EDGE LINKING IMPLEMENTATION METHOD TO DETECT EDGE LINE IN DIGITAL IMAGE

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I.   ABSRACT

The edge detection process continued by the edge linking which is presented in this paper can be clear by the following: 1) it appears from the results of the edge linking that the part with bright colour is indicative of the big change in the intensity value of the original image, and 2) the edge detection in the geometric shapes or Morphological shapes are more significant or more contrast rather than ordinary image. The edge linking, the gradient components G_x and G_y of the image are present here to detect an edge linking of geometric figure (morphology shape) and digital image. There are three kinds of discontinuity in digital image; they are point, line, and edge. In practice, the most common method to find the discontinuity of an image is to use the mask that is operated in all of the pixels in the image, we use of the masks of the size of (3 * 3). To implement the contrast stretching process in a computer, we present an algorithm to Sobel method to write a program able to 1) open the file containing digital images, 2) display the digital image in the screen, 3) process the edge linking, and 4) display the digital image resulting from the process, and we used image file in BMP format and of the size of (256 * 256) pixel with 256 grey level.

الخلاصة

تحديد وربط الحافة في هذا البحث يكون واضح من خلال 1) النتائج التي تم التوصل إليها في ربط الحافة حيث أن الجزء ذو اللون المضيء يؤشر تغيير كبير في كثافة الصورة الأصلية, 2) تحديد الحافة في الإشكال الهندسية تكون أكثر وضوحا من الصورة الرقمية الاعتيادية. ربط الحافة ومكونات الانحدار G_x, G_y قد تم تناولها في هذا البحث لربط الحافة للإشكال الهندسية والصورة الرقمية على حد سواء. هناك ثلاثة أنواع من عدم الاستمرارية في الصورة الرقمية, وهي النقطة, الخط, والحافة, من الطرق الشائعة في التطبيقات العملية لإيجاد عدم الاستمرارية للصورة الرقمية هو استخدام قناع **Mask** ذو حجم (3 * 3) يمكن تطبيقه على كافة البتات **Pixel** المتكونة منها الصورة الرقمية. لتنفيذ هذا الإجراء تم بناء خوارزمية لكتابة برنامج لطريقة سوبل **Sobel** يقوم بالعمليات التالية: 1) فتح الصورة الرقمية, 2) عرض الصورة الرقمية, 3) تحديد عملية ربط الحافة, 4) وعرض ناتج تحديد حدود الصورة الرقمية بعد إجراء عملية ربط الحافة لها, حيث تم استخدام الصورة الرقمية من نوع **BMP** ذات الحجم (256 * 256) الرمادية المستوى

II.   THEORETICAL BASIS

1.   Image Segmentation

Image segmentation is an initial step in the process of image analysis that aims at accessing the information in an image. Meanwhile, the image segmentation divides the image into parts and objects. The extent to which the division is conducted depends on the existing problem. Ideally, it is stopped when the expected objects have been successfully separated.

In general, the automatic segmentation is a difficult task in image processing. It determines the success or the failure of the analysis process. However, it is highly possible that an effective segmentation gives a good result.

The segmentation algorithm for monochrome image is usually conducted by considering one or two characteristics of a grey level value: discontinuity and similarity. In the discontinuity the approach used is to separate the image on the basis of the drastic change in the grey level value, while in the similarity the approach used is to determine the threshold, growing region splitting, and merging.

2. Discontinuity Detection

There are three kinds of discontinuity in digital image. They are point, line, and edge. In practice, the most common method to find the discontinuity of an image is to use the mask that is operated in all of the pixels in the image. The use of the masks of the size of (3 * 3) in the following image will result in:

$$R = w_1 z_1 + w_2 z_2 ... w_9 z_9 \quad …………………………………………..(1)$$

where z_i is the grey level of the pixel in comformity with the mask coefficient of w_i.

w_1	w_2	w_3
w_4	w_5	w_6
w_7	w_8	w_9

3. Point Detection

The method to detect the insulated point is to directly use the mask in the following figure.

-1	-1	-1
-1	8	-1
-1	-1	-1

A point is considered to be detected in central location of the mask when

$$|R| > T \quad …………………………………………..(2)$$

where T is positive threshold, and R is calculated by equation (1) above.
using the a aforementioned mask.

Basically, it is to measure the difference in the grey level between the central point and the neighbouring points. The idea is that an insulated point will have significant grey level difference as compared to the neighbouring points.

4. Line Detection

The subsequent step in the continuity detection is line detection. The line is detected by using four masks as follow:

-1	-1	-1
2	2	2
-1	-1	-1

-1	-1	2
-1	2	-1
2	-1	-1

-1	2	-1
-1	2	-1
-1	2	-1

2	-1	-1
-1	2	-1
-1	-1	2

Horizontal $+ 45^o$ Vertical $- 45^o$

The first mask will gives a strong response at the line with horizontal direction, while the other masks are used to detect the lines with the vertical direction of 45° and -45°. It appears that the direction of the detected line is in conformance with that of the mask coefficient, which is of the bigger value than that of other mask coefficients. They are:

If R_1, R_2, R_3, and R_4 are the responses of the four masks as indicated in the figure above, and the four responses are operated in the same pixel, the highest R value is indicative of the closest direction to the pixel.

5. Edge Detection

Edge detection plays an important role in computer vision tasks, and has received considerable attention in image processing literature [1]. It's also considered to be most important image attributes that provide valuable information for human image perception. With the advent of artificial intelligence systems and forensic science the process of edge detection has achieved the most sought status. Edge detection is a very complex process affected by deterioration due to different level of noise. A number of operators are defined to solve the problem of edge detection [2–7]. They behave well in one application but poorly in other.

Edges are points where there is a boundary (or an edge) between two image regions. In general, an edge can be of almost arbitrary shape, and may include junctions. In practice, edges are usually defined as sets of points in the image which have a strong gradient magnitude. Furthermore, some common algorithms will then chain high gradient points together to form a more complete description of an edge. These algorithms usually place some constraints on the properties of an edge, such as shape, smoothness, and gradient value. Locally, edges have a one dimensional structure [8].

Edge detection is a fundamental tool used in most image processing applications to obtain information from images as a precursor step to feature extraction and object segmentation. This process detects boundaries between objects and the background in the image at which the image brightness changes sharply or more formally has discontinuities. The image containing these boundaries is known as edge map [9]. The purpose of detecting sharp changes in image brightness is to capture important events and changes in properties of the world.

There are many ways to perform edge detection, however most of them grouped into two categories, gradient and Laplacian. The gradient method detects the edges by looking for the local maximum and minimum in the first derivative of the image. The Laplacian method searches for zero crossings in the second derivative of the image. Some of the early gradient operators include Roberts [10], Prewitt [11], Sobel [12], Canny [13] edge operators. They involve small kernels to convolve with an image to estimate the first-order directional derivatives of the image brightness distribution. The edge value is calculated by forming a matrix centered on each pixel. If the value is larger than a given threshold, then the pixel is classified as an edge. All the gradient-based algorithms have kernel operators that calculate the edge strength in directions which are orthogonal to each other, commonly vertically and horizontally. The contributions of the both components are combined to give the total value of the
edge strength.

In early processes, the edge detection was mainly performed on software due to its large hardware requirement and also the application-specific integrated circuits have not gain much advancement. But present researches on programmable devices make it possible to implement edge detection algorithms on these devices whose design turn-around time varies from few hours to few days.

Edge detection is the most common approach to detect a grey level discontinuity. It is because the insulated point or line is rarely found in a practical application. An edge is the boundary between two regions with a relative different grey level.

Essentially, the underlying idea of most of the edge detection techniques is to use the calculation of local derivative operator [14]. The gradient of an image $f(x,y)$ in the location (x,y) is a vector which is shown in an equation (3).

$$\nabla f = \begin{bmatrix} G_x \\ G_y \end{bmatrix} = \begin{bmatrix} \dfrac{\partial f}{\partial x} \\ \dfrac{\partial f}{\partial y} \end{bmatrix} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots..(3)$$

The most important value in the edge detection is the magnitude of the vector, which is usually referred to only as the gradient and written as ∇f, where:

$$\nabla f = mag(\nabla f) = \sqrt{\left[G_x^2 + G_y^2 \right]} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots..(4)$$

In general, an absolute value is used in the gradient value approach as follow:

$$\nabla f \approx |G_x| + |G_y| \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots..(5)$$

The formula is easier to implement, especially when a processing hardware is used. The direction of the gradient vector also represents an important quality. If $a(x,y)$ indicates the direction of the vector angle ∇f at (x,y), the vector analysis is as follow:

$$a(x, y) = \tan^{-1}\left(\frac{G_x}{G_y} \right) \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots..(6)$$

where the angle direction is measured to x axis.

A derivative may also be implemented digitally using Sobel operator, which is by the use of the following mask:

-1	-2	-1
0	0	0
1	2	1

The mask to calculate G_x

-1	0	1
-2	0	2
-1	0	1

The mask to calculate G_y

6. Edge Linking

Ideally, the technique to detect the discontinuity ought to result only in the pixels at the boundary of the regions. However, it is rarely the case because of the presence of noise, the separated borders due to uneven lighting, and other effects resulting from intensity variation. Therefore, the edge detection algorithm is usually continued by an edge linking procedure to arrange the pixels into an entity that produces meaningful information [14].

One of the techniques to do the edge linking is local processing, which is to analyze the characteristics of the pixels in a neighbourhood (3 * 3) or (5 * 5) at all of the point (x, y) of edge-detected image. Subsequently, all of the points of similar kind are connected to form the pixel cluster of the same characteristics.

Two major characteristics used to determine the similarity of the pixel edge in the analysis are:
1) the magnitude of the used gradient operator response
2) the gradient direction.

The first characteristic is represented by the ∇f value discussed above. Thus, a pixel edge with the coordinate (*x'*,*y'*) and has the neighbour of (*x*,*y*) is considered to have the same magnitude as that of the pixel in (*x*,*y*) if:

$$\left| \nabla f(x,y) - \nabla f(x',y') \right| \leq T \quad \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots..(7)$$

where *T* is a positive threshold.

Meanwhile, the direction of the gradient vector is expressed as *a*(*x*,*y*) as discussed earlier. A pixel edge in the coordinate (*x'*,*y'*) and has the neighbour (*x*,*y*) is considered to have the same angle as the pixel (*x*,*y*) if:

$$\left| a(x,y) - a(x',y') \right| < A \quad \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots..(8)$$

where *A* is the angle threshold. A neighbour point of (*x*,*y*) is connected with the point (*x*,*y*) if it meets the criterions above in terms of both its magnitude and its angle. The linking process is repeated to all of the point locations of the image.


III. STUDY METHOD

To implement the contrast stretching process in a computer, we write a program able to:
1) open the file containing digital images,
2) display the digital image in the screen;
3) process the edge linking;
4) display the digital image resulting from the process.

The program is used image file must be in BMP format and of the size of (256 * 256) pixel with 256 grey level.

1. The digital image in BMP format

The image file in BMP format is one of the standard formats used in Windows operating system. The file is usually saved with the extension (.BMP). The structure of the BMP file is as follow:

BitmapFileHeader
BitmapInfoHeader
Array RGBQUAD
Colour Array
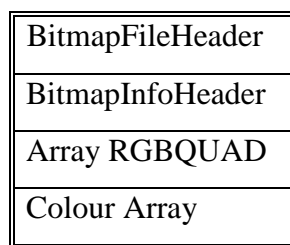
The structure (BitmapFileHeader) indicates the kind and the size of the file. The structure (BitmapInfoHeader) indicates the size (i.e., the width and the height) of an image, the color format of the image and the number of the colours of the image. The structure (RGBQUAD) contains the colour intensity value that is divided into the components of R, G, and B (red, green, and blue). Meanwhile, the colour array contains the information about the image contents, which are the pixels of the image.

The pixels contained in the (BMP) file are copied into array variable to accelerate the processing process of the digital image. Thus, it is not necessary in the subsequent process to read the file repeatedly.

2. Edge Linking Process

Once all of the pixels have been saved in the array variable, the component G_x and G_y of the gradient is calculated. The process takes place following the Function (newpix) in the program. Then, the data resulting from the calculation is saved in a separated array and can be displayed in the screen. Sobel operator is used to produce the components G_x and G_y. Followings are the quotations of the algorithm to calculate the components of G_x and G_y using the Sobel operator.

```
Public Function newpix(ByVal i ← Integer, ByVal j ← Integer) ← Long
Dim p3(1 To 3, 1 To 3) ← Long
    p3(2, 2) ← GetPixel(Picture1.hdc, i, j)
    p3(1, 1) ← GetPixel(Picture1.hdc, i - 1, j - 1)
    p3(3, 3) ← GetPixel(Picture1.hdc, i + 1, j + 1)
    p3(1, 2) ← GetPixel(Picture1.hdc, i - 1, j)
    p3(1, 3) ← GetPixel(Picture1.hdc, i - 1, j + 1)
    p3(2, 1) ← GetPixel(Picture1.hdc, i, j - 1)
    p3(2, 3) ← GetPixel(Picture1.hdc, i, j + 1)
    p3(3, 1) ← GetPixel(Picture1.hdc, i + 1, j - 1)
    p3(3, 2) ← GetPixel(Picture1.hdc, i + 1, j)
    For i ← 1 To 3
        For j ← 1 To 3
            s1 ← p3(i, j) * a(i, j) + s1
            DoEvents
    Next j, i

    For i ← 1 To 3
        For j ← 1 To 3
            s2 ← p3(i, j) * B(i, j) + s2
            DoEvents
    Next j, i

    newpix ← Sqr((s1 ^ 2) + (s2 ^ 2))
End Function
```

Once the calculation of the gradient component has been completed, the calculation of the magnitude of the gradient and the gradient angle of each of the pixels follows. The magnitude of the gradient can be obtained using the equation (5) which is mentioned above. Meanwhile, the magnitude of the gradient angle is obtained by using the equation (6).

Once both information above have been obtained, the edge linking process proceeds by comparing each of the neighbouring pixels. If the difference in the magnitude of the gradient angle between a pixel and the neighbouring pixels meets the determined criterions, it is considered to be connected.

VI. RESULTS AND DISCUSSION

Following is the example of the try-out results using a digital image that is processed using the edge linking. The initial image display as in figure (1):

Figure (1): Initial Grey Scale of Digital Image

The display of the gradient components G_x and G_y of the image as shown in figure (2):
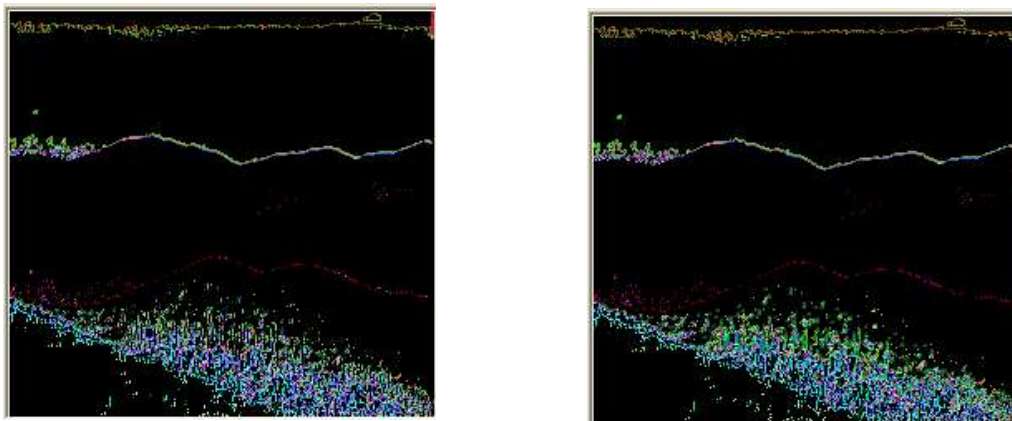

Figure (2): Horizontal (G_x) and Vertical (G_y) of Edge Detection for Digital Image.

It appears in the component G_x that the detected border is close to the horizontal direction, while in the component G_y the detected border is close to the vertical direction. The display of the resulting image of the full edge linking as in figure (3):
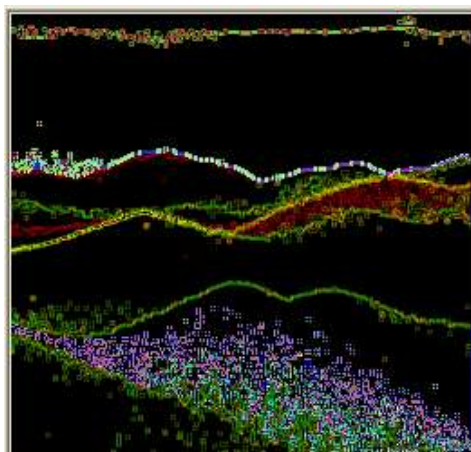

Figure (3): Full Edge Detection of Digital Image.

Another example to detect an edge of Geometric figure by this method as shown in the figure (4), and The display of the resulting Geometric image of the full edge linking as in figure (5):
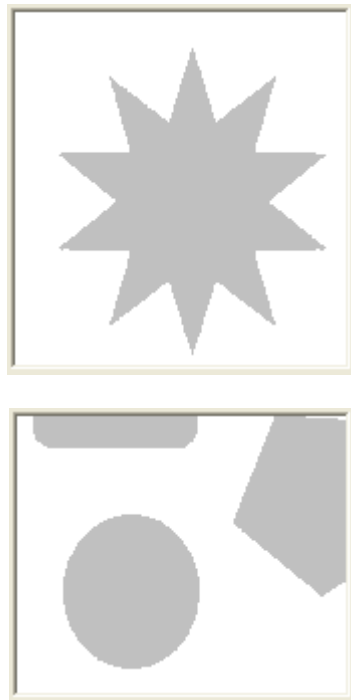

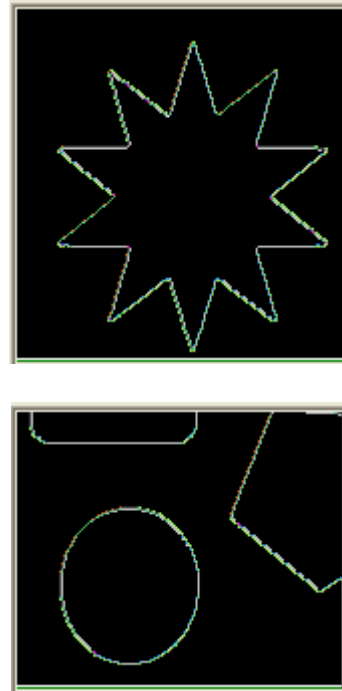Figure (4): Initial Grey Scale of Geometric Digital Image

Figure (5): Full Edge Detection of Geometric Digital Image.

It appears in the results of the edge linking that the part with bright colour is indicative of the big change in the intensity value of the original image.

It is clearly observed from the example above that the edge linking process enables us to obtain new images that display the parts and the objects in the image for further analysis.

VII. CONCLUSION

The edge detection process continued by the edge linking which is presented in this paper can be clear by the following: 1) it appears from the results of the edge linking that the part with bright colour is indicative of the big change in the intensity value of the original image, and 2) the edge detection in the geometric shapes or Morphological shapes are more significant or more contrast rather than ordinary image.

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