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Performance analysis of gradient based image edge detection

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***Abstract*---**Edge detection is a dynamic area of research and it gives support to higher level image analysis. Edge detection is a method of image processing used to make points in a digital image with discontinuities, sharp modifiers in the image brightness. Edge detection methods used in this work are Sobel, Prewitt, Roberts, Laplacian of Gaussian and Canny. The performance evaluation measures such as accuracy and specificity calculated from the Berkeley Segmentation dataset. Edge detection is used for object detection which offers various applications like medical field, industrial field, biometrics etc.

***Keywords*---**Edge detection, Sobel, Prewitt, Roberts, Laplacian of Gaussian, Canny.

1. Introduction

Edge detection is the most important approach for detecting features discontinuities in intensity values. Edges are local alters in the image intensity. Edges typically emerge on the boundary between two regions. Edge detection methods convert original images into edge images that profit from the changes of gray scale quality in the image. The most commonly used discontinuity-based edge detection techniques have been explained in this statistical section and their results are evaluated. Those techniques are Sobel, Prewitt, Roberts, Laplacian of Gaussian and Canny edge detection method.

2. Review of Literature

Hui-hong Xu et al have proposed to resolve the problem of edge detection and information capture better, significantly improves the edge effect and defend the efficiency of edge information. It reduces the signal-to-noise ratio of the smoothed image and greatly develops the effect of image smoothing [1]. **Zhen Zheng et al** haveproposed a novel image edge detection algorithm based on the gray prediction model. They performed a sequence of experiments to test the proposed

algorithm's edge detection capability and noise-sensitivity capability [2]. **Keumsun park et al** have proposed pre-processing and machine learning method is verified as the important method of pre-processing image from image signal processor in order to gain better edge detection image. It is possible to more clearly and simply resolve the object essential when performing Auto White Balance (AWB) or Auto Exposure (AE) in the Image Signal Processing (ISP) [3]. **Jian Liu et al** have studiedthe adaptive multi-scale edge detection method based on canny algorithm, and through theoretical analysis, compares the advantages and disadvantages of various algorithms in image edge detection. Evaluates with the conventional modulus greatest edge detection method and defeats the opposition that can contain the obstruction of noise and achieve a better edge detection effect to a certain level [4]. **Yang and Lianxin Wei et al** have proposed an enhanced eight-direction Sobel operator based on graycorrespondence degree, which combines 5 × 5 Sobel operator with a gray comparativedegree and a new eight-direction gray relevancy method. The results show that this method can detect the valuable information of edge more perfectly and get better anti-noise performance [5]. **Sanida et al** have realized the Sobel filter, one of the most efficient and popular edge detection algorithms in image processing, in the OpenCL programming language. The results of their implementation are evaluated to other existing implementations and established to accomplish better performance [6]. **Ehsan Akbari Sekehravani et al** have proposed method edges in noisy images can be discovered effectively and better in edge and detail detection than regular canny algorithm [7]. **Prasantha** has proposed to pre-process the Singular Value Decomposition (SVD) which refuses the computation complexity to evaluate time or clock cycles to SVD. This method entitles as Modified SVD (MSVD) which is variation with the actual SVD and other deviation of SVD based on dissimilar constraints [8]. **Keumsun Park et al** have proposed pre-processing method to find optimized intensity and contrast for enhanced edge detection and extract features from image information and execute machine learning such as K-Nearest Neighbor (KNN), MultiLayer Perceptron (MLP) and support vector machine (SVM) to take enhanced model by regulate brightness and gap. It facilitates construction faster and more powerfully throughout the optimistic ISP [9]. **Kavita Rathi et al** have proposed a well-organized supervised learning approach used for merging forgery detection among low classification error rates as the existing work gets the optimal value to obtain their needed result [10].

3. Edge Detection Techniques

Edges are essential local alterations of intensity in a digital image. An edge is a set of connected pixels that forms a boundary between two disjoint regions, such as horizontal edges, vertical edges and diagonal edges. This edge detection is a process of segmenting an image into regions of discontinuity. In this edge detection permits users to survey the features of an image for a major change in the gray level. It decreases the amount of data in an image and conserves the structural properties of an image. These edge detection operators are gradient and Gaussian. Gradient supports operator which calculates first-order derivations in a digital image like, Sobel operator, Prewitt operator and Robert operator. Gaussian base operator computes second-order derivations in a digital image like canny edge detector and Laplacian of Gaussian. The performance of existing edge

detection techniques evaluated using Berkeley Segmentation Dataset of (BSDS300). BSDS300 dataset contains 200 images for training. Additionally it consists of 100 images for testing. The five edge detection algorithms used in this research work are some of the more broadly known image detection algorithms and were preferred based on their different pros and cons.

3.1. Sobel Edge Detection

Sobel operator measures the gradient magnitude and direction at every pixel in a gray scale image. Pixels that have high scale form an edge and it's accessed by performing several manipulations to the x and y derivatives. To find the Sobel derivative subsequent to the x-direction, that performs an outer result between a one-dimensional Gaussian filter and the x derivative. The Sobel y filter is accessed by performing an outer result between a one-dimensional Gaussian filter and the y derivative. The Gaussian filter is purposed for decreasing noise that results in unclear images. Thus, the Sobel operator calculates the image gradient with low noise.

Sobel Operator [X-axis] = [-1 0 1; -1 0 1; -1 0 1]
Sobel Operator [Y-axis] = [-1 -1 -1; 0 0 0; 1 1 1]

Sobel algorithm can be describing in four steps:

Step1: Modifying the image into gray scale.
Step2: Modifying the gray image with Sobel-X filter.
Step3: Modifying the gray image with Sobel-Y filter.
Step4: Scheming the gradient magnitude and direction.

3.2. Prewitt Edge Detection

Prewitt operator identifies horizontal edges or along the x-axis, and vertical edges or along the y-axis. Anywhere there is unpredicted alteration in pixel intensities, an edge is identified by the mask. As the edge is defined as modified in pixel intensities, it can be considered by using differentiation. Prewitt mask is a first-order derivative mask. In the graph control of Prewitt-mask's result, the edge is represented by the local maxima or local minima. Both the first and second derivative masks contain these three properties, additional weight means further edge detection; the opposite sign should be current in the mask. (+ and -), the addition of the mask values must be equal to zero. Prewitt operator proposed two masks one for detecting edges in the horizontal direction and further for detecting edges in a vertical direction.

Prewitt Operator [X-axis] = [-1 0 1; -1 0 1; -1 0 1]
Prewitt Operator [Y-axis] = [-1 -1 -1; 0 0 0; 1 1 1]

Algorithm:

Step 1: Modify into gray scale if it is color.
Step2: Modify into the double format.
Step3: Describe the mask or filter.
Step4: Discover the edges along the X-axis.
Step5: Discover the edges along the Y-axis.
Step6: Merge the edges detected along the X and Y axes.
Step7: Present all the images.

3.3. Roberts Edge Detection

It presents a simple, fast to calculate, Two-dimensional spatial gradient dimension on an image. This technique highlights regions of high spatial frequency which often match to edges. The input to the operator is a gray scale image similar to the output is the most common usage for this technique. Pixel values in every point in the output signify the predictable entire scale of the spatial gradient of the input image at that point.

Roberts Operator [X-axis] = [+1 0; 0 -1]
Roberts Operator [Y-axis] = [0 -1; +1 0]

Algorithm:

Step1: Modifying the image into gray scale.
Step2: Modifying the gray image with Robert-X filter.
Step3: Modifying the gray image with Robert-Y filter.
Step4: Scheming the gradient magnitude and direction.

3.4. Laplacian of Gaussian Edge Detection

The Laplacian is typically used to establish whether a pixel is on the dark or light side of an edge. Laplacian of Gaussian of an image f(x,y) is a second order derivative described. It has two properties, it smoothes the image and it works out the Laplacian, which gives up a double edge image. Establishing edges then consists of the zero crossings among the double edges. It uses linear exclamation to verify the sub pixel position of the edge. The performance of the Log edge detector is mainly governed by the regular deviation of the Gaussian smoothing filter used in the Laplacian of Gaussian filter. In addition, smoothing may prepare edge detection tasks to be difficult. Edges can be expressed as points of high intensity gradient.

3.5. Canny Edge Detection

This method used highly efficient and various differences too many other techniques. It is a multi-stage algorithm used to classify a wide range of edges.

Algorithm:

Step1: Convolve image f(r, c) with a Gaussian function to get a smooth image
Step2: Apply first divergence gradient operator to calculate edge strength then edge magnitude and direction are found as before.
Step3: Concern non-maximal or significant restraint to the gradient magnitude.
Step4: Concern threshold to the non-maximal restraint image.

Parameter used for comparison

In this paper accuracy and specificity are used to evaluate the performance of each edge detection techniques have measured using accuracy and specificity.

Accuracy = (TN + TP)/ (TN+TP+FN+FP) = (Number of correct estimations)/ (Number of all estimations)

Specificity = TN/ (TN + FP) = (Number of true negative estimation)/(Number of all negative estimation)

Experimental Results

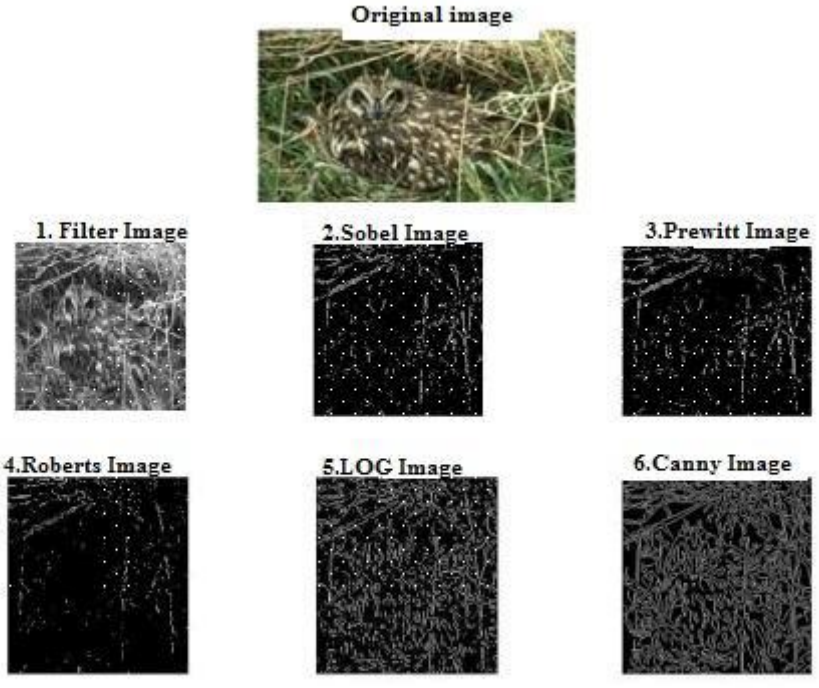

Figure1: Edge detection Techniques

Table1: Performance Evaluation of Edge detection method

Dataset	Methods	Accuracy	Specificity
BSDS300	Sobel	0.87878	0.95832
	Prewitt	0.87918	0.95869
	Roberts	0.87882	0.97012
	Log	0.84661	0.91866
	Canny	0.81724	0.89228

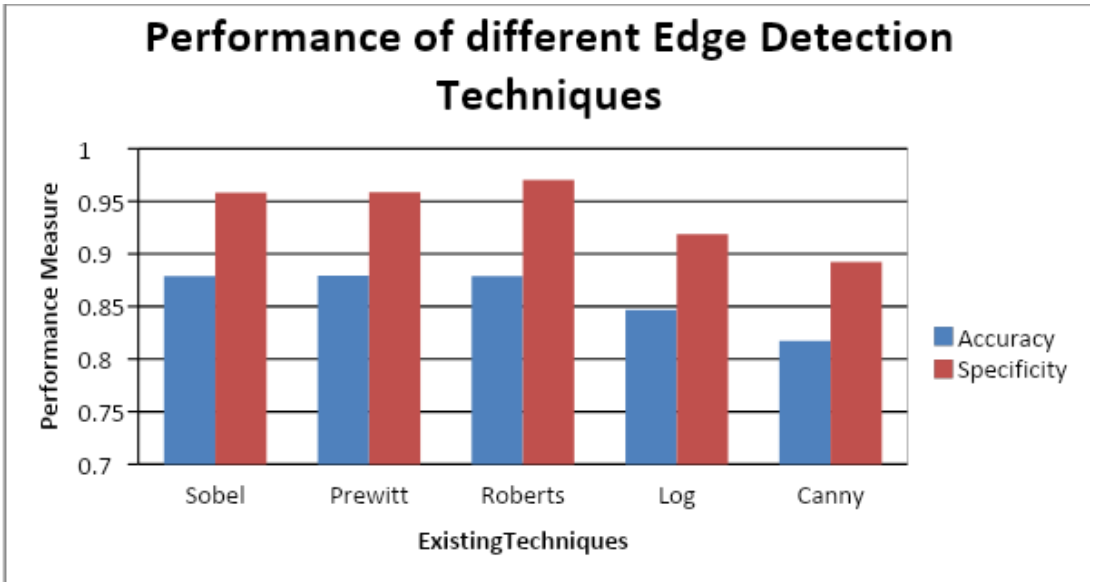

Figure 2 : Performance of different edge detection methods

Conclusion

There are five edge detection techniques such as Sobel, Prewitt, Roberts, Laplacian of Gaussian and Canny edge detection tested using the BSDS300 dataset. The performance measures such as accuracy and specificity have calculated. All the five existing edge detection techniques perform well. However, Roberts edge deduction technique generates high accuracy 87.888% specificity 97.01% .Additionally Roberts edge detection techniques works better than other existing edge detection techniques used in this research work.

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