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Computer Aided System Using Canny Edge for Long Bone Fracture Detection

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Abstract: Bone fracture is a common condition in humans that arises as a result of excessive pressure applied to the bone or as a result of a simple accident. Therefore an accurate bone fracture prognosis is critical in clinical situations. Image processing techniques are now widely used in a variety of applications. The image processing technique is used in fracture detection using image enhancement, image segmentation and feature extraction. This project used the canny edge detection method and Hough transform to assist in the fracture detection algorithm. Canny edge detection is deemed superior as it identifies thin edges in noisy images and can detect all existing edges in an image and is unaffected by noise. This project use Hough Transform for line detection in the sample image. The main aim of this project is to detect bone fractures from x-ray images. The algorithm is tested on sample images that have been provided. The suggested system is quite precise and efficient, according to the findings of several trials.

Keywords: Canny Edge Detection, Hough Transform, Fracture Detection, X-ray

1. Introduction

Imaging plays a critical role in the diagnosis and treatment of a wide range of disorders in many hospitals. Medical imaging is the technique and process of imaging the interior of the body for clinical analysis and medical intervention, as well as visual representation of the function of some organs or tissues. There are many types of medical imaging and X-ray is one of them. An X-ray image can be used to detect fractures in the human body. Fracture detection in X-ray images is an important task in emerging healthcare automation systems [1].

A fracture is another term for a broken bone and it can occur anywhere along the bone and in varying degrees of severity. A fracture is a partial or complete break in the bone [2]. The substantial cause of fracture is high impact or force against a bone that it can structurally bear. Bone fractures caused by trauma and stress are prevalent in the human body. Traumatic fractures are caused by a vehicle accident, a violent fall, or purposeful causes such as physical abuse, whereas stress fractures are

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common among athletes and military personnel. The bone fracture risk is high in the elderly due to the weaker bone [3].

Even in the most industrialized countries, bone fractures are a prevalent problem, and the frequency of fractures is rapidly increasing. Bone fractures are a result of pressure, accidents, and osteoporosis. Furthermore, bone is a rigid component that supports the entire body. As a result, the efficiency of any given treatment depends on a quick and accurate diagnosis [4]. For such an important topic, relying solely on human expertise has resulted in unbearable blunders. As a result, the concept of an automatic diagnosing technique has long appealed. Nowadays, computer-assisted diagnostic systems are popular because they increase the interpretation of medical images for doctors and medical expert professionals when compared to early identification of various ailments [4]-[7]. The manual technique for diagnosing a broken bone takes a long time and has a high chance of inaccuracy. As a result, developing a computer-based method to reduce fracture bone detection time and mistake probability is essential [8]. It also aids medical practitioners in making treatment decisions by assisting in illness diagnosis and enhanced patient care. The main approach of this project is to detect long bone fractures using the Canny edge method. This project is different from all existing methods as it used Canny edge for line detection and Hough Transform to smoother the line detected by the edge detection. This project consists of Graphical User Interface (GUI) development for the edge detection method.

2. Materials and Methods

2.1 Project Flowchart

This project is a software-based project with graphical user interface tools. A canny edge algorithm was developed using MATLAB software and was tested using an x-ray image for fracture detection. Figure 1 shows the general flowchart for designing the image quality assessment algorithm. The flowchart was used to simplify the entire project by explaining the project procedures and subtasks in order to meet the work's objectives. This flowchart consists of three stages which are pre-processing, image segmentation and fracture detection. Each stage has its own workflow. The performance and outcomes of the system are assessed and analyzed after it is completed. After then, the system goes through a number of troubleshooting operations until it achieves the necessary level of perfection. Finally, a discussion and conclusion would be provided based on the findings.

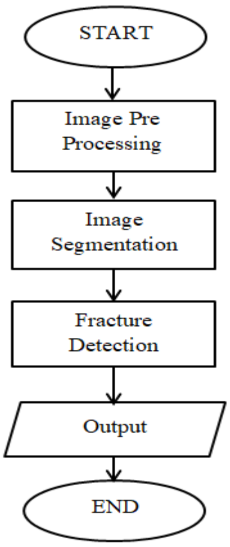


Figure 1: General Flowchart

2.1.1 Pre-processing

The actions taken to format images before they are utilized in model training and inference are known as image pre-processing. This covers resizing, orienting, and color corrections, among other things. The goal of pre-processing is to improve the image's quality so that it can be analyzed better. It can reduce unwanted distortions and boost some properties that are important for the pre-processing application. Figure 2 shows the flowchart for the pre-processing stage.

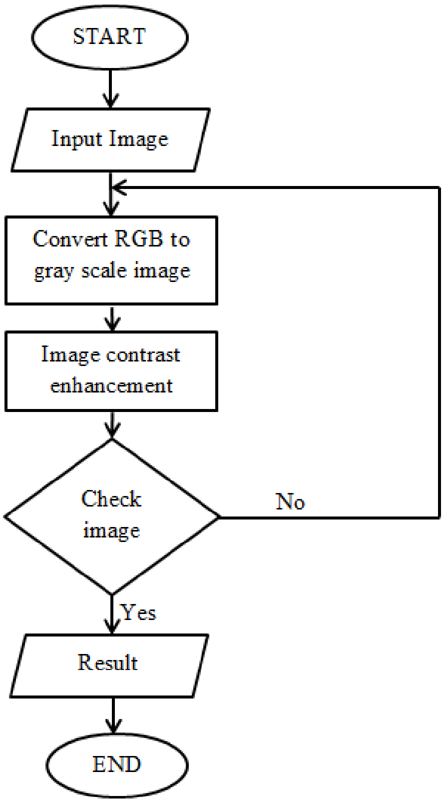


Figure 2: Pre-processing flowchart

2.1.2 Image segmentation

Image segmentation is the first stage in analysing and extracting information from images. It is the process of dividing a picture into a collection of related pixel sets. The major goal of the segmentation procedure is to obtain additional information in the image's region of interest, which aids in the annotation of the object scene. It is a fundamental step in image assessment that locates and limits objects. In this paper, a canny edge detector will be used for the segmentation of x-ray bone images.

The Canny edge detector is an edge detection operator that detects a wide range of edges in pictures using a multi-stage approach. To compute the intensity of the gradients, it employs a filter based on the derivative of a Gaussian. The Gaussian filter decreases the impact of picture noise. Then, by deleting non-maximum pixels of the gradient magnitude, possible edges are reduced down to 1-pixel curves. Finally, applying hysteresis thresholding on the gradient magnitude, edge pixels are maintained or eliminated. Figure 3 shows the flowchart for the segmentation stage and Figure 4 shows the coding used for the edge detection process.

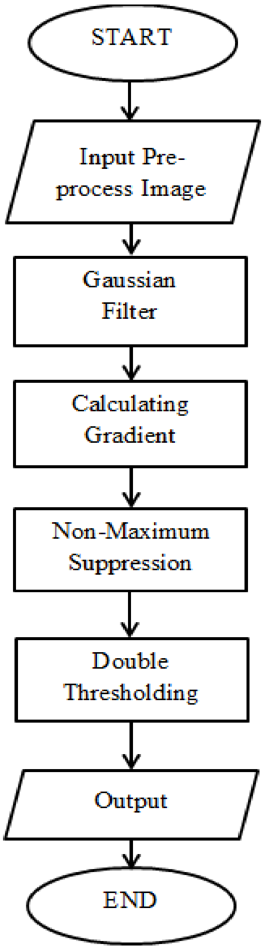


Figure 3: Image segmentation flowchart

```
edgeRegs = regionprops(edge_final, 'Area', 'PixelIdxList');
AreaList = sort(vertcat(edgeRegs.Area), 'descend');
edgeRegs(~ismember(vertcat(edgeRegs.Area), AreaList(1:2))) = [];
c = zeros(size(b, 1), size(b,2));
c(vertcat(edgeRegs.PixelIdxList)) = 1;

axes(handles.axes1);
imshow(c);
cla(handles.axes2, 'reset');
setappdata(0,'c',c);
```

Figure 4: Edge detection code

2.1.3 Fracture detection

The last stage of this system is fracture detection. In this stage, a useful feature which is line detection can be extracted and used to distinguish between fracture and non-fracture bone images. The feature detects the fracture line by looking for straight lines in the picture to determine the bone angle. Every edge point in the edge map is converted to every line conceivable. After pre-processing and segmenting the input image, the Hough transform is used to extract the features in a binary image. In image processing, the Hough transform is a feature extraction technique used in image analysis, computer vision, and digital image processing. Its purpose is to use a voting mechanism to locate imperfect examples of objects inside a given class of forms. This voting mechanism is carried out in parameter space, from which object candidates are produced as local maxima in an accumulator space, which is generated explicitly using the Hough transform algorithm. A graph of max Hough transform against theta value will be plotted in the system. Theta value measures the rate of decline in the value of an option due to the passage of time. Figure 5 shows the flowchart for fracture detection while Figure 6 shows the coding of the Hough transform technique.

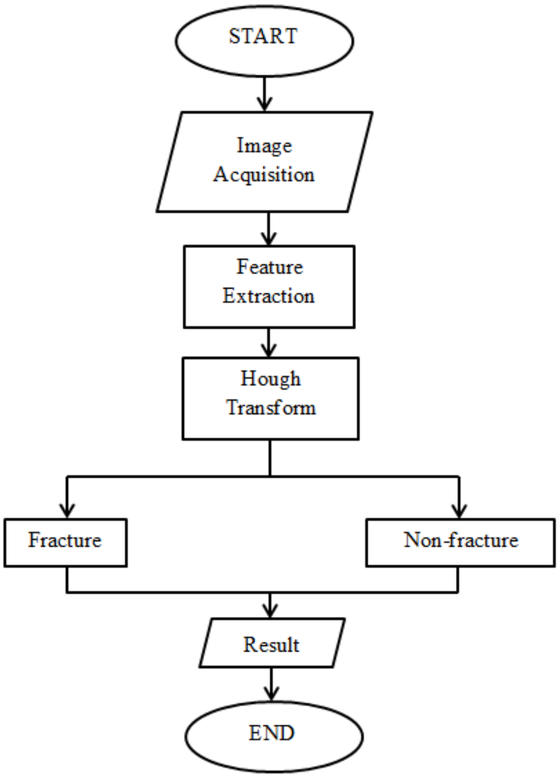


Figure 5: Fracture detection flowchart

```
axes(handles.axes2);
plot(T, maxHough);
hold on
plot([min(T) max(T)], [HoughThresh, HoughThresh], 'g');
plot(T(HoughPeaks), maxHough(HoughPeaks), 'rx', 'MarkerSize', 12,
'LineWidth', 2);
hold off
xlabel('Theta Value'); ylabel('Max Hough Transform');
legend({'Max Hough Transform', 'Hough Peak Threshold', 'Detected
Peak'});
title('Hough Detection Plot : Max Hough transform vs Theta');
```

Figure 6: Hough transform code

3. Results and Discussion

3.1 Graphical User Interface (GUI)

In this project, a GUI is designed based on the flow of the work for bone fracture detection. GUI is a sort of user interface that uses visual indication representations to allow people to interact with it. The GUI for this project is shown in Figure 7.

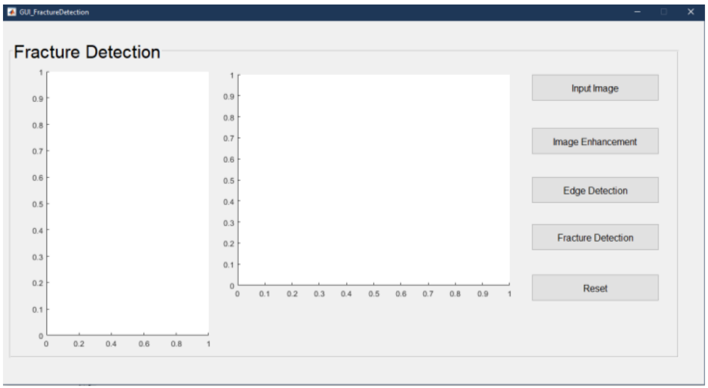


Figure 7: Graphical User Interface

The GUI consists of 2 panels and 5 buttons. The panels are used to show the image of the bone and graph plotting. The input image button is used to choose an image from the file that is stored inside the computer and will appear on the blank panel. The image enhancement button is to convert the image to a grayscale image and enhance the contrast of the input image. The edge detection button applied canny detection to the input image and left out only important edges. The fracture detection button is used to locate the break location from the input image and plot a Hough transform against the theta value graph. The reset button clears the previous data from the GUI.

3.2 Simulation

In this paper, the systems were tested using 15 sample images of high-resolution fractured long bone x-ray images. The sample images were obtained from Imaging Department, Gleneagles Hospital Medini, Johor. The image was tested step by step using the designed GUI.

3.2.1 Input Image

Image of broken bone x-ray imported from the file in computer picked by the user into the GUI. Once the button is pushed, a file appeared asking the user which image to use for the system. The format of the image used for this system is jpeg and an error occurred if the image format is different. The image will appear on the panel after the user selected the image to use as shown in Figure 8.

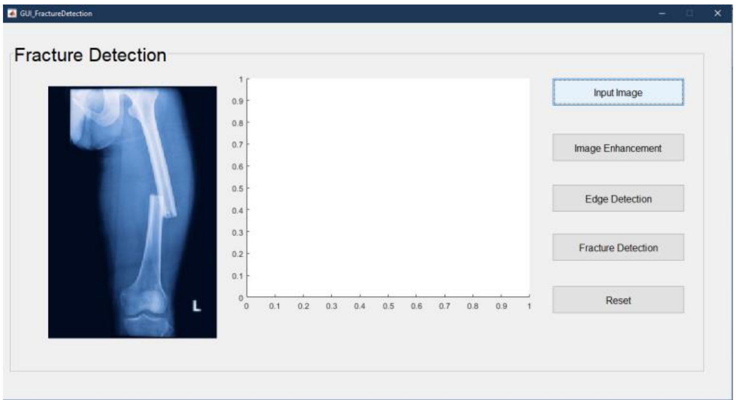
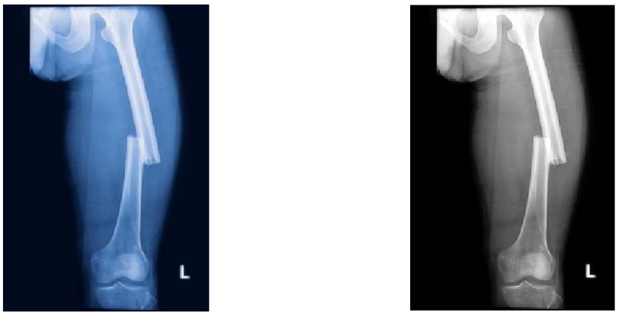


Figure 8: The image selected appeared in the panel

3.2.2 Image enhancement

The selected images were enhanced by the system. The purpose of image enhancement is to improve the quality and information content of the original data before processing. The selected image was converted from RGB (red, green, blue) image into a grayscale image. Contrast enhancement is applied to the grayscale image for a better output as shown in Figure 9.

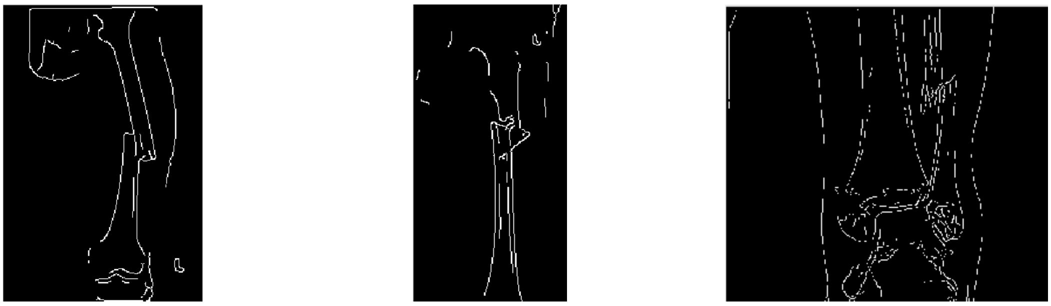


(a) (b)

Figure 9: (a) Original Image (b) Enhanced Image

3.2.3 Edge detection

Edge detection is applied to the enhanced image for extracting all-important line that can be obtained from the image. The canny edge operator is used for this system. Gaussian filter is applied to smooth out and decrease the impact of picture noise. The picture was reduced down to a 1-pixel curve and hysteresis thresholding was applied. Figure 10 (a) – (c) shows the output image samples.



(a) (b) (c)

Figure 10: (a) (b) Femur bone and (c) Fibula Bone Edge Detection Image

3.2.4 Fracture detection

Fracture detection located the break or fracture site in the x-ray images. The system will point out the location of the break. A graph of max Hough transform against theta value was plotted in the panel as in Figure 11. After obtaining the result the processed picture is compared with the original image using naked eyes as the original x-ray image has high image resolution as shown in Figure 12.

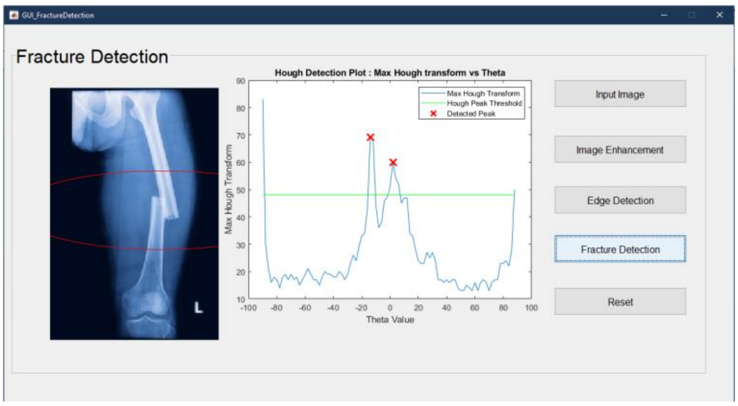


Figure 11: Fracture location and Hough Detection Plot

(a)

(b)

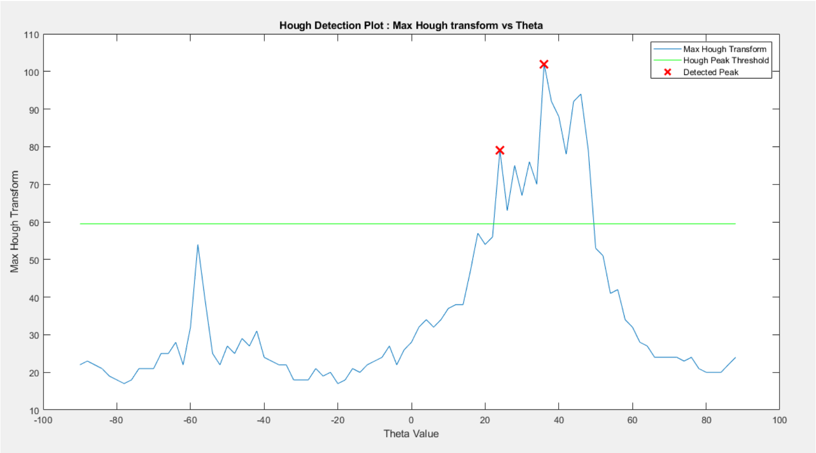
Figure 12: System points out the fracture location of (a) tibia and (b) femur bones

3.3 Simulation result analysis

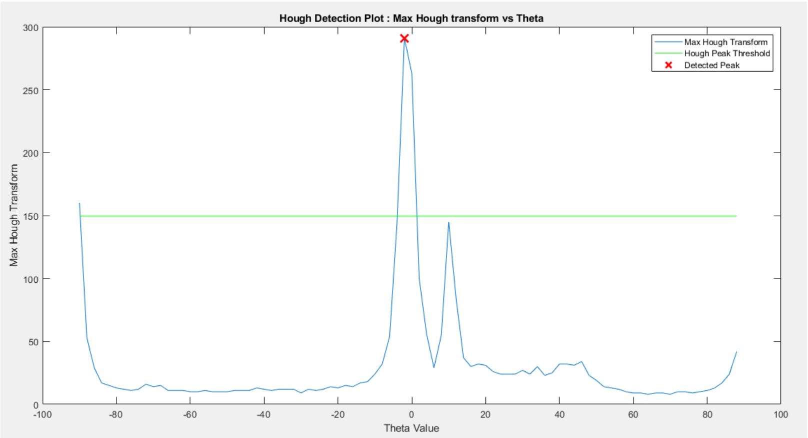
The observation of the system is done based on the plot graph of max Hough transform against theta. The threshold value is used to find the fracture point and preserved as a straight line for bone. If the is an angle present between the straight line the peak will be plotted in the graph. There will be two peaks identified if there were more than one major angle contribution, but just one peak if there is only one major angle contribution. If two peaks are detected in the graph it indicates the bone is a fracture but if only one peak it indicates nonfracture presence as in Figure 13.

Figure 13: Non-fractured bone use for comparison

The green lines in Figure 14 graph represent the Hough peak threshold, the blue lines represent the maximum Hough transform, and the red mark cross represents the detected peak. The edge image is then convoluted with the Hough transform's line of the measured angle. Finally, the system compares the differences between the convoluted pictures and determines where the difference crosses zero, which is the site of the break and draws a bounding ellipse around the breakpoint in the image. Theta value is the angle between the x-axis and the rho vector. The theta value is used to measure the rate of decline in the value of an option due to the passage of time.



(a)



(b)

Figure 14: Hough Detection Results for (a) Fracture Bone and (b) Non-Fracture Bone

3.4 Discussion

In this project, 15 sample images are tested on the system. All of the sample images are fracture x-ray images. From the result obtained the system manages to detect the fracture location of 13 sample images. The system cannot detect the fracture location correctly in 2 sample images. The system manages to detect fractures in sample image number 5 and 11 but it marks the fracture location in the different areas of the image. In this project, a canny edge detector is used as it gives better results and a clear picture of the bone structure. Hough transform is used to detect lines in the images. The graph of max Hough transform against theta is plotted to detect the Hough peak as shown in Figure 11. The detected peak can be used to detect the presence of fracture in the sample image. The accuracy of the system is about 86.67% and can be further by utilizing an intensive picture training set.

4. Conclusion

This paper presented fracture detection in bone x-ray images using canny edge detection. The approach proposed has been successfully implemented into the system design. The approach is developed to detect fracture location in a long bone x-ray. The accuracy of the system to detect the fracture site is 86.67% but it can be improved further by utilizing an intensive picture training set. The system managed to plot the max Hough transform against the theta graph. The graph is used to detect between fracture and non-fracture images.

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