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An Improved Approach for Edge Detection in Colored Images

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***Abstract*: Edge is defined as a sharp intensity change in a image. Edge detection is a process of detecting the presence and location of these intensity transitions. An edge detection must be efficient and reliable because in many applications there is a possibility of subsequent processing steps that depends on it. For example, Edge detection has a key role in machine vision and image understanding systems. The exact edge feature and its orientation in the image is the precondition of successful completion. But, the edge detection algorithms are sensitive to contrast, noise and uneven (or) bad illumination and correct edge detection is too difficult so classical edge detectors usually fail to handle images with dull object outline or strong noise. It is usually introduced by the transmission or compression of the image. To reduce the influence of noise, many techniques have been developed. Methods have also been proposed to approximate the image with a smooth function. A remarkable property of the proposed method is its ability to characterize the local regularity of functions. Therefore, edge detection using gradient is an effective method. To evaluate the efficiency of the proposed edge detector to noise, the Pixel density of proposed edge detector on image is computed and it is compared with traditional edge detection method.**

***Keywords*: Edge detector, gradient, pixel density, smooth function.**

1. Introduction

The Edge detection is one of the most commonly used operations in image analysis. It is a main tool in pattern recognition, image segmentation, and scene analysis. Edge is defined as a sharp intensity change in a grey image. Edge detection (ED) is a process of detecting the presence and location of these intensity transitions. An ED must be efficient and reliable because in many applications there is a possibility of subsequent processing steps that depends on it. Various Edge Detection techniques like Canny, Sobel, Prewitt and Wavelet Filters Edge Detection are required to control the noise while detecting edges in illumination varying images. Gradient based technique is proved to be very efficient in detecting the edges of the image with noise reduction. The main procedure applied to reduce the noise while detecting edges before applying the Wavelet Transform is Fourier Transform which provides the base for computation of wavelet transform. Efficiency is proved better by graphical representation in terms of Pixel density. Engineers and mathematicians developed analytic methods that were adapted to these problems, therefore avoiding the inherent difficulties in classical Fourier analysis. For this purpose, Dennis Gabor introduced a "sliding-window" technique. He used a Gaussian function g as a "window" function, and then calculated the Fourier transform of a function in the "sliding window". High level image processing applications such as object recognition, object tracking, robot vision etc. depends upon the performance of edge detection technique. Edges may be defined as boundaries between distinct regions present in a particular image and they contain the most relevant information of the image. There may be different regions present in an image which are characterized by the properties like grey level, texture, intensity etc.

In case of color image processing, Color images require more memory space for storage than grey scale images and also the transmission of color information requires a larger bandwidth. By using an efficient edge detection technique, the unnecessary details of a color image can be discarded and the useful information can be stored for further processing. This can effectively reduce the memory space for storing the color information and lower the transmission bandwidth.

The edge detection techniques can be broadly classified as:

- Edge detection in grey-scale images
- Edge detection in color images

The fundamental difference between a grey-scale image and a color image is, the pixel in a grey-scale image is a scalar valued function whereas in color image, a pixel is considered as a vector valued function as it consists of three color components (red, green and blue). Due to this, vector valued techniques are preferred for edge detection in color images.

2. Existing methods

A. *Canny edge detection*

The Canny edge detector is regarded as one of the best edge detectors currently in use, Canny's edge detector ensures good noise immunity and at the same time detects true edge points with minimum error.

The steps of Canny algorithm are as follows:

- *Smoothing:* Blurring of the image to remove noise by convolving the image with the Gaussian filter.
- *Finding gradients:* The edges should be marked where the gradients of the image has large magnitudes, finding the gradient of the image by feeding the smoothed image through a convolution operation with

the derivative of the Gaussian in both the vertical and horizontal directions

- *Non-maximum suppression:* Only local maxims should be marked as edges. Finds the local maxima in the direction of the gradient, and suppresses all others, minimizing false edges.
- *Double thresholding:* Potential edges are determined by thresholding, Instead of using a single static threshold value for the entire image, the Canny algorithm introduced hysteresis thresholding, which has some adaptivity to the local content of the image. There are two threshold levels, th, high and tl, low where th>tl. Pixel values above the th value are immediately classified as edges.
- *Edge tracking by hysteresis:* Final edges are determined by suppressing all edges that are not connected to a very strong edge.

B. Sobel & Prewitt Edge Detection

Sobel and Prewitt algorithms are widely used for image edge detection and segmentation [16]-[19].It is a discrete differentiation operator, computing an approximation of the gradient of the image intensity function. At each point in the image, the result of the Sobel–Feldman operator is either the corresponding gradient vector or the norm of this vector.

The Sobel–Feldman operator is based on convolving the image with a small, separable, and integer-valued filter in the horizontal and vertical directions and is therefore relatively inexpensive in terms of computations. On the other hand, the gradient approximation that it produces is relatively crude, in particular for high-frequency variations in the image. The Prewitt edge detector is considered to be the relevant way to calculate the magnitude and orientation of an image. Prewitt is comparably similar to Sobel operator and is widely used to detect the vertical and horizontal edges of an image. The basic idea behind edge detection is to find places in an image where the intensity changes rapidly.

3. Proposed methods

Edges correspond to locations in images where brightness undergoes a sharp change, so a naive idea would be to differentiate the image and look for places where the magnitude of the derivative I'(x) is large. That almost works. The peaks arise because of the presence of noise in the image. If we smooth the image first, the spurious peaks are diminished. The noise can be modeled with a Gaussian probability distribution, with each pixel independent of the others. One way to smooth an image is to assign to each pixel the average of its neighbors. This tends to cancel out extreme values. A weighted average that weights the nearest pixels the most, then gradually decreases the weight for more distant pixels. The Gaussian function with standard deviation σ and mean 0 is

$$N_\sigma(x)= \frac{1}{\sqrt{2\pi}\sigma}\, e^{-x2/2\sigma^2} \text{ in one dimension, or}$$

$$N_\sigma(x,y)= \frac{1}{2\pi\sigma^2} e^{-(x2+y2)\,/\,2\sigma^2} \text{in two dimensions.}$$

The application of the Gaussian filter replaces the intensity I(x0,y0) with the sum, over all (x,y) pixels, of I(x,y)Nσ(d), where d is the distance from (x0,y0) to (x,y). This kind of weighted sum is so common that there is a special name and notation for it. We say that the function h is the convolution of two functions f and g (denoted f∗g)

$$h(x)=(f*g)(x)=\sum_{u=-\infty}^{\infty} f(u)g(x-u)$$

$$h(x,y)=(f*g)(x,y)=\sum_{u=-\infty}^{\infty}\sum_{u=-\infty}^{\infty} f(u,v)g(x-u,y-v)$$

So the smoothing function is achieved by convolving the image with the Gaussian, I ∗Nσ. A σ of 1pixel is enough to smooth over a small amount of noise, whereas 2 pixels will smooth a larger amount, but at the loss of some detail. Because the Gaussian's influence fades quickly at a distance, we can replace the ±∞ in the sums with ±3σ.

We can optimize the computation by combining smoothing and edge finding into a single operation. It is a theorem that for any functions f and g, the derivative of the convolution, (f ∗ g)', is equal to the convolution with the derivative, f ∗ (g'). So rather than smoothing the image and then differentiating, we can just convolve the image with the derivative of the smoothing function, N'_σ. We then mark as edges those peaks in the response that are above some threshold. Once we have marked edge pixels by this algorithm, the next stage is to link those pixels that belong to the same edge curves. This can be done by assuming that any two neighboring edge pixels with consistent orientations must belong to the same edge curve.

4. Results

Fig. 1. Original image

Fig. 2. Canny edge detected image

Fig. 3. Sobel edge detected image

Fig. 4. Prewitt operator edge detected

Fig. 5. Proposed method edge detected image

5. Result analysis

The Experimental analysis of presented work is performed using the concept of Pixel Density. This value is calculated by counting the number of pixels in the edge detected image i.e. a binary image (where each pixel is either black or white) that are greater than 0, or in other words calculate the number of pixels whose value is white.

Pixel Density for the above edge detected image

Table 1
Experimental results

Canny	Sobel	Prewitt	Proposed
20114	96709	18401	44555

Although the Pixel Density of Sobel is greater than the proposed method it is clearly visible that the Sobel method has added noise to the edge detected image. The Proposed method thus gives a better result in comparison with all other methods.

6. Applications

The introduced algorithm can be utilized at different applications such as boundary detection, color segmentation and objects classification. Different regions of interest can be extracted from other background colors and analysed independently. Also, the ability to distinguish the edges of different color layers based on RGB intensity values of interest may serve as a significant tool in text recognition at uneven colored light conditions.

7. Conclusion

The proposed edge detection method works efficiently on color images in detection actual edges. Color edge operators are able to detect more edges than gray-scale edge operators. Thus, additional features can be obtained in color images that may not be detected in gray-scale images. However, it depends on the application (and the class of images) whether these color edge features are required. To extract the visual information necessary for the tasks of manipulation, navigation, and recognition, intermediate representations have to be constructed. Proposed edge detection algorithm extract features from the image, such as edges. Classical edge detectors like Roberts, Sobel, Prewitt, Canny and Laplacian operators fail to detect edges in color images. Edge detection is an important field in image processing, machine vision and computer vision, particularly in the areas of feature detection and feature extraction, which aims at identifying points in a digital image at which the image brightness changes sharply or, more formally, has discontinuities. The proposed method can also be extended to apply in various higher level image processing applications.

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