Implementing Edge Detection For Medical Diagnosis of a Bone Fracture

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Abstract-In the field of medical sciences, there are a number of instruments and software's developed to help the doctors and the surgeons cure the patients by supporting them with high technical expertise. A bone's integrity suffered with breakdown is known as fractured bone. Edges of an image are considered a type of key information that can be extracted by applying detectors with different methodology. Edge detection is a basic and important subject in an image processing and computer vision. In this Paper we discuss many Digital Image Processing Techniques applied in edge feature extraction. For finding out the accuration of an X-Ray we analyzed some edge detection operators, by comparing them It is found that the canny edge detection operator can obtain better edge feature. Canny Edge Detection method is an optimal edge detection algorithm on determining the end of a line with less error rate and changeable threshold. The results have shown how canny edge detection can help determine location of fractures in x-ray images.

Key words: Fracture, Edge, Edge Detection, Canny, x-ray images.

1.INTRODUCTION

In day to day life many such cases occurs in which minute hair line fracture may not get noticed in the X-ray by the Doctors in such cases Bone fracture detection using Digital Image Processing will help the doctor to avoid such errors. Digital image processing is an expanding area with application regarding to our daily lives, especially in progressive transmission of images video coding, digital libraries image database, remote sensing, and other image database, remote sensing, and other and analysis techniques have been developed to aid the interpretation of remote sensing images and to extract as much information as possible from the image. The huge collection of digital images are collected due to the improvement in the digital storage media, image capturing devices like scanners, web cameras, digital cameras and rapid development in internet. This leads to rapid and efficient retrieval of these images for visual information in different fields of life like medical, medicine, education, art, architecture, crime preventions, etc[1].

In the recent year the medical imaging field has grown substantially and has generated additional interest in methods and tools for management, analysis, and communication of medical image. Many diagnostic imaging modalities, such as x-ray, digital radiography, magnetic resonance imaging (MRI) and ultrasound are currently available and are routinely used to support clinical decision making.

In the present study, comparative analyses of different edge detection operators are presented. It has been observed from the present study that the performance of canny edge detection operator is Much better than Sobel,Roberts, Prewitt, Zero crossing and LOG (Laplacian of Gaussian) in respect to the object boundary localization and image appearance. The software tool that has been used is MATLAB[2].This image processing system use MATLAB(matrix laboratory) and Canny Edge Detection Method that expected to minimize error on detecting bone fracture. MATLAB is open source with all essential features [3].

This paper will focus on canny edge detection that help radiologist in diagnosis. Radiologist frequently experiencing difficulty on reading x-ray image. This can be caused by the lack of lighting, noises that happened on image capturing process or fractures the hardly seen by naked eyes. By building the system, we hope the system can help people especially radiologist on detecting bones anomaly that happened on x-ray images [4].

2.CONCEPT

A. Image Processing

Image Processing is a technique in which the data from an image are digitalized and various mathematical operations are applied to the data, generally with digital computer.

B. Edge orientation

Orientation of edge pixels implies their direction. An edge may have a vertical orientation (pixels on a vertical line/curve) or a horizontal orientation (pixels on a horizontal line), or it may be slanted. The edge orientation can be represent by an angle (in degrees or radians).

C. Noise environment

Edge detection is very difficult in noisy images, since both the noise and the edges contain high-frequency content. Try to lessen the noise result in blurred and distorted edges. It results in less accurate localization of the detected edges. Operators applied to noisy images are generally larger in scope, so they can average enough data to discount localized noisy pixels [5].

D. Edge structure

Not absolutely all edges involve an action change in intensity. Effects such as refraction or poor focus can lead to objects with boundaries defined by a gradual change in intensity. The operator must be chosen to be attentive to this type of gradual change in those cases. Newer wavelet-based techniques [6] actually characterize the type of the transition for every single edge in order to distinguish, for example, edges connected with hair from edges associated with a face.

3.EDGE DETECTION TECHNIQUES

3.1 Existing Techniques

3.1.1 Sobel Operator

It had been invented in 1970 [7]. The Sobel operator performs a 2-D spatial gradient measurement on a picture and so emphasizes elements of high spatial gradient that correspond to edges. Typically it's used to get the approximate absolute gradient magnitude at each point in an input gray-scale image.

In theory at the very least, the operator contains a set of 3×3 convolution kernel as shown in Figure 4 [8]. One kernel is merely the other rotated by 90° ;.That is very similar to the Roberts Cross Operator.

$$Gx=\begin{bmatrix}-1 & 0 & 1\\ -2 & 0 & 2\\ -1 & 0 & 1\end{bmatrix} : Gy=\begin{bmatrix}1 & 2 & 1\\ 0 & 0 & 0\\ -1 & -2 & -1\end{bmatrix}$$

Fig-1 : Sobel convolution kernel

These kernel are made to respond maximally to edges running vertically and horizontally relative to the pixel grid, one kernel for each of the two perpendicular orientations. The kernel may be applied separately to the input image, to make separate measurements of the gradient component in each orientation (call these Gx and Gy). These can then be combined together to get the absolute magnitude of the gradient at each point and the orientation of this gradient. Advantage of Sobel operator is that, sobel kernals are more suitable to detect edges over the horizontal and vertical axes. Disadvantage of the Sobel operator, it places focus on pixels that are closer to the center of the kernel.

3.1.2 Prewitt Operator

It had been invented in 1970 [7]. The Prewitt edge detector is a proper method to estimate the magnitude and orientation of an edge. Although differential gradient edge detection requires a rather time intensive calculation to estimate the orientation from the magnitudes in the x and y-directions, the compass edge detection obtains the orientation from the kernel with the maximum response. The Prewitt operator is restricted to 8 possible orientations, however experience shows that a lot of direct orientation estimates aren't a lot more accurate. This gradient based edge detector is estimated in the 3x3 neighborhood for eight directions as in Figure 5. All of the eight convolution kernel are calculated. One convolution kernel is then selected, namely that with the largest module[9].

$$Gx=\begin{bmatrix}-1 & 0 & 1\\ -1 & 0 & 1\\ -1 & 0 & 1\end{bmatrix} : Gy=\begin{bmatrix}1 & 1 & 1\\ 0 & 0 & 0\\ -1 & -1 & -1\end{bmatrix}$$

Fig-2 : Kernel for the Prewitt gradient edge detector

Advantage of this operator is that it generally does not place any focus on pixels that are closer to the center of the kernel. Disadvantages are Sensitivity to noise and Inaccurate.

3.1.3 Roberts Operator

It had been invented by Larry Roberts in his 1962 Stanford Thesis. In Robert cross algorithm the horizontal and vertical edges bring out individually and chances are they assembled for the resulting edge detection. The Roberts operator performs an easy, quick to compute, 2-D spatial gradient measurement on an image. It thus highlights elements of high spatial gradient which often correspond to edges. In its most frequent usage, the input to the operator is a grey-scale image, as is the output. Pixel values at each point in the output represent the estimated absolute magnitude of the spatial gradient of the input image when this occurs [9].

In theory, the operator contains a set of 2×2 convolution kernel as shown in Figure 2.One kernel is merely the other rotated by 90° ;.That is very similar to the Sobel operator.

$$Gx = \begin{bmatrix}+1 & 0\\ 0 & -1\end{bmatrix} ; Gy = \begin{bmatrix}0 & +1\\ -1 & 0\end{bmatrix}$$

Fig-3 : Roberts Cross convolution kernel

These kernel are made to respond maximally to edges running at 45° to the pixel grid, one kernel for each of the two perpendicular orientations. The kernel may be applied separately to the input image, to make separate measurements of the gradient component in each orientation (call these Gx and Gy) [8]. These can then be combined together to get the absolute magnitude of the gradient at each point and the orientation of this gradient. Robert's operator has the main advantage of providing an easy approximation to the gradient magnitude and is able to detect edges run over the vertical axes of 45 degree and 135 degree. However, its accuracy is low because as the gradient magnitude of the edges decreases, which most likely decreases the accuracy. Also Robert's cross kernel are relatively small, they are highly susceptible to noise in the detection of the edges and their orientations. The escalation in the noise to the image will ultimately degrade the magnitude of the edges.

3.1.4 Laplacian Of Gaussian

It absolutely was invented by Marr and Hildreth in 1980[10] .The Laplacian is really a 2-D isotropic measure of the 2nd spatial derivative of an image. The Laplacian of a graphic highlights regions of rapid intensity change and is therefore often used for edge detection. The Laplacian is usually applied to a graphic that has first been smoothed with something approximating a Gaussian Smoothing filter to be able to reduce its sensitivity to noise. The operator normally has a single gray level image as input and produces another gray level image as output.

$$\begin{bmatrix}1 & 1 & 1\\ 1 & 8 & 1\\ 1 & 1 & 1\end{bmatrix} \qquad \begin{bmatrix}-1 & 2 & -1\\ 2 & -4 & 2\\ -1 & 2 & -1\end{bmatrix}$$

Fig-4 : Three commonly used discrete approximations to the Laplacian filter.

Because these kernels are approximating another derivative measurement on the image, they're very sensitive to noise. To counter this, the image is usually Gaussian Smoothed before applying the Laplacian filter. This pre-processing step reduces the high frequency noise components ahead of the differentiation step. Actually, since the convolution operation is associative, we could convolve the Gaussian smoothing filter with the Laplacian filter to begin with, and then convolve this hybrid filter with the image to accomplish the required result. Doing things in this way has two advantages: Since both the Gaussian and the Laplacian kernels are generally much smaller compared to the image, The LoG (`Laplacian of Gaussian') [11] kernel can be pre-calculated in advance so only one convolution needs to be performed at run-time on the image.

Laplacian of Gaussian has the advantages to finding the right places of edges, testing wider area round the pixel and Disadvantages are: Malfunctioning at the corners, curves and where in actuality the gray level intensity function varies and it doesn't locating the orientation of edge due to using the Laplacian filter.

3.2 Proposed Technique

3.2.1 Canny Edge Detector

The Canny edge detector is an edge detection operator that uses a multi-stage algorithm to detect edges in image. It was developed by John F. Canny in 1986. Canny produced a computational theory of edge detection explaining how the technique works.

Edges are most important image attributes that provide valuable information for human image perception. Edge detection is a very complex process affected by deterioration due to noise [12]. An edge is the boundary between the background and an object. Edge detection is characteristic points during a digital image at that the image brightness changes sharply or formally has discontinuities. The purpose of detecting sharp changes in image brightness is to capture important events and changes in properties of the image [12].

Edge detection is used for identification of blurred frame among rough and smooth surface of cement and asphalt. Canny uses two thresholds to find the continuous edges in image. The Canny edge detection is performed with the sensitive threshold values (upper threshold 10000 and lower threshold 4900) and again it is performed with the insensitive threshold values (upper threshold 50000 and lower threshold 9800) [12]. If a pixel has a gradient greater than the upper threshold value, then it is an edge pixel. If a pixel has a gradient lower than the lower threshold value then it is not an edge pixel. If the pixel's gradient is between the upper and the lower threshold values then it is considered as an edge, only if it is connected to a pixel that is above the high threshold value as given above [13,14].

There are several criteria on edge detecting that can be fulfilled by Canny Edge Detection

(a) Good detection - There should be a high probability to mark real edge points, and low probability of falsely marking nonedge points. So we need to mark as many real edges as possible.

(b) Good localization - The points marked out as edge points by the operator should be as close as possible to the centre of the real edge. Operator should be capable of producing minimum gap between detected edge and the real image edge.

(c) Minimal response – there should be only one response to a certain edge. If there are two responses to the same edge then one of them must be considered false. So, the essence is that an edge should be marked only once and image noise should not create false edges.

(d) Image noise reduction.

(e) More sophisticated algorithm and models on morphological image process.

The Process of Canny edge detection algorithm has 5 different steps are as follows:

Step 1: Apply Gaussian filter to remove the noise and making the image smooth.

Step 2: Find intensity gradients of the image.

Step 3: Apply non-maximum suppression to minimize the emerging edge line.

Step 4: Apply upper and lower threshold to determine potential edges.

Step 5: Track edge and finalize the detection of edges by suppressing all the other edges that are weak and not connected to strong edges.

3.2.2: System Overview

Here, we discussed the System overview of this program in detail. The next figure show the flowchart of system design. It explains the process flow from detecting X-ray image until producing the bone fracture detection on the X-ray image.

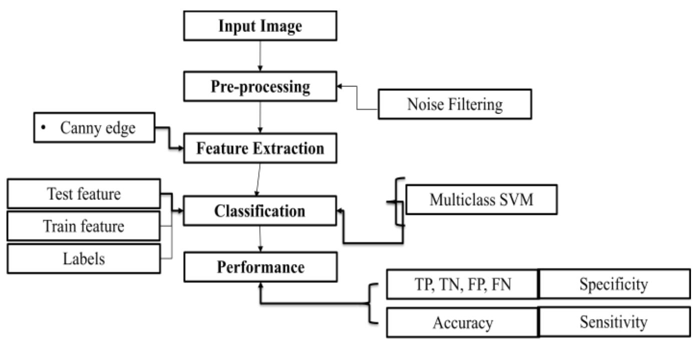

Fig-1 : Flowchart System

Here is an explanation of the performance of the system:

1. First user must input an image to be processed; the image will then be carried filtering to remove noise from the image.
2. After image filtering process, Noise reduction is done by filtering is applied to the sputum image to remove any impulse noise present in the image.
3. Filter image after noise reduction is applied to, Canny edge detection is a technique to extract useful structural information from different vision objects and dramatically reduce the amount of data to be processed.
4. In the Classification step, the implementation of the Matching process is done to detect the crack is present in the image or not.
5. In next step, the performance of the process was evaluated by means of the accuracy, sensitivity and specificity.

5.RESULT

To clarify the performance of the system, we decided to process the more images. Here is an example of the results of the image processing

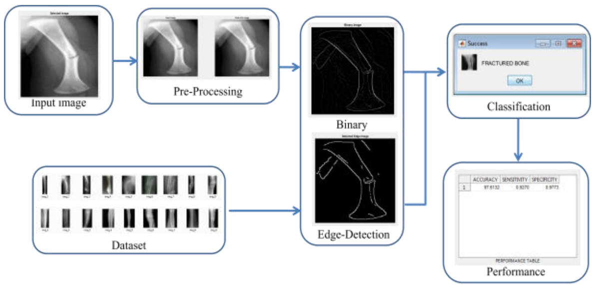

Fig-2 : Flow Diagram

After attempts to detect the location of the fracture, the results of the experiments are summarized in following Table.

Table -1: Result of Fracture Detection

Sr. No.	Image	No.of Pixels	Fracture Size	Classification
1	F1	11717	26mm	Major
2	F2	23232	34mm	Major
3	F3	13065	26mm	Major
4	F4	2611	12mm	Hairline

Table shows the number of results for the bone fracture detection.

6.CONCLUSION

This Paper presented the Canny Edge detection method to assist radiologist in detecting fractured bones from x-ray images. It has been tested with real data. Previous study shows that the system need to improve it's performance and reduce the response time.

There are problems of missing true edges, false edge detection, producing thin or thick lines and problems due to noise etc.

Prewitt filter have a drawback of being very sensitive to noise. The size of the kernel filter and coefficients are fixed that's why they cannot be adapted to a given image. Sobel edge detection method is not able to produce smooth and thin edge compared to canny method.

An adaptive edge-detection algorithm is required to provide a robust solution that is adaptable to the varying noise levels. According to the test result a conclusion can be made that the performance and accuration of the detection method is affected by the quality of the image. If the image quality is better than the system gets better result.

The performance of the Canny algorithm depends on the adjustable parameters which is the standard deviation for the Gaussian filter. It also controls the size of the Gaussian filter. Canny's edge detection algorithm is computationally more expensive than the Sobel, Prewitt and Robert's operator. However, the Canny's edge detection algorithm performs better than all these operators under all scenarios. At the time of evaluating the images, it is proved that under noisy condition Canny, LoG, Sobel, Prewitt, Roberts's exhibit better performance, respectively. This method is not easily disturbed by noise and can keep the good balance between edge detection and noise. It can also detect the true weak edges with smooth continuous pixels.

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