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# Performance Analysis of Canny, Sobel and Perwitt Edge Detection Methods in Biometric Security Identification

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## Abstract

Nowadays, biometric authentication is mostly used to protect access to highly confidential assets. Identity management is more important than ever as to strengthen global security, make transportation safer and protect a vital commercial entrance. Iris acknowledgment perceives individuals precisely and dependably in view of the irregular texture that noticeable on the iris of the eye while additionally being one of the minimum invasive. To build up an iris acknowledgment algorithm for individual distinguishing proof, this paper analyzes different edge recognition systems for various iris images. Algorithm needs to go through some basic images for pre-preparing steps because of iris image quality including nonlinearly twisted, separation, moving and faked iris images all are open issues in the iris acknowledgment framework. A fundamental work to take care of the problems to design and create algorithms for every one of these varieties of images. Albeit current literature has an assortment of edge detection methods like canny, Sobel, Prewitt and this paper does not always prompt satisfactory results. But the test result demonstrates that the Canny method has better capacity to distinguish point in the digital image, where image gray level changes even at a moderate rate. We have inspected noisy iris images applying salt and pepper noise as well as Gaussian noise. Different filtering techniques can be applied to eradicate the undesirable noise. The effects of edge detection techniques of the mean, median and Gaussian filtered images have been observed in the paper. By applying Gaussian filters at the vertical orientation is executed to normalized iris images and the time complexity of this methodology is lessened impressively. Experimental results demonstrate the legitimacy of this methodology.

## Keywords

Digital Image, Gaussian Noise, Image Edge Detection, Image Segmentation, Image Thresholding

## 1. Introduction

Biometric-based personal authentication systems have recently gained intensive research interest due to the unreliability and inconvenience of traditional authentication systems. Biometrics recently became a vital element of any successful person identification solutions as biometric traits cannot be stolen, shared or even forgotten individual recognizable. Biometrics proof has dependably been an alluring objective in computer vision. There are numerous ways and means for individual recognizable proof and Verification. Token based procedure makes use of ID cards for distinguishing proof or approval. Memory based procedure requires the client to know passwords for recognizable proof purposes. Some burdens have incorporated into these antiquated techniques. They are not dependable since the tokens can be lost or the passwords may be forgotten. In the modern age reliance on computers and electronic gadgets are expanding, there is a requirement for profoundly secured and programmed solid validation innovation. Therefore, a vigorous and propelled method for individual recognizable proof namely biometrics has been created in recent years. Numerous sorts of biometric

technology are utilized like Fingerprint checking [1-2], Face acknowledgment [3], Voice acknowledgment [4] and Hand geometry examining [5]. These technologies are valuable yet none of these have as precision as iris acknowledgment. Iris-based authentication systems bear more advantages than any other biometric technologies as it offers an excellent recognition performance. Iris patterns are believed to be unique due to the complexity of the underlying environmental and genetic processes that influence the generation of iris pattern. These factors result in extraordinary textural patterns that are unique to each eye of an individual. Iris acknowledgment innovation catches the digital image of iris patterns with the assistance of an iris examining gadget or Camera like LG3000, LG2200. Digitalized pictures are put away in a database for future reference alongside some different parameters like name and address or serial number [6]. Iris information is more solid in view of covering by a defensive sheath which shields it from being harmed. Iris examples are accepted to be special to every eye of an individual even distinct between twins [7]. Iris acknowledgment framework mainly incorporates eye image capturing, picture pre-handling and edge location through iris region segmentation and pattern coordinating. Edge detection process makes pupil boundary recognition precisely and easily. Circular edge discovery method is utilized to search for a circle in the image which has most extreme gray level contrast with its neighbor. Hough transform utilizes distinctive methodologies which are computationally complex [8]. A texture-based technique first localized high contrast parts of boundary then distinguishes external boundary and eyelids [9]. An abstracted contour graph analysis was presented to detect the iris [10].

The paper is oriented in this fashion; Methodology describes in division II. Types of edge detection methods describes in division III, under this division sobel, canny and prewitt edge localization methods are illustrated. Division IV designates the experimental results. Besides performance accuracy represents in division V and division VI accomplishes this paper.

## 2. Methodology

Edge detection is the name for an arrangement of mathematical techniques. It is separated into three fundamental steps, image pre-handling, feature extraction of iris image and template coordinating. The image pre-handling stage requires the confinement of the iris. The photo of the iris is captured by a CCD camera. The captured image then prepared by an exceptional sort of software, which separates the primary iris designs from the external and the inward boundaries of the iris. The accomplishment of this stage relies on upon the imaging quality of eye images. Images in the CASIA iris database don't contain specular reflections because of the utilization of close infra-red light for illumination. Figure 1 demonstrates a typical iris acknowledgment framework.

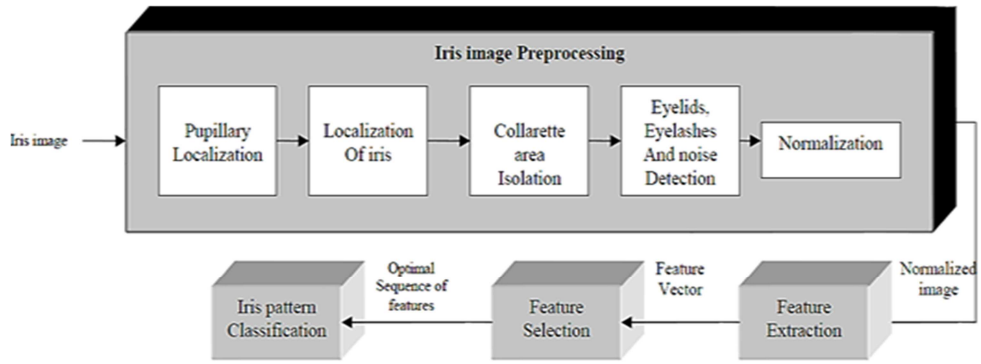


***Figure 1.*** *Typical Iris recognition system.*

## 3. Edge Detection Methods

Generally, edge recognition method goes for distinguishing point in a digital image at which the picture brightness changes pointedly or more formally has discontinuities. The focus at which the digital picture sharply changes and normally composed an arrangement of curved line fragments termed edges. There are numerous edge discovery procedures, for example, Sobel, Canny, Prewitt, etc. In this paper, the Canny edge recognition Prewitt edge discovery and the Sobel edge location techniques are deliberated.

### 3.1. Sobel Edge Detection

The Sobel operator is a discrete separation operator and preparing an estimate of the edge of image intensity capacity. At each point in the picture, the outcome of the Sobel operator is either the comparing gradient vector [11]. If we characterize A as the source image and $G_x$ and $G_y$ are two images which every point contains the horizontal and vertical subsidiary approximations, the calculations are as follow,

$$\nabla f = grad(f) = \begin{bmatrix} G_x \\ G_y \end{bmatrix} = \begin{bmatrix} \frac{\partial f}{\partial x} \\ \frac{\partial f}{\partial y} \end{bmatrix}$$

Magnitude of vector,

$$M(x,y) = mag(\nabla f) = \sqrt{G_x^2 + G_y^2}$$

Directions of gradient vector,

$$\alpha(x,y) = tan^{-1}\begin{bmatrix} G_x \\ G_y \end{bmatrix}$$

$$G_x = \begin{bmatrix} -1 & 0 & 1 \\ -2 & 0 & 2 \\ -1 & 0 & 1 \end{bmatrix} * A \text{ and } G_y = \begin{bmatrix} +1 & 2 & +1 \\ 0 & 0 & 0 \\ -1 & -2 & -1 \end{bmatrix} * A$$

Method 1: Sobel edge detection

Step-1: Read the input image

Step-2: Transform the image to double

Step-3: Use F1 mask for x direction and F2 mask for y direction to obtain image A gradient.

Filter Masks are,

F1= [-1 0 1; -2 0 2; -1 0 1];

F2= [-1 -2 -1; 0 0 0; 1 2 1];

Step-4: Find the magnitude of the vector.

For i=1: size (A, 1)-2

For j=1: size (A, 2)-2

Magnitude of vector:

$$I(i+1, j+1) = \sqrt{G_x^2 + G_y^2}$$

When i=1 and j =1, then I (2, 2) will be image I pixel position.

Step-5: Since 3x3 image pixels are required and the fringe pixels are not measured, so edge identification process begins from pixel (2, 2).

Step-6: The filter mask is 3x3 and last position to be prepared in our example is I (3, 3) and typically it will be I (size (A, 1)- 2, size (A, 2)- 2). Subsequently borders are left.

Step-7: Threshold the image.

Step-8: Show the Sobel Edge detected image.

### 3.2. Canny Edge Detection

An image gradient is a directional change in the intensity or color in a picture. For instance, the canny edge identifier utilizes image gradient for edge recognition. Canny edge discovery calculation keeps running in a few stages. Firstly, smoothing step utilizing Gaussian filtering, the operator obscures the image to expel noise where the crude image is convolved with a filter. At that point in discovering gradient step operator to compute the substantial extent of gradient of image and denote the edges. In non-greatest suppression step the operator search for neighborhood maxima and showed it as edges. At that point, the operator applies utilizes double thresholding with hysteresis to finish up potential edge. Subsequent to finishing this procedure, a binary image is procured where every pixel is demonstrated as either an edge pixel or a non-edge pixel [12][13]. The binary edge map acquired along these lines can likewise be treat as an arrangement of edge curves that can be exemplified additionally as polygons in the image area.

Method 2: Canny edge detection

Step-1: Read the input image.

Step-2: Convert to Gray scale.

Step-3: Noise Reduction

Step-4: Compute Gradient Magnitude and Angle

Step-5: Non-Maximum Suppression

Step-6: Hysteresis Thresholding

Step-7: If pixel (x, y) gradient magnitude less than low threshold value, so discard of the edge (work out black).

1. If pixel (x, y) has gradient extent more prominent than high threshold value, keep the edge (work out white).
2. If pixel (x, y) gradient magnitude is amongst low and high threshold value and its neighbors in a 3 × 3 region around it have gradient magnitudes more prominent than thigh and keep the edge (work out white).
3. If none of pixel (x, y's) neighbors have high gradient magnitudes but not less than one falls amongst low and high threshold value, search the 5 × 5 region to check whether any of these pixels have a size more prominent than the high threshold value. If so, keep the edge (write out white) Else, discard the edge (write out black).

### 3.3. Prewitt Edge Detection

It can be described as a discrete separation operator. An estimation of the slope of the image intensity limit is prepared by this operator. At each point in the image, the consequence of the Prewitt operator is the relating gradient vector or the standardization this vector [13][14]. If we define A as the input image, and $H_x$ and $H_y$ are two images which at each point contain the horizontal and vertical subsidiary approximations, the computations are as per the following,

$$H_x = \begin{bmatrix} -1 & 0 & +1 \\ -1 & 0 & +1 \\ -1 & 0 & +1 \end{bmatrix} * A \text{ and } H_y = \begin{bmatrix} +1 & +1 & +1 \\ 0 & 0 & 0 \\ -1 & -1 & -1 \end{bmatrix} * A$$

## 4. Experimental Results

Sobel operator in both x and y axis direction have been observed in Figure 2. Figure 3 demonstrates canny edge detected image in x-axis and y-axis direction. From Figure 4, it is observed the thresholding and thinning effect of image by applying canny operator. Gradient component of edge detected iris image employing Prewitt operator in both x and y axis direction have been observed in Figure 4. Figure 5 illustrates the effect of salt & pepper noise and Gaussian noise effect of original eye image. Figure 6 indicates the output of the eye image after applying mean, median and Gaussian filter in canny, Sobel and Prewitt edge detected images to remove the salt and pepper (SP) noise. From Figure 7, it can be noticed the effect of using mean_3, median_3 and Gaussian_5 filters in the Gaussian noisy image. The outcome got above figures indicate how quickly and easily the image changes. Canny operator is ideal even for images included with noise. Canny operator fills the hole amongst strong and weak edges of the image compare with other edge location systems like Sobel, Prewitt, this operator is less tricked by fraudulent noise.

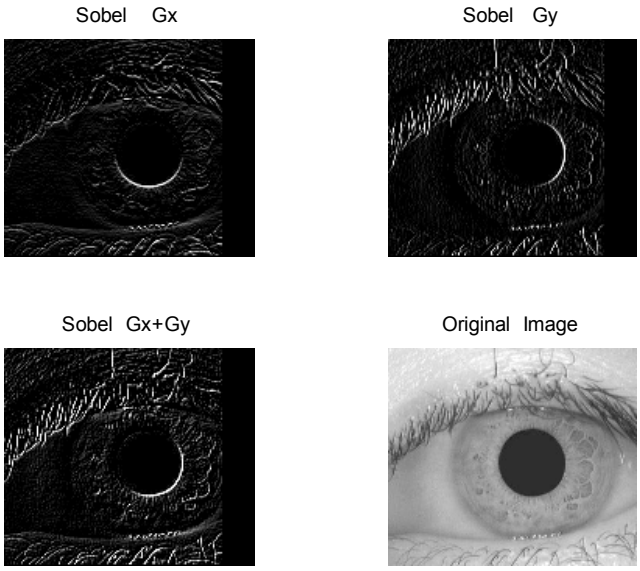


***Figure 2.*** *Sobel Edge Detection.*

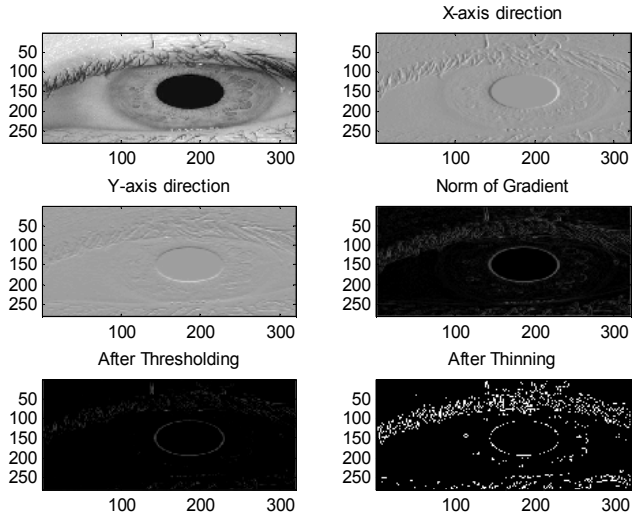


***Figure 3.*** *Canny edge detection.*

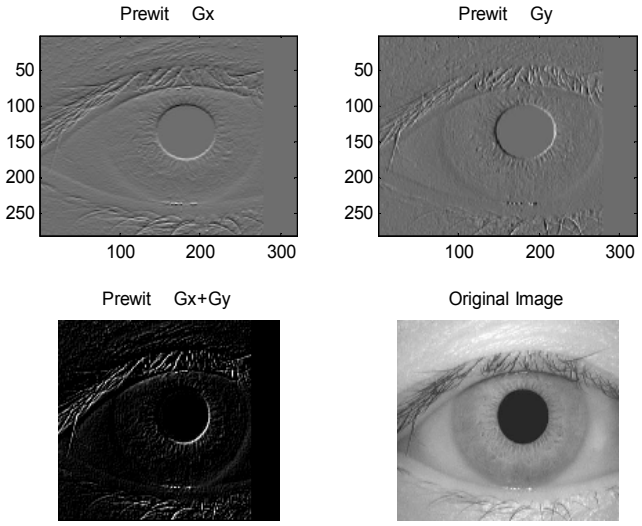


***Figure 4.*** *Prewitt edge detection.*

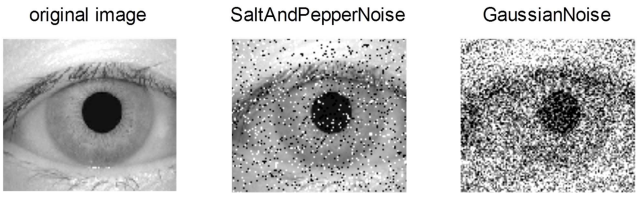


***Figure 5.*** *Original image with Salt and Pepper and Gaussian noise.*


***Figure 6.*** *Applying mean, median and Gaussian filter to remove salt and pepper noise.*

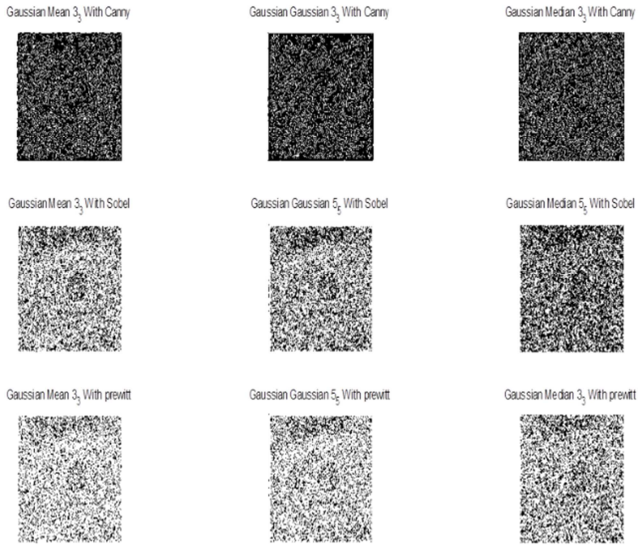


***Figure 7.*** *Applying mean, median and Gaussian filter to remove Gaussian noise.*

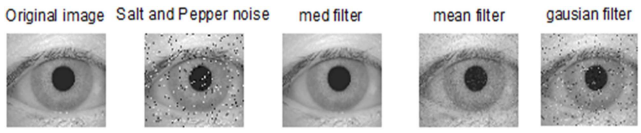


***Figure 8.*** *Removal of salt and pepper noise of image using median, mean and Gaussian filter.*


***Figure 9.*** *Removal of Gaussian noise of image using median, mean and Gaussian filter.*

From the Figure 8 and Figure 9 it has been observed that median filter can provide better performance than mean filter and Gaussian filter in order to eliminate the salt and pepper noise whereas mean filter can give better performance than median filter and Gaussian filter in order to remove the Gaussian noise.

***Table 1.*** *Threshold value selected for various operators.*

| | Operators | | |
|---|---|---|---|
| | **Canny** | **Sobel** | **Prewitt** |
| *Threshold value* | 1.5 | 0.1429 | 0.1111 |

Table 1 shows the optimum threshold value that is used for different edge detector operator. Table 2 shows the MSE, AD and PSNR comparisons among three detection techniques.

***Table 2.*** *MSE, AD & PSNR Calculations.*

| Edge detection methods | MSE | PSNR (dB) | Average Difference (AD) |
|---|---|---|---|
| Canny | 215.94 | 24.7024747 | 122.84 |
| Sobel | 232.06 | 24.5088674 | 140.50 |
| Prewitt | 222.83 | 24.6850048 | 133.80 |

Generally, for image quality measurement, if the value of MSE, AD is low and PSNR is high for an image of a particular noise type then it is defined as a best quality edge detected image. Table 2 & Figure 10 shows canny edge detection method has lower MSE, AD and higher PSNR value compare to sobel as well as prewitt edge detection method. So canny edge detection method is comparatively better than sobel and prewitt edge detection methods.

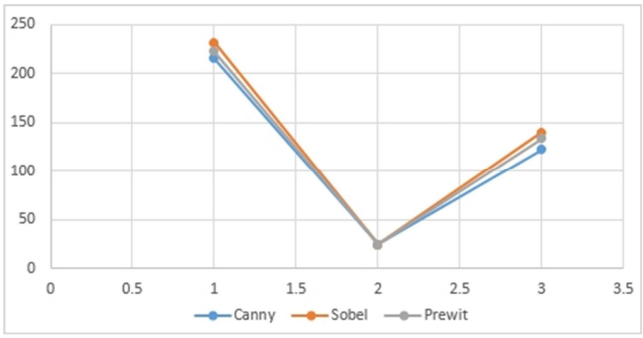


***Figure 10.*** *Performances analysis of edge detection methods.*

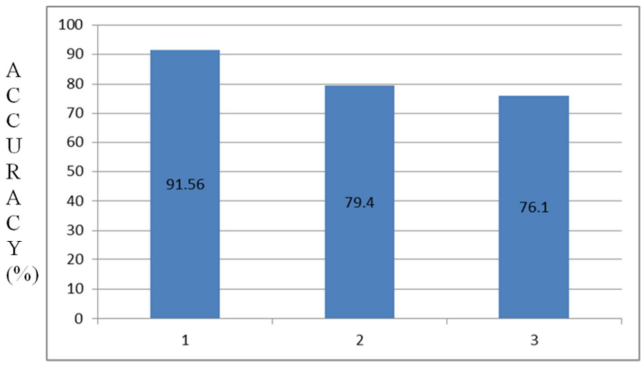


***Figure 11.*** *Accuracy measure of edge detection techniques.*

## 5. Performance Evaluation

Canny edge discovery algorithm outperforms well when compared with Sobel and Prewitt edge recognition methods. From the Figure 11, it is watched that Canny edge identification method achieves high rate of accuracy compared to Prewitt and Sobel edge discovery method.

## 6. Conclusion

This paper has discussed on edge detection methods, which impacts a key part in the field of image processing. There are numerous edge recognition techniques like canny edge discovery, Sobel edge identification and Roberts cross edge location. These edge detection techniques depend on separating image with one or more masks. This paper discussed Canny, Sobel and Prewitt edge detection procedures. It is experimentally observed that the canny edge discovery technique has better performance compare to other two edge identification methods. If not, the preconditions are predominantly suitable, it is hard to find an edge indicator that offers impressively better performances over the Canny edge detector. However, Sobel and Prewitt edge recognition procedure can identify both horizontal and vertical edges separately that presented in combined form and in this manner, computation is generally financially effective.

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