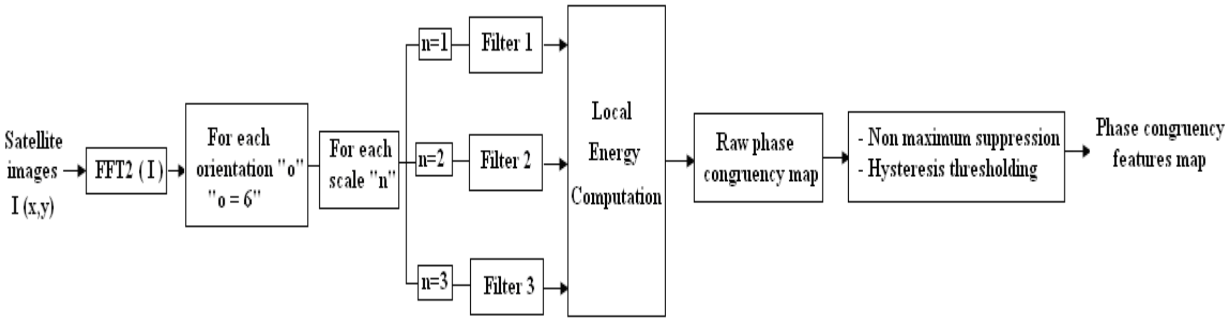

Fig. 1. Block diagram of phase congruency computation scheme

In the new application of local energy model in satellite images, the 2D log Gabor filter is used. The same parameters used by Kovesi [3] have been employed in this manuscript.According to [2] the raw phase congruency images were obtained by applying equation (1) to the images with the following parameters: Local frequency information was obtained using two-octave bandwidth filters over three scales and six orientations. The wavelength of the smallest scale filters was 3 pixels; the scaling between successive filters was 2. The 2D log Gabor filters were constructed directly in the frequency domain. A logarithmic Gaussian functions in the radial direction and a Gaussian in the angular direction. In the angular direction, the ratio between the angular spacing of the filters and angular standard deviation of the Gaussians was 1.2.

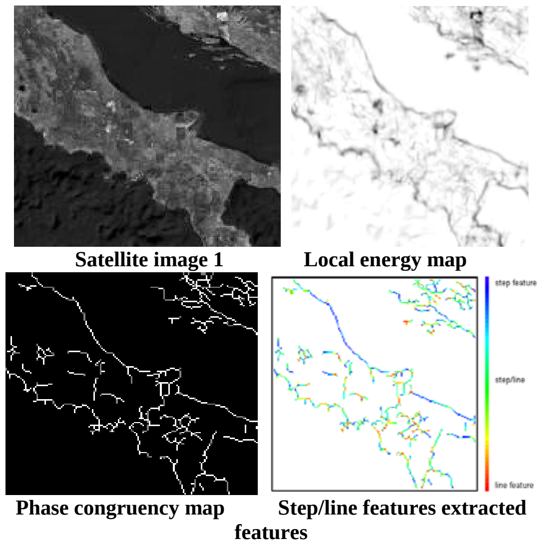

Fig. 2. Features on satellite image 1

A noise compensation k value of 2.0 was used. The phase congruency feature maps were obtained by performing nonmaximal suppression on the raw phase congruency images followed by hysteresis thresholding with upper and lower hysteresis threshold values fixed at phase congruency values. The hysteresis threshold values was set to [0.6-0.3] for proposed satellite image. The line and step features are detected and classified using the mean weight phase angle [4]. Moreover, we present the detected features in the smoothed images using two techniques of smoothing.

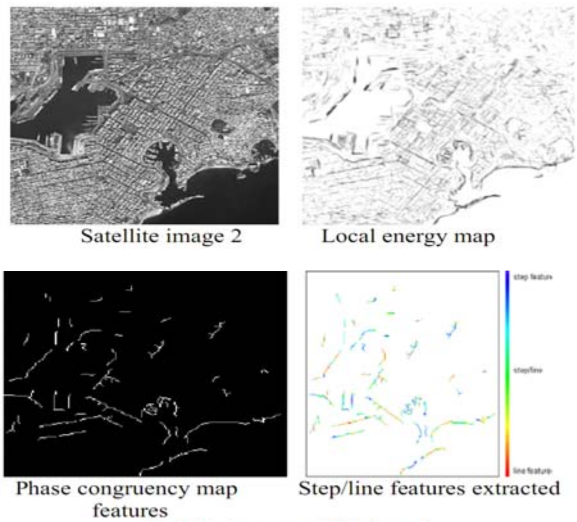

Fig. 3. Features on satellite image 2

The first method is presented in [15] by Liu for synthetic images boundary detection. The second method preserves the phase of the image and consequently preserves the features present in the satellite images.

III. SATELLITE IMAGES EDGE SEGMENTATION SCHEME

The proposed method for edge segmentation of satellite images is composed by two principles steps. Firstly, we propose the use of the nonlinear contextual smoothing algorithm to smooth the input satellite images. Secondly, we compute the phase congruency map of the smoothed images. The principles steps for phase congruency computing in [3] are investigated.

A. Nonlinear smoothing

Often, the real image and especially the satellite images are corrupted by many types of noise in its acquisition and transmission. In the recent years, there has been a great amount of research on images denoising or smoothing [6], [7], [8], [9], [10] and many technique of thresholding. In our context, several denoising algorithms are not efficient since it remove phase component of the input images. Here, we bases on contextual nonlinear smoothing algorithm. This algorithm is based on orientation sensitive probability measure.

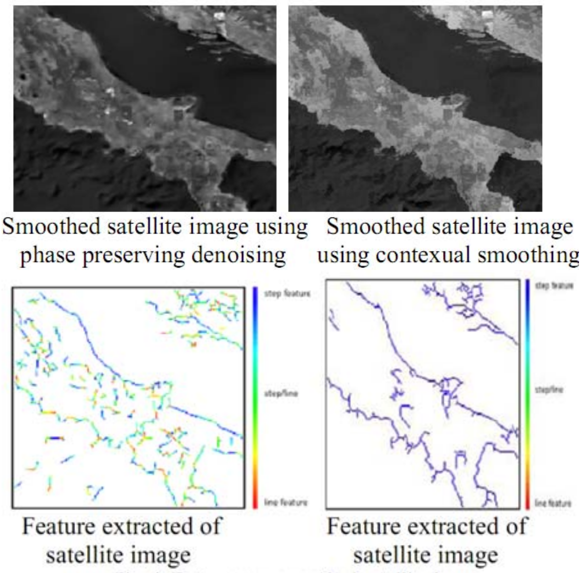

Fig. 4. Features on smoothed satellite image

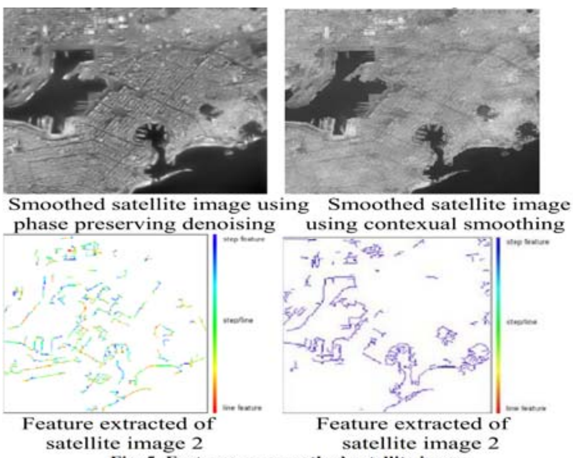

Fig. 5. Features on smoothed satellite image

B. The filter function

To overcome some drawbacks for Gabor filter and many others filters banks; and in order to remove the multiple response of the S-Gabor filter used in [8], we propose a modified stretched Gabor filters for phase congruency map computing of satellite images. In the previous work [8], the radial variation is a stretched Gabor function and the angular variation is a power of cosine. Here, we use the same 2D radial component of stretched Gabor filters [8]. But, instead of the use of the power cosine function, we propose the modified angular component expressed by

$$R(\varphi) = (\cos(\varphi_0 - \varphi) + |\cos(\phi_0 - \varphi)|)^{2m} \quad (7)$$

The product of angular and radial component produces the resulting 2D stretched Gabor filter used to compute phase

Congruency map. It is expressed by

$$F(r,\varphi) = G(r) * R(\varphi) \quad (8)$$

Where G(r) is given by

$$G(r) = e^{(-r^2/2\sigma^2)} * \cos(2\pi \nu_0 r \varsigma(r)) * \sin(2\pi \nu_0 r \varsigma(r)) \quad (9)$$

The 2D frequency representation of the proposed stretched Gabor filter is shown by the following figure.

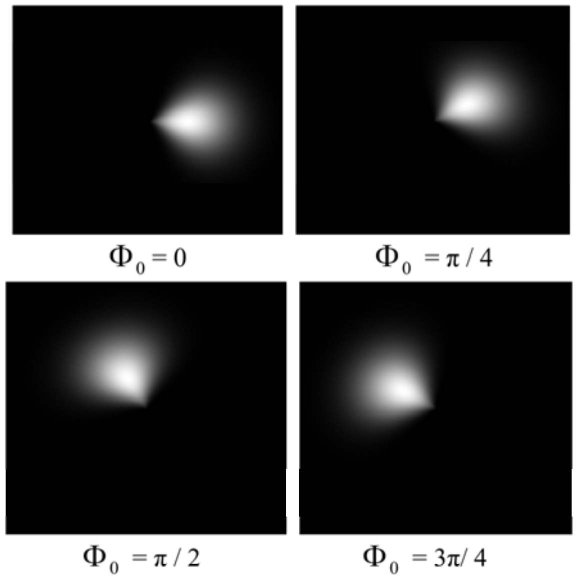

Fig. 6. 2D frequency representation of SG filter

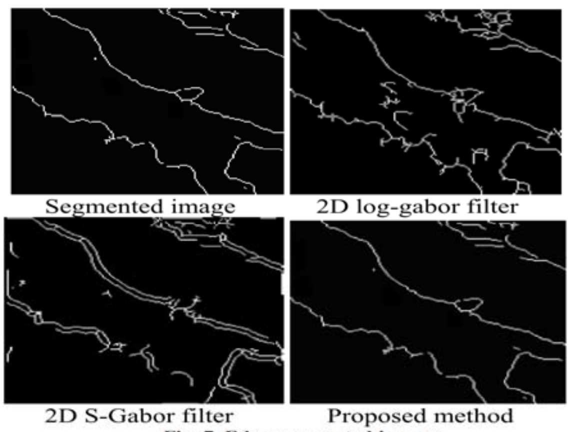

Fig. 7. Edge segmented images

Fig (5) & (6) shows the edge segmentation results of the proposed approach compared with Susan edge detector. Visually, the proposed method gives thinner and connected edges than Susan approach. The Susan approach remains sensitive to the choice of the thresholding value. Accordingly, we conclude that the method based on 2D log Gabor filter is sensitive to noise than the proposed method. Additionally, the method based on stretched Gabor filter, using the power of cosine as an angular component, present multiple responses. Our method detects only the major boundaries, a thinned and connected edge of all satellite images. We remark that the Kovesi [3] edge detector cannot find all correct edges and detect some false features. In addition, its presents many disconnected features. On the other hand, the measure of the phase congruency based on stretched Gabor filter defined by & produces multiple responses and presents some false detected edges. Both approaches present discontinuities of some edges. Accordingly, for the proposed approach some details and features are smoothed out while major edges and junctions are preserved accurately. Indeed, we note that the proposed algorithm gives thinner and better connected edges than two others methods.

Susan edge detector　　Proposed Method

Fig. 8. Comparison of Edge segmented images

IV. PROJECTIONS

In general, current edge detection approaches can be characterized by the use of spatial or frequency domain information. Spatial detection algorithms, including derivative-based (also Canny edge detection) and regularization-based, have been extensively studied in the past. Model fitting, a special spatial approach, is rather computational expensive compared with other approaches. It's somewhat like regularization-based approach. We think it can be used for particular purposes, for example it can be extended for special shape "corner" detection, due to its elaborate mathematical models and considerations. Phase congruency, a relatively new frequency-based approach, has shown its role in edge detection due to unique properties. And it was also found to be similar to some degree with animal vision. Yet it encountered the problem of expensive computation and ill-posed condition. We believe it's possible to combine the characteristics of spatial and frequency domain knowledge in edge detection. We think that human vision is not uniquely limited in spatial domain or frequency domain, because both approaches have gotten some promising results and also encountered some problems. Further research in this direction should be made and evidence should be collected, in combination with human research results from biometry. Further, for edges and corners, many intrinsic properties have not been discovered completely. Some concepts from other domain may be adopted, for example, symmetry for texture analysis can be used for corner type description.

V. CONCLUSIONS

The phase congruency model is used on the wide range of images. This model suffers some drawbacks like the sensitivity to the noise and the very computational costs. While the satellite images present many types of noise in their transmissions and acquisition. This work deals the application of the phase congruency model in satellite images. Accordingly, we conclude that the method based on 2D log Gabor filter is sensitive to noise than the proposed method. Additionally, the method based on stretched Gabor filter, using using the power of cosine as an angular component, present multiple responses. All approaches presented here are sensitive to the choice of the low and high values of hysteresis thresholding. Here, the values of threshold are set according to the values of the phase congruency map. We can say that, low pass filter is not fit in processing this stripped noise. And the other two methods are relatively suitable.

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