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Comparison of Various Edge Detection Technique

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Abstract

Edge is the basic feature of image. Edges form the outline of an object. The need of edge detection is to find the discontinuities in depth, discontinuities in surface orientation, changes in material properties and variations in scene illumination. So edge detection is one of the most commonly used operations in image analysis and there are probably more algorithm for detecting edges. In this paper various edge detectors like Canny, Sobel, Roberts and Prewitt are compared. These operators are more susceptible to noise and do not give satisfactory result for face outline. For overcoming this disadvantage morphological method is studied and the result of edge detection using morphological method is compared with Canny edge detector, Sobel edge detector, Roberts edge detector and Prewitt edge detector.Wood and Glass Images are taken up as a special conditions for wider number of applications.

General Terms

Image Processing, Image Segmentation Algorithms, Operators for Edge Detection

Keywords

Edge detection, image analysis, morphological face detection.,Image Resolution,Wood and Glass Images

1. Introduction

[1][4] [3][6] Interpretation of image contents is a significant objective in image processing and it has received much attention of researchers during the last three decades. An image contains different Information of scene, such as object shape, size, color, and orientation. In order to extract the contour of an object, we must detect the edges forming that object, and this fact reveals the constitutional importance of edge detection in image processing. Edge detection is a process that detects the presence and location of edges constituted by sharp changes in color intensity (or brightness) of an image. Since, it can be proven that the discontinuities in image brightness are likely to correspond to: discontinuities in depth, discontinuities in surface orientation, changes in material properties and variations in scene illumination.Edge detection is also used in face recognition application. As Face is primary focus of attention for conveying identity. Human face detection in image processing has become a major field of interest. Detection of faces in a digital image has gained much importance in the last decade, with application in many fields. In this paper various edge detector techniques has studied for detecting the edge of plastic, glass and human face image. Canny, sobel, Roberts, prewitt and morphological method is discussed.

As per Mr. Beant Kaur *et. al.,* the edge detection using mathematical morphology is more efficient than the traditional methods (canny, Roberts, prewitt and sobel). As per Mr. Raman Maini *et. al.,* the Canny's edge detection algorithm performs better than all these operators under almost all scenarios and under noisy conditions.

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Canny, Sobel, Prewitt, Roberts's exhibit better performance, respectively.

2. Edge Detection Technique

2.1. Sobel Operator

[9][5][10] The gradient of a 2D function *f*(x, y) is defined as the vector ∇f = [Gx Gy] and the magnitude of vector is ∇*f* = mag (∇F) = [Gx²+Gy²]½.

The fundamental property of the gradient vector is that it points in the direction of the maximum rate of change of *f* at coordinate (x, y). The angle at which this maximum rate of change occurs is α(x, y) =arctan (Gy/Gx).

The sobel operator uses the masks as shown in Figure 1.1 to approximate digitally the first derivative Gx and Gy. It gives slightly more prominence to the central pixel.

Figure 2.1 Mask used by sobel operator.

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

2.2. Roberts Cross Operator

[9][10] The Roberts Cross operator performs a simple, quick to compute, 2-D spatial gradient measurement on an image. This detector is used considerably less than others due its limited functionality like it is not symmetric and cannot be generalized to detect the edges that are multiplies of 45˚.the parameter used in this function is identical to sobel operator.

Its gradient magnitude is given by:

$\Delta f = \text{mag}(\Delta F) = [Gx^2+Gy^2]^{1/2}$

The angle of orientation of the edge giving rise to the spatial gradient is given by:

$\theta = \arctan(Gy/Gx) - 3\Pi / 4.$

Figure 2.2 mask used by Roberts operator.

1	0
0	1

1	0
0	1

2.3 Prewitt operator:

[9][8][10] The parameter of the prewitt edge operator is identical to sobel operator. It is slightly simpler to implement computationally than the sobel operator but it produce somewhat nosier result.

Figure 2. 3 mask operated by Prewitt edge detector.

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

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

2.4 Canny Edge Detector:

[7][9][10] Canny edge detector is consider to be most powerful edge detector. It performs following operations:

1) The image is smoothed by Gaussian filter with a specified standard deviation σ, to reduce the noise.

2) The local gradient given by:

$$g(x, y) = [Gx^2+Gy^2]^{1/2}$$

and the direction angle given by:

$$\alpha(x, y) = \arctan(Gy/Gx)$$

are computed at each point.

3) The algorithm performs edge linking by incorporating the weak signal that are connected to the strong pixels.

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

Gx

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

Gy

Figure 2.4. Mask Operated by Canny Edge Detector

The magnitude, or edge strength, of the gradient is then approximated using the formula:

$|G| = |Gx| + |Gy|$.

3.Visual Comparison of Various Edge Detectors

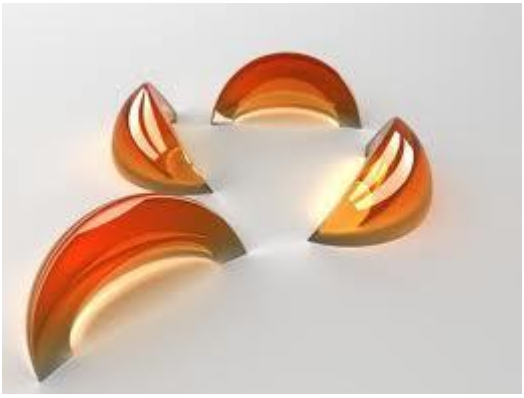


Figure 3. Image Used for Edge Detection Analysis (Glass.jpg)

Edge detection of all four types was performed on Figure 3. Canny yield the best result. But when we are interested in only boundaries, canny's algorithm does not prove beneficial. In that case as seen from result sobel operator is better than all others. Sobel operator gives better outer line detection with less discontinuity.

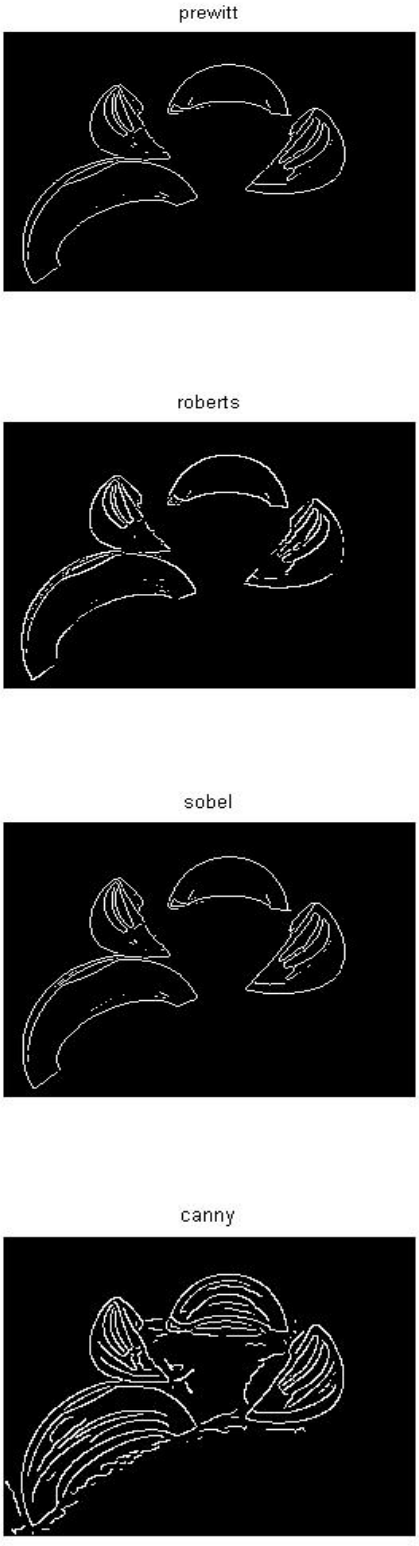
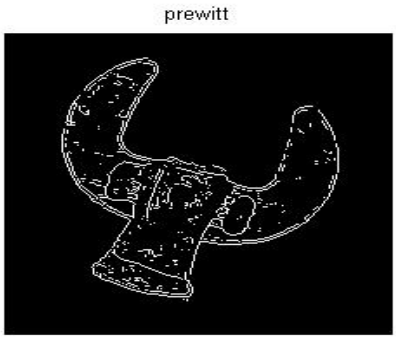
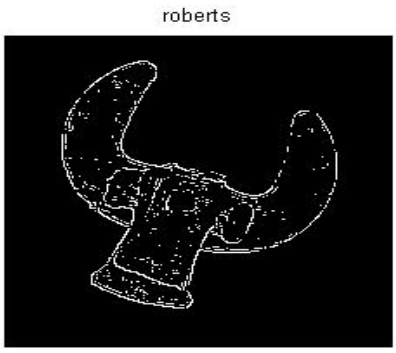


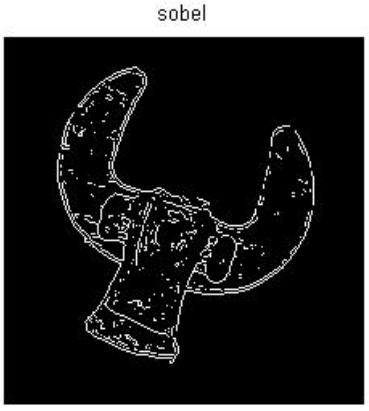
Figure 4. a) Result of Edge Detection on Figure 3 by Prewitt Method, b) Robert Method, c) Sobel Method, d) Canny Method

Comparison on plastic object. Following is the output

a) Original image







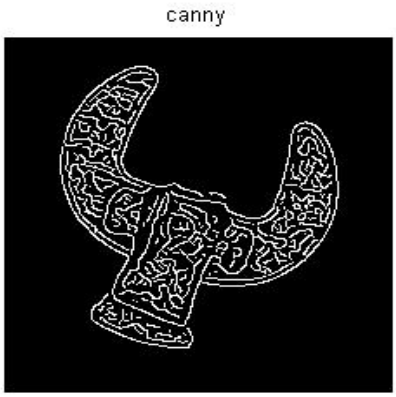


Figure 5. Result of Edge Detection on Plastic Image

Result for face detection by using these four operators. Following shows the output:

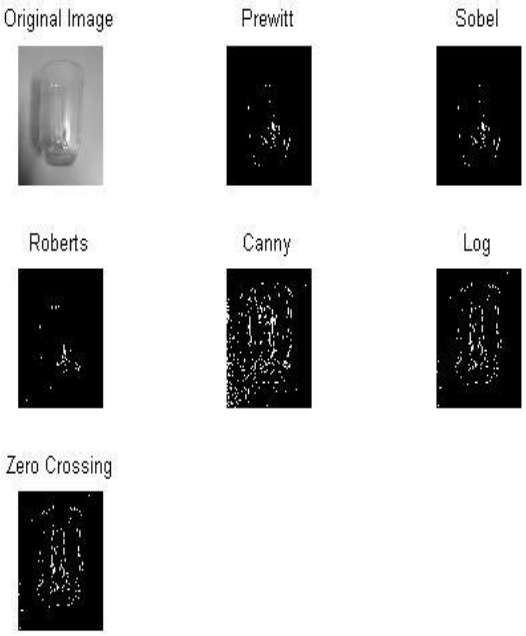
a) Original image

Figure 6. Face Detection by b) Prewitt Method, c) Roberts Method, d) Sobel Method and e) Canny Method.

From Figure 6 it is clear that for face boundary detection sobel and canny both fails. Their result is not so beneficial for face outline detection.

Result for Wood and Glass Image Edge Detection

Figure 7. Low Resolution Images used for Edge Detection



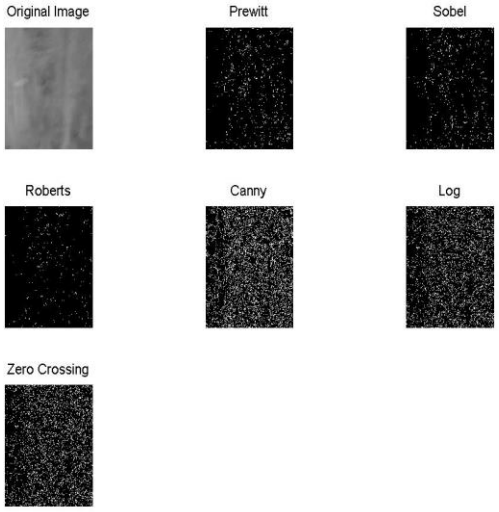
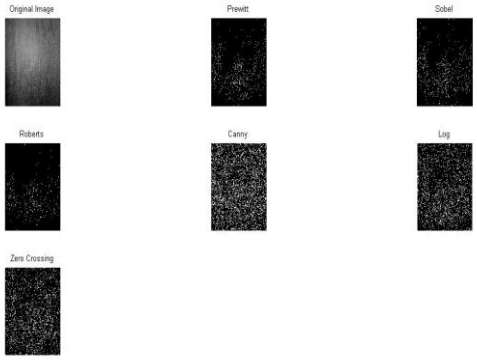


Figure 8. Results of Edge Detection Techniques on Wood and Glass Images

Figure 9. Original High Resolution Images



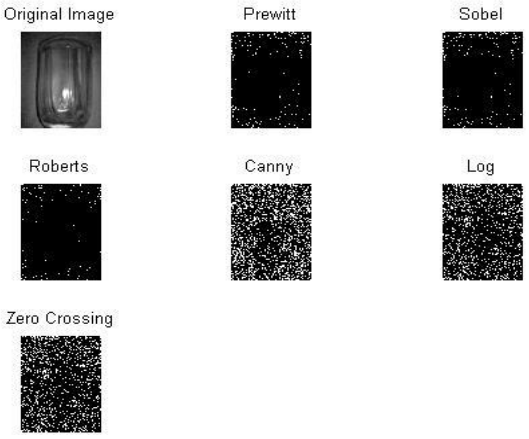


Figure 10. Results of High Resolution Image

4. Morphological Face Detection Method

[5][7][8]Since various edge detector used for face boundary detection were not successful for giving good result, hence we move toward morphological method. In this method there are two operation dilation and erosion.

Dilation: Dilation is an operation that "grows" or "thickens" the object. Basically it performs the ORing operation between the original binary image and the structuring element. The specific manner and the extent of the thickening is control by structuring element. The structuring elements are represented by the matrix of 0s and 1s. Mathematically the dilation of A by B defined in terms of set of operation as: $A \oplus B = \{x | B_x \cap A \neq \varnothing\}$ Where $\varnothing$ is the empty set and B is the structuring element. This expression means that dilation of A by B is the set consisting of all the element of origin locations where the reflected and translated B overlaps at least some portion of A.

Erosion: Erosion is an operation that "shrinks" or "thins" the object. That is it performs the ANDing operation between the original binary image and structuring element. As same in dilation the extent of shrinking is controlled by the structuring element.

The mathematical definition of erosion is similar to that of dilation and is defined as:

$A \ominus B = \{x | B_x \cap A^{c} \neq \varnothing\}$.

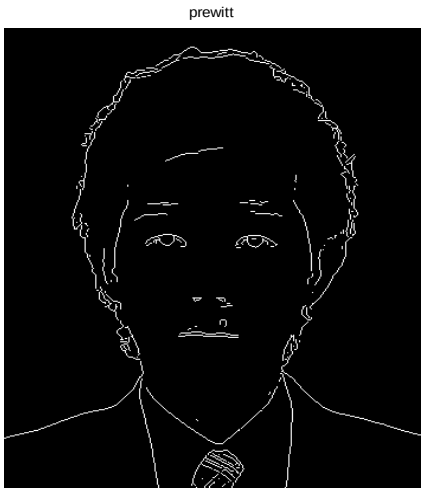
It means that erosion of A by B is the set of all structuring element of origin location where the translated B has no overlap with the background of A.

5. Image Resolution Importance In Wood And Glass Images

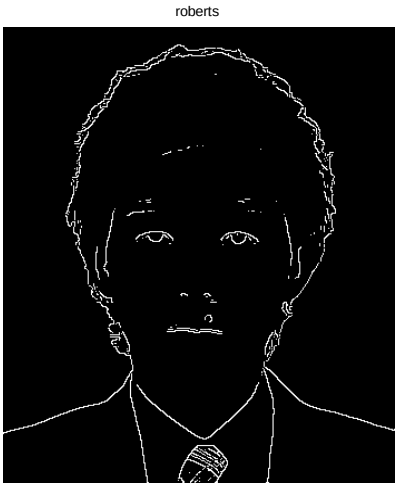
Cameras have a complex circuitry and are very interesting and playing a vital role by replacing scanner with hand held imaging devices like Digital Cameras, Mobile phones and gaming devices attached with the camera. Availability of High Resolution Camera has lead to new dimension in digital image processing. Different mobile phones are available and very powerful in nature due to their capability of multifunctional. The main idea of the project is to detect the edges from camera captured images of wood and glass based on edge based algorithms and compare the result with the existing system under different conditions. Different parameters are considered for analysis It is the number of pixels (individual points of color) contained on a display monitor, expressed in terms of the number of pixels on the horizontal axis and the number on the vertical axis. The sharpness of the image on a display depends on the resolution and the size of the monitor.

The same pixel resolution will be sharper on a smaller monitor and gradually lose sharpness on larger monitors because the same number of pixels are being spread out over a larger number of inches. In our project we used 12.1 MP and 1.3 MP camera. There is an importance of the image resolution of the camera which shall yield different results for the images. A high resolution image shall yield different results for the operators. Edge detection of all four types was performed on the wood and glass images. Canny yield the best result. But when we are interested in only boundaries ,canny's algorithm does not prove beneficial. In that case as seen from result sobel operator is better than all others. Sobel operator gives only outer line detection with less discontinuity.

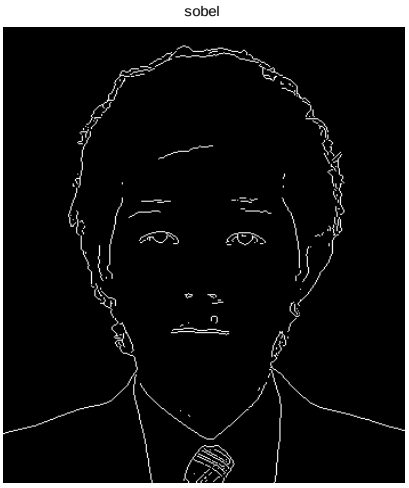
6. Comparison of Edge Detection Technique on Faces



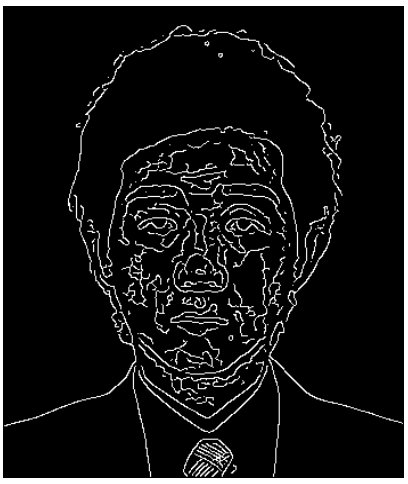
a)



b) Roberts method



c) Sobel method



d) Canny detection

e) Morphological-dilation

Figure 7. Original Face Image

Figure 11. Comparison of various edge detection techniques on Figure 7. showed in a, b, c, d and e.

From Figure 11 it can be seen that morphological method gives best result for face boundary detection. They provide the result with less noise and so more accurate. Also see the morphological result for human face detection on two images shown as following,

Figure 12. Original Image

Figure 13. Morphological Method Perform on Figure 12

Figure 14. Original Image and Morphological Image

7. Conclusion

Various edge detectors have been studied. Canny proves the better detector for outer and inner lines of object forming edges and has better immunity to noise than sobel, prewitt and Roberts detector.

For detecting only outer lines or continuous boundary of an object Sobel proves better. It provide less distorted boundary of object.

But when human faces are concerned for detecting the boundary both the detector canny ,sobel and also other detector like Roberts and prewitt do not provide the valid result. So for face detection Morphological method is studied and compared with these traditional detectors.I t can be concluded that Morphological method proves better than all other detector for face detection. We observed that for high resolution images of wood and glass canny and log operator worked the best, but for low resolution canny was the only best operator. The time of edge detection taken by the operators was minimum for canny and sobel operators. There was a further important observation which we got from the above results was that the edge detection was efficient in low resolution images than the high resolution images. This shall be a significant result in itself, because it can be used for many applications where we can use low resolution image, thus saving computation time. This has a huge application in image processing applications for biomedical images, which are used in many places. There are many practical applications of this comparison especially in robotics and computer vision.

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