Diaphysis Fracture on Tibia and Fibula Detection Based on Digital Image Processing and Scan Line Algorithm

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Abstract—**The X-Ray images of tibia and fibula are the important aiding for clinical diagnosis of fracture because detection fracture performed by medical practice based on it. Under conditions of tired eyes, some medical practice miss fracture case. There are many previous research developed various methods to process X-Ray images and make system that can detect fracture automatically.**

In this paper, we proposes the simple system that can detect fracture on the tibia and fibula in two stages. The first stage image pre-processing using image enhancement, edge detection, filtering to remove noise and results the edge of image perfectly. The second stage is feature extraction using scan line algorithm that find maximum value of the difference distance to the nearest pixels from the right and left border margin of image. The maximum value of scan line is used as a threshold to classify normal cases or fracture cases.

Accuracy is calculated based on images were tested right images for all images tested. Total images that used are 70 images, 30 normal images and 40 fracture images. Accuracy in this simulation reach 100% for normal images and 90% for fracture images, with time computation about 2.33 seconds.

Keywords— **fracture**, **digital image processing, scan line algorithm.**

I. INTRODUCTION

Fracture is a crack or break in the bone that relatively common occurrence in human [4]. The tibia and fibula fracture is probably the most often occur, especially in soccer players and ballet dancers. Handling fracture tibia and fibula is through surgery by orthopedic surgeon by see the results of X-ray image of the patient's leg before operation. X-Ray image is very important, especially to know the condition of closed fracture case that does not tear the skin, if not immediately obtain the proper medical treatment, it can make closed fracture change to be opened fracture that tears the skin and can be serious condition . The blurred results of X-ray images or medical eye conditions that fatigue after seeing lot of X-ray images of the bones may cause errors resulted in the diagnosis and make error handling. Researchers use various methods to improve the quality of X-ray images and develop applications that can detect fractures automatically. They developed a variety of image processing methods to improve the quality of image. Image processing is to improve their quality and by preprocessing, some unwanted variations or noise can be reduced and desired features enhanced [3].

Several methods have been used in detecting fracture in previous studies, one of them was used Hough transform [2] as feature extraction to classify some fracture cases, beside that another researcher used Hough transform as feature extraction and used fusion classifier [5] or combining classifier [1] to get the best performance from the system. In this research, designed a system to detect fracture by using a simple method of fracture in diaphysis part of tibia and fibula as region of interest (ROI) using scan line algorithm. Scan line algorithm is a simple method to detect fracture but it's very depend on the perfect edge of image before entering scan line process. Various experiments from researcher proved that the Sobel edge detection algorithm is fast and efficient in identifying the edges [6], so In this paper used Sobel operator as edge detection and some filtering process before scan line process.

II. MATERIALS AND METHOD

In figure-1 explains the general flow diagram was proposed in this paper. The X-ray images was collected from Halmahera Hospitals, Bandung Indonesia.

In general, the X-Ray images of tibia and fibula will enter the preprocessing stage before entering the next stage. In image preprocessing stage is treated with a variety of digital image processing method to uniform conditions of different images and to make easier subsequent processing stages.
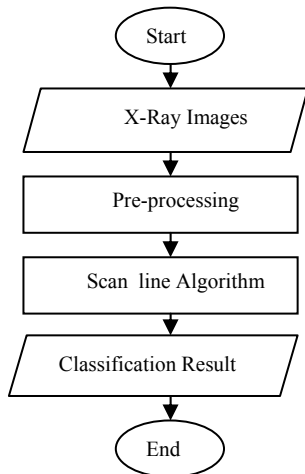
Figure 1. The general flow diagram of tibia and fibula fracture detection system

A. Preprocessing

In the preprocessing stage performed several steps to improve the quality of the image and getting the region of interest (ROI)

X-Ray image of the Tibia and Fibula : The image as input to the system is the X-ray image of tibia and fibula bones in adults with an age range of 17-58 years from Halmahera hospital. The number of images that used are 70 images, 30 normal image and 40 fracture images. Some of them show in figure 2.
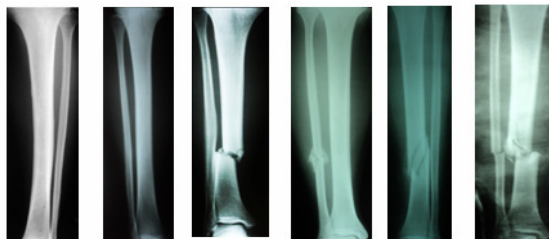

Figure. 2. The X-Ray images of tibia and fibula as an input system

Resize : The first step is Resize dimensional image, X-Ray images obtained comparable dimensions to 300x800 pixels, this step aims to facilitate the subsequent stage.

Converting to grayscale: To enter the next stage of preprocessing the X-Ray image must be converted to grayscale. The X-Ray image is a RGB that essentially does not contain much color, so converting to grayscale will not significantly reduce the important information of the image.

Image Enhancement : At this stage the result of a grayscale image enhanced contrast in each pixel value. This process aims at improving the quality of image to obtain good results.

Edge detection : Edge detection is a process to find a real intensity change in an image, so the image intensity differences greatly affect the results of edge detection, as well as the selection of edge detection operators are used. Sobel, Robert, and Prewitt operator are the first derivative edge detection, this means utilizing the difference in value of a pixel with its neighboring pixels. While the canny edge detection operator is a second derivative. In some images, the edge detection results using Robert, Sobel and Prewitt operator did not show significant differences, as like as using canny operator. However, in more common use, Sobel operator is more suitable to get all the edges of images with less noise. Which is in line with the theory that the excess of Sobel operator is capability to reduce noise before doing edge detection process. The next is filtering process which aims to eliminate the noise in order to obtain accurate results for the feature extraction.

Filter : Edge detection results still consist of noise, so filtering is needed to remove noise. After edge detection using Sobel operator was used median filter, dilation, and erosion of the banks to get the perfect image.

Cropping : The final step of preprocessing is done to get the ROI (Region of Interest) and dispose of non-essential parts so that the parts to be examined more specific and to make feature extraction more efficient. In this paper the ROI of X-Ray image is diaphysis of tibia and fibula.

B. Feature Extraction

Feature extraction is a method to obtain characteristics of an image. This process is an important step in detecting fracture on the tibia and fibula bones. The image feature extraction process will be done by analyzing the edge of image as a result of scan line process, so it will look a regularity curve in normal case as show in figure 3 (a) and there is a discontinuity or high jump amplitude curve in fracture case as show in figure 3 (b).
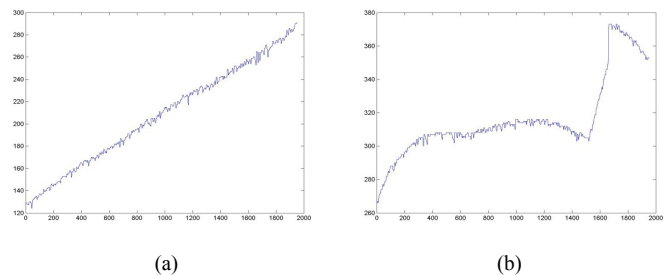

(a)   (b)

Figure 3. The curve of scan line process in normal and fracture cases.
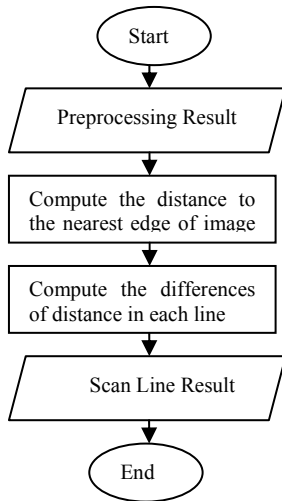
Figure 4. The flow diagram of scan line algorithm

Scan line algorithm that used in this paper is a simple logic by calculating the difference between the shortest distance from image boundary to the closest edge of image that was encountered. After going through several stages of digital image processing, X-ray image in RGB format turned into grayscale and after filtering is converted again into BW format. BW format image is basically a bunch of pixels on a matrix which have value 0 and 1. The white line shows the value of 1 and black indicates a value of 0. The mean of distance in the scan line algorithm is the number of columns that was through in matrix from both sides of the border until reach the column that has value 1. After that calculated the difference in the distance on each line with line before as the illustration in figure 5. The green bold show in figure 5 is difference between line 6 with line 5, this value will be the result of scan line process and used as threshold to classify normal bone and fracture bone.
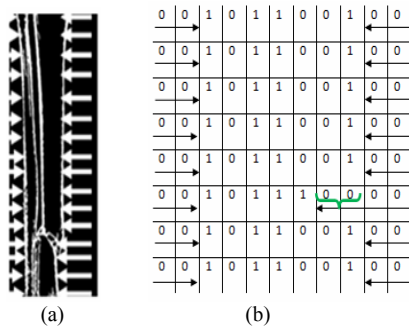

Figure 5. Illustration of scan line algorithm
    a. Illustration of scanline process in ROI;
    b. Illustration pixels in matrix of bone X-Ray image
       in BW format.

III. EXPERIMENTAL RESULT.

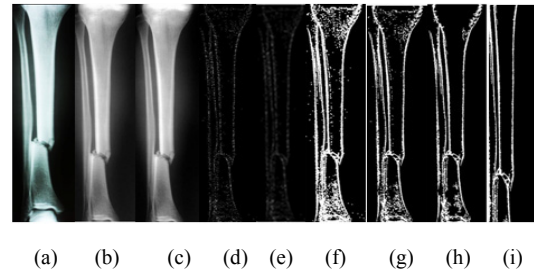(a)   (b)   (c)   (d) (e)   (f)   (g) (h)   (i)

Figure 6. Result in each step of preprocessing

a. X-Ray image as input system; b. Conversion to grayscale; c. Image enhancement; d. Edge detection; e. Median filter; f. Dilation; g. Erosion; h. BW area open; i. ROI

Result of image at any stage of the process is show in Figure 6. Scan line stage depends on the outcome of pre-processing if the result is good then bone condition will be detected accurately.
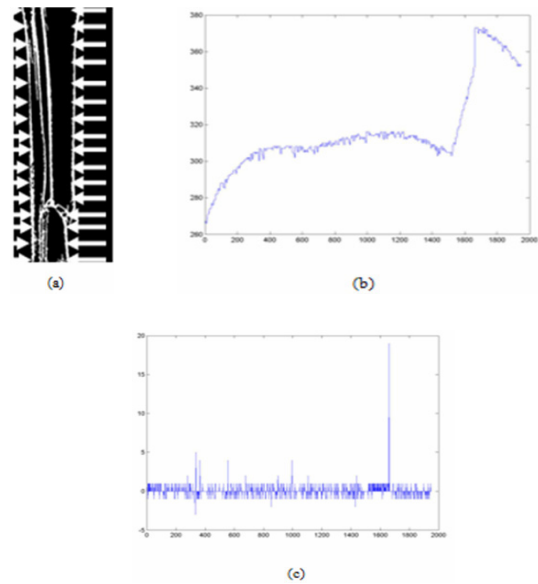

Figure 7. Result of scan line algorithm

In Figure 7 (a) illustration of a scan line process on the results of the preprocessing with the ROI part diaphysis of tibia and fibula were fractured. In figure 7 (b) is a plot of the distance between border in the image and the nearest edge of X-Ray image, in fracture condition will result a curve with a fairly high spike difference. In figure 7 (c) is the result of difference scan line distance between a line with line before, in case of fracture the difference between each line spacing is high enough, by see the figure 7 (c) the scan

line value is 20. This value will be used as the threshold value to classify the condition of bone.

Table 1 Accuracy system using some threshold scan line algorithm

No	Threshold Value	Normal	Fracture
1	10	86.67%%	95%
2	15	93.33%	90%
3	18	100%	90%
4	20	100%	90%
5	21	100%	90%

By trying to sample the existing image and get a result of scan line as a threshold value, then conducted several experiments by setting the threshold value to classify the condition of the bone as seen in the table 1. From the table the highest accuracy is obtained when the threshold 18 and more than 18, the calculation accuracy of the system with 40 fracture images and 30 normal images as input reach 90% in detection fracture case and reach 100% in detection normal case with time computation 2.33 second.

IV. DISCUSSION

This paper discusses about the detection of fractures in diaphysis of tibia and fibula bones using a scan line algorithm. Based on the simulation results using MATLAB to conduct a trial in 40 fracture images and 30 normal images scan line algorithm has successfully detect and classify X-Ray bone image that occur in two conditions, namely, normal and fracture. Therefore, if it is only used to detect fractures and classified them into two conditions, scan line algorithm can be used. Some of the advantages of this algorithm is fast computing time, scan line method is simple and result high accuracy if get the edges of image perfectly and preprocessing stage is successful to remove noise. However, other research develop more required method that will be used to rely more complex fracture, so not only can classify into two normal case and fracture case, but also to recognize and differentiate various types of fracture.

V. CONCLUSIONS

Fracture is one of the conditions that are common and can be experienced by anyone. Handling fracture is performed by medical personnel perform surgery by looking at X-ray image to determine the condition of the bone fracture. X-Ray image is very important, especially to know the condition of closed fracture that does not tear the skin, if not immediately obtain the proper medical treatment the closed fracture can be opened fracture and make condition of fracture more serious. The condition of most X-ray images are blurred and unclear, so it can cause undetected no fractures. Researchers developed a system that can automatically detect fractures with various methods. In this paper scan line algorithm is used as a method to detect fractures. Based on the results of the simulation system by conducting experiments on 70 images, scanline algorithm can detect fractures with an accuracy of 90%. Moreover this algorithm is very simple and efficient in terms of computing time. But, scan line algorithm that used in this paper is only able to detect the condition of normal case and fracture case, can not distinguish between different types of fracture. Necessitating further learning and development of methods to produce a system that can detect various types of fractures.

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