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Comparison of Various Gradient Types for Biological Image with Morphological Operations

Layla Hussein[1*], Amel H.Abbas[2]

[1]Department of Computer Science, College of Science Al-mustansiriyh University, Baghdad, Iraq
[2]Department of Physics, College of Science Al-mustansiriyh University, Baghdad, Iraq

Abstract

Biological image edge detection preserving the important structural properties in an image. Detecting accurate edges are very important for analyzing the basic properties associated with a biological image. Gradient operator plays very important role in edge detection. In this paper the images had been using are color biological images taken from microbiology laboratory at the biological department college of science Al-MustansiriyhUniversity and the effect of gradient operation have applied on around 10 different biological color images but view only two. In our proposed approach comparative of various gradient of biological image include (gradient of image, gradient of image using first order derivative edge detection (Soble,Prewitt,Roberts)and gradient image using morphological operation and The comparative output images using quality assessment include (MSR, PNSR, l2rat, maxerr, entropy). The software tool that has been used is MATLAB 7.0 from the results we found that morphological and Robert gradient edge detection algorithm better performs than the others and are important with extraction features of biologic images.

Keywords: edge detection using Gradient; first order edge detection, morphological operations.

المقارنة بين مختلف أنواع التدرج للصورة البيولوجية مع عمليات التشكيل

ليلى حسين عباس[1]*، امل حسين عباس[2]

[1]قسم الحاسبات ، كلية العلوم ، الجامعة المستنصرية ، بغداد ، العراق
[2]قسم الفيزياء ، كلية العلوم ، الجامعة المستنصرية ، بغداد ، العراق

الخلاصة

الكشف عن حافة الصور البيولوجية للحفاظ على خصائص هيكلية هامة في الصورة وكشف الحواف عملية دقيقة ومهمة لتحليل الخصائص الأساسيةالمرتبطة بالصور مشغل التدرج يلعب دوراهاما جدا في الكشف عن الحافة.في هذه البحث الصور التي تم استخدامهاعبارة عن صور البيولوجية ملونة مأخوذة من مختبر الاحياء المجهرية في قسم علوم الحياة كلية العلوم الجامعة المستنصرية تأثيرعملية التدرج طبقت على بحوعشرة من الصور البيولوجية الملونة ولكن عرض اثنين فقط في بحثنا المقترح تم مقارنة انواع التدرج مختلفة على الصور البيولوجية وتشمل(التدرج من الصورة،والتدرج من الصورةباستخدام مشقة الدرجة الاولى لكشف الحواف باستخدام (سوبل ،بروت، روبرت) وعملية التشكيل الرياضي اداة لبرامجيات التي تم استخدامها هي ماتلاب. مقارنة الصور الانتاجة باستخدام تقييم الجودة وشملت (MSR, PNSR, l2rat,maxerr, entropy) من النتائج وجدنا ان التدرج باستخدام روبرت والتشكيل الرياضي أفضل من الآخرين،ومهم في استخراج مميزات الصور البيولوجية.

*Email : Dr_ amal2006@yahoo.com

1-Introduction

Image plays an increasingly important role in many field of science and its countless sheaving upon images for their progress. As a consonance of the ever increasing rapidly decreasing cast of mass storage and communication media .biological image are growing exponentially in size and are carrying more and more information extracting this information need image processing and analysis to reach a higher level of sensitivity accuracy and objectivity [1].Edge-based features are defined as local contrast, i.e., a strong difference of (gray scale or color) values of adjacent pixels [2].Edges characterize boundaries are therefore a problem of fundamental importance in image processing. Edge detecting an image significantly reduces the amount of data and filters out useless information, while preserving the important structural properties in an image. Edges are significant local changes in the image and are important features for analyzing images. Due to its importance, edge detection continues to be an active research area. Such discontinuities are detected by using first- order derivatives. In the first category, the approach is to partition an image based on abrupt intensity changes, such as edges in an image. In the second category, the approaches are based on partitioning an image into regions that are similar according to a set of predefined criteria[3].

2-Gradient

Edge detection is essentially the operation of detecting significant local changes in an image. In one dimension, a step edge is associated with a local peak in the first derivative. The gradient is a measure of change in a function, significant changes in the gray values in an image can be detected by using a discrete approximation to the gradient (is the two-dimensional equivalent of the first derivative and is defined as the *vector)*

$$\boldsymbol{G|f(x,y)|} = \begin{bmatrix} \boldsymbol{G_x} \\ \boldsymbol{G_y} \end{bmatrix} = \begin{vmatrix} \dfrac{\boldsymbol{\partial f}}{\boldsymbol{\partial x}} \\ \dfrac{\boldsymbol{\partial f}}{\boldsymbol{\partial x}} \end{vmatrix} \qquad (\mathbf{1})$$

The two important properties associated with the gradient are:

1- The vector *G [j(x, y)]* points in the direction of the maximum rate of increase of the function *f(x, y),*

2- the magnitude of the gradient, given by

$$\boldsymbol{G|f(x,y)|} = \sqrt{\boldsymbol{G_x^2 + G_y^2}} \qquad (\mathbf{2})$$

From vector analysis, the *direction* of the gradient is defined as:

$$\boldsymbol{a(x,y)} = \mathbf{tan^{-1}}(\frac{\boldsymbol{G_x}}{\boldsymbol{G_y}}) \qquad \mathbf{(3)}$$

Where the angle *a* is measured with respect to the *x* axis. Note that the magnitude of the gradient is actually independent of the direction of the edge. Such operators are called *isotropic operators* [3- 5]**.** A numbers of operators have been proposed which approximate the first derivative of the image gradient there are**:**

1- Sobel Operator: The operator consists of a pair of 3×3 convolution kernels as shown in Figure-1. One kernel is simply the other rotated by 90°.

-1	**0**	**+1**
-2	**0**	**+2**
-1	**0**	**+1**

Gx

+1	**+2**	**+1**
0	**0**	**0**
-1	**-2**	**-1**

Gy

Figure 1- Mask use by Soble Operator

These kernels are designed to respond maximally to edges running vertically and horizontally relative to the pixel grid, one kernel for each of the two perpendicular orientations. The kernels can be applied separately to the input image, to produce separate measurements of the gradient component in each orientation (call these *Gx* and *Gy*). These can then be combined together to find the absolute magnitude of the gradient at each point and the orientation of that gradient [6]. The gradient magnitude is given by:

$$\boldsymbol{|G|} = \sqrt{\boldsymbol{G^2}_x + \boldsymbol{G_y}^2} \qquad (\mathbf{4})$$

The angle of orientation of the edge (relative to the pixel grid) giving rise to the spatial gradient is given by:

$$\theta = \mathbf{arctan}\left({}^{G_x}\!/_{G_y} \right) \quad (\mathbf{5})$$

2- Robert operator: The Roberts operator performs a simple, quick to compute, 2-D spatial gradient measurement on an image. Pixel values at each point in the output represent the estimated absolute magnitude of the spatial gradient of the input image at that point. The operator consists of a pair of 2×2 convolution kernels as shown in Figure-2. One kernel is simply the other rotated by 90° [7]. This is very similar to the Sobel operator.

+1	0
0	-1

Gx

0	+1
-1	0

Gy

Figure 2- Masks Robert operator.

These kernels are designed to respond maximally to edges running at 45°. The gradient component for each orientation (Gx and *Gy*).The absolute magnitude and orientation of the gradient are given by:

$$|\boldsymbol{G}| = \sqrt{\boldsymbol{G^2}_x + \boldsymbol{G^2}_y} \quad (\mathbf{6})$$

An approximate magnitude is computed using:

$$|\boldsymbol{G}| = |\boldsymbol{G_x}| + |\boldsymbol{G_y}| \quad (\mathbf{7})$$

The angle of orientation of the edge giving rise to the spatial gradient (relative to the pixel grid orientation) is given by.

$$\theta = \mathbf{arctan}\left({}^{G_x}\!/_{G_y} \right) - {}^{3p}\!/_{4} \quad (\mathbf{8})$$

3- Prewitt's operator: Prewitt operator is similar to the Sobel operator and is used for detecting vertical and horizontal edges in images [8].

-1	0	+1
-1	0	+1
-1	0	+1

Gx

+1	+1	+1
0	0	0
-1	-1	-1

Gy

Figure 3- Masks for the Prewitt gradient edge detector

3-Morphological image processing

Mathematical morphology is a powerful tool that can be used to extract features and components from an image. It is often used to pre-process or post-process images to facilitate analysis. In morphology, a small shape (structuring element) is translated across the image during the course of processing. Certain mathematical logic operations are performed on the image using the structuring element to generate the processed image. The two fundamental operations in mathematical Morphology are dilation and erosion [9]. Dilation adds pixels to the boundaries of objects in an image, while erosion removes pixels on object boundaries. The number of pixels added or removed from the objects in an image depends on the size and shape of the structuring element used to process the image. The morphological dilation and erosion operations are [10].

3-1 Dilation

The value of the output pixel is the maximum value of all the pixels in the input Pixel's neighborhoods. In a binary image, if any of the pixels is set to the value 1, the output pixel is set to 1

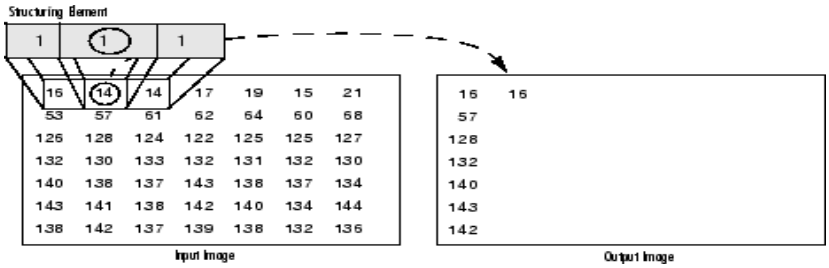

Figure 4- Dilation of gray scale image [11].

3-2 Erosion

The value of the output pixel is the minimum value of all the pixels in the input pixel's neighborhood. In binary image, if any of the pixels is set to 0, the output pixel is set to 0[10, 12].

3-3 Grey-scale erosion and dilation with flat structuring elements

Flat structuring elements have height values which are all zero and are thus specified entirely by their neighborhood. When a flat structuring element is assumed, grey-scale erosion and dilation are equivalent to local minimum and maximum filters respectively. Erosion with a flat element results in each grey-scale value being replaced by the minimum value in the vicinity defined by the structuring element neighborhood. Conversely, dilation with a flat element results in each grey-scale value being replaced by the maximum [13].

3- 4 morphological image gradient works.

The morphological gradient works: replacing a given pixel by the minimum or maximum value in the local neighborhood defined by the structuring element will effect little or no change in smooth regions of the image. However, when the structuring element spans an edge, the response will be the difference between the maximum and minimum-valued pixels in the defined region and, hence, large. The thickness of the edges can be tailored by adjusting the size of the structuring elements if desired [13].

4-Image quality measurements

Table 1- The methods using for quality assessment based on the biological images

So.N.	Type	Description
1	MSR (mean square error)	$mse = \frac{1}{\mathrm{MN}}\sum_{i=1}^{\mathrm{M}}\sum_{\mathrm{j}=1}^{\mathrm{N}}(\mathrm{x(i,j}-\mathrm{y(i,j)})^2$
2	PSNR (peak signal to noise ratio)[15]	$psnr = 10\log_{10}(\frac{2^n-1)^2}{\sqrt{MSE}}$
3	L2RAT	The ratio of the squared norm of the image approximation to the input image.[16]
4	maxerr	Is the maximum absolute squared deviation of input image from the approximation output image
5	entropy	$entropy = -\sum_i\sum_j p(i,j)\times\log_2 p(i,j)$

5-Results

In this paper the images had been using are color biological images taken from microbiology laboratory at the biological department college of science Al-Mustensiriyh University. and the effect of gradient operation have apply on around 10 different color images but view only two are given in the paper. The flowcharts of the approach of generation gradient images is given below (A,B,C) to get the results: **A**- gradient of color biological image .**B**- gradient of image color biological using first order edge detection ((Prewit, Robert, &Sobel).**C**- gradient using morphological (erosion &dilation)operations explain in (2-4).2- Figure-6 a&b show the result of applying of image(1,2)while Figure-3,4 graph for evaluation the methods using for quality assessment based on the biological mages(MSR entropy,PSNR,mse,l2rat,maxerr)values for image (1,2)

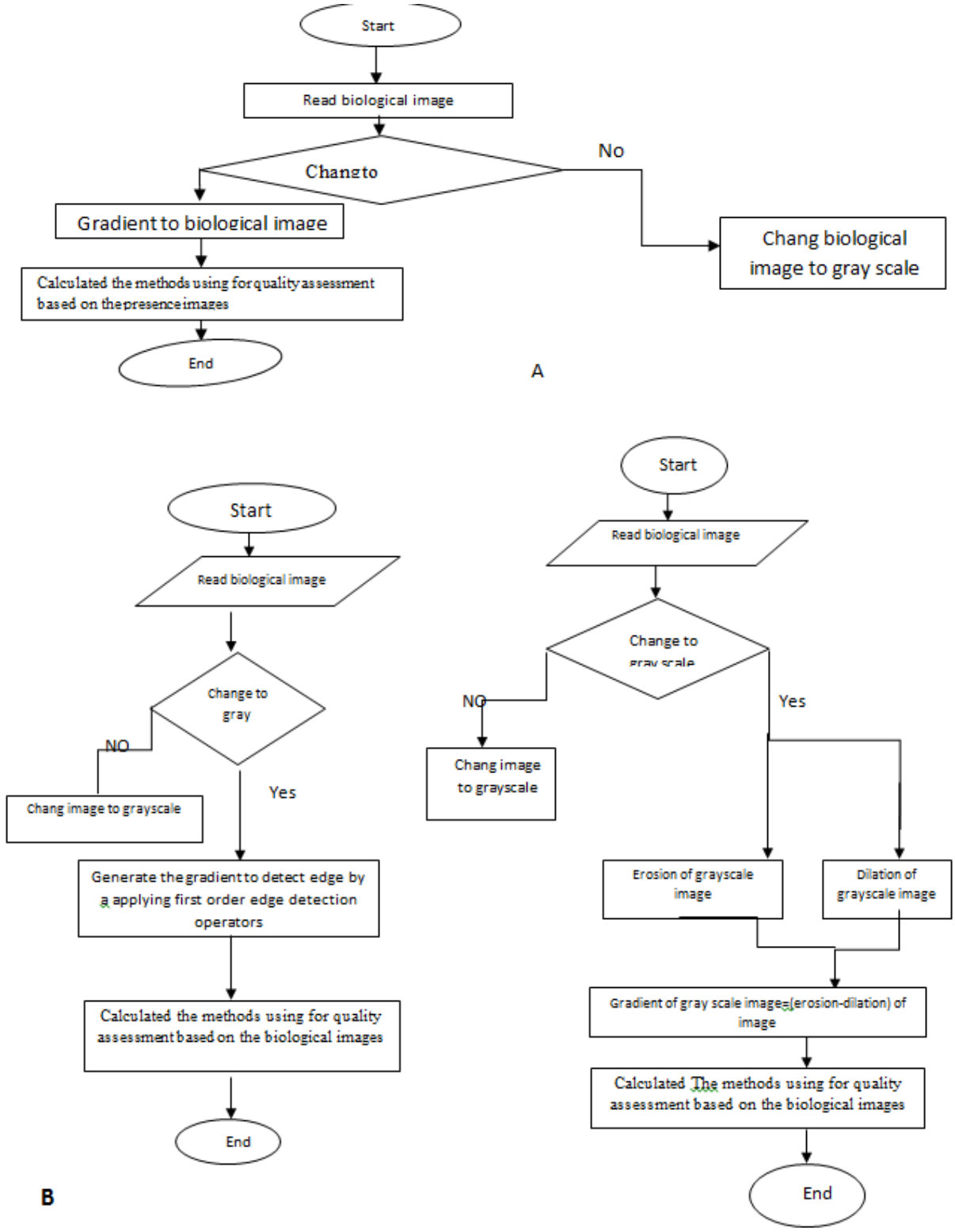

Figure 5- Flow chart of Proposed Model

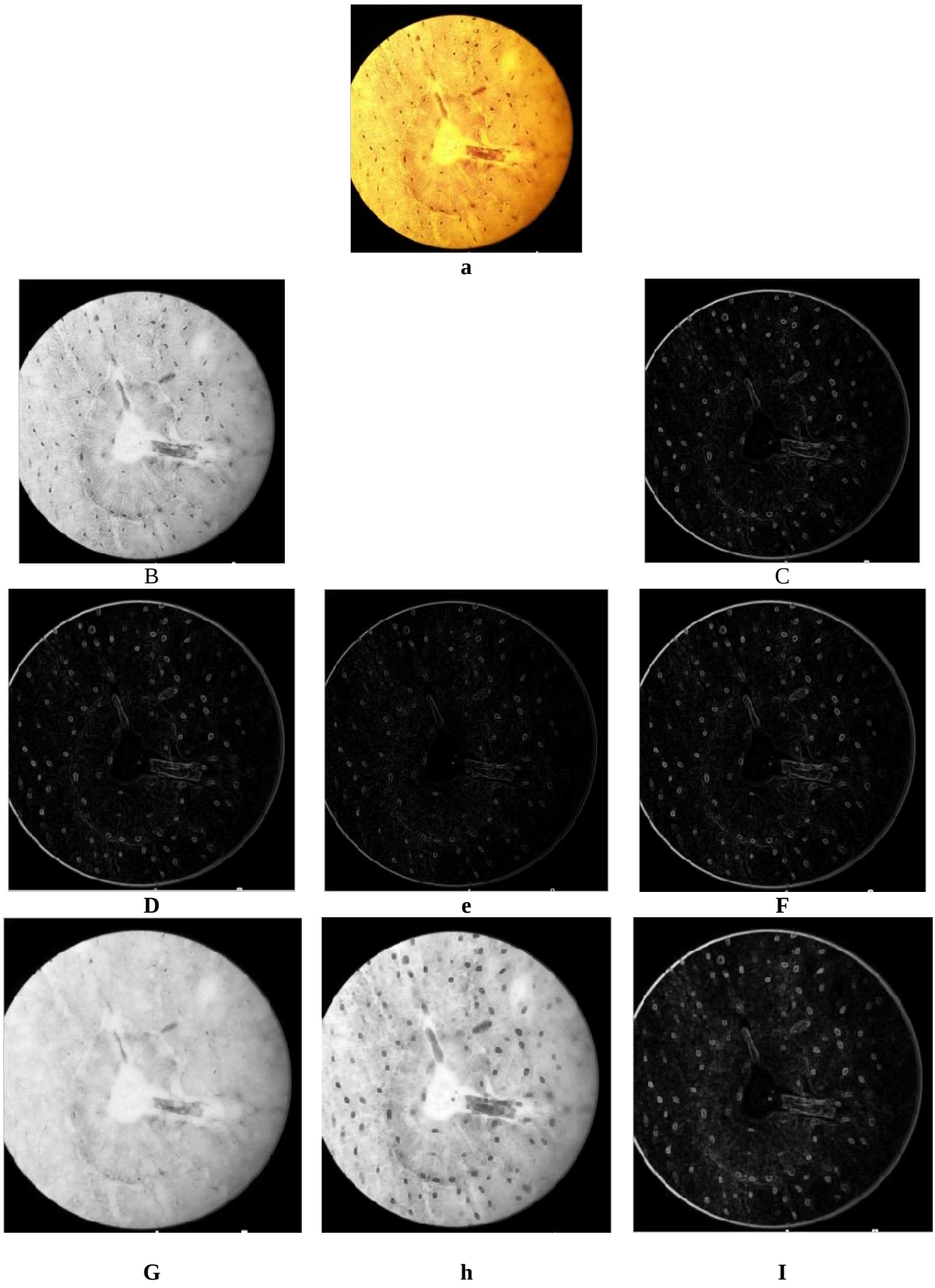

Figure 6- a for image 1 :- (a)original color image ; (b) grayscale image ;(c) gradient of grayscale image;(d) gradient of grayscale image using ***Prewitt***;(e) gradient of grayscale image using ***Roberts***; (f) gradient of grayscale image using ***Sobel***;(g) grey-scale dilation with flat 3*3 structuring element; (h) grey-scale erosion with flat 3*3 structuring element; (i) difference of;(g) and (h) equal the ***morphological*** gradient.

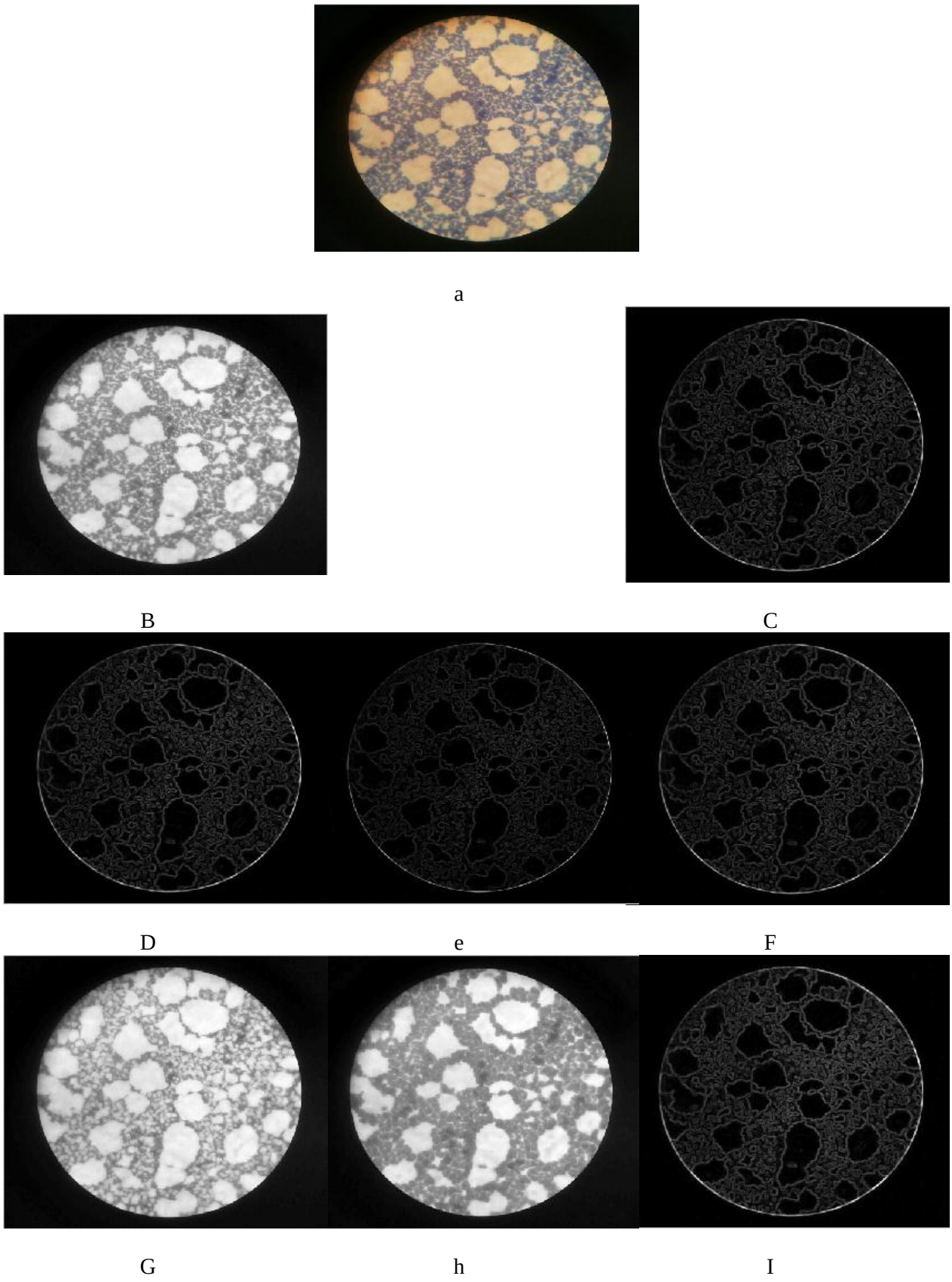

Figure 6- b for image 2 :- (a)original color image ; (b) grayscale image ;(c) gradient of grayscale image;(d) gradient of grayscale image using ***Prewitt***;(e) gradient of grayscale image using ***Roberts***; (f) gradient of grayscale image using***Sobel***;(g) grey-scale dilation with flat 3*3 structuring element; (h) grey-scale erosion with flat 3*3 structuring element; (i) difference of;(g) and (h) equal the ***morphological*** gradient.

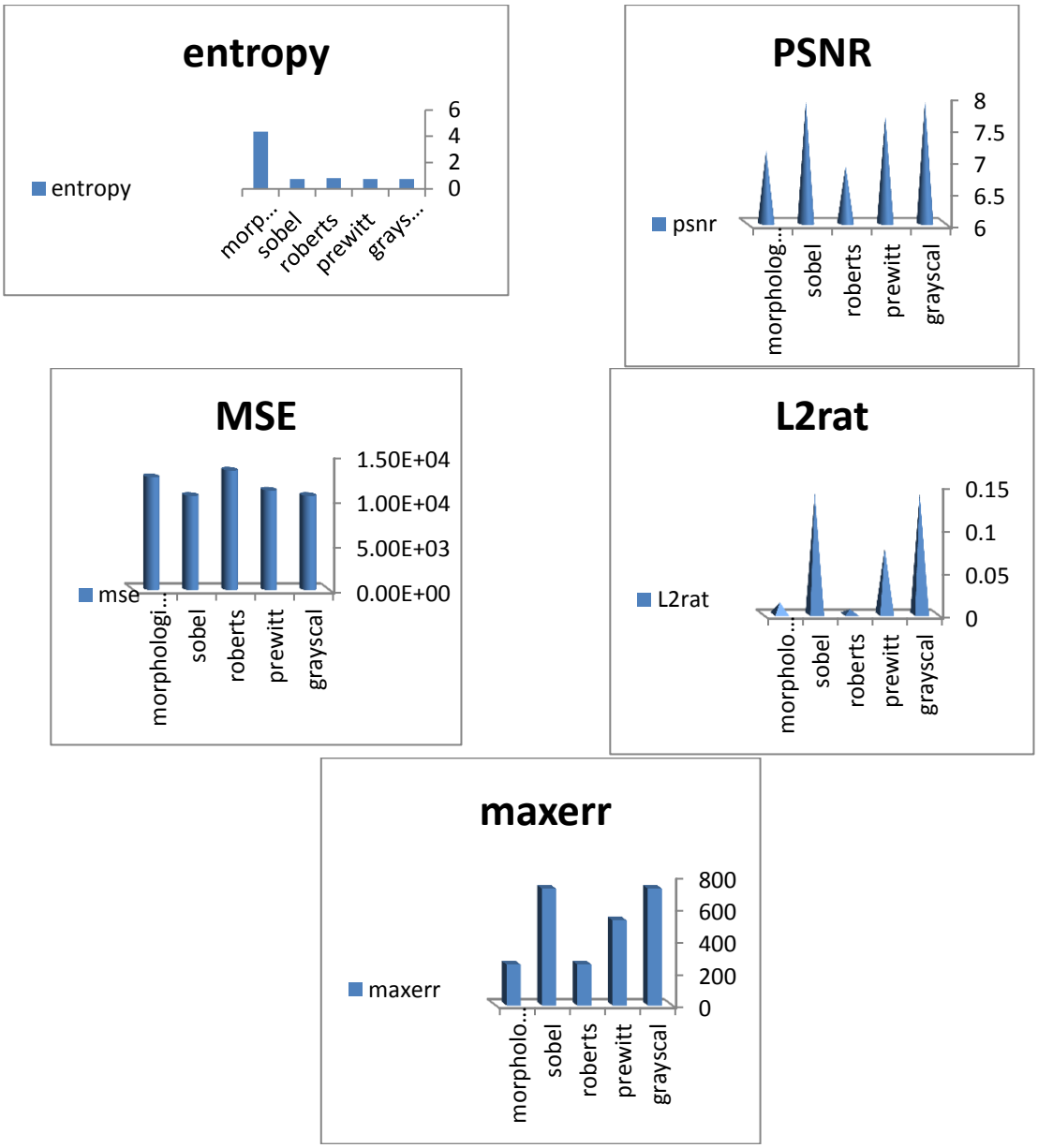

Figure 7- graph for evaluation of entropy,psnr,mse,l2rat,maxerr values for image1

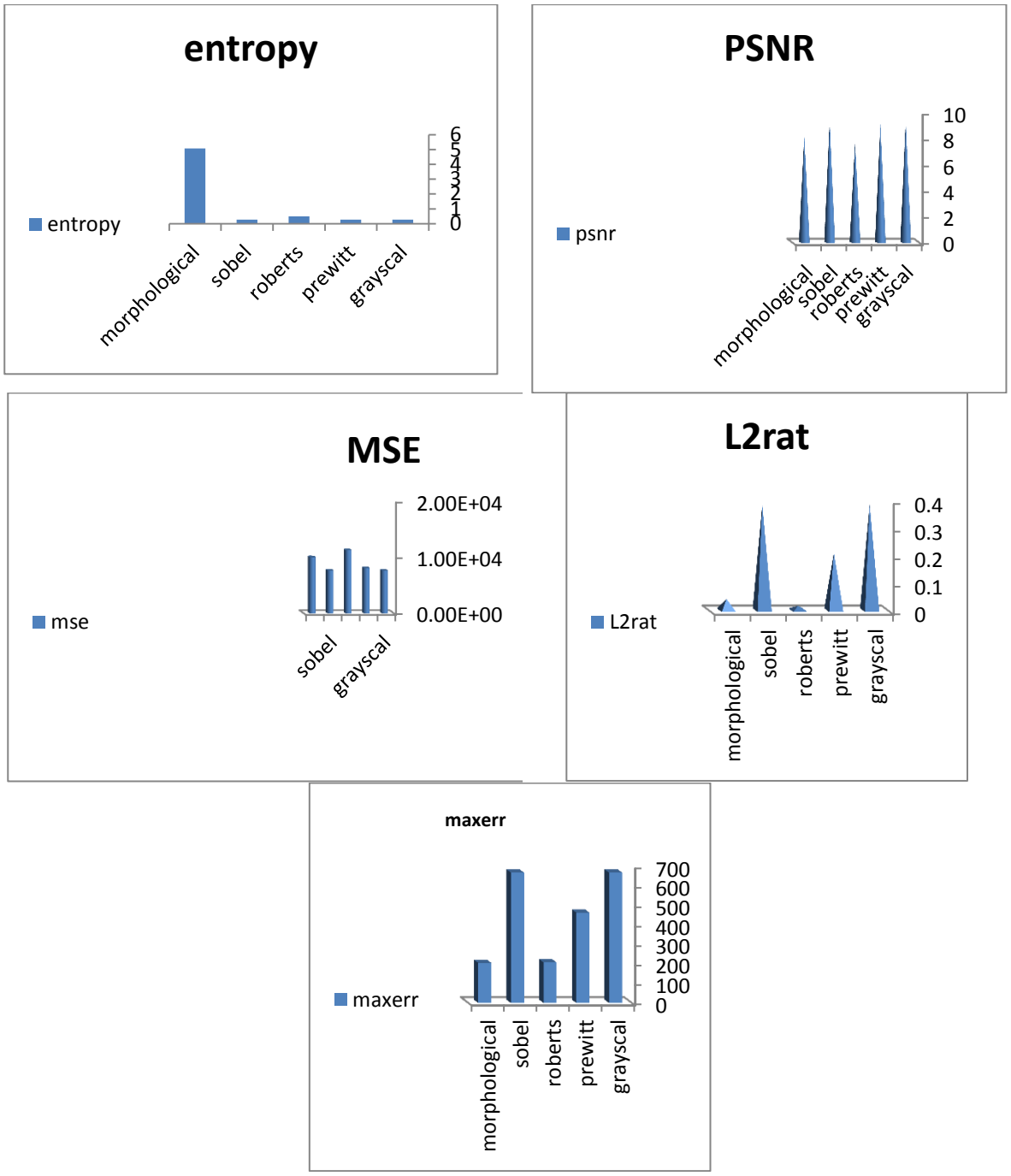

Figure 8- graph for evaluation of entropy,psnr,mse,l2rat,maxerr values for image2

6- Discussion

Gradient operator plays very important role in edge detection of biological image in this paper comparative of various include (gradient of image, gradient of image using first order derivative edge detection Soble,Prewit,Roberts)and gradient image using morphological operation .and from the Evaluation of methods using for quality assessment based on the biological image1 and image2 calculated (entropy,psnr,mse,l2rat,maxerr). results shown that Robret and morphological gradient edge detection algorithm performs better than the others and are important with extraction features of biologic images and so it can be used in biological image has continuous edge as compared to traditional operator's results. The main advantages of mathematical morphology are direct geometric interpretation, simplicity and efficiency in hardware implementation.

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