Evaluation and Analysis of Different Type of Edge Detection Techniques on Cartridge Case Image

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Abstract: The forensic identification of ballistics specimens relies on the detection, recognition and ultimate matching of markings on the surfaces of cartridges and projectiles made by the firearms. The feature extraction from the images is always a very important step in automated examination system. The edge detection refers to the process of identifying and locating sharp discontinuities in an image which helps in pattern recognition. The edge detection of ballistics specimens like, the firing pin mark, head stamp mark and striation on cartridge case the positive identification is based mainly on the image segmentation and feature extraction of the proposed area. Thus, applying an edge detection algorithm to an image may significantly reduce the amount of data to be processed and may therefore filter out information that may be regarded as less relevant, while preserving the important structural properties of an image. If the edge detection step is successful, the subsequent task of interpreting the information contents in the original image may therefore be substantially simplifiedIn this paper we have compared different techniques of Gradient-based and Laplacian based edge detection on the cartridge case image with MATLAB tool.

***Keywords**: Edge Detection, Digital Image Processing, Sobel, Prewitt, Roberts, Canny.*

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1. INTRODUCTION

Forensic ballistics involves analysis of bullets and bullet impacts to determine information of use to a court or other part of a legal system. Separately from ballistics information, firearm and tool mark examinations ("ballistic fingerprinting") involve analyzing firearm, cartridge case bullet, evidence in order to establish whether a certain firearm was used in the commission of a crime.

Digital image processing has become an functional as well as popular research area that goes from specialized photography to several different fields such as astronomy, meteorology, computer vision, medical imaging, among others. The main goal of digital image processing is to improve the pictorial information .The area of digital image processing refers to processing digital images by means of a digital computer [1].Numbers of edge detectors are developed each year. Effects such as refraction or poor focus can result in objects with boundaries defined by steady change in intensity. So, there are problems of false edge detection, missing true edges, edge localization, high computational time and problem due to noise [2]. In order to significantly reduce the complexity of image processing algorithms, edge detection is used as the pre-processing step which helps in reducing the amount of data to be processed [3]. Therefore our objective is to compare and analyze the performance of various edge detection techniques based on various parameters like role, type of edge, nature and edge localization.

1. Edge Detection

Edge Detection Edge detection refers to the process of identifying and locating sharp discontinuities in an image. Edge is the area of major change in the image intensity or contrast and Edge Detection is locating areas with strong intensity contrasts We use edge detection –because it helps in extracting information about the image. E.g. location of objects present in the image, their shape, size, image sharpening and enhancement [4]. Edge detection is used for image segmentation based on abrupt changes in intensity. In a continuous image, a sharp intensity transition between neighbouring pixels is considered as an edge [5].

Three steps in edge detection are:

- Image smoothing: for noise reduction these steps involve filtering the image for improving the performance of edge detector.
- Detection: This step involves extracting all edge points that are possible candidates to become edge point.
- Edge localization: This step involves selecting from the candidate edge points only the points that are true members of set of points comprising an edge.

METHODOLOGY

We mainly used two types of operators in edge detection which are:

1.1 Gradient Based Edge Detection

The gradient method detects the edges by looking for the maximum and minimum in the first derivative of the image. When the gradient is above the threshold there is object in the image. The popular edge detection operators are Roberts, Sobel , Prewitt .They are all defined on a 3x 3 pattern grid, so they are efficient and easy to apply.

1.2 Laplacian Based Edge Detection

The Laplacianbased edge detection method searches for zero crossings in the second derivative of the image to find edges. An edge has the one-dimensional shape of a ramp and calculating the derivative of the image can highlight its location. Examples are LOG andCanny.

1.3 Sobel's Operator

The operator consists of a pair of 3×3 convolution kernels as shown in Figure No.1. One kernel is simply the other rotated by 90°. The kernels can be applied separately to the input image, to produce separate measurements of the gradient component in each orientation ($G_x$and G_y). These can then be combined together to find the absolute magnitude of the gradient at each point and the orientation of that gradient.

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

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

Figure No.1 Masks used by Sobel Operator

The gradient magnitude is given as:

$$|G| = \sqrt{(G_x^2 + G_y^2)}$$

Typically, an approximate magnitude is computed using

$$|G| = |G_x + G_y|$$

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

$$\theta = arctan\left(\frac{G_x}{G_y}\right)$$

1.4 Robert's Operator

The Roberts Cross operator performs a simple, 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 No. 2. One kernel is simply the other rotated by 90°. This is very similar to the Sobel operator.

1	0
0	-1

0	1
-1	0

Figure No.2. Masks used for Robert operator.

The kernels can be applied separately to the input image, to produce separate measurements of the gradient component in each orientation (G_x and G_y). The gradient magnitude is given as:

$$|G| = \sqrt{(G_x^2 + G_y^2)}$$

Typically, an approximate magnitude is computed using

$$|G| = |G_x + G_y|$$

This is much faster to compute. The angle of orientation of the edge giving rise to the spatial gradient is given by:

$$\theta = arctan\left(\frac{G_x}{G_y}\right) - \frac{3\pi}{4}$$

1.4 Prewitt's Operator

Prewitt operator [6] is similar to the Sobel operator and is used for detecting vertical and horizontal edges in images.

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

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

Figure No.3. Masks for the Prewitt gradient edge detector

1.5 Laplacian of Gaussian

The Laplacian is a 2-D isotropic measure of the 2nd spatial derivative of an image. The Laplacian of an image highlights regions of rapid intensity change and is therefore often used for edge detection. The Laplacian is often applied to an image that has first been smoothed with something approximating a Gaussian Smoothing filter in order to reduce its sensitivity to noise. The operator normally takes a single gray level image as input and produces another gray level image as output. The Laplacian L(x, y) of an image with pixel intensity values I(x, y) is given by

$$L(x,y) = \frac{d^2 i}{dx^2} + \frac{d^2 i}{dy^2}$$

Since the input image is represented as a set of discrete pixels, we have to find a discrete convolution kernel that can approximate the second derivatives in the definition of the Laplacian.

1	1	1
1	-8	1
1	1	1

-1	2	-1
2	-4	2
-1	2	-1

Figure No.3. Three commonly used discrete approximations to the Laplacian filter.

1.7 Canny's Edge Detection

Canny operator [7] is based on three criteria. The basic idea uses a Gaussian function to smooth image firstly. Then the maximum value of first derivative also corresponds to the minimum of the first derivative. In other words, both points with dramatic change of gray- scale (strong edge) and points with slight change of grayscale (weak edges) correspond to the second derivative zero-crossing point. Thus these two thresholds are used to detect strong edges and weak edges. The fact that Canny algorithm is not susceptible to noise interference enables its ability to detect true weak edges. Canny defined optimal edge finding as a set of criteria that maximize the probability of detecting true edges while minimizing the probability of false edges. To smooth the image, the Canny edge detector uses Gaussian convolution, is the spread of the Gaussian and controls the degree of smoothing.

$$g(m,n) = G\,(m,n) * f(m,n)$$

$$G_\sigma = \frac{1}{\sqrt{2\pi\sigma^2}} exp\left[-\frac{m^2+n^2}{2\sigma^2}\right]$$

The gradient magnitude and direction at each pixel are calculated in this step (Figure No. 5). Note that the maxima and minima of the first derivative gradient are the same as the zero crossings of the second directional derivative.

$$M(m,n) = \sqrt{g_m^2\,(m,n) + g_n^2\,(m,n)}$$

Only the maxima crossings are of interest because these pixels represent the areas of the sharpest intensity changes in the image. These zero-crossings are the ridge pixels that represent the set of possible edges. All other pixels are considered non-ridge and subsequently suppressed. Finally, a two-threshold technique or hysteresis is performed along the ridge pixels to determine the final set of edges.

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

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

Figure No.5. Kernels

Instead of using a single threshold value for filtering ridge pixels, the Canny algorithm implements a connected components analysis technique based on a hysteresis thresholding heuristic.

This step uses two thresholds, t1, t2 where t1 > t2, to partition the ridge pixels into edges/non-edges. Pixels with gradient magnitudes above t1 are classified as definite edges. Pixels between t2 and t1 are classified as potential edges. Pixels under t2 are classified as non- edges. Next, all potential edges that can be traced back to a definite edge via adjacent potential edges are also marked as definite edges. The process solves some of the issues associated with edge streaking and discontinuity in the results achieved by simple detectors by identifying strong edges while accounting for comparatively weaker ones.

RESULTS AND DISCUSSION

We applied both Gradient-based and Laplacian basededge detection methods namely Sobel, Roberts, Prewitt and Canny algorithms on the cartridge case image and results are shown in Figure No1.

The edge detection is the primary step in identifying an image object, it is very essential to know the advantages and disadvantages of each edge detection filters. In this paper we dealt with study of edge detection techniques of Gradient based and Laplacian based. Edge Detection Techniques are compared on cartridge case image. The software was implemented using MATLAB. Gradient-based algorithms have major drawbacks are sensitive to noise. The performance of the Canny' algorithm relies mainly on the changing parameters which are standard deviation for the Gaussian filter, and its threshold values. Canny's edge detection algorithm is computationally more expensive compared to Sobel, Prewitt and Robert operator. However Canny's edge detection algorithm performs better than all these operators under almost all scenarios. Whereas LoG gives better response than Sobel, Robert and Prewitt which are found sensitive to noise.

CONCLUSION

In this paper we have evaluated various Edge Detection Operators that are Sobel, Robert, Prewitt, LOG and Canny. From the above results, it is concluded that Canny's operator is the best method to detect edges. Canny algorithm is not susceptible to noise interference enables its ability to detect true weak edges. It's optimal edge detection algorithm.

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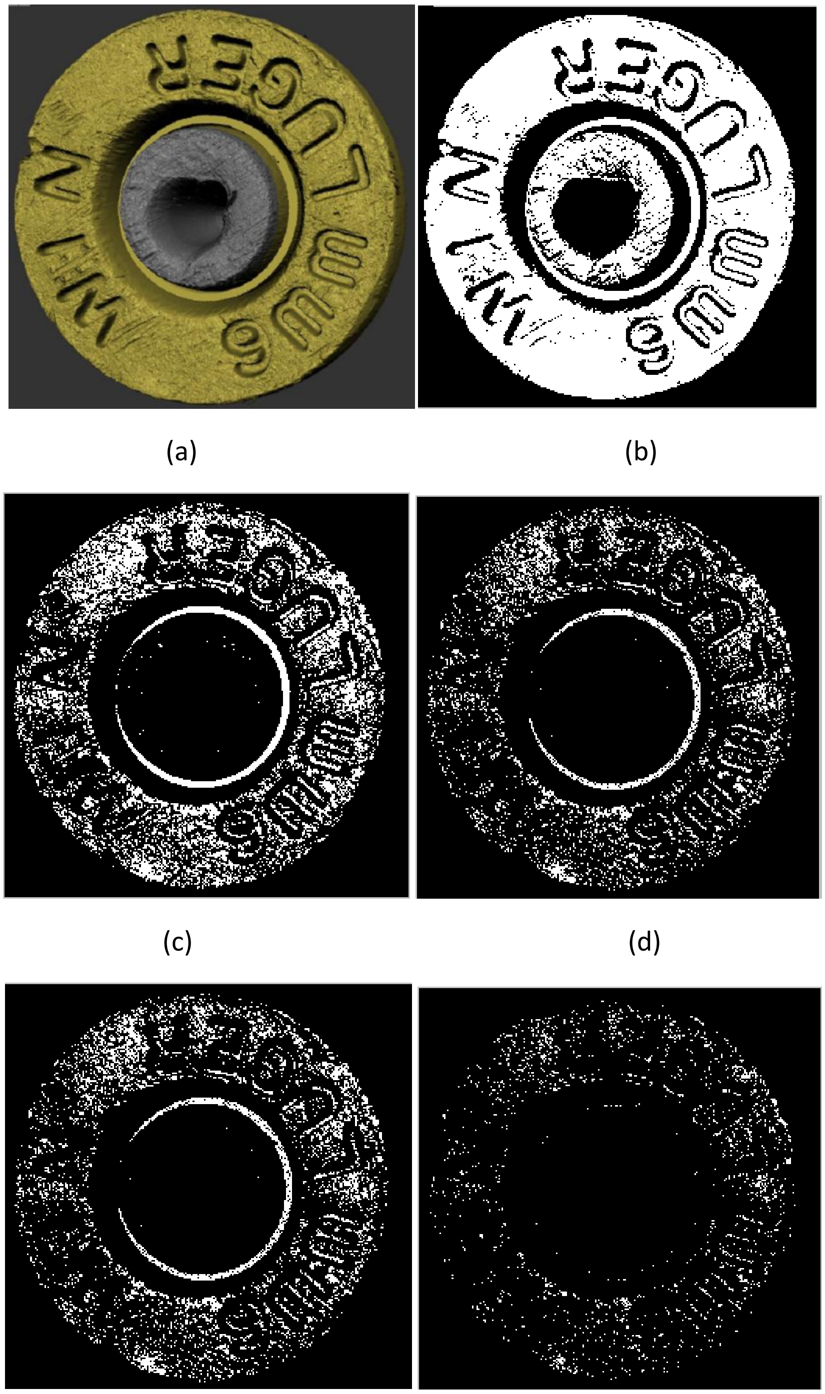
Legends to Figures

Figure No.1 (a) Original (b) Canny (c) LoG (d) Sobel (e)Prewitt (f) Robert



(a) (b) (c) (d) (e) (f)