Identification tibia and fibula bone fracture location using scanline algorithm

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Abstract. Fracture is a condition that there is a damage in the continuity of the bone, usually caused by stress, trauma or weak bones. The tibia and fibula are two separated-long bones in the lower leg, closely linked at the knee and ankle. Tibia/fibula fracture often happen when there is too much force applied to the bone that it can withstand. One of the way to identify the location of tibia/fibula fracture is to read X-ray image manually. Visual examination requires more time and allows for errors in identification due to the noise in image. In addition, reading X-ray needs highlighting background to make the objects in X-ray image appear more clearly. Therefore, a method is required to help radiologist to identify the location of tibia/fibula fracture. We propose some image-processing techniques for processing cruris image and Scan line algorithm for the identification of fracture location. The result shows that our proposed method is able to identify it and reach up to 87.5% of accuracy.

1. Introduction
Fracture or broken bone is caused by trauma, high force impact or stress, or a certain medical condition that weaken bones. The soft tissue around the bone will determine whether the happened fracture is complete or not. A complete fracture happens when the parts of the fractured bone are completely separated from each other, while incomplete fracture extends partly across the bone. Tibia/fibula fracture happens more often than the other bone fracture because of the thin periosteum lining the tibia, especially in front area covered by skin, so that the bone often fractures because it is directly located under the skin [1]. The way to diagnose fracture is clinical examination and then followed by radiological examination (X-ray) [2]. Generally, radiologist analyze the bone fracture from the X-ray image manually and it takes longer time to diagnose it. The X-ray images also contain much noise, that possibly cause errors while diagnosing. Moreover, reading X-ray images requires highlighting to make the objects in it appear more clearly. Therefore, many previous researches based image processing to identify the fracture using various method to get higher accuracy [3].
In 2011, Mahendran and Baboo detected the fracture from X-ray image using Wavelet and morphological operations to segment the image. They used gray level method to extract features based
texture and concluded that their proposed method can run exceedingly fast and can generate results in seconds [4].

Another method proposed by Chai, et al. to detect bones fracture. They used Gray Level Co-occurrence Matrix (GLCM) to analyze the texture of fracture by calculating features of homogeneity, contrast, energy, correlation. In the conclusion, the accuracy of their proposed method is achieved at least 86.67% which can be further improved [5].

Bone fracture detection through x-ray images was also done by Al-Ayyoub et al. in 2013. They used Sobel edge detector to detect the edges of the hand bone, used the combination of Wavelets, Curvelets and GLCM to extract features and compared some classifier methods, namely Neural Network (NN), Naïve Bayes (NB), Bayesian Network (BN) and Decision Tree (DT). They concluded that 91.8% of accuracy was obtained by applying boosting and bagging on the Bayesian Network classifier [6].

Next research in 2014, Kurniawan used OpenCV combined with canny edge detection for fracture detection. They stated that canny edge detection has optimal advantage for identifying the location of bone fracture from X-ray image [7].

In this research, we proposed some image processing techniques to enhance the image, canny edge detection to extract feature and scan line algorithm to identify the location of bone fracture. This paper is organized as follows; Section II describes the proposed method. Experimental results are presented on Section III. Section IV describes the summary and suggestions for future research.

2. Concept Development

In this research, there are several steps to identify the location of tibia and fibula fracture, namely collecting data of tibia and fibula image, cropping to get the region of interest (ROI), resizing to get the same image resolution of cruris image (image of detected fracture), gray scaling, sharpening to enhance the image, and then using canny edge detection and scan line algorithm to identify the location of tibia and fibula fracture. General architecture of our proposed method can be shown in Figure 1.

![General Architecture](image)

**Figure 1.** General Architecture

2.1. Image Acquisition

The used data in this research is acquired cruris image from Haji Adam Malik Hospital and also from web. The digital images are fractured tibia/fibula, totaled 40 images in JPG (Joint Photographic Group) format and then will be used for the next step of the proposed method. A sample cruris image is shown in figure 2(a).
2.2. Pre-processing
This step consist of four steps, namely cropping, resizing, grayscaling and sharpening, which will be clearly explained in the next sub subsection.

- **Cropping.** It is conducted to get the region of interest (ROI) and separate it from unnecessary area of cruris image. Figure 2(b) shows the result of cropping cruris image.

- **Resizing.** This process is conducted to make all images have the same size. In this research, we resize all the used image data into smaller size, 100 x 400 pixels, to make the process run quickly. The sample result from resizing can be shown in figure 2(c).

- **Grayscaling.** After resizing the colour image (has RGB components), it will change into grayscale. The conversion from RGB into grayscale can be done using equation (1). Figure 2 (d) shows the result of grayscaling process.

\[
G = \frac{R + G + B}{3} \tag{1}
\]

- **Sharpening.** As the principle of High Pass Filter, sharpening is done to enhance the image quality and emphasize the edge of image object. Figure 2(e) shows the result of sharpening.

2.3. Feature Extraction
Feature extraction is to get unique feature from the image so that it will be an input for process of identification or classification. In this research, we use canny edge detection to extract the feature then the detected edges will be an input for scan line algorithm to identify the location of tibia/fibula fracture. There are several steps in canny edge detection, namely:

- Removing noise using Gaussian filter to remove unnecessary pixel so that it is undetected as an edge.

- Setting upper threshold 3f and lower threshold 50.5f. If the pixel value is greater that upper threshold, then it is detected as an edge. Figure 2(f) shows the result of canny edge detection. The binary image obtained from thresholding will be an input for scan line algorithm.

![Figure 2](image_url)

**Figure 2.** (a) Cruris Image. (b) Cropping. (c) Resizing. (d) Grayscaling. (e) Sharpening. (f) Canny edge detection.

2.4. Identification using Scan line Algorithm
Figure 3 shows the illustration of scan line algorithm. There are several steps of scan line algorithm for identifying bone fracture, namely:

- Calculate the number of white pixel (1) in a row using equation (2)

\[
Rn = C1 + C2 + \cdots + Cn \tag{2}
\]

- Calculate total number of white pixel for three rows around, formulated as in equation (3).
\[ S_n = B(n - 1) + Bn + B(n + 1) \]  

- Determine the rows which contains the highest number, then it will be the location of fracture.

| 0 0 1 0 0 0 0 1 1 3 6 |
|------------------------|
| 0 0 1 0 0 0 0 1 1 3 9 |
| 0 0 1 0 0 0 0 1 1 3 9 |
| 0 0 1 0 0 0 0 1 1 3 9 |
| 0 0 1 0 0 0 0 1 1 3 1 |
| 0 1 1 0 0 0 1 1 1 5 1 5 |
| 0 1 1 1 1 1 1 0 1 7 3 9 |
| 0 1 1 1 1 1 1 0 1 7 1 7 |
| 0 1 0 0 0 1 0 1 0 3 3 3 |
| 0 1 0 0 0 1 0 1 0 3 9 |
| 0 1 0 0 0 1 0 1 0 3 9 |
| 0 1 0 0 0 1 0 1 0 3 6 |

(a) **Figure 3.** (a) Scan line Algorithm. (b) Illustration of scan line algorithm calculation

3. **System Design**

In the main page view of the application, there are several facilities such as cruris image selection, cruris image processing, and the result of identification of cruris image fracture location. The design of the main page view is shown in figure

**Information:**

- The "Home" button allows the user to go back to the beginning.
- The "About" button allows the user to see a brief description of the system.
- The "Browse" button allows the user to select a bone cruris image on the image store. After the image is selected, the image will be displayed in the "Cruris Image".
- The "Process" button allows the user to perform the process of identifying the location of the fracture. After the identification process is complete, the pre-processing result image of the grayscaling, sharpening, and canny detection process will be displayed, and the result of identification of the location of the fracture will be displayed in the "identification result" section.
- The "Reset" button allows the user to delete the input image along with all the processing results.
- Represents each process that will be shown after the user selects the image and selects the "Browse" button.
4. System Prototyping
The methods used in identifying the location of tibia and fibula bone fractures are implemented into the system using Java programming language in accordance with the design that has been done. In designing applications to identify the location of bone fractures of the tibia and fibula using Scanline algorithm requires hardware and software support include:

4.1. Specification of hardware and software used
The hardware and software specifications used to construct a bone fracture identification system are as follows.

- Processor Intel Core i3-820M CPU 1.9GHz
- Memory (RAM) 4.00 GB DDR3
- 500 GB Hard Drive Capacity
- The operating system used is Microsoft Windows 8.1 Enterprise 64 Bit
- NetBeans IDE 7.0
- JDK 1.7

5. System Testing
The images of the selected tibia and fibula will then be displayed on the "Cruris Image" panel as shown in figure below. After the fracture image of the tibia and fibula bones is displayed on the "Cruris Image" panel, the "Process" button and the "Reset" button can be used. The "Process" button is used to initiate the process of identifying the location of the fracture from the selected bone fracture of the tibia and fibula, starting from pre-processing, feature extraction, and identification using the Scanline Algorithm. The results of the pre-processing process will be displayed in the grayscaling panel of grayscaling images, the sharpened image with the "Sharpening" panel, the feature extraction using canny edge detection will be displayed on the "Canny Detection" panel, and the results will be displayed on the panel "Identification Result" as shown in Figure below:

![Figure 5. Application in Identifying Process](image)

In the sharpening process, the edge of the image is sharper and clearer. The result is obtained by applying the principle of High Pass Filter (HPF) in sharpening process.
The results of the identification process using the Scanline Algorithm are displayed in the "Results Identification" panel. Display of result of process Identification of location of fracture of tibia and fibula bone image is shown in Figure 4.9. The value of the features obtained in the canny process will be calculated to get the highest score. The highest value will be the central point in determining the location of fractures of the tibia and fibula bone.

6. Result And Evaluation

In this section, we analyze the ability of our proposed method for identifying the location of tibia/fibula fracture. Therefore, system testing is conducted using 40 acquired images of tibia/fibula fracture (crusis image). The testing result is shown in Table 1.

|   | Fraktur1.jpg | True | 21 | Fraktur21.jpg | True |
|---|--------------|------|----|---------------|------|
| 2 | Fraktur2.jpg  | True | 22 | Fraktur22.jpg  | True |
| 3 | Fraktur3.jpg  | True | 23 | Fraktur23.jpg  | True |
| 4 | Fraktur4.jpg  | True | 24 | Fraktur24.jpg  | True |
| 5 | Fraktur5.jpg  | True | 25 | Fraktur25.jpg  | True |
| 6 | Fraktur6.jpg  | True | 26 | Fraktur26.jpg  | True |
| 7 | Fraktur7.jpg  | True | 27 | Fraktur27.jpg  | False|
| 8 | Fraktur8.jpg  | True | 28 | Fraktur28.jpg  | True |
| 9 | Fraktur9.jpg  | True | 29 | Fraktur29.jpg  | True |
| 10| Fraktur10.jpg | False| 30 | Fraktur30.jpg  | True |
| 11| Fraktur11.jpg | True | 31 | Fraktur31.jpg  | True |
| 12| Fraktur12.jpg | True | 32 | Fraktur32.jpg  | True |
| 13| Fraktur13.jpg | True | 33 | Fraktur33.jpg  | True |
| 14| Fraktur14.jpg | True | 34 | Fraktur34.jpg  | True |
| 15| Fraktur15.jpg | True | 35 | Fraktur35.jpg  | False|
| 16| Fraktur16.jpg | False| 36 | Fraktur36.jpg  | True |
| 17| Fraktur17.jpg | True | 37 | Fraktur37.jpg  | True |
| 18| Fraktur18.jpg | True | 38 | Fraktur38.jpg  | True |
| 19| Fraktur19.jpg | True | 39 | Fraktur39.jpg  | True |
| 20| Fraktur20.jpg | False| 40 | Fraktur40.jpg  | True |

Based on Table 1, from 40 images of testing data, there are 5 testing data detected error while identifying the location of tibia/fibula fracture, namely data to 10, 16, 20, 27 and 35. So, from all the testing result, we can conclude that the obtained accuracy for identifying the location of tibia/fibula fracture using scan line algorithm is 87.5%.

\[
\text{Percentage of Accuracy} = \frac{35}{40} \times 100\% = 87.5\%
\]
7. Conclusion
Based on all testing results for identifying the location of tibia/fibula fracture, scan line algorithm is able to help the radiologist to identify the fracture location. The obtained accuracy also depends on the number of acquired data. In this research, our proposed method can give 87.5% of accuracy for testing 40 images. The identification result much depends on the image quality generated from pre-processing and feature extraction. The better the image quality, the higher the generated accuracy.

Future work can be done using another method for detecting more than one location of fracture. Another research possibly done is classifying two conditions of bone, namely normal and fracture, or identifying the type of fractures.

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