

Image edges detection using morphological operations

جعفر صادق جعفر
جامعة الكوفة / كلية العلوم / قسم الحاسبات

Abstract:

Morphological operation consists of two types:- Basic operations and derivative. Basic operations are ,dilation ,erosion and (hit & miss) ,where as the derivative operations are :open ,close , tophat , bothat , skeleton. The process of finding the limits of the image (edge detection) means finding the boundary between the neighboring regions which differ from each other in gray levels value .There are three basic methods for finding limits of images:-

linear, non-linear and common approximating methods.

An algorithm is applied to identify the image edges of the image, there are generally three stages:-

- 1-filtering procedure to reduce the noise.
- 2-improvement operations
- 3-finding the strong border points which are required.

According to the method of change the intensity image there are several types of edges of images such as (line edges, step edge, ramp edge) .

Due to the absence of specific suitable method to detect all types of edges ,the present work has been implemented three methods based on the fundamental morphological operations to find the limits and the image terminals by selecting different size and extensions converted to images of grey levels ,results were compared to determine the most suitable and better methods . The present work using matlab functions (version 6.5)

المستخلص :

تتكون عمليات التشكيل من نوعين من العمليات هي الاساسية والعمليات المشتقة منها. ان عمليات التشكيل الاساسية هي التمدد (dilation) ،التاكل (erosion) ،عملية (hit and miss) ،اما العمليات المشتقة منها مثل (close , open , bothat , tophat , skeleton)

ان استخدام معالجة التشكيل هي استخلاص مكونات الصورة التي تكون مفيدة في تمثيل وتوصيف اجزاء معينة من الصورة ويكون خرجها دائما خصائص او سمات صورة . ان استخدام خوارزمية ايجاد حدود الصورة مهمة في مجالات كثيرة كالصور المرسله من الفضاء الخارجي الخاصه بالكواكب الاخرى والصور الطبيه وفي عملية السيطرة على الانسان الالي وفي مجالات صناعية كثيرة . عملية ايجاد حدود الصورة تعني ايجاد الحدود الفاصلة بين مساحتين متجاورتين مختلفين عن بعضهما بقيمة المستويات الرمادية . هنالك ثلاثة طرق اساسية لايجاد حدود الصور هي : الطريقة الخطية ، الطريقة اللاخطية طريق التقريب الشائع .

يتم تطبيق خوارزمية تحديد حافات واطراف الصورة بشكل عام على ثلاثة مراحل

- ١- اجراء الترشيح لتقليل الضوضاء الموجودة على الحافات الضعيفة .
- ٢- اجراء عمليات التحسين للصورة (حساب قيمة ميل الصورة).
- ٣- ايجاد الحدود القوية ذات النقاط المطلوبة .

اعتمادا على طريقة تغير شدة الصورة هناك انواع عديدة من حواف الصور اهمها الحافات الخطية ، الحافات العتبية ، الحافات المنحدرة ونظرا لعدم وجود طريقة محددة تصلح لكشف جميع انواع الحواف فقد تم في هذا البحث تنفيذ ثلاثة طرق بالاعتماد على عمليات التشكيل الاساسية المذكوره لايجاد حدود واطراف صور مختارة مختلفة الاحجام والامتدادات متعددة الاغراض محولة الى صور ذات مستويات رمادية وتمت مقارنة النتائج لمعرفة انسب وافضل الطرق المتبعه .

(Matlab version 6.5) . نفذت كل البرامج باستخدام دوال ماتلاب

Introduction :

The digital image is essentially a two dimensional array of numbers, called pixels. Each pixel represents the color or gray level seen at some small of the scene, and each pixel can be located into the image by its vertical and horizontal position

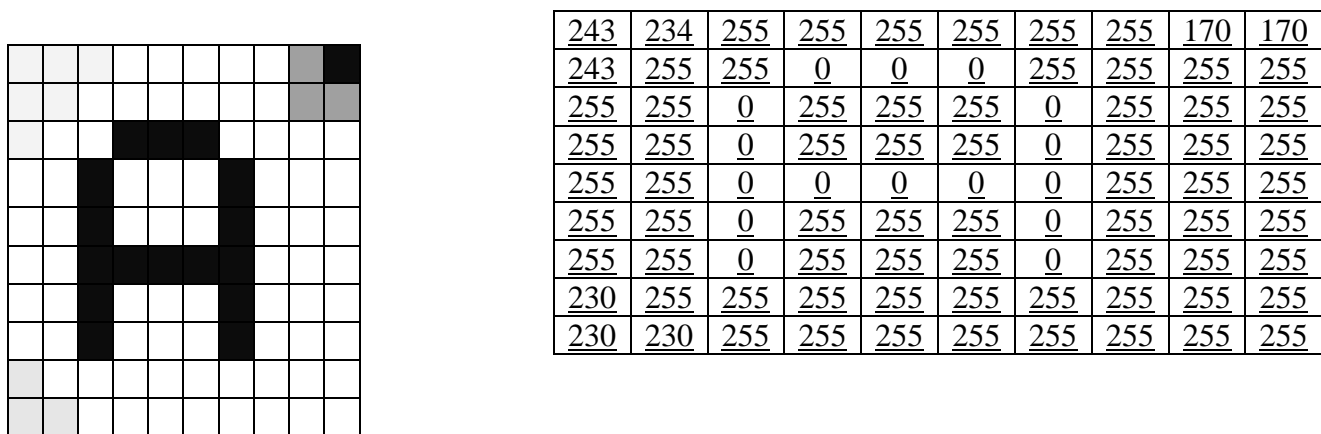


Figure (1) Digital Image Representation

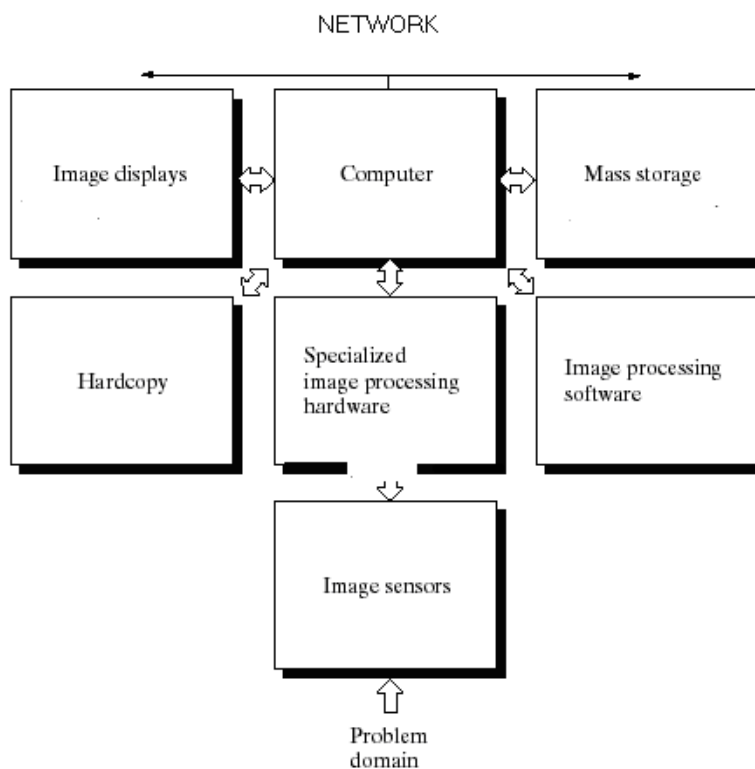


Figure (2) Fundamental Components of a Digital Image Processing System

Morphological Image Processing :

The identification of objects within an image can be a very difficult task. One way to simplify the problem is to change the grayscale image into a binary image, in which each pixel is restricted to a value of either 0 or 1. analysis, connectivity analysis, and morphological image processing (from the Greek word *morphē*, meaning shape or form) [10] . The foundation of morphological processing is in the mathematically rigorous field The techniques used on these binary images go by such names as. blob of *set theory*; however, this level of sophistication is seldom needed. Most morphological algorithms are simple logic operations and very *ad hoc*. In other words, each application requires a custom solution developed by trial-and-error. This is usually more of an art than a science. A bag of tricks is used rather than standard algorithms and formal mathematical properties.

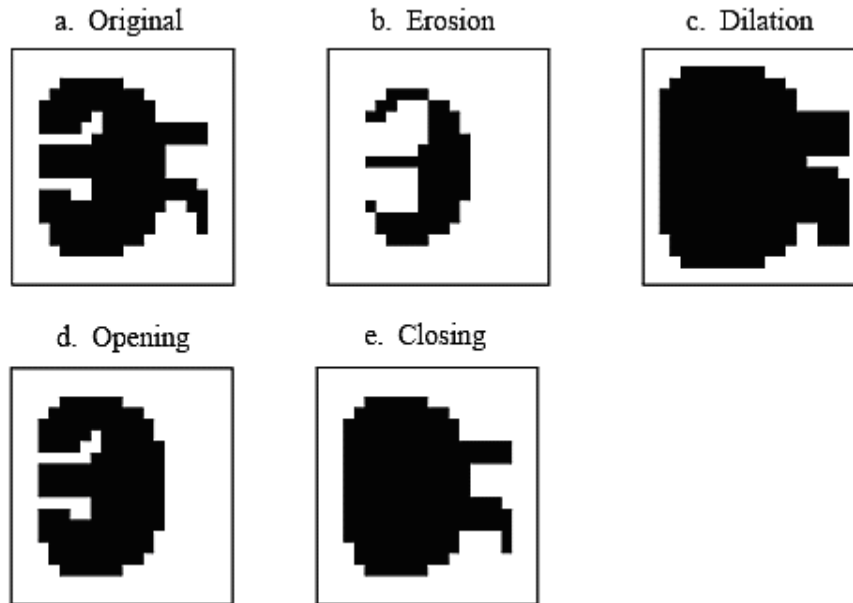


Figure (3) Morphological operations
Figure (3) Fundamental Components of a Digital Image Processing

System

Mathematical morphology is a method of processing digital images based on shape. Morphing is available when working with images, surfaces, and Six morphing options are available for use in Tools: dilate, erode , morph open, morph close, morph gradient, and morph tophat

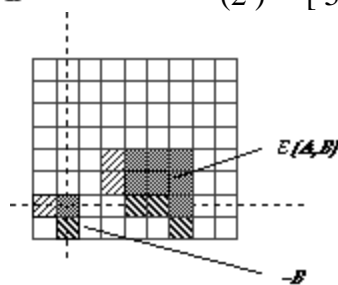
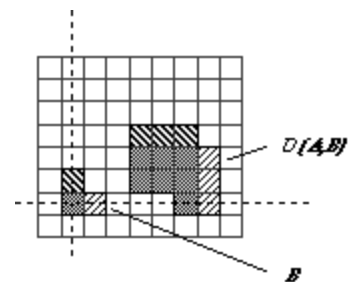
<i>Morphing Option</i>	<i>Description</i>
Dilate	Dilate is commonly known as "fill", "expand", or "grow." It can be used to fill "holes" of a size equal to or smaller than the structuring element.
Erode	Erode does to the background what dilation does to the foreground. Given an image and a structuring element, erode can be used to remove islands smaller than the structuring element.
Morph open	Morph open is simply an erosion operation followed by a dilation operation. Applying morph open more than once produces no further effect. Morph close
Morph gradient	Morph gradient is the subtraction of an eroded version of the original image from a dilated version of the original image.
Morph tophat	Morph tophat is implemented by first applying the opening operator to the original image, then subtracting the result from the original image. Applying tophat shows the bright peaks within the image.

Dilation and Erosion:

From these two Minkowski operations we define the fundamental mathematical morphology operations *dilation* and *erosion*:

Dilation - $-B = \{-\beta | \beta \in B\}$ ----- (1)

Erosion - $E(A,B) = A \ominus B = \bigcap_{\beta \in B} (A - \beta)$ ----- (2) [5, 7]



(a) Dilation D(A,B)

(b) Erosion E(A,B)

Figure (4): A binary image containing two object sets A and B .

The three pixels in B are "color-coded" as is their effect in the result. While either set A or B can be thought of as an "image", A is usually considered as the image and B is called a *structuring element* [5,7]. The kernel is to linear filter theory. *structuring element* is to mathematical morphology what the convolution *Dilation*, in general, causes objects to dilate or grow in size; *erosion* causes objects to shrink. The amount and the way that they grow or shrink depend upon the choice of the structuring element. Dilating or eroding without specifying the structural element makes no more sense than trying to low pass filter an image without specifying the filter. The two most common structuring elements (given a Cartesian grid) are the 4-connected and 8-connected sets, N_4 and N_8 . They are illustrated in Figure(4)

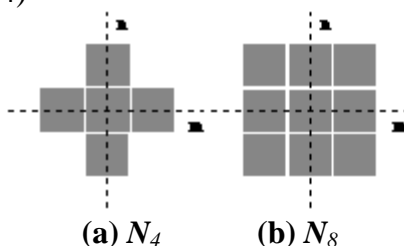
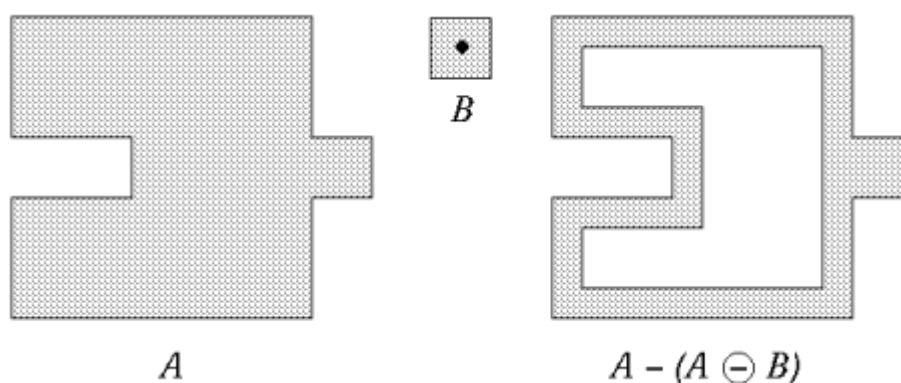


Figure (5) : The standard structuring elements N_4 and N_8 .

Boundary Extraction:

The boundary of set A can be found by first eroding A by B , then taking the set difference between the original A and the eroded A .



Figure(6) binary image outlining

Left side there is the original image, right side is the outlined image

Images in MATLAB:

The Basic structure in MATLAB is the array .an order set of real or complex elements, this objects is naturally suited to the representation of Images, real valued, ordered sets of color or intensity data (MATLAB Dose not do support complex valued image).MATLAB stores most images as a two-dimensional array (i.e. matrices)In which each element of the matrix corresponds to a single Pixel in the displayed image . For example an image composed of 200 raw& 300 columns of different Colored dots would be stored in MATLAB as a (200 by 300) matrix

Basic Methods for Edge detection:

- 1- Linear
- 2- Non-linear
- 3- Common Approach

Edges are significant local changes in the image and are important features for analyzing images .Edges typically occur on the boundary between two different regions in an image [4] .

Edge detection is frequently the first step in recovering information from images. Due to its importance, edge detection continues to be an active research area. An edge in an image is a significant local change in the image intensity, usually associated with a discontinuity in either the image intensity or the first derivative of the image intensity .

Discontinuity in either in the image intensity can be either (1) step discontinuities, where the image intensity abruptly changes form one value on one side of the discontinuity to a different value on the opposite side,or (2) line discontinuities, where the image intensity abruptly changes value but then returns to the starting value within some short distance.However, step and line edges are rare in real images, because of low frequency components or the smoothing introduced by most sensing devices, sharp discontinuities rarely exist in real signals, step edges become ramp edges and line edges become roof edges, where intensity changes are not instantaneous but occur over a finite distance. Illustrations of one-dimensional edge profiles are shown in figure (5)

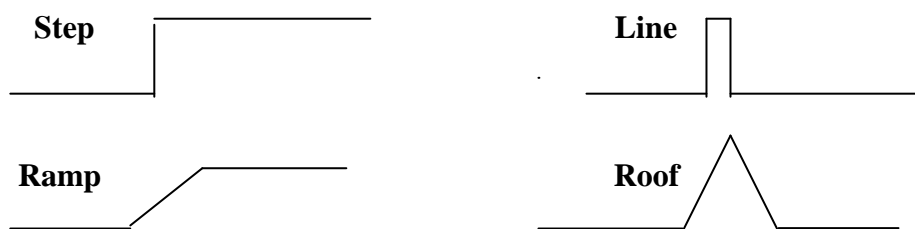


Figure (7): One-Dimensional Edge Profiles

In figure (7) we can see the practical example of two-dimensional edge profile

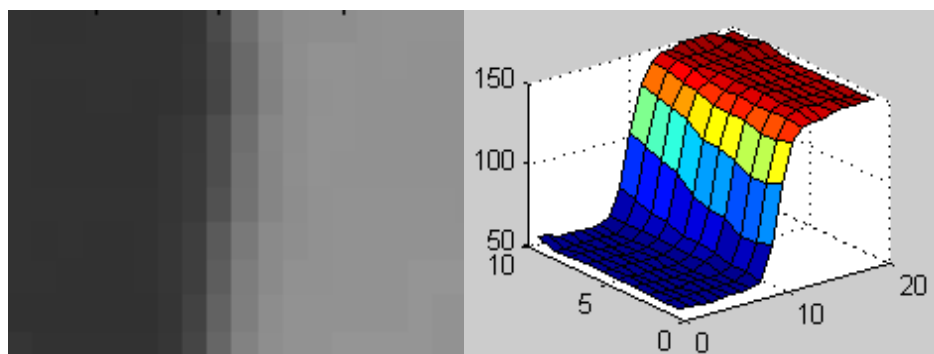


Figure (8): Two-Dimensional Edge Profiles

Why we using Edge detection

- °Edge Features are perhaps thatmostimportant features used by humans .
- °Independent of illumination.
- °Easy to detect computationally.
- °Used to form higher level features (lines , curve ,Corners,.....etc

Edge detection algorithm :

approximating. An algorithm is applied to identify the edges of the image, the parties generally

three stages :-

- 1-filtering procedure to reduce the noise on the weak edges .
- 2-conducting operations improvement which is mean calculate the value of image gradient .
- 3- finding a strong border points which are required

The conventional approach to image processing involves the following steps

- °Image transformations and color conversions where the acquired image and in range is converted into standard form in color space
 - °Image filtering (cleaning up the image to improve S/N ratio) can be accomplished using localized filters or mathematical transforms.
 - °Threshold operation to convert the image from a gray-scale to a binary form.
 - °Morphological filtering usually follows the threshold operations but some morphological operations can actually precede the threshold step .Typical morphological filters include: erosion/dilation, opening/closing. tophat and watershed.
 - °Particle analysis is the operation where the filtered binary image is analyzed by quantifying various spatial properties of different particles (i.e., spots or regions) in the image.
- The spatial measurements include :- location, area, perimeter and moments for calculating a fitting ellipse.

These steps comprise a basic Fundamental Components of a Digital Image Processing System .With the ability to convert images into digital form and back into visible form, one is able to define and execute digital.

Edge detection operators:

1- Roberts Operator:

The Roberts cross operator provides a simple approximation to the gradient magnitude:

$$G[f[i, j]] = |f[i, j] - f[i + 1, j + 1]| + |f[i + 1, j] - f[i, j + 1]| \text{ ----- (3) [5 , 7]}$$

Using the masks, this becomes

$$G[f[i, j]] = |G_x| + |G_y| \text{ ----- (4)}$$

Where G_x and G_y are calculated using the following masks:

$$G_x = \begin{bmatrix} 1 & 0 \\ 0 & -1 \end{bmatrix} \qquad G_y = \begin{bmatrix} 0 & -1 \\ 1 & 0 \end{bmatrix}$$

Figure (8): Roberts Mask

2- Prewitt Operator :

As mentioned previously, a war avoid having the gradient calculated about an interpolated point between pixels is use a (3×3) neighborhood for the gradient calculations . Consider the arrangement of pixels about the [I, j] shown in figure (9) . The prewitt operator is the magnitude of the gradient computed by

$$M = \sqrt{s_x^2 + s_y^2} \text{ ----- (5)}$$

Where the partial derivatives are computed by

$$s_x = (a_2 + ca_3 + a_4) - (a_0 + ca_7 + a_6) \text{ ----- (6)}$$

$$s_y = (a_0 + ca_1 + a_2) - (a_5 + ca_5 + a_4) \text{ ----- (7)}$$

With the constant c = 1

$$S_x = \begin{bmatrix} -1 & 0 & 1 \\ -1 & 0 & 1 \\ -1 & 0 & 1 \end{bmatrix} \qquad S_y = \begin{bmatrix} 1 & 1 & 1 \\ 0 & 0 & 0 \\ -1 & -1 & -1 \end{bmatrix}$$

Figure (9): Prewitt mask :

3- Canny Operator:

Is represented by the templates:

-1	0	1
-1	0	1
-1	0	1

1	1	1
0	0	0
-1	-1	-1

0	1	1
-1	0	1
-1	-1	0

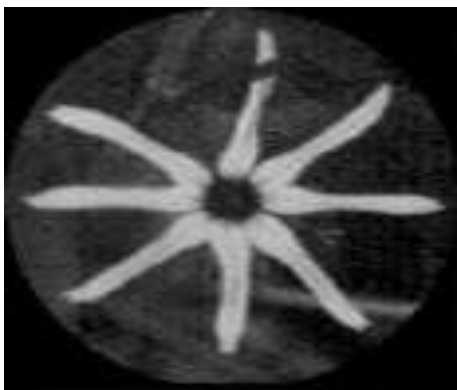
0	1	0
1	0	-1
0	-1	-1

Figure (10) : Canny Mask :

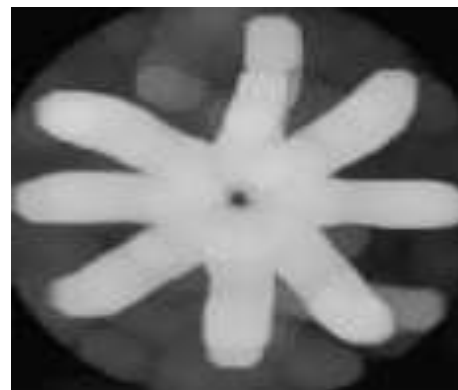
Experimental Results

The aim of this research has been the investigation the morphological operations and edge detection techniques on the selected images .A brief overview of some essential fundamental concepts of digital images has first been introduced . al l the programs used in implementation were written by the authors in (MATLAB 6.5) computer code .

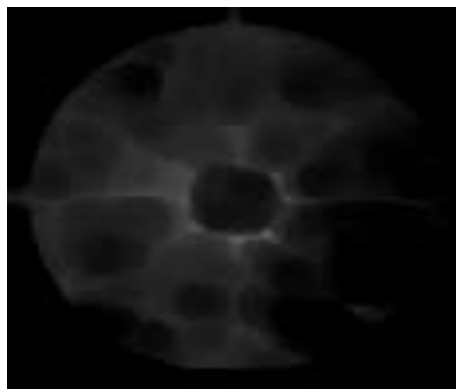
Main morphological operations results_



a-Original image



b- imdilated



c- imrode



a- Original image



b- opening



c_closing after opening

Edges detection results:



Original image



Canny method



Prewitt method



Robert method



Original image



Canny method



Prewitt method



Roberts method

Conclusions :

Image Edge detection methods:

• (Roberts and prewitt) Edge detectors

1- The results showed that it is hard to see different effect between the (Roberts and Prewitt) operators . the EDGE function finds edge by thresholding the gradient .The Roberts method is slower to compute than the Prewittcross operator But it is large convolution kernel smoothes the input image to a greater Extent & so makes the operator less sensitive to noise Its operator also Generally produces considerably higher out put values for similar edges Compared with the Roberts cross Prewitt compass edge detection involves convolution

the image with a set Of (usually 8) kernel, each of which's sensitive to a different edge orientation .

2 - the Roberts method finds edges using the Roberts approximation to the derivative. It returns edges at those points where the gradient of (I) is maximum .

3 - The prewitt method finds edges using the prewitt approximation to the derivative . it returns edges at those points where the gradient of (I) is maximum ,so we can say (Robert and prwitt) is a simple method for edge detection .

• **Canny's Edge detector :**

1.Canny edge detector first smoothes the image with a Gaussian filter to eliminate the noise .Then it finds the image gradient to high light regions with high spatial Derivatives.

2- Calculate the gradient (magnitude & orientation of the smooth Image)

3- Apply non –maximal suppression .

4- Perform hysteresis

5-the dge points be well localized ,the distance between the edge pixel found by the detector & the actual edge is to be at a minimum is to have only on response to a signal edge .

Through the experiment result :

1- the canny method is the best method because it has a

• Good detection : mark as many real edges in the image are possible

• Good Localization : edge marked should be as closed as possible to the edge in the real image .

• Minimal response : a given edge in the image should only

• be marked once. & where possible image noise should not create false edges .

2.The Canny algorithm is adaptable various environments ,its Parameter allow it to be tailored to recognition of edges of differing characteristic depending on the particular requirements of given implementation .

2- The size and the extensions of the images don't affect on accuracy of the results

3- For canny method , we noted that the out put edges closer to the real image , so we took many samples of the image to contrast the differences in the edges for the three methods .

4- There are an others methods can finds the edges such as ,[sobel ,Laplacian of Gaussian and zero- cross] methods may be discuss them in the next time .

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