EDGE DETECTION FOR COLOR DIGITAL IMAGES USING LINEAR FITTING FUNCTION[+]

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Abstract

The relationship of the local image elements in homogeneous regions of the image which are systemized by increasing or decreasing manner, that approachs the linear function. Therefore, we depend on this property for recognition of the edge regions from homogeneous regions, this done via using least square algorithm to fit image data to the linear formula. Then calculate summation of the differences between the real values y(x) and the approximated values Y(x) from the linear function. The small differences are verified in the homogeneous regions of the image where the values of y(x) approach Y(x) values, while the high differences are verified in the non-homogeneous regions (edge regions). Here we can depend on these differences in the edges recognition. We depend on this algorithm to detect the edge for the color image after analysis to its (Red, Green, Blue, and Luminosity). Then apply fitting algorithm each band then calculate the differences to each band and determine the mean value for the four differences in order to compare it with threshold to determine the center element of the mask as an edge or not.

The result of this algorithm produced accurate and good edges comparing with the results of the other edge detection operators.

المستخلص :

إن العلاقة بين قيم عناصر الصورة الموضعية في المناطق المتجانسة والمرتبة ترتيبا تصاعديا أو تنازليا مع تسلسلاتها تقترب من الصيغة الخطية. لذا تم اعتماد هذه السمة في تمييز المناطق الحافية عن المتجانسة إذ اعتمدت خوارزمية المربعات الصغرى لتقريب بيانات الصورة الى الصيغة الخطية. ومن ثم حساب مجموع الفروق بين القيم الفعلية y(x) والقيم التقريبية Y(x) من الصيغة الخطية.

أن الفروق الصغيرة تتحقق في مناطق الصورة المتجانسة حيث تقترب قيم y(x) من قيم Y(x) اما الفروق الكبيرة فأنها تتحقق في المناطق غير المتجانسة (مناطق حافية). هنا يمكن اعتماد هذه الفروق في تمييز الحافات. لقد اعتمدنا هذه الخوارزمية في تحديد الحافات في الصورة الملونة بعد تحليلها الى حزمها (الحمراء والخضراء والزرقاء والأضاءة). ثم تطبيق خوارزمية التقريب لكل حزمة و حساب الفروق لكل حزمة و حساب قيمة المعدل لهذه الفروق لغرض مقارنة هذه القيمة مع العتبة لتحديد إن كان عنصر النافذة المركزي يحتل حافة أم لا.

[+]**Received on 5/12/2005 , Accepted on ٢٠٠٧/٤/٢٩ .**
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أن النتائج لهذه الخوارزمية تميزت عن الطرق السابقة في حساب الحافات للصورة الملونة وأعطت الدقة في ذلك من خلال أيجاد حافات وحدود جيدة.

List of Abbreviations

th	Threshold value
y(x)	real value for the local intensity
Y(x)	fitting value for the local intensity
x	Index of real value and fitting value
L	Luminosity
E_r	Absolute error between the real data y(x) and fitting data Y(x) for red color
E_g	Absolute error between the real data y(x) and fitting data Y(x) for green color
E_b	Absolute error between the real data y(x) and fitting data Y(x) for blue color
E_L	Absolute error between the real data y(x) and fitting data Y(x) for Luminosity
m_1	Mean value of four errors values E_r, E_g, E_b, and E_L that are produced from (R, G, B, and L) by using mask1.
m_2	Mean value of four errors values E_r, E_g, E_b, and E_L that are produced from (R, G, B, and L) by using mask2.
m_g	Great mean value which is chosen from the two means values (m_1 & m_2)

1. Introduction.

Edge detection methods are fundamental to computer vision, because edge detection is often the first stage of a lengthy image interpretation process. The goal of edge detection is to locate the pixels that correspond to the edges of the objects seen in the image. This is usually done with a first and /or second derivative measurement followed by a test which marks the pixel as either belonging to an edge or not. The result is a binary image, which contains only the detected edge pixels [1].

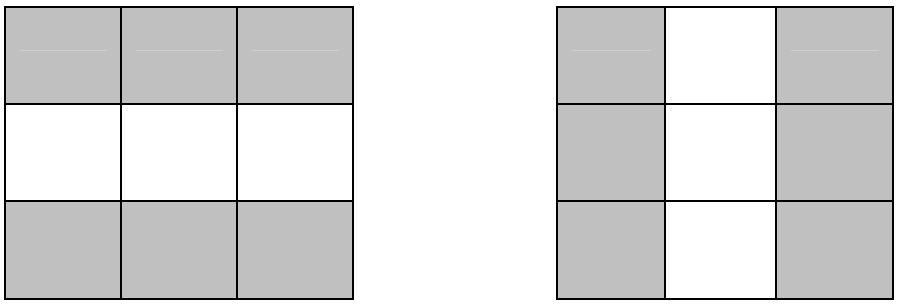
The edge detection methods described so far use intensity differences as the metric to detect edges. Also, edges can be determined using intensity ratios as the metric. Intensity ratios are independent of scene illumination [2]. The problem of edge detection is one of the most outstanding problems in image processing. There are many ways to tackle it each of which produces another edge detector that performs, in some way, better than any previous one but all edge detectors can detect edges up to certain accuracy [3].

It is difficult to design general edge detection algorithm that performs well in many contexts and captures the requirements of subsequent processing stages. Edge detection operators are based on the idea that the edge information in an image is

found by looking to the relationship which a pixel has variance with its neighbors. If the pixel gray level values are similar to those around it, there is probably not an edge at that point. However, if a pixel has neighbors with widely varying gray levels, it may represent an edge point [4].

The edge detection filters are normally grouped into two classes non-directional and directional filters. The difference between them is that the non-directional filters don't focus on a particular direction within the image but rather deal with linear features in all directions, while directional filters can be very useful if we are only interested in accenting the features in one direction, or a limited number of directions. [5,6]

Most of the edge and line detection operators are implemented with convolution masks based on discrete approximations to differential operators. Differential operators measure the rate of change in pixel values [7]. Ali and Haidar [5] introduced method to be applied to various gray level images with different edge strength and different orientations and directions, where they exploit the non-agreement with the fitted line to precise the edge points [5]. Edge detection is an important process in low level image processing. Since color images provide more information than gray value images,more detailed edge information is expected from color edge detection [8]. Therefore, in this paper we extend the method of Ali and Haidar [5] to detect edges in color images, with easy method which depends on the analysis of the pixel value of color image to (Red, Green, Blue, and Luminosity), and use least square line fitting to find the error value between real and fitting data for each band, then calculate the mean value for these errors values to compare it with threshold value to locate edges. So, we add new steps which make the operator have two masks as Sobel operator, where the algorithm is used to find two error values one for each mask, then choose the great error value to compare it with threshold value, Figure (1) demonstrates representation of adopted masks.



(a) (b)

Figure (1) Representation of adopted masks:
(a).mask1.(b).mask2. where the gray elements represent the adopted pixels values that used for algorithm, while the white elements represent the pixels values ignored from processing steps.

2. The Color Images

Color image can be modeled as three-band monochrome image data, where each band of data corresponds to red, green, and blue color. The actual information sorted in the digital image data is the brightness information in each spectral band. When the image is displayed, the corresponding brightness information is displayed on the screen by picture elements that emit light energy corresponding to that particular color. Typical color images represent the three bands image as RGB images. The corresponding color image would have 24 bits/pixel(8-bits for each band of the three color bands). Fig. (2) below depicts representation of color image [9].

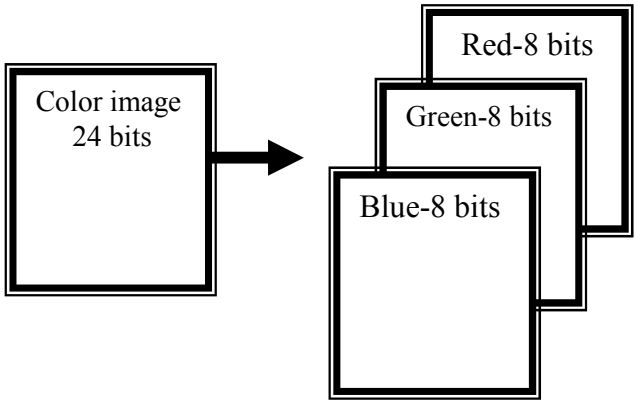


Figure (2): Representation of color image.

3. Theoretical Concept

In this study, we use method of line regression to detect image edges [5] to expand it with color image, where this algorithm was previously utilized to introduce adaptive digital smoothing filter for reducing noise from images [10].

To explain the advantage of least square fitting for edge detection method, we take three regions (labeled by square gray blocks) from certain image shown in Figure (3: a), where the three regions are white homogenous region, black homogenous region, and region between white and black (edge region). When we re-ascend the real data (for each region) by increasing manner or decreasing manner (i.e., present the values as a set of sorted numbers [x, y(x)]), where x=1, 2, 3…n, it represents the index of pixel band value y(x), and (n) is the number of adopted points in the selected region, Then the sorted data can be presented by Linear function.

When we apply least square fitting to line function to get fitting values Y(x), we find the errors between the real values y(x) and fitting values Y(x) are so small in the homogenous image region (white or black) see Figure (3: b and c),while, the non-homogenous region (edges image region) always contain points from two different targets. So, the estimated curve fitting introduces high errors between y(x) and Y(x) see Figure (3: d), this error is considered as measurement to find edge. This contrast

between homogenous regions and non-homogenous regions is exploited to detect image edges.

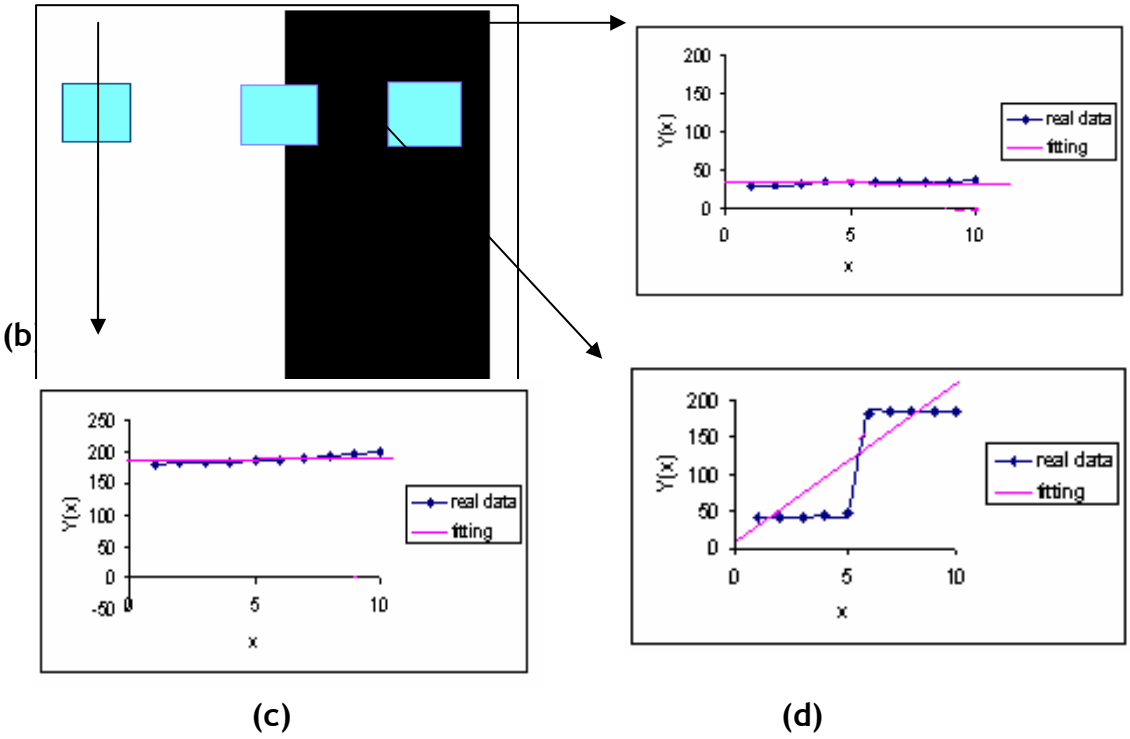


Figure (3) : Relation between the sorted data y(x) and their indices (x), and its approximation in a linear function using least square fitting algorithm:
(a).The adopted image to determine the real data curve and linear fitting curve, for the three different regions. (b). Relation for black homogenous region.
(c). Relation for white homogenous region.
(d). Relation for non-homogenous region (Edge region).

The points in any homogenous image region, where we keap sorting the local band values, in increasing manner (i.e. present the values as a set of sorted numbers[x,y(x)], x=1,2,3,,…n) where x represents, the index of band value y(x), and n is the number of extracted values from used mask (usually equal to 6).

We analyze the pixel value to four bands, then assume that points ([x,y(x)],x=0,1,2,…n) for red, green, blue, and Luminosity always have linear relation

between x and y(x) for these bands are homogenous region. So, we can estimate the best fitting line for this data by using least square curve fitting algorithm. This is by done using line equation as follows:

$$Y(x) = a + bx \text{.....(1)}$$

where $Y(x)$ represent the estimated function of the data, a, and b are coefficients which must be computed from fitting algorithm. To determine the values a, and b the following equations are used:

$$b = \frac{n \cdot \sum_{x=1}^{n} x \cdot y(x) - \sum_{x=1}^{n} x \sum_{x=1}^{n} y(x)}{n \cdot \sum_{x=1}^{n} x^2 - \left(\sum_{x=1}^{n} x \right)^2} \text{..... ....(2)}$$

$$a = \frac{\sum_{x=1}^{n} y(x) - b \sum_{x=1}^{n} x}{n} \text{..... ....(3)}$$

So the data of $y(x)$, can be approximated by using equation (1) to get $Y(x)$.

Here we can determine the errors between the real data $y(x)$ and the approximated values $Y(x)$ for each band (Red, Green, Blue, and Luminosity). We can calculate the luminosity for every pixel from the following equation [11]:

$$L = 0.299\ r + 0.587\ g + 0.114\ b \text{..... .... (4)}$$

where the errors are so small in homogenous regions while, in edge image (non-homogenous) regions are always high. These differences between homogenous regions and non-homogenous regions in the image bands are exploited to locate color image edges.

The proposed edge detector, preformed by using the following steps:

Linear Fitting Algorithm to Detect Edges for the Color Image

Start algorithm

i. **Input edge threshold (th).**
ii. Input size of sliding mask (3x3).
iii. Apply the sliding mask1 (see figure-1a), on the image plane, then extract the values from the image.
iv. Analyse every pixel value from the extracted pixels values to the (r, g, b, and L), where Luminosity can be calculated for each pixel by using eq.(4).
v. Then re-ascend the resulting red band (r) data in increasing manner and present in a vector $y(x)$, where (x=1, 2, 3…n), and n is the number of extracted values usually equal to (6). *Initially used Red band (i.e. y(x) =r).*
vi. Estimate (a and b) of the best fitting line for the sorted data in vector y(x), by using equations (2), and (3), then the equation of the best fitted line Y(x) can be stated by eq.(1).
vii. Estimate the absolute error (E_r) between the data y(x) and the approximated curve Y(x), by using equation:

$$E_r = \frac{1}{n}\sum_{x=1}^{n} \left| y(x) - Y(x) \right| \cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots (6)$$

viii. Repeat the steps (v, vi, and vii) for g, b, and L in order to find four errors values.
ix. Compute the mean value (m_1) for the four errors values:

$$(m_1 = (E_r + E_g + E_b + E_L)/4)$$

x. Extract the values from the image by mask2 (see Figure-1b) then apply the steps (iv, v, vi, vii, viii, and ix) again to find (m_2).
xii Choose the great mean of the errors (m_g)from the two values (m_1 and m_2).
xiii. If m_g > th..then..can be assigned the central mask point as an edge point.
End Algorithm

4. Results and Discussion :

Real color image (Nerjes) is used to evaluate the implementation efficiency of the suggested algorithm. This image has spatial resolution (256 x 256) pixels, and true color resolution 24 bits/pixel. To determine the power of the introduced edge detector, compare its results with that of Sobel, and Robert edge detectors. From the results shown in Figure (4) we be find the present Least Square Linear Fitting (LSLF) edge detector gives best results (thin connected edges and with small number of isolated edge points), comparing with the mentioned edge detectors. Hence,it can be said that

the color image regions in RGB bands values can be locally modeled as linear function in the homogenous region. Any contrasts with this model, mean that the band region represents an edge region or non-homogenous region, and the physical meaning of color edges is that they are produced by discontinuities in the color values (R, G, and B). This edge detector is highly successful in determining straight lines and edges of color image see Fig.(4) below.

a. Nerjes

b. Linear

c. Sobel

d. Robert

Figure (4) : Results of edge detectors:
a. Original image.
b. Represents result of introduced detector.
c and d represent results of traditional detectors.

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