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# Radius Bone Fracture Detection Using Morphological Gradient Based Image Segmentation Technique

Swathika.B[1, 4], Anandhanarayanan.K[2,*], Baskaran.B[3] and Govindaraj.R[2]

[1]*Student Trainee, Central Electronics Engineering Research Institute, Chennai Centre, CSIR Madras Complex, Taramani, Chennai, India*

[2]*Central Electronics Engineering Research Institute, Chennai Centre, CSIR Madras Complex, Taramani, Chennai, India*

[3]*Government Royapettah Hospital, Royapettah, Chennai, India*

[4]*Department of Computer Science, Dhanalakshmi College of Engineering, Chennai, India*

***Abstract*— Medical X-ray imaging has wider acceptance in computer aided clinical diagnosis. Computer aided bone fracture detection technique is mainly implemented to assist doctors to provide better diagnosis report. Bone fracture can occur in any part of human body such as the leg (tibia and fibula), hand (radius and ulna) and foot etc. This paper mainly discusses the computer aided diagnosis of radius bone fracture detection in X-ray images. Accurate bone structure and fracture detection is achieved using a novel morphological gradient based edge detection technique, in which canny edge detection is applied after finding morphology gradient. The morphological gradient technique removes noise, enhances image details and highlights the fracture region. The fracture edges are more prominently revealed due to the combined effect of morphological gradient technique and canny edge detection algorithm. The processed image output show that the proposed technique provides efficient fracture detection when compared with other edge detection methods.**

***Keywords*– X-ray image, Radius bone, gray scale morphology, morphology gradient, dilation, erosion, canny edge detection.**

## I. INTRODUCTION

X-ray medical imaging plays a vital role in diagnosis of bone fracture in human body. The X-ray image helps the medical practitioners in decision making and effective management of injuries. In order to improve diagnosis results, the stored digital images are further analyzed using medical image processing.

The most common ailment of the human bone is fracture. Bone fractures are nothing but the cracks which occur due to accidents. There are many types of bone fractures such as normal, transverse, comminuted, oblique, spiral, segmented, avulsed, impacted, torus and greenstick [1, 2]. Generally for X-ray image segmentation of bone fractures, a number of edge detection algorithms like sobel, prewitt, roberts and canny [3, 4, 5, 6] were used. Jaskirat kaur et al. compares image segmentation of X-ray image using various edge detection techniques and found that best segmentation results were obtained using canny edge detection [3]. Subodh kumar et al performed X-ray image segmentation using sobel edge detection method [5]. Satanage et al has applied different edge detection methods on X-ray images and observed that the conventional edge detection methods also provide best segmentation results [7].

This paper discusses about development of a novel X-ray image segmentation technique for bone fracture detection using the combination of morphology gradient and canny edge detection method. This paper is organized as follows: Section II describes about image morphology. Section III explains about proposed fracture detection technique. Image processing results are discussed in section IV.

## II. IMAGE MORPHOLOGY

Image morphology can be defined as a theory for analysis of spatial structures in gray scale image [8]. Morphological operators aim at extracting relevant structures of the image considered as a set through its sub-graph representation. This is obtained by probing the image with another set of known shape called structuring element (SE). The size of the SE is usually chosen based on priority knowledge about the shape of the relevant and irrelevant structures found in the image. Different shapes of structuring elements are disc, hexagon, diamond, horizontal line segment and pair of points. A disc shape SE was chosen in this application after studying the spatial topology of X-ray images.

## III. PROPOSED FRACTURE EDGE DETECTION TECHNIQUE

### *A. Pre-processing*

The digital X-ray images of bone fracture needs to be pre-processed to improve the quality of image before analysis. In the pre-processing stage, noise removal, shading correction and contrast enhancements are performed on the X-ray images. To perform shading correction, a linear intensity transformation is applied to tackle the intensity variation found in the image caused due to angular projections of X-rays. In linear intensity transformation, the total image is subtracted from the average pixel value to obtain pre-processed image. The average pixel value for each row is computed by taking 10 pixels along the column from the background portion of the image. The application of morphology gradient operator in the algorithm automatically removes the noise and improves the contrast of the image.

### *B. Canny Edge Detection*

Canny edge detector is a powerful edge detection method applied for bone structure detection [3, 6]. The image is smoothed using a Gaussian filter with a specified standard deviation σ, to reduce noise. Here two threshold values [T1, T2] are used, where T1 represents the maximum threshold and T2 represents the minimum threshold [4, 9]. If the pixel value has a gradient higher than maximum threshold value then that pixel is considered as an edge. If the pixel value has a gradient lower than the minimum threshold value then the pixel is considered as a background image. If the pixel value has a gradient between the maximum threshold and minimum threshold then the pixel will be considered as an edge only when the nearby pixel has a gradient higher than the maximum threshold.

### *C. Morphology Gradient Based Bone Fracture Segmentation*

Morphological gradients [10] are operators enhancing variations of pixel intensity in a neighbourhood, which is determined by a symmetric structuring element. Dilation and erosion are the two main morphological operators [11]. The erosion/dilation outputs for each pixel the minimum/ maximum value of the image in the neighbourhood defined by the structuring element [8, 12]. To find morphological gradient image, following three combinations are preferred: a) Arithmetic difference between dilation and erosion. b) Arithmetic difference between the dilation and the original image. c) Arithmetic difference between the original image and its erosion. Initially X-ray image is pre-processed using linear shade correction method. Then the pre-processed image undergoes dilation (thickening or growing) and erosion (thinning or shrinking) process. Difference image is computed by subtracting the eroded image from the dilated image. Morphological gradient image is obtained by subtracting the difference image from the pre-processed image. Before edge detection process, image dilation is performed for smoothing the gradient image. Finally canny edge detection is applied to obtain the bone and fracture edges as shown in the flowchart Fig.1.

The proposed algorithm based on morphological gradient analysis and canny edge detection has following steps:

1. Initially input X-ray image f(x, y) [Fig.2a] is pre-processed with linear intensity transformation technique.
2. Difference image is obtained by subtracting the eroded image from the dilated image.
   $diff(x, y) = f_d(x, y, B) - f_e(x, y, B)$
   Where B denotes disc shape structuring element of mask size (3 x 3).
   diff(x, y) denotes the difference image [Fig.2c].
   $f_d(x, y, B)$ denotes the dilated image.
   $f_e(x, y, B)$ denotes the eroded image.
3. Gradient image [12, 13] is obtained from subtracting the difference image from the pre-processed image [Fig.2b].
4. Dilation of the gradient image [Fig.2d] is performed using a diamond shape structuring element of mask size (3 x 3).
5. Apply canny edge detection algorithm.

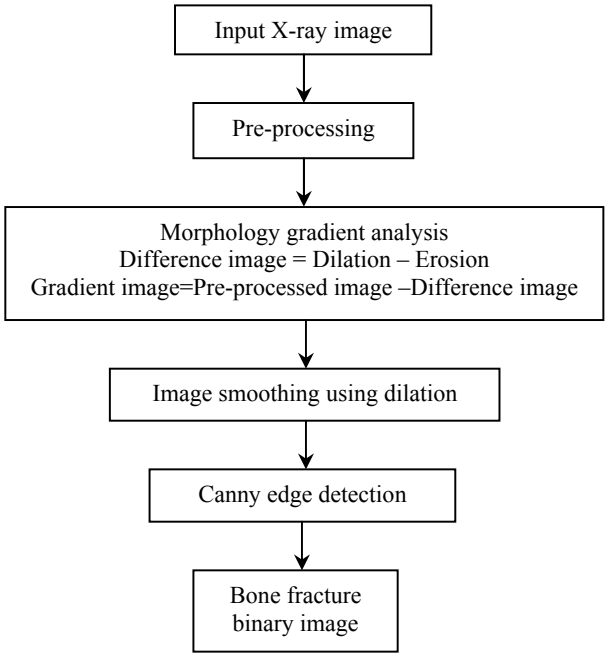


Fig.1. Flowchart for the morphological gradient based bone fracture segmentation algorithm

## IV. IMPLEMENTATION AND RESULTS

Radius bone fracture detection algorithm was developed to add additional features to computer aided diagnosis systems and support doctors for better treatment. This work is developed using explicit coding in MATLAB (ver.7.12). Since X-ray images are larger in size, resizing of the images were done to satisfy MATLAB image format. By default X-ray images are stored in RGB; therefore grayscale conversion is done prior to image pre-processing stage. A few sample digital X-ray images of radius bone fracture were taken from radiograph film resolution (4096x2048).The images were resourced from an orthopedic doctor. The algorithm was developed to detect the radius bone fractures and the results were compared with other edge detection methods.

The results of edge detection techniques such as sobel, prewitt and canny directly applied on pre-processed image were shown in the Fig.2e to Fig.2g. The image results show that the prewitt and sobel edge detectors provide an accurate fracture edge detection but unable to eliminate noise and detect the radius bone structure. In case of canny edge detector, the bone structure is detected accurately without noise, but fails to detect the fracture edges. Our proposed morphology gradient based bone fracture segmentation algorithm accurately detects the bone structure and fracture edges as shown in the Fig.2h. The proposed algorithm has following advantages:

1. Construction of enhanced X-ray image by eliminating noise pixels.
2. Morphology gradient technique highlights the fracture area.
3. Clear bone edge detection provides detail information about the exact location of the fracture.

Fig.2a. X-ray image with fracture indication

Fig.2b. Pre-processed image

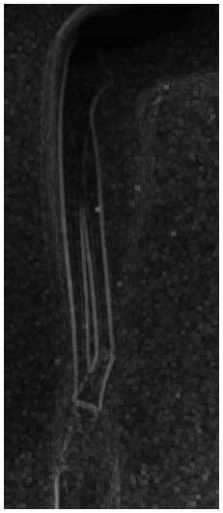

Fig.2c. Difference image

Fig.2d. Morphological Gradient Image

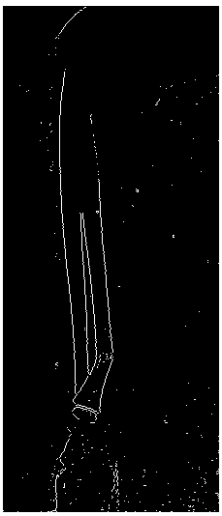

Fig.2e. Sobel Image obtained from Pre-processed image

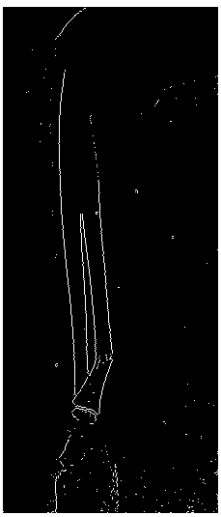

Fig.2f. Prewitt Image obtained from Pre-processed image

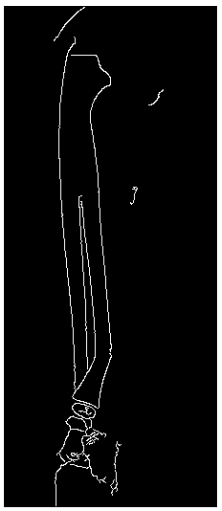

Fig.2g. Canny image obtained from Pre-processed image

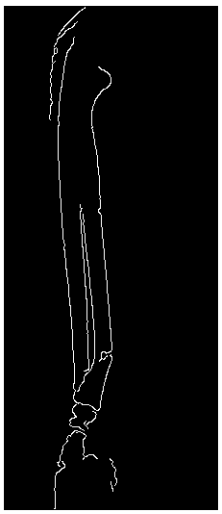

Fig.2h. Proposed bone fracture segmentation algorithm

## V. CONCLUSION

In this paper, a novel morphology gradient based image segmentation algorithm is proposed to detect the radius bone fracture edges. The image processing results as depicted in Fig.2a to Fig.2h, show that bone structure and fracture edges are detected more accurately using proposed image segmentation method compared with other edge detection techniques like sobel, prewitt and canny. Here, the morphological gradient image clearly highlights the sharp gray level transition occurring in the fracture region. Since the canny edge detection method is applied to the morphology gradient image, an appropriate lower and upper threshold value needs to be provided manually. The same algorithm can be extended to other type of bone fracture detection with slight modification.

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