Detecting Leg Bone Fracture In X-Ray Images

San Myint, Aung Soe Khaing, Hla Myo Tun

Abstract: The image processing techniques are very useful for many applications such as biology, security, satellite imagery, personal photo, medicine, etc. The procedures of image processing such as image enhancement, image segmentation and feature extraction are used for fracture detection system.This paper uses Canny edge detection method for segmentation.Canny method produces perfect information from the bone image. The main aim of this research is to detect human lower leg bone fracture from X-Ray images. The proposed system has three steps, namely, preprocessing, segmentation, and fracture detection. In feature extraction step, this paper uses Hough transform technique for line detection in the image. Feature extraction is the main task of the system. The results from various experiments show that the proposed system is very accurate and efficient.

Keywords: X-Ray images, Leg bone, Image processing, Fracture detection.

I. INTRODUCTION

Bone fracture is common problem even in most developed countries and the number of fractures is increasing rapidly. Bone fracture can occur due to a simple accident or different types of diseases. So, quick and accurate diagnosis can be crucial to the success of any prescribed treatment [2]. Depending on the human experts alone for such a critical matter have cause intolerable errors. Hence, the idea of automatic diagnosis procedure has always been an appealing one.The main goal of this paper is to detect the lower leg bone fracture from X-Ray images using MATLAB software.The lower leg bone is the second largest bone of the body. It is made up of two bones, the tibia and fibula. The fibula bone is smaller and thinner than the tibia. However, the tibia fracture is most commonly occurs due to it carries a significant portion of the body weight. Among the four modalities (X-ray, CT, MRI, Ultrasound), X-ray diagnosis is commonly used for bone fracture detection due to their low cost, high speed and wide availability. Although CT and MRI images gives better quality images for body organs than X-ray images, the latter are faster cheaper, enjoy wider availability and are easier to use few limitations . Moreover, the level of quality of X-ray images is enough for the purpose of bone fracture detection [2]. The motivations of this system are: (i) saving time for patients and (ii) to lower the workload of doctors by screening out the easy case. Another motivation for our research is to reduce human errors because doctors in hospitals manually inspect a large number of X-ray images for fracture. Manual inspection is tedious and time consuming. A tired radiologist has been found to miss a fracture image among healthy ones. Computer vision system can help to screen X-ray images for suspicious cases and alarm the doctors. This paper is summarized as follows: Section 2 presents a general overview of the literature. The two Sections 3 and 4 discuss the proposed method and its experimental results. Section 5 is system discussion. In the last Section, this paper is given conclusion and future directions are discussed.

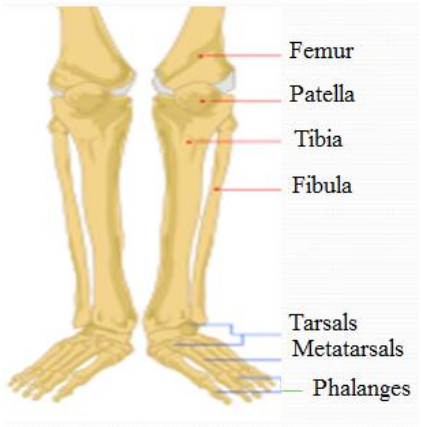


Figure1.*Structure of Lower Leg Bone[15]*

II. RELATED WORKS

Samuel FebriantoKurniawan, et al. [3] presented the Canny Edge Detection method to assist radiologists in detecting fractured bones from X-ray images. They observe that simulation result shows that the system needs to be improved on its performance and reduce the response time. This work can be made conclusion that the performance and accuracy of the detection method affected by the quality of the image. Ms.SnehalDeshmukh, Ms.ShivaniZalte, et al. [4] applied image processing techniques to find crack in a bone. The authors compare the different edge detectors and describe the advantages and disadvantages of these detectors. It is that the Canny method produce equally good edge with the smooth continuous pixels and thin edge. Sobel edge detection method cannot produce smooth and thin edge compared to Canny method. But same like other methods, Sobel and Canny methods also very sensitive to the noise pixels. Sometime all the noisy image cannot be filtered perfectly. Tai PengTian, Ying Chen, Wynne Hsu, et al. [5] analyse a method of computing neck-shaft angle for detecting femur fracture. This work is performed the extraction of femur contour by using a combination of algorithms, namely Canny edge detection and Hough transform for detecting significant straight line and curve features, and active contour mode (i.e.,elastic snake) with Gradient Vector Flow (GVF) method to snap on to the continuous femur contour based on the line and curve features detected. The authors describe that test results show that the algorithm correctly computed the neck-shaft angles for 99.3% of the training and testing images.

III. METHODOLOGY

In this section, the overall system design is described, image pre-processing, image segmentation and fracture detection. Figure 2 shows the flow diagram of our developed algorithm. First, user must input an image to be processed. The tested X-ray images were taken from local hospital and Internet website.

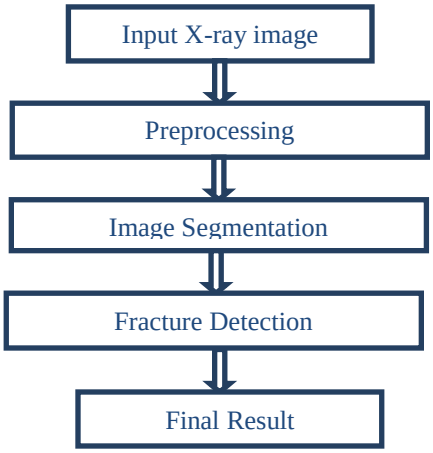


Figure 2.*System Flow Diagram*

A. Preprocessing

This stage consists of the procedures that enhance the features of an input X-ray image so that the result image improves the performance of the subsequent stages of the proposed system. In this work, the main procedures for image enhancement are noise removal, adjusting image brightness and colour adjustment. Noise can be defined as unwanted pixel that affects the quality of the image. There are different types of noise such as poison, Gaussian, Salt & pepper, etc. Gaussian noise is the most common types of noise that can be found in X-ray images. This type of noise is generally caused by the sensor and circuitry of a scanner or digital camera. So, the system choses to use Gaussian filter to reduce the noise while preserving the edge and smooth of the image. The Gaussian smoothing filter is a very good filter for removing noise draw from a normal distribution. A Gaussian filter is parameterized by σ, and the relationship between σ and the degree of smoothing is very simple. A large σ implies a wider Gaussian filter and greater smoothing. After filtering, this system is performed adjusting image brightness and colour to distinct the desired object or bone shape from the image. Then, the adjusted image is converted into the gray scale image to speed up processing time and less computation. Figure 3 shows the results of image smoothing on an X-ray bone image.

(a)*Original image*

(b)*Brightness adjusted image*

(c) *Color adjusted image*

(d) *Gray scale image*

Figure 3.*Results of Image preprocessing*

B. Segmentation

Image segmentation is the fundamental step to analyse image and extract data from them. It is an operation of partitioning an image into a collection of connected sets of pixels. The main purpose of segmentation process is to get more information in the region of interest in an image which helps in annotation of the object scene. There are three main approaches of image segmentation which are region approach, boundary approach and edge approach. In this work, edge based-based segmentation is used which is more suitable for bone image. Edge detection is one of the mostwidely used operations in applications that require determiningobjects' boundaries in an image. It is based on analysing the changes in the intensity in the image. This paper describes the comparison of the results of different edge detectors such as Sobel, prewitt, Robert and Canny detector. According to the experimental results, Canny operator is rather than other edge detectors.The edge boundaries of Sobel and prewitt edge detectors are not continuous and do not show the important imformation because most of them lost the important structure. In Robert edge detector, the pixel of the image is noisy and the edges are not smooth and thin. In this paper, Canny method is used to produce good view of the bone structure.

1) **Canny Edge Detection:** Canny edge operator is considered as superior edge detection operator among the available operators based on the experimental results. It detects faint edges more efficiently even in noisy image and show road feature. In this work, Canny method is capable to mark all existing edges in the image and immune noisy environment. Canny edge detection is a multistage algorithm to detect a wide range of edges in images.
   1. The original image is smoothed implementing with a Gaussian filter. The result is an image with less blur. It is intended to obtain the real edges of the image.
   2. The edge is detected with Sobel operators for finding horizontal (Gx) and vertical (Gy). Sobel kernel in x and y directions are given as follow:

$$\begin{bmatrix} \begin{bmatrix} -1 & 0 & 1 \\ -2 & 0 & 2 \\ -1 & 0 & 1 \end{bmatrix} & \begin{bmatrix} 1 & 2 & 1 \\ 0 & 0 & 0 \\ -1 & -2 & -1 \end{bmatrix} \end{bmatrix}$$

$G_x G_y$

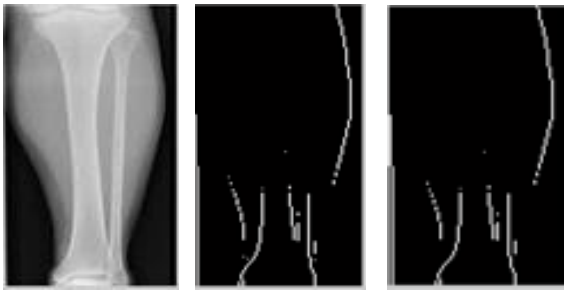
Sobel Masks

   3. After that, the gradient magnitude and direction of the image can be calculated using the following equations:

$$|G| = \sqrt{G_x{}^2 + G_y{}^2} \quad (1)$$

$$\theta = \tan^{-1}\left(\frac{G_y}{G_x}\right) \quad (2)$$

4. Then, the algorithm tracks along these regions and suppresses any pixel that is not at maximum called non-maximum suppression. It is carried out to preserves all local maxima in the gradient image, deleting everything else this result in thin edges.
5. The last step is binarizing the image pixels by applying two threshold (lower and higher) values. The output of non-maxima suppression still contains the local maxima created by noise. Therefore, double thresholding is used for avoiding this problem. When the edge pixels greater than the higher threshold that are marked as 1and if the edge pixel less than the lower threshold then it is set to 0. If the edge pixel falls in between the two thresholds and is adjacent with higher pixel, then it is set to 1, otherwise it is set to 0. Figure 4 show the result images of different edge detectors.



(a)*Original image* ***(b)****Sobel edge image* ***(c)****Prewitt edge image*

(d) *Robert edge image* ***(e)*** *Canny edge image*

Figure 4.*Result images of different edge detectors*

C. Fracture Detection

The last stage of this system is fracture detection it is performed by the procedures. First, the useful features such as straight lines can be extracted from the image. And then, these features are used to detect fracture or non-fracture image. In this work, the straight lines in the image can be a good feature to distinguish fracture or non-fracture. After enhancing and segmentation the input image, the process is extracted the features in binary image by using Hough transform. The Hough transform is a feature extraction technique it is concerned with the identification of straight lines, shapes, curves in a given image. It takes a binary image as an input. In this work, it is used to detect the existence of a line in the image. A line can be represented as

$$r = x\cos\theta + y\sin\theta$$

Where, r (Distance) is the perpendicular line from origin to the test line, θ (Angle) is between the perpendicular line and thehorizontal axis and then x,y are constants. A line in the image space is mapped to a point in the parameter space. Similarly, each pixel of the image space is transformed to a parameterized curve of the parameter space.Each transformed point in theparameter space is considered as a candidate for beinga line and accumulated in the corresponding cell of anaccumulator.Finally, a cell with a local maximum ofscores is selected, and its parameter coordinates areused to represent a line segment in the image space. The resolution of the accumulator determines the precision with which lines can be detected.

1) Line Detection: To calculate the bone angle, the algorithmfinds the straight lines in the image to detect the fracture line.Every edge point in the edge map is transformed to all possible lines. In this work, the minimum length of a line was set to 7 pixels, and the algorithm was allowed to connect lines through holes of up to 7 pixels. In this work, only a few important lines are to be detected. Then, the algorithm plot the Hough lines in image with green color and the beginnings and ends of the lines were set to yellow and red color respectively. In this paper, figure 5(a), (c) and (e) are edge images. Figure 5(b), (d) and (f) are shown that detecting Hough lines in the image.

IV. Experimental Results

The experimentation has been done using 21digital X-ray images of lower leg bone. After extracting the straight lines, this system is performed the break point detection. In this experiment, the threshold value (40) is used to find the break point. This reference value may need to be changed if break is not in middle of the bone. This system uses 5° weight value or Hough peak distance to find vertical lines at which lines are oriented. If the weight value more than 5°, this line cannot take as vertical straight line. This system is assigned that the vertical straight line must have between 85° and 90°. If there is more than one major angle contribution there will be two peaks detected but only one peak if there is only one major angle contribution (i.e. peak = number of located bones). In figure 6(a) and (b), there are the two detected peak points in the graph as the fracture exist in the image. In figure 6(c), the graph shows only one detected peak point because there is no fracture in the image. In this graph, the dotted lines of red color refers to as Hough peak threshold and theblue color refers to as maximum Hough transform and the red mark crossshows the detected peak. After that, the end point of the longest line segments is determined. Then, the edge image is convoluted with the line of detected angle from the Hough transform. Finally, system takes the differences between the convoluted images and findsthe place this crosses zero (within 0.25 of break line tolerance) should be where the break is. And then, a bounding ellipse and draw around the break location in the gray-level image. Figure 7(a) and (b) are shown that fracturedetection results, in figure 7(c) there exists no fracture in the image. The experimental results show that the proposed system is very accurate and efficient.

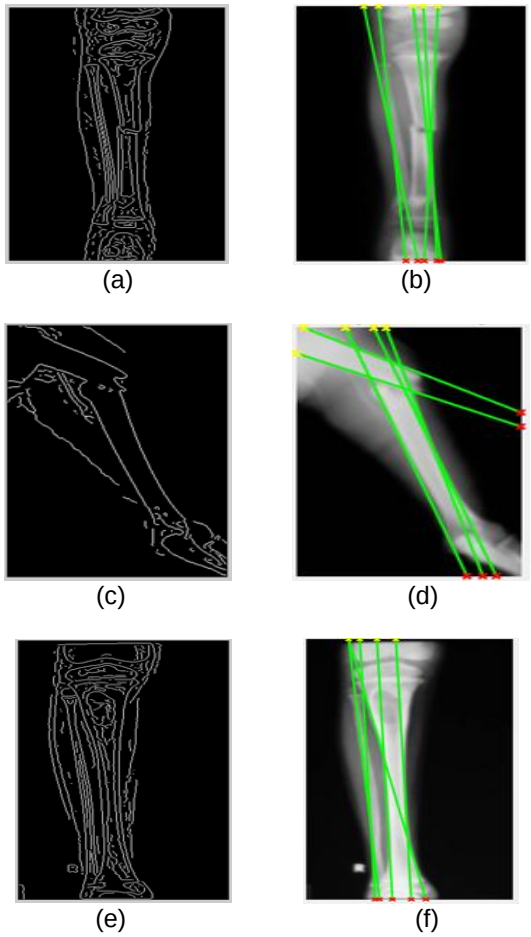


Figure 5. *Edge Images and Hough Lines in Images*

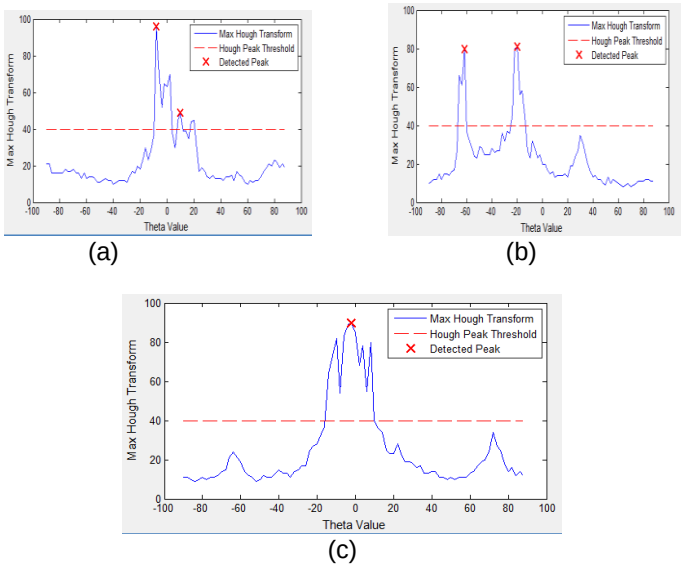


Figure 6. *Hough Detection Results for Fracture and Non-Fracture image*

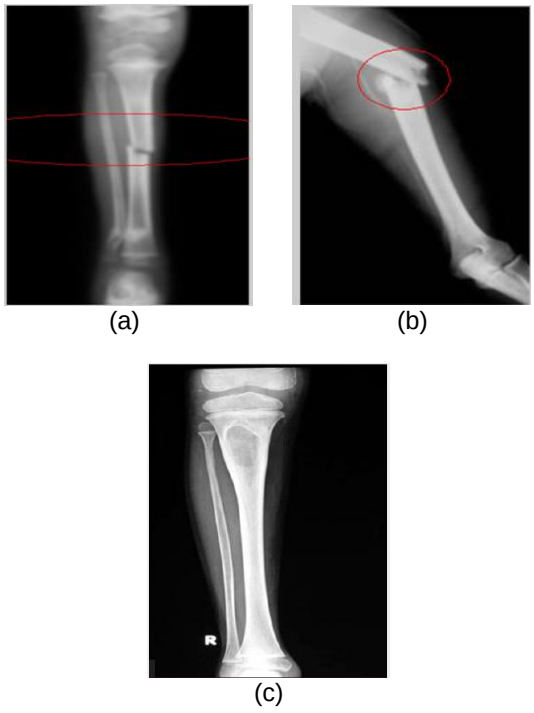


Figure 7. *Fracture Detection Results*

IV. Discussion

As mentioned in the introduction, this paper considers the problem of detecting leg bone fracture. Many X-ray images are collected from local hospitals and Internet websites. In this experiment, 21X-ray images are tested. Among them, 16 images are fractures and 5 images are normal X-ray images. The algorithm cannot detect correctly in 2 fracture images. According to the test results, the performanceof the detection method affect by the quality of the image. This paper examines the performances of Canny edge detector in comparison with other edge detectors such as Sobel, Prewitt, and Robert, which are applied to the X-ray images of lower leg bone. From the experimental results, it is observed that the Canny operator gives better results and produces good view of bone structure. After edge detection, this system discussed the performance of Hough transform which is applied on edge image to find the straight line and angles at which bone pieces are found.The idea of Hough transform is that every edge point in the edge map is transformed to all possible lines. After that all, this system determined whether a fracture exists or not in the image.

V. Conclusions

This paper presented the image processing technique to detect the bone fracture.The fullyautomaticdetectionof fractures in leg bone is an important but difficult problem. According to the test results, the system has been doneto detect the bone fracture. A conclusion can be made that the performanceof the detection method affected by the quality of the image. The better the image quality, the better the result system got. In future work, focusing on other works like detecting on smaller bone, ankle fractures, etc. may be considered.

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