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Evaluation of the Best Edge Filters in Image Processing Based on the Color Fabric Texture

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Abstract

With the development and complexity of life, the need to improve images appeared, especially when used in field such as industry, which affect the life of citizens, such as the manufacture of fabrics. Precision is required in the production of these fabrics especially when it comes to the colors and patterns of these fabrics. Edge identification is the first step in many digital image-processing applications. Edge identification greatly decreases the data quantity, undesirable filters or unimportant data and provides the important data into the image. This paper presents a practical study to compare different edge detectors to determine which edge detector achieves better results, which in turn reflects the best pattern in the fabric. These detectors are Canny, Roberts, Laplace and Gabor. A database of thirty color JPG images collected from the Internet was arranged and a quality scale was used to compare filter detectors. The system MATLAB2020 was used to program the proposed work. The results enhancement was measured by the quality coefficient. This coefficient estimated as follows for Roberts filter (44.27-51.09); Gabor filter (43.46-44.48); Canny filter (44.46-52.05); and Laplace filter (44.71-5.40). Therefore, it turns out that the Gabor filter is the best of these filters in defining the edges that were used in defining the pattern.

Keywords: Texture, Canny, Edge, Gabor and Laplace

تقييم أفضل مرشحات الحواف في معالجة الصور اعتمادا على لون نسيج القماش

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الخلاصة

مع تطور الحياة وتعقيدها، ظهرت الحاجة إلى تحسين الصور، خاصة عند استخدامها في مجالات الحياة، بما في ذلك الصناعة وفروعها، مما يؤثر على حياة المواطن، مثل صناعة الأقمشة. الأمر الذي يتطلب الدقة في إنتاج هذه الأقمشة من ألوان ونمط القماش. تحديد الحافة هو الخطوة الأولى في العديد من تطبيقات معالجة الصور الرقمية. يقلل تحديد الحافة بشكل كبير من كمية البيانات أو المرشحات غير المرغوب فيها أو البيانات غير المهمة ويوفر البيانات المهمة في الصورة. هناك بعض المشكلات مثل تحديد الحافة الزائفة ومشكلات الضوضاء والتباين المنخفض ومشكلات الحافة الأخرى. تقدم هذه الورقة دراسة عملية لمقارنة مرشحات كشف الحواف المختلفة

لتحديد مرشحات الحواف الذي يحقق نتائج أفضل، والذي بدوره يعكس أفضل نمط في النسيج. هذه المرشحات هي Canny و Roberts و Laplace وGabor. تم ترتيب قاعدة بيانات من ثلاثين صورة JPG ملونة تم جمعها من الإنترنت واستخدم مقياس الجودة لمقارنة أجهزة الكشف عن المرشحات. تم استخدام نظام MATLAB2020 لبرمجة العمل المقترح. قيست النتائج باستخدام معامل الجودة وكانت تحسينات النتائج كما يلي. لمرشح روبرتس (27،44−09،51). مرشح غابور (46،43−48،44) ومرشح لابلاس (71،44− 40،51). وأخيرا معامل الجودة لمرشح كاني تساوي (44 ، 46−52.05). لذلك، اتضح أن مرشح Gabor هو أفضل هذه المرشحات في تحديد الحواف التي تم استخدامها في تحديد النمط.

الكلمات المفتاحية: نقشة، حافة، كاني، جابور و لابلاس.

1. Introduction

Edge identification is a term in image processing and computer vision. Edge identification is one of most important image processing algorithms for object detection[1]. This importance and necessity required a good understanding of edge identification and selection filters in a theoretical and practical (mathematical) way. To study these filters, they are compared and different measures of similarity are adopted[2].

The effectiveness and efficiency of image processing and computer vision tasks depends on perfection in edge identification. It is a procedure for recognizing severe interruptions in a digital image. Dropouts are instantaneous changes in the focus of a point of light that mark the boundaries of objects in the image. There are many different methods of edge identification techniques, each one planned to be mindful of specific types of edges [3]. The edges are classified as vertical, horizontal or diagonal[4]. There are some problems with edge false detection, real edge loss, issues with noise, lengthy computations, and other factors [5].

The importance of edge identification technology is its ability to extract the exact edge line and crucial tool for image separation is edge recognition. The most popular method for identifying significant intensity value discontinuities is edge identification. Edges typically appear where two sections converge. Edge identification is used to find objects that are useful for various applications, including biometrics, industrial applications, and medical image processing. Research on edge identification is ongoing and helps with more advanced picture analysis [1][6].

The gray plane contains three various kinds of discontinuities, including point, line, and edge. You can use spatial masks to find all kinds of discontinuities in an image. The research on image segmentation includes a number of edge identification methods. [3]. In the early 20th century, edge identification technology began to be studied by humans. Until the 1960s, edge identification technology has been rapidly developed.

Jules firstly proposed the concept of edge identification in 1959. Since then, edge identification has been diffusely applied for various practical requests[6].

The projected paper is considered complementary to previous works. However, the difference is that the author used the best edge filters known in the literature within the field of image enhancement. The work compared them as a study used in the fabrics production and textiles. Then, the study confirmed in its results that the Gabor filter is the best of these filters.

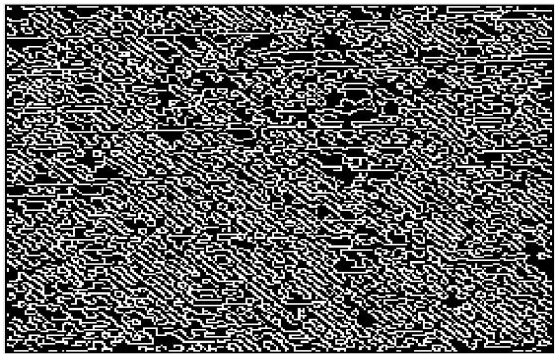
2. Edge Identification for Images

Edge Identification is an image processing technique for revealing the boundaries of an object in an image. The image is divided into different parts and data, most of the traditional edge detectors are

designed using the intensity of edge illumination, which is higher than its neighbors are when it is determined by the large difference between a pixel and its neighbors. The edges may be detected using what is called a warp mask. Some edge identification operations carry the so-called edge direction or edge magnetism. There are two parameters when applying edge identification operations. Figure (1) represents the original image and the edge selection image [7][8].

1- The size of the mask used in defining the edge. If it is large, it will be less sensitive to edge identification, for example, a (3*3) matrix is more sensitive than (7*7).

2- Gray Level Threshold value, if it is low, this will reduce the noise illumination [9] [10].



2.1. Roberts Edge Identification Filter

This method was developed by Lawrence Roberts (1965) to detect the 2D edge by measuring the spatial gradient on the image. This technique replicates the high-frequency spatial region that often corresponds to the edges. Both the operator's input and output are intensity images. Each point's pixel values in the output correspond to the estimated absolute magnitude of the location representing the color gradient of the input image at that point. This detector is used to detect edge points without giving any information about the edge direction and this detector takes two forms [3][8].

I(i-1,j-1)	**I(i-1,j)**
I(i,j-1)	**I(i,j)**

1. Equation (1) determined the edge by calculating the square root of the squares sum of The crosswise different.

$$Edge = \sqrt{[I(\dots, j) - I(i-1, j-1)]^2 + [I \dots - (i-1, j)]^2} \dots\dots\dots\dots\dots\dots (1)$$

2.The second method is by using equation (2):

$$Edge = \left| [I(r,c) - I(r-1, c-1)] + [I(r, c-1) - 1(r-1, c)] \right. \dots\dots\dots\dots (2)$$

The sum of the differences of adjacent diagonals is found using the absolute value.

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

G_X

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

G_Y

2.2. Laplace Edge Identification Filter

Laplacian edge filters are derived filters recycled to find regions of quick alteration (edges) in images. Subsequently derived filters are precise subtle to noise, it is communal practice to soften the image (for example, with a Gaussian filter) before relating Laplacian. This two-step process is called the Laplacian of Gaussian (LoG) process. The LoG operative proceeds the second derivative of the image.

When the image is basically identical, LoG will equal to zero.Where alteration occurs, the LoG will give a positive answer on the dark side and a damaging answer on the brighter side. At a harsh edge between two positions, the reaction will be:

• Nothing off the edge.
• Progressive only one-sided.
• Only damaging on another sideways.
• a zero at the same edge, in the middle of them.

Discovered by scientist Marr (1982) this filter uses the second derivative as in equation (3):

$$\nabla^2 f = \frac{\partial^2 f}{\partial x^2} + \frac{\partial^2 f}{\partial y^2} \qquad \text{…….... (3)}$$

This filter has two effects, the first is to smooth the image, and the second is to calculate the Laplace equation, from which we get a paired edge. The numerical employment of the Laplace role uses the masks below, one for the horizontal edge and the other for the vertical edge. Laplace is used to find which pixel is in the light edge or the dark edge [3][10].

0	**-1**	**0**
-1	**4**	**-1**
0	**-1**	**0**

G_X

-1	**-1**	**-1**
-1	**8**	**-1**
-1	**-1**	**-1**

G_Y

2.3. Canny Filter for Edge Identification

An edge identification engine utilizes a number of co-algorithms to identify a variety of edges in images. It has become one of the most popular edge identification algorithms. It was established by John F. Canny in 1986. Canny also produced an edge identification as a compute idea that explains why this technique works. This filter has been extensively useful in many computer vision systems. Canny originates that the necessities for applying edge identification to various vision schemes are similar. Thus, an edge identification resolve might be applied to meet these necessities in a wide variety of conditions. Common standards for edge identification include:

Edge identification has a low error ratio, which means that as many edges in the image as practicable must be accurately recorded by the detection. The edge point that the trigger finds must be precise at the edge's center. When possible, only one edge of the image should be noticeable. Image noise should not generate incorrect noise. Canny used variance arithmetic, a method that determines which function gets much better for a certain work, to satisfy these objectives [3][7][11].

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

X **Y**

It is a multi-stage algorithm, and its general algorithm is as follows [8]:

1. Smoothing the noised image by Gaussian filter.
2. Discovery image intensity slopes.
3. Apply a double threshold to define possible edges.
4. Edge Lag Path: Finalize the edge identification by eliminating all other frail and unrelated strong Edges.

2.4. Gabor Edge Identification Filter

Gabor filters imitate the human brain's ability to recognize tissue because Gabor functions are similar to the retina; the images were decomposed into many filtered images, each carrying varying densities over a constrained frequency range and direction. Gabor filters with two dimensions (0-2) in the spatial domain are a Gaussian Seed formula embedded by the planar wave with sine waves. Gabor filters are known as "a group of wavelets, with every wavelet picking up energy". Gabor filters with two dimensions have the benefit and efficiency in accumulating the local information of the image perfection, in addition to their ability to reach the minimum similarities between the space and frequency slitting of data. Consequently, Gabor filters have been used in many image analysis applications, like texture fragmentation, defect identification, biometrics, and image retrieval. [12][13]. Equation (4) represents the two-dimensional Gabor equation 2D-Gabor function[14][15]:

$$gw2D(x,y) = \frac{1}{\sigma\sqrt{\pi}}\, e^{-\left(\frac{(x-x_0)^2+(x-x_0)^2}{2\sigma^2}\right)} e^{-j2\pi f0((x-x_{0)\cos(\theta)+(y-y_0)\sin(\theta))} \quad \ldots.(4)$$

Represents the standard deviation of a Gaussian envelope, as for 0, it is an angle that represents the orientation angle of the Gabor function, and (x0, y0) is the vertex of the Peak of the function.

2.5. Rating Scales

Rating scales, also called distance scales, are the key to measuring accuracy between images based on content. In this research the author used Blind/Reference less Image Spatial Quality Evaluator no-reference image quality score (BRISQUE). The less the parameter value, the better image superiority [16].

3. Suggested Algorithm

More than one image of different size, color and format was used.

1- Inserting a color image into the program as shown in Figure (2).

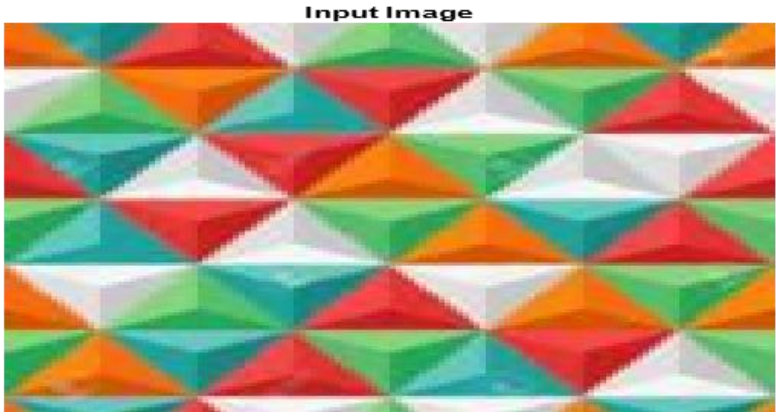


Figure (2) the image entered into the program

2. The image is scaled to 128 x 128 and finally converted to a grayscale image and then to a binary image as shown in Figure (3).

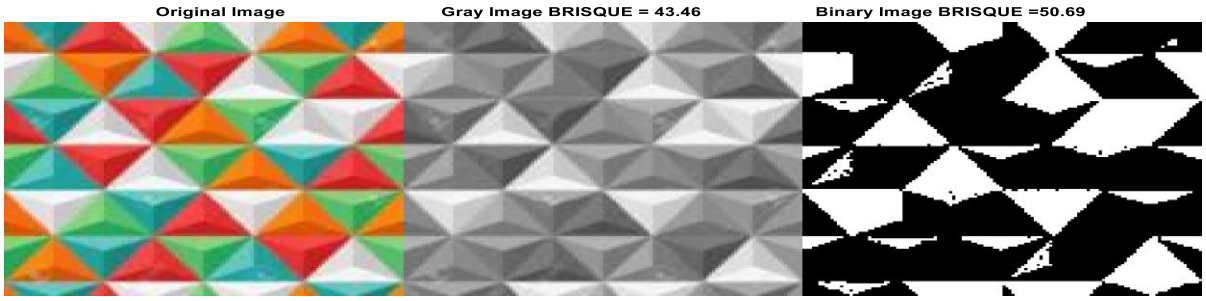


Figure (3) the image entered into the program, the gray image, and the binary image

3. Using the BRISQUE parameter. The smaller the parameter value, the better image superiority.
4. The binary image was added to the defining filters, which are the Laplace filter and the Canny filter to determine the pattern, as shown in Figure (4).

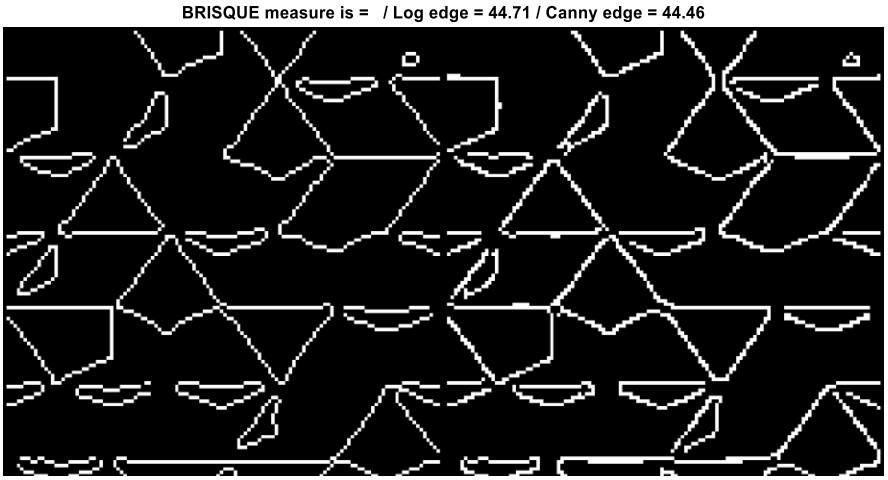


Figure (4) Pattern identification images using the canny filter and the Laplace filter

At the same time, the binary image was introduced to the Roberts and Gabor filters, and Figure (5) shows the images of these filters and their results.

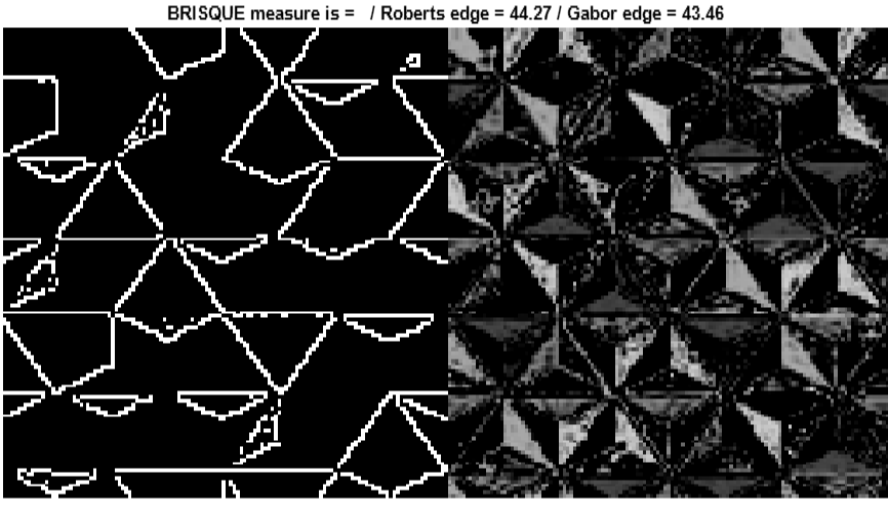


Figure (5) Pattern identification images using the Roberts and Gabor filter

Figure (6) shows some of the input images and their results sequentially.

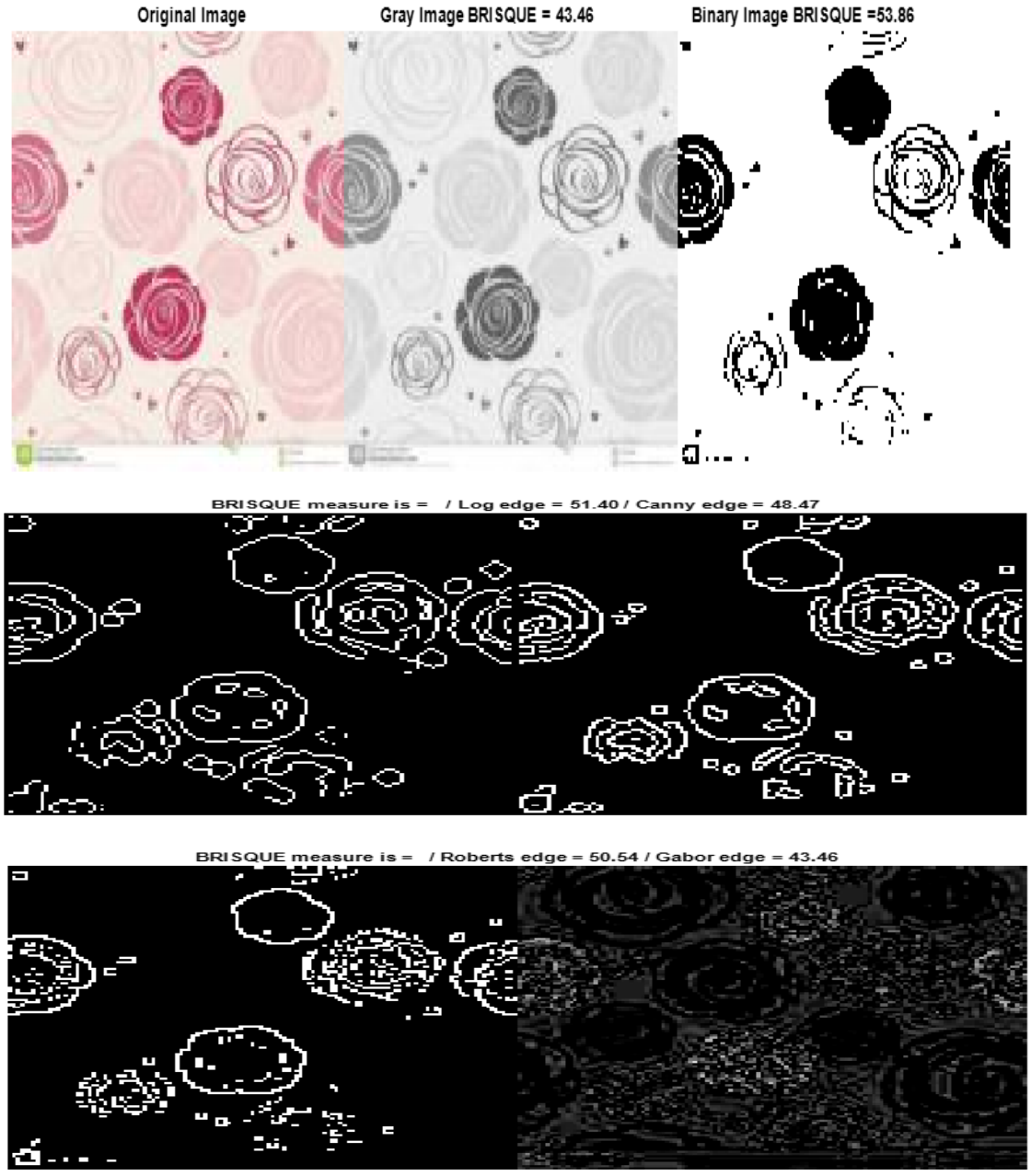


Figure (6) Program results

4. Results and Discussion

After executing the program on the input image, which was thirty images, the images of the edges were extracted and the values of the coefficients were calculated for a sample of those images. The results of the spatial image quality factor were analyzed and reviewed, which were entered into Table (1), which represents the best image of a texture:

Table (1) Quality metrics

image	BRISQUE Canny	BRISQUE Laplace	BRISQUE Gabor	BRISQUE Roberts
	**44.46**	**44.71**	**43.46**	**44.27**
	**48.47**	**51.40**	**43.46**	**50.54**
	**48.40**	**50.17**	**43.46**	**48.57**
	**50.58**	**46.84**	**44.47**	**48.31**
	**52.02**	**50.01**	**43.48**	**51.09**

From the above table, the image quality of the edges can be seen in the sequence of filters, the Gabor filter, the Canny filter, the Roberts filter, and the last Laplace filter according to the quality parameter. The quality coefficient of the Roberts filter was recorded (44.27-51.09), the Gabor filter (43.46-44.48), the Laplace filter (44.71-51.40), and finally the quality coefficient of the Canny filter (44.46-52, 05). Therefore, the Gabor filter is the best of these filters in defining the edges, which was used in defining the pattern, as it displayed its highest and lowest values as the lowest values compared to the other three filters.

5. Conclusions

In order to improve the accuracy of image edge identification and its use in design in fabric, this paper introduced traditional image edge identification algorithms known in image enhancement. The texture pattern was then detected using the image edge filters. By the algorithms presented in this paper, the results of the filters applied were evaluated and compared with each other. From the program application, and the estimation of the effects. It became clear that the Gabor filter is better and more efficient in detecting edges than the other filters used in this research.

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