Adaptive Canny Algorithm Using Fast Otsu Multithresholding Method

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Abstract

In this research, an adaptive Canny algorithm using fast Otsu multithresholding method is presented, in which fast Otsu multithresholding method is used to calculate the optimum maximum and minimum hysteresis values and used as automatic thresholding for the fourth stage of the Canny algorithm.

The new adaptive Canny algorithm and the standard Canny algorithm (manual hysteresis value) was tested on standard image (Lena) and satellite image. The results approved the validity and accuracy of the new algorithm to find the images edges for personal and satellite images as pre-step for image segmentation.

Keywords Edge detection, image segmentation, fast Otsu multithresholding method, Canny edge detection algorithm.

Introduction

Image segmentation is an important technique in image processing and thresholding is a technique which is commonly used for image segmentation. Image segmentation is a process of dividing an image into different regions such that each region is uniformed in a certain sense and union of any two regions is not uniformed. The goal of segmentation is typical to locate certain objects of interest which may be depicted in the image [1]. Image segmentation plays an import role in image analysis and computer vision system; this is the process for subdividing an image into the homogeneous regions [2]. The automatic thresholding techniques are a popular tool used in image segmentation, where its wide applicability to other areas of the digital image processing, quite a number of thresholding methods have been proposed over the years [3].

Edge detection is the problem of fundamental important in image analysis, and edge detection techniques are generally used for finding discontinuities in gray level images. Edge based segmentation methods detect discontinuities and produce binary images contained edge and their background as the output of them [4]. The edge detection process serves to simplify the analysis of images by drastically reducing the amount of data to be processed, while at the same time preserving useful structural information about object boundaries [5].

The purpose of edge detection in general is to significantly reduce the amount of data in an image, while preserving the structural properties to be used for further image processing. Several algorithms exist, and this research focuses on a particular one developed by John F.Canny (JFC) in 1986. Canny algorithm is the most famous and commonly used edge detectors [4, 6, & 7].

The results of adaptive and the standard Canny algorithm can be compared, as a manually and automatically thresholding edge detection on test images.

Canny operator

Canny operator is the optimum-approaching operator of the product of signal to noise radio (SNR) and the location .Canny algorithm smoothes the image by Gaussian filter, calculates the magnitude and direction of gray level gradient, which has the non-maxima suppression on gradient magnitude, and detects and connects the edge from the candidate points by the high and low thresholds [8].

The Step of the Standard Canny algorithm

1-Smoothing: Blurring of the image to remove noise by convolving the image with the Gaussian filter.

2-Find gradients: The edges should be marked where the gradients of the image has large magnitudes, finding the gradient of the image by feeding the smoothing image through a convolution operation with the derivative of the Gaussian in both the vertical and horizontal directions.

3-Non –maximum suppression: Only local maxims should be marked as edges. Finds the local maxima in the direction of the gradient, and suppresses all others, minimizing false edges.

4- Double thresholding: potential edges are determined by thresholding, instead of using a single static threshold value for the entire image, the Canny algorithm introduced hysteresis thresholding, which has some adaptively to the local content of the image. There are two threshold levels, high and low values, where (high value > low value) the pixel values above the high value are immediately classified as edges.

5-Edge tracking by hysteresis: Final edges are determined by suppressing all edges that are not connected to a very strong edge [9].

Otsu method

Otsu method had been proposed in 1979, and it is deduced by least square method based on gray histogram as a nonparametric and unsupervised method. Otsu method is the best method of selecting an optimal threshold value automatically by the discriminant criterion, namely, so as to maximize the separability of the resultant classes in gray levels through the variance maximum value between these classes. The principle of this procedure is utilizing only the zeroth- and the first-order cumulative moments of the gray-level [10, & 11].

Test Images

Lena image had been used as a standard image shown in fig. 1-(a), and Al-Ramadi city scene as a second image which used also in this research, this scene is located in Al-Anbar provenience of the Iraq region, and it covers (581.72) km^2 west of Baghdad as shown in fig. 1-(b). The available scene was TM exposure at March 04, 1990. This region lies between latitudes 33° 27' 21.44" N to 33° 14' 14.05" N and longitudes 43° 29' 17.91" E to 43° 44' 36.64" E. This region represents Alluvial Plain; the hot desert climate prevails in the sedimentary plain and the western plateau. It contains some vegetation cover, many soil and rock erosion were noticed.

Research Methodology

In this research, the Canny algorithm has been built by using MATLAB version 2009b. Language and didn't use the package program, to correct the Canny algorithm and dovetailing it's with the fast Otsu multithresholding method. Fig. (2) illustrates the adaptive Canny algorithm had been adopted and summarized in the block-diagram.

Results and Discussions

In order to study the fast Otsu method as an automatic thresholding method to create binary images, the fast Otsu multithresholding method had been implemented and applied on the test images (Lena and Al-Ramadi region). This study was performed by using 64 bit computer platform of core 2Due 2.2 GHz processor and MATLAB version 2009.

In Canny algorithm, the standard deviations (std), Canny algorithm was equal to (1). To ensure the more than 90% of the Gaussian operator is effecting on the image, the sliding mask size was adopted according to the following equation:

$$\text{Mask size} = 6 * (\text{std} + 1) \quad \ldots\ldots (1)$$

From the results of applying the fast Otsu multithresholding method as thresholding method which is deprecated in fig. (1), the following steps can be noticed:

- Calculating the threshold value in the Canny algorithm via Otsu, eliminate the tray and error step to find the optimum threshold value (maximum and minimum hysteresis value) in the standard Canny algorithm.
- The thresholding via Otsu was able to recognize the main edges of the objects in the image and eliminates the minor edge due to the fain details that have a disruption on the main edge.
- The edges that are found though Canny algorithm via Otsu were suffering from discontinuity that makes it hard to follow the edges.

- Applying the Canny algorithm using Otsu on the satellite image was more efficient to recognize the main edges in the image comparing to the manually Canny thresholding method.

The threshold values of Canny algorithm (manually method) and the proposed method (automatically method) for test images (Lena and Al-Ramadi region) are listed in tables (1, & 2).

Conclusions

According to the results, the automatic thresholding (maximum and minimum hysteresis value) via fast Otsu multithresholding method to find the edge using Canny algorithm were recommended, for their ability to separate the main edges from the minor edge, which make it easier to separate the main object from the background. The discontinuity in the resultant edges that are found by using the proposed method can be over rid though farther post processing step like applying Hough transform.

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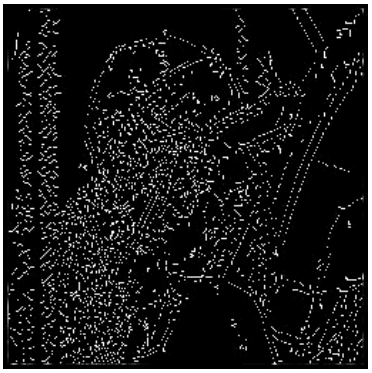
Table No. (1) Threshold Values of Canny Algorithm & Proposed Method for Lena image

Manually		Via Fast Otsu Multithresholding	
Min_Hysteresis	Max_Hysteresis	Min_Hysteresis	Max_Hysteresis
93	151	2.25	25.5

Table No.(2) Threshold Values of Canny algorithm & Proposed Method for Al-Ramadi Image

Manually		Via Fast Otsu Multithresholding	
Min_Hysteresis	Max_Hysteresis	Min_Hysteresis	Max_Hysteresis
72	154	2.25	25.5

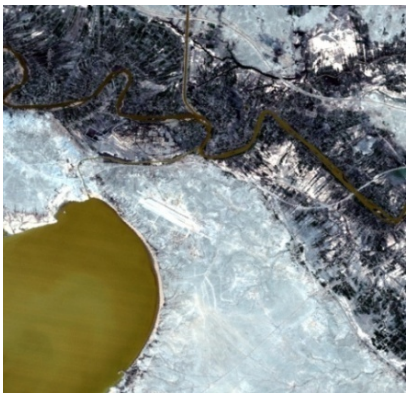
Lena Image



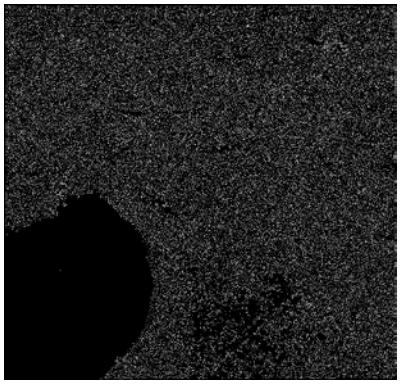
Canny Operator (Manually Method)

Canny Operator with Fast Otsu Multithresholding (Automatically Method)

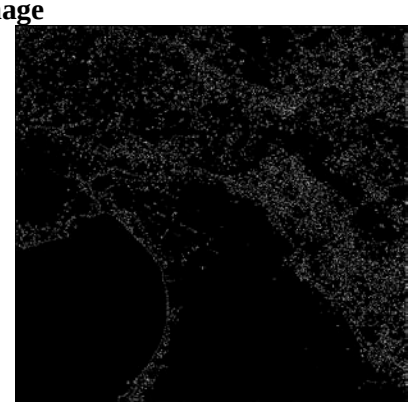
(a)



Al-Ramadi_Image



Canny Operator (Manually Method)



Canny Operator with Fast Otsu Multithresholding (Automatically Method)

(b)

Figure No. (1) Canny Edge Detection Operator & Proposed Method for (a) Lena image (b) Al-Ramadi Images

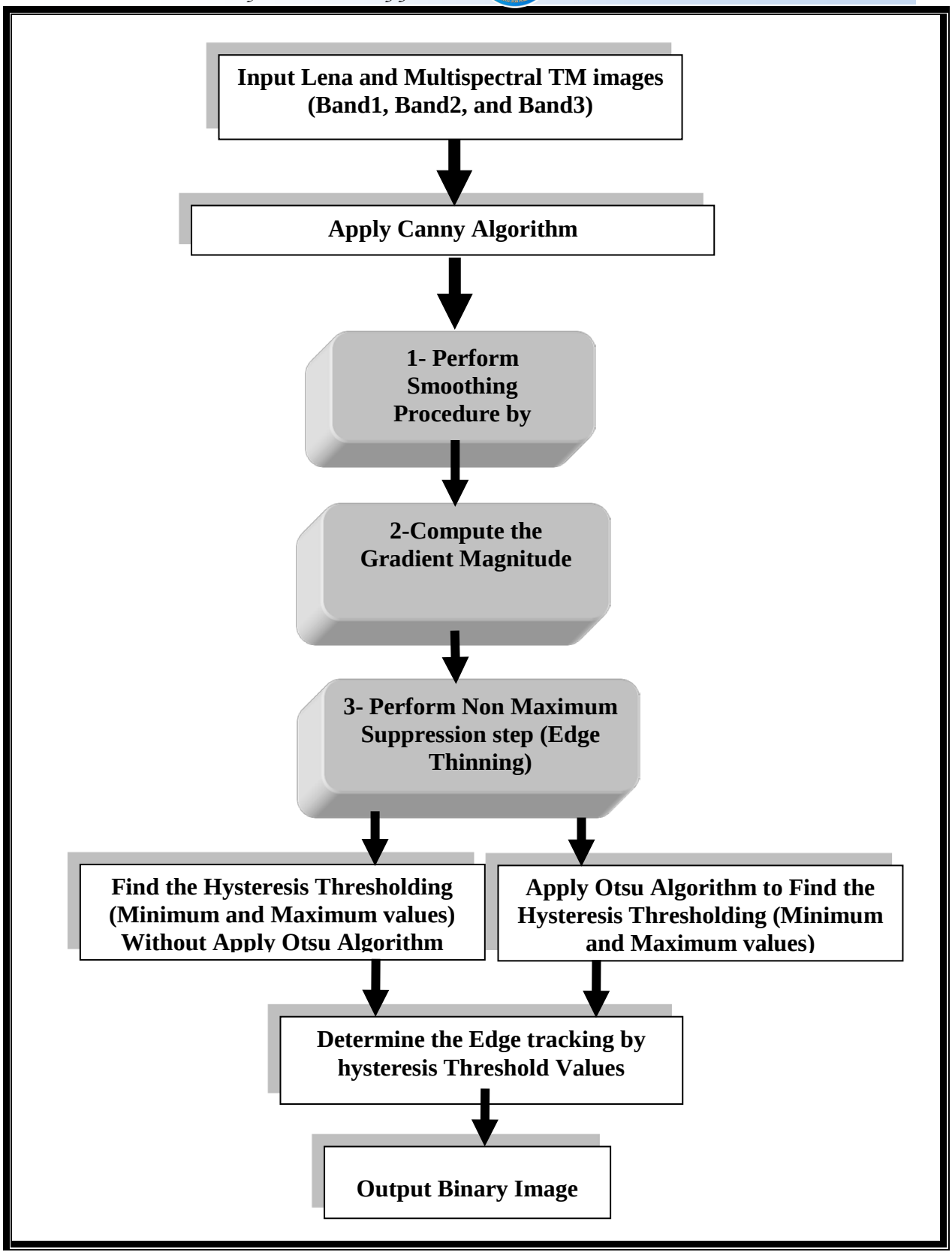


Figure No. (2) Block Diagram Summarizes the Procedure Steps for the Adaptive Canny Technique

خوارزمية كاني المطورة باستعمال طريقة أوتسو السريعة المتعددة حد العتبة

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استلم البحث في22 نيسان 2013 قبل البحث في 24 ايلول 2013

الخلاصة

قدم هذا البحث طريقة مطورة لخوارزمية كاني باستعمال طريقة أوتسو السريعة المتعددة حد العتبة، التي تستعمل فيها طريقة أوتسو السريعة المتعددة حد العتبة لحساب قيم الهسترة الأعلى القصوى والدنيا، والمستعملة حد عتبة آلي للخطوة الرابعة من خوارزمية كاني. اختبرت الخوارزمية المطورة الجديدة والخوارزمية القياسية (قيم الهسترة اليدوية) لكاني على الصورة القياسية (لينا) والصورة الفضائية، أثبتت النتائج صحة ودقة الخوارزمية الجديدة لإيجاد حواف الصور الشخصية والفضائية خطوة أولية لتقسيم الصور.

الكلمات المفتاحية:- كشف الحواف، تقسيم الصورة، طريقة أوتسو السريعة المتعددة حد العتبة ،خوارزمية كاني لكشف الحواف.