Comparative Study of Prewitt and Canny Edge Detector Using Image Processing Techniques

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Abstract Medical image processing provides the information regarding the detection of brain tumor. Image processing techniques are used to find out the brain tumor with the help of various steps. The steps are image acquisition of MRI images, image preprocessing, image enhancement which improves the quality of image, feature extraction and classification. Edge detection is a process of classifying and perceiving shrill cutouts in an image. The disjointedness is unforeseen deviation in pixel strength gray-level value. Edge detection is an important technique in many image processing applications such as object recognition, motion analysis, pattern recognition and medical image processing. In this manuscript various edge detection techniques are discussed. This paper shows the comparison between Prewitt and Canny operators with various images to extract edge of objects in the images. Comparison of these edge detectors shows that Canny produced the sharpest images and produced the best continuity of the edge lines. Results also show that Canny produces sharpest and clear edge than Prewitt.

Keywords Edge detectors · Image processing · Canny · Prewitt · Edge detection

1 Introduction

Edge detection is one of the most important procedures that has been commonly executed in image processing. In image processing it is used for segmentation, registration and identification. The concept of the edge in an image is the greatest vital

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feature of the image because the edge contains valuable information about the internal objects inside image. Hence, edge detection is one of the key research works in image processing. Edge detection of an image is a very significant step in the direction of understanding image features. Therefore, other image processing claims such as segmentation, identification and object recognition can yield whenever edges of an object are detected. There are some techniques developed to achieve this task, such as Sobel, Prewitt, Laplacian, Laplacian of Gaussian (LOG) and Canny which are used to be the ideal edge detectors.

Edge detection is tough to implement in piercing images, subsequently both noise and edges cover high frequency gratified. Edge detection operator that wants to be selected should be approachable to steady change which is a consequence of refraction or from deprived concentration of the entity with limitations. This averts problems of incorrect edge detection, misplaced factual edges, edge localization and high computational time. Hence the objective for comparison of edge detection techniques and analysis of the performance are discussed in this manuscript under different conditions. An idea behind writing this paper is to show the different edge detection methods and difference between them. This section contains the introduction. Section 2 contains literature review of the research work. Section 3 contains edge recognition overview. Section 4 contains background which discuss the gradient and Laplacian edge detector. Section 5 contains steps involved in the edge detection. Section 6 contains execution which shows the images that contain different edge detectors. Section 7 concludes on details of edge detection methods.

2 Literature Review

Hemasundara Rao et al. [1], in their research paper, focus on detecting the brain tumor region with the help of preprocessing, edge detection and segmentation methods. They also used the K-means clustering to improve the result of brain tumor identification by using this methodology. Telrandhe et al. [2] used the K-means clustering and SVM to increase the accuracy in the brain tumor detection after preprocessing, and feature extraction method. The result improved due to the support vector machine. Pande et al. [3] developed a system on 2D MRI data which identifies the data of tumor. The authors developed an automated tool for the brain tumor detection. They used noise removal function to remove the noise from the given MRI images, and also used the water shade segmentation to detect the brain tumor. The accuracy improved by using their proposed technology. Hemanth et al. [4] developed brain tumor identification system by using fuzzy methodology. They used fuzzy clustering for accurate brain tumor detection system used in abnormal brain image segmentation. This method gives better accuracy in the brain tumor recognition system. Angel [5] proposed the procedure for identification by using CAD system with water shade algorithm. They used 2D and 3D for enhancing the shapes of brain tumor. Naga Rajuet proposed an edge detection algorithm based on multi-structure elements morphology. The eight different edge detection results are obtained by using morphology gradient

algorithm and final edge [6] results are obtained by using synthetic weighted method [7]. Mitra Basu presented a survey of Gaussian-based edge detection techniques. This described in a gray-level image of an edge. Edge detection is the process which detects the presence and locations of these intensity transitions [8].

3 Edge Recognition Overviews

There are certain types of edge variables involved in choosing a sensitive edge detector. They include:

- Edge orientation: The geometry of the operator regulates a distinctive way in which it is most complex to edges. Operator can be adjusted to look for horizontal, vertical or diagonal edges.
- Noise environment: Edge detection is diverse in noisy images. Meanwhile, both noise and edges contain high-frequency gratified effort to reduce the noise effect in blurred and partial edges. Operators use of noisy images are naturally greater in space, so they can usual adequate data to markdown limited noisy pixels. This results in a smaller amount of exact localization of the separated edges.
- Edge structure: Not completely edges contain stage modification in strength belongings such as refraction or poor focus can result in objects with restrictions defined by gradual alteration in intensity. The operator needs to be responsive to such gradual change so that we do not have problems of false edge detection, missing true edges, edge localization and high computational time. Edge detection is one of the most frequently used techniques in digital image processing. The boundaries of object surfaces in a scene often lead to oriented localized changes in intensity of an image called edges. Edge detection is a difficult task, hence the objective for the comparison of various edge detection techniques and analysis of the performance of the various techniques under different conditions is considered in this paper.

4 Background

Edges consist of expressive, significant data and features. Applying an edge sensor to an image may lessen the amount of data to be handled and may filter out data that may be observed as less applicable, although conserving the mechanical belongings of an image. The vital idea of the mainstream edge detectors is to regulate approximately border data in an image that denotes the image's interior objects. Edge is a set on connected pixels that lie on the boundary between two regions. Also, an edge in an image is a contour across which the brightness of the image changes suddenly in amount. Edge refers to the pixel set whose gray level or gradient direction suddenly changes and usually evinces linear feature.

Commonly, an edge is defined as the marginal pixels that connect two mutually exclusive regions that differ in their luminance and tristimulus values. The edge of an object is reflected in the discontinuity of the gray [9]. Hence, the fundamental method of edge detection is the local operator edge detection method. In this method, pixel in a region must be compared with its neighbors for the differences in order to detect the edge. The detection operation starts with the inspection of the local discontinuity at each pixel in the region. Consequently, the determination of an edge is based on some characteristics that are amplitude, location and orientation of a region. Therefore, based on these characteristics, the investigator has to examine each pixel to determine whether it is an edge or not [10].

There are many ways to perform edge detection, however, majority of the different methods can be grouped into two major categories:

- Gradient: The gradient method detects the edges by looking for the maximum and minimum in the first derivative of the image.
- Laplacian: The Laplacian method searches for zero crossing in the second derivative of the image to find edges.

5 Steps Involved in Edge Detection

Edge detection consists of three major steps, which are filtering, enhancement and detection.

- Filtering: Images are often corrupted by noise which is a variation on intensity values; common types of noise are salt and pepper, impulse and Gaussian noise. Salt and pepper noise contains random variation of both black and white intensity values. However, more filtering is done to reduce noise, which results in loss of edge strength.
- Enhancement: To facilitate the detection of edges, it is important to determine changes in intensity in the neighborhood of a point. Enhancement emphasizes pixels where there is significant change in local intensity values and it is performed by computing the gradient magnitude.
- Detection: Points in an image have a non-zero value for the gradient and not all of these points are edges for a particular application. So, a method is created to determine which points are edge points. Frequently, thresholding provides the criteria used for detection [11].

5.1 Edge Detection Systems

There are different edge detection techniques available and the compared ones are as follows:

- Prewitt detection: The Prewitt operator is similar to the Sobel operator and it is used for detecting vertical and horizontal edges in images. The Prewitt edge detector is an appropriate way to estimate the magnitude and orientation of an edge. The Prewitt operator is limited to eight possible orientations although most direct orientation estimates are not exactly accurate. The Prewitt operator is estimated in the 3×3 neighborhood for eight directions. The entire eight masks are calculated, and then the one with the largest module is selected.

−1	+1	+1
−1	−2	+1
−1	+1	+1

+1	+1	+1
−1	−2	+1
−1	−1	+1

- Canny operator: Among the already discussed edge detection algorithms, the Canny edge detection algorithm is widely used. In 1986 [12], John Canny defined a set of goal for edge detection and described an optimal method for achieving them. Canny specified three issues that an edge detector must address. They include:
  - Good detection (low error rate): The edge detector should respond only to edges and should find all of them; no edges should be missed. This is explained by the following equation:

$$\text{SNR} = \frac{\vdots \int_{-w}^{w} G(-x) f(x) dx \vdots}{\sqrt[no]{\int_{-w}^{w} f^2(x) dx}}$$

    where f is the filter, G is the edge signal; denominator is the root-mean-squared (RMS) response to noise $n(x)$ only.
  - Good spatial localization: The distance between the edge pixels as found by the edge detector should be possible. It measures the increase as localization improves using the reciprocal of the root-mean-squared distance of the marked edge from the center of the true edge; it is expressed by the following equation:

$$\frac{1}{\sqrt{E\left[x_0^2\right]}}$$

- Good response rate: The edge detector should identify multiple edge pixels where only a single edge exists. There is only one response to a single edge. This is implicit in the first criterion, but made explicit to eliminate multiple responses. The first two criteria can be trivially maximized by setting $f(x) = G(-x)$. A typical implementation of the Canny edge detector follows the below steps:

– Smooth the image with appropriate Gaussian filter to reduce desired image details.
– Determine gradient magnitude and gradient direction at each pixel.
– If the gradient magnitude of a pixel is larger than those of its two neighbors in the gradient direction, mark the pixel as an edge; otherwise mark the pixel as the background.
– Remove the weak edges by hysteresis thresholding to ensure that closed edge contours are obtained and one may use the zero crossings of the Laplacian of Gaussian (LOG) of the image.

6 Execution

Before feature extraction edge detection has taken place. Given below are the sample original images and edge detected images.

Edge detection was performed on the image shown in Fig. 1 as original image. This was done using MATLAB 8.0 (R2013a) and the three algorithms discussed above were all implemented on that image. The result of these algorithms is shown in Fig. 1. Figure 2 shows the result of Prewitt edge detector. Figure 3 shows the result of Canny edge detector. Figure 4 shows the result of Canny and Prewitt edge detectors.

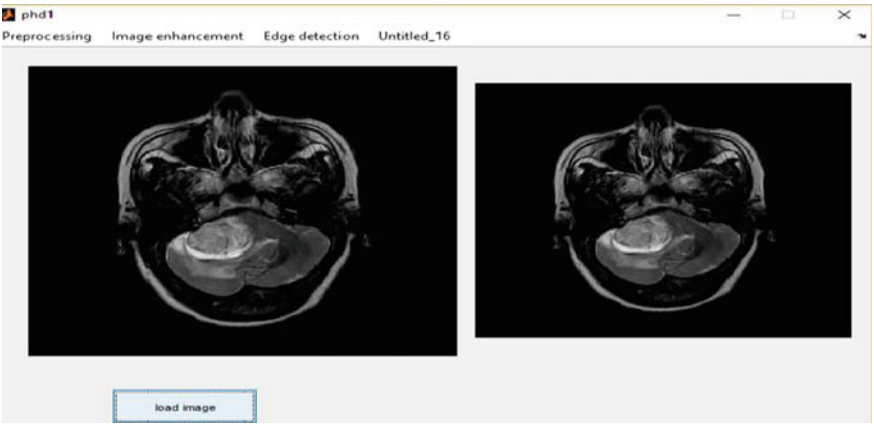

Fig. 1 Original image is converted in RGB to gray

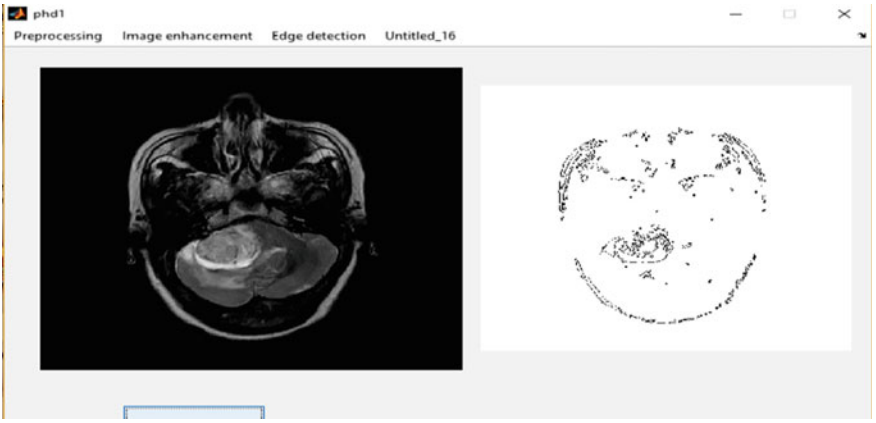

Fig. 2 Result of Prewitt edge detector

Fig. 3 Result of Canny edge detector

Fig. 4 Difference between Canny and Prewitt edge detector

7 Conclusions

This paper discussed edge detection as one of the furthermost imperative techniques that has been usually applied in image processing. It is used in image segmentation, registration and identification of image processing. It is very important to know the differences between edge detection techniques. In this paper we studied the most commonly used edge detection techniques of gradient-based and Laplacian-based edge detection. The software is developed using MATLAB 8.0 (R2013a).

Gradient-based algorithms such as the Prewitt filter have a foremost weakness of being very delicate to noise. The presentation of the Canny edge detection algorithm hangs on profoundly on the variable parameter sigma (•).

Cranny's edge detection algorithm is computationally more exclusive and associated to Canny and Prewitt operators. However, the Cranny's edge detection algorithm accomplishes improvement than Prewitt operator under all states. Valuation of the images presented under noisy conditions shows that Canny displays better performance than Prewitt.

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