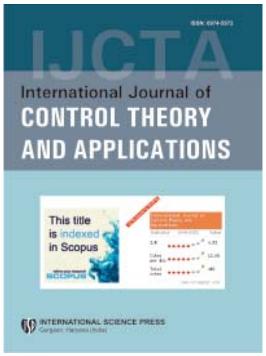

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Computerized Fracture Detection System using *x*-ray Images

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Abstract: An orthopaedician examines *x*-ray images to detect the fracture in bones. Due to lack of clarity in images or because of an over sight the orthopaedician might go wrong in the diagnosis of the fracture. Everything around is computerized in today's world. Now-a-days image processing techniques are used in many applications in medicine. One of its major applications is fracture detection. This paper discusses computerizing fracture detection in bone from *x*-ray images, which makes an orthopaedician's work easy and also helps him in diagnosing the fractured part more accurately in least possible time. In further sections of this paper, steps like loading the image into the system, pre-processing,segmentation and finally the fracture detection of the bones are involved. To improve the effectiveness and usage of this system, a Graphical User Interface (GUI) is also designed. This paper completely uses MATLAB 8.5.0 (R2015*a*).

Keywords: *Image processing, x-rays, fracture detection, feature extraction.*

1. INTRODUCTION

The medical condition where there is a dislocation or the gap in the bone is termed as a bone fracture. Usually, fractures occur when there's intense pressure or stress on the bone. Most of the fractures are due to accidents or because of a fall. To detect fractures, *x*-rays are most commonly used. They play a major role in fracture detection, diagnosing the type of fracture and its treatment. Sometimes fractures are not visible in the *x*-rays due to low resolution, then the orthopaedicians would suggest for MRI or CT scans. Though the MRI and CT scans give the most reliable and high-quality images, *x*-rays also give good quality images at a low price. Except for few types of fracture, many of them can be detected by using *x*-rays only [1].DICOM, the standard format for the storage of medical images which includes text.

There might be a case where an orthopaedician might miss detecting a fracture after looking through many healthy bone *x*-ray images. This is where automatic fracture detection is important and it plays a very major role in reducing the work for the radiologist by increasing the accuracy of fracture detection as well [2]. This paper's main aim is to detect the fractured bone and the location of the fracture following a series of steps. The steps involved are image enhancement, edge detectionand feature extraction are described in the coming sections.

2. LITERATURE SURVEY

Image enhancement involves reduction of noise and image sharpening to improve the image quality. Images contain the noises like Poison, Speckle and Gaussian noises. The papers [3,4],use the filters like median, average, Gaussian, log, Wiener to obtain a noise-free image.

Contrast enhancement of images has a significant part in medical applications. Different techniques and algorithms like Gamma Correction (GC),Linear Stretch, Convolution mask enhancement, Region based enhancement, Histogram Equalization(HE), and Contrast Limited Adaptive Histogram equalizer (CLAHE) are used [5,6,7,8] for enhancement of contrast in medical images.

The authors of [9],used Classification fusion methods for fracture detection. Classifier fusion is a method in which fractures are detected by combining the results of different classifiers. An enhanced method of segmentation is used for extracting the structure of bone and diaphysis from the x-ray images in [10]. The paper [11] proposes a new morphology gradient based image segmentation algorithm which helps in detecting the radius of the edges that are fractured on providing the lower and upper limits of the threshold. This gradient edge focuses mainly on the area of the gray level which appears only in the fractured area.Neural Networks can be used to detect the fractured region [12]

This paper [13], describes a method which is used for computerized detection of fractured area. The covering fractured region, the skeleton diagram are superposed to find the area of the fracture. The authors of [14], used methods like Active Contour Model, Geodesic Active Contour Model for boundary detection and hence fracture detection. In [15], shape detection algorithm is used for fracture detection and also used different colored point detection to identify the type of fractures like hairline or major.

3. METHODOLOGY

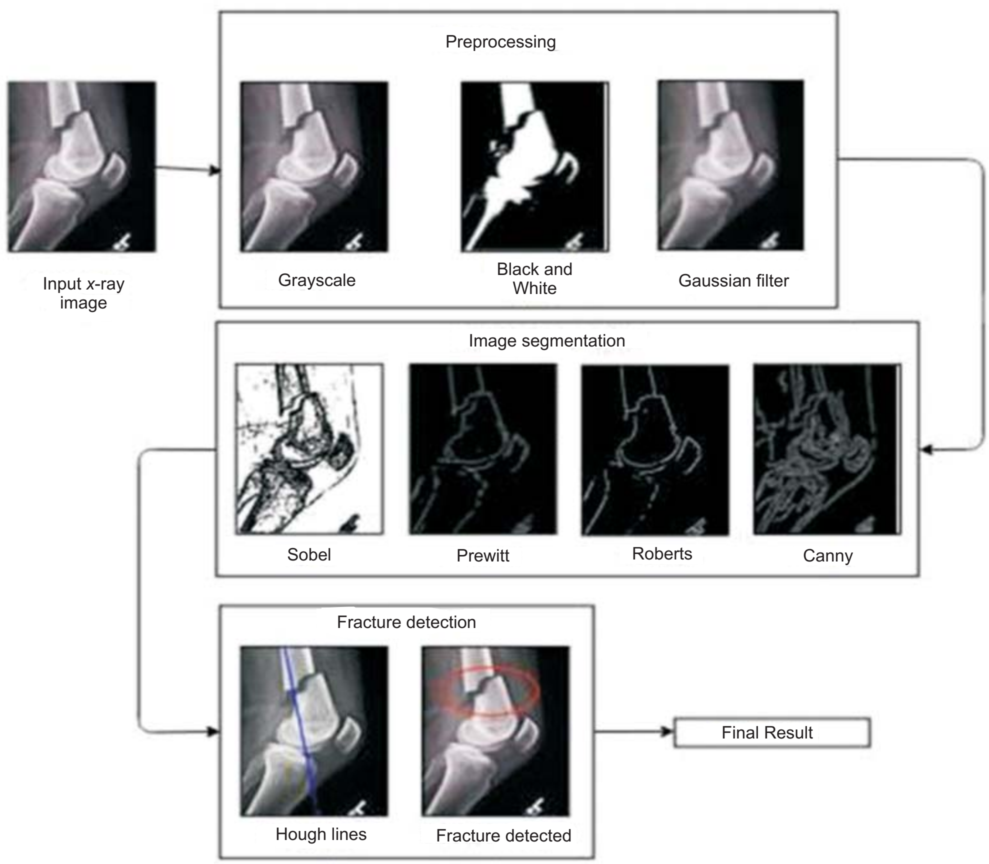

Figure 1: Flow Diagram representation of the proposed system

This section of the paper describes the overall design of the system which detects the fractured bones. The design involves preprocessing of images, image segmentation and finally the part of bone fracture detection phases. Figure 1 describes the flow chart of this system.

In order to detect the bone fracture, firstly, an *x*-ray image should be taken as input.

3.1. Preprocessing

Image preprocessing is a phase in which the errors of image data which is recorded using the *x*-ray sensors are controlled with respect to brightness values and geometry of the pixels. This phase is for lessening noise in images, highlighting the edges and to display images. Resolution and contrast enhancement are included in enhancement phase. Here, an *x*-ray image which is loaded into the system as input is converted into a grayscale image. The most common noise found in *x*-rays is the Gaussian noise which can be removed by using the Gaussian filter. The edge and smoothness of the image are left undisturbed. In order to get smoother and a wide Gaussian filter, a larger σ is to be used. A standard image with no noise is the output of this phase.

3.2. Image Segmentation

The major goal of segmenting an image is to resolve the representation of that image, to an image which is easy to analyze. In images, it is mainly used for object and boundary location. Face detection and recognition, traffic control systems, fingerprint recognition are few applications of image segmentation. To determine the boundaries of objects in images, edge detection plays a vital role. This paper implements Prewitt, Roberts, Log, Sobel and Canny edge detection algorithms and compares the results obtained. The results obtained depicts that Sobel edge detector which has high-speed efficiency when compared to the results of the canny edge detector.

3.3. Sobel Edge Detection

This edge detection is developed by Irwin Sobel and Gary Feldman and hence is named after them. This Sobel operator convolves two 3 × 3 kernels with the initial image to compute the derivative approximations. Out of them, one kernel is used for logging the horizontal changes and the other is used for logging vertical changes. Let the initial image be defined using A and then G_x, G_y be two images which at both points contain the horizontal and vertical derivative calculations separately. Those calculations are done below:

$$G_x = \begin{bmatrix} -1 & 0 & +1 \\ -2 & 0 & +2 \\ -1 & 0 & +1 \end{bmatrix} * A$$

and

$$G_y = \begin{bmatrix} +1 & +2 & +1 \\ 0 & 0 & 0 \\ -1 & -2 & -1 \end{bmatrix} * A$$

Then, the direction and gradient magnitude of the images are computed using the below mentioned equations:

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

$$\Theta = a \tan\left(\frac{G_y}{G_x}\right)$$

The image pixels are binarized by applying both the lower bound and upper bound threshold values. If the edge pixels fall between the lower bound and upper bound threshold values, then the logical image is displayed.

3.4. Fracture detection

The last phase of this system deals with fracture detection. Till now the images are processed and segmented in order to get high-quality images which have no noise, enhanced and the edges been detected. Now, the straight lines in the image are detected since they are the most useful features in any image. This feature helps in classifying the *x*-ray as fractured or non-fractured. Hough transform is used to detect lines in images. It is used to extract features like lines, shapes, and curves from the taken input image which should be a binary image. This line is represented as mentioned below:

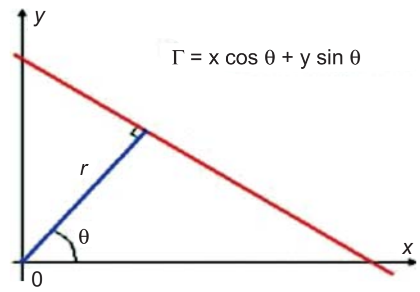

Figure 2

Here,

r = Perpendicular distance between the line in red and point of intersection of both the axes *i.e*. the origin,

θ = Angle between the line in red and the horizontal axis.

Algorithm:

1. Implement edge detection techniques like Canny or Sobel edge detector.
2. Map the edge points to the Hough space and then keep those mappings in an accumulator.
3. Interpret that accumulator such that the lines which are of infinite length are produced. This interpretation should be done by mentioning the threshold values manually which possibly can consider different constraints
4. Converting an infinite number of lines to a finite number of lines.

4. EXPERIMENTAL RESULTS

Figure 3: (*a*) Input image

Figure 3: (*b*) Black and white

Figure 3: (*c*) Grayscale

Figure 3: (*d*) Gaussian filter

Figure 3: (*e*) Brightness increased

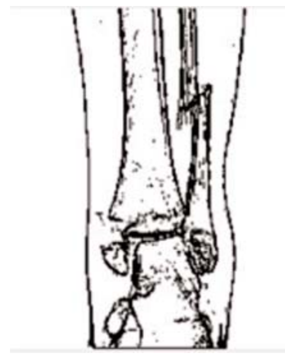

Figure 3: (*f*) Sobel edge detection

Figure 3: (*g*) Prewitt edge detection

Figure 3: (*h*) Roberts edge detection

Figure 3: (*j*) Hough lines detected

Figure 3: (*i*) Canny edge detection

Figure 3: (*k*) Longest hough line

Figure 3: (*l*) Fracture detected

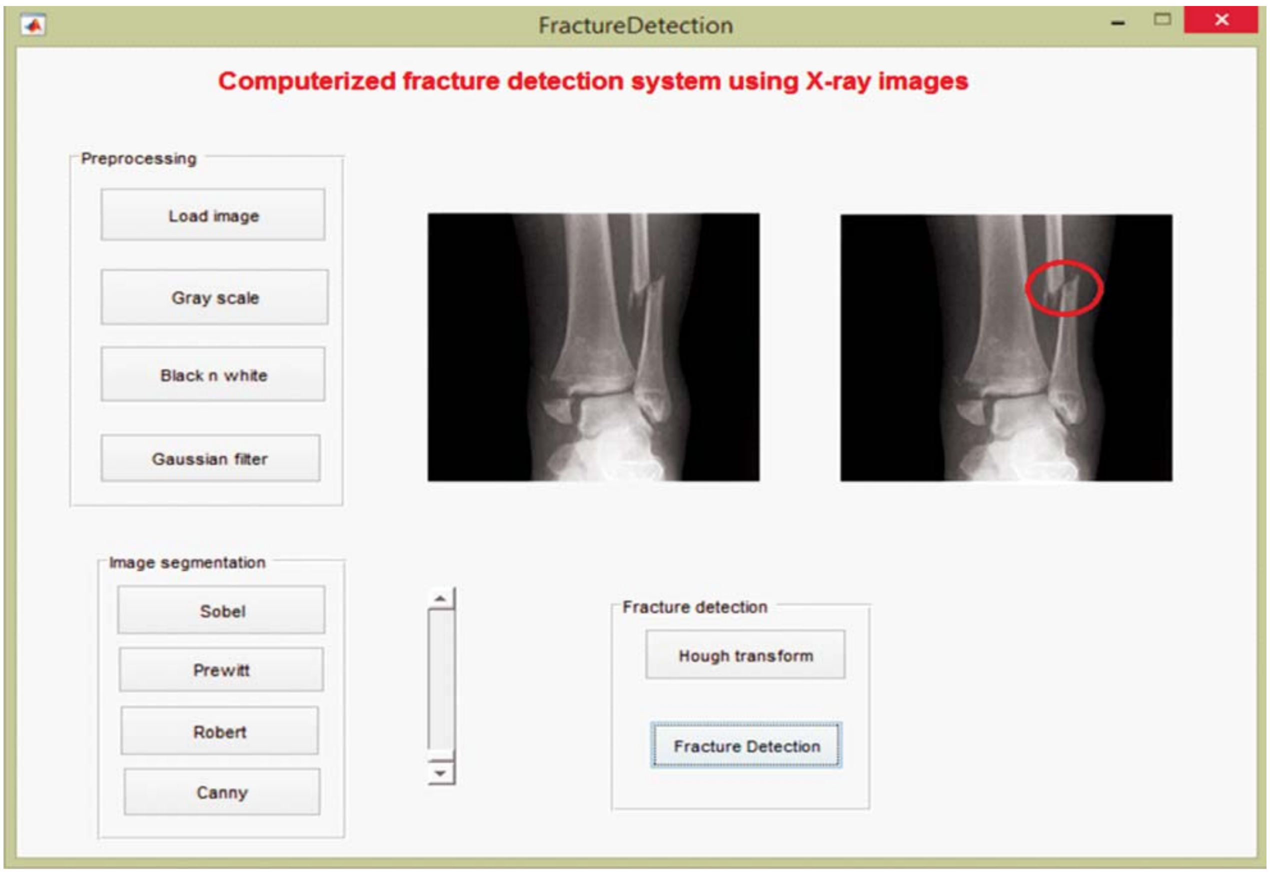

Figure 3: (*m*) GUI for fracture detection system

5. DISCUSSION

MATLAB(R 2015a) is the tool used for the implementation of the proposed system in this paper. Figure 3(*m*), depicts that a GUI is designed with a couple of push buttons and two axes for the detection of fractures. Push buttons are for executing the tasks like loading images, preprocessing, image segmentation and fracture detection. One of the axes is for showing the input image and the other is for showing the output images. Figures 3(*a*), 3(*b*), 3(*c*), 3(*d*) and 3(*e*) are the images of the preprocessing step of the proposed system. Figures 3(*f*), 3(*g*), 3(*h*) and 3(*i*) are the outputs related to Sobel, Prewitt, Roberts and Canny edge detectors of the image segmentation phase respectively. A comparison is made between the four edge detectors and the following conclusions are drawn. Though Roberts method is fast in identifying edges, Sobel method is best suited for detecting edges. Canny edge detector has less speed efficiency when compared to Sobel edge detector. So, Sobel edge detector which is more efficient than the rest of the edge detectors is used for detecting the Hough lines. Figures 3(*j*) and 3(*k*) are the outputs of the Hough transform. Finally, in the last phase *i.e*. the fracture detection phase, figure 3(*l*) shows that there is a fracture in the loaded input *x*-ray image.

6. CONCLUSION

A Computerized fracture detection system is designed to remove noise, enhance images in order to increase the quality of image, detect edges in images using edge detection algorithms like Sobel, Prewitt, Roberts, Canny and finally identify the fractured area(if it exists) in the *x*-ray image of the bone using Hough transform. This helps the orthopaedicians to identify the fractured area of the bone accurately in no time. Identification of the type of fracture in the bone can be found using the proposed system which saves more time for the radiologists. It can also be used as a second reference or opinion.

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