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Fracture detection in X-ray images of long bone

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Abstract— Image processing used in wide variety of applications such as Image restorations, satellite, and medical etc. With enrichments of the image processing libraries especially of openCV and Matlab, many applications are being developed day by day in computer vision or image processing domain. We have designed the bone fracture detection method using *"Image Processing*" toolbox in Matlab. Aim of the project is to locate exact fracture area in inputted X-ray image. We will check bone integrity to detect any crack or disjoint of two cartilages. The professed algorithm is divided in few step namely pre-processing, Segmentation and ROI search and detection. Features like area, length and pixel locations of the segments are used to identify fracture in X-ray image. Algorithm has been simulated on various X-ray images which show good results to locate fracture in image. Also, in this approach we found that canny edge detection works far better than any other edge detection for segmenting the fractured part.

Keywords— Atutomatic, Bone, Canny, Fracture, Image Processing, Preprocessing,Segmentation, X-Ray

I. INTRODUCTION

Recent medical technologies are highly depends on the medical imaging field where X-ray, Magnetic resonance imaging (MRI),digital radiography and ultrasound are used for many diagnostic or decision purpose. Because of this, it makes physician more confident for further process by showing qualitative and quantitative data about the disease or problem. In our work, we have tried to cover radiology field problem of localizing exact fracture in bone. To detect bone segments accurately edge detection is first step. Among the various methods of boundary localization, Soble, Robert, Prewitt, Zero crossing and LOG(Laplacian of Gaussian), canny edge operator performs better[1]. So we have used it to detect edges in X-ray image. The proposed algorithm is developed in Matlab R2013b.

Bone fracture must be localized fast in some of the sever situations to apply any medical treatment. Some time human expertise fails for consistent judgment in all cases and makes intolerable error. Hence, machine (computer vision) based analysis is always faithfully then human. In this work we have tried to locate lower leg bone fracture. Lower leg bones made of two main bones, tibia and fibula, where tibia carries a significant portion of the body weight so it is more prone to fracture in most of the cases. Here transmissive type imaging is used to detect fracture, in which X-ray passes from the body mussels part an attenuate maximally when passing through bones. Section 2 represents the earlier work and section 3 reveal overview of the digital image processing and proposed algorithms. Section 4 shows promising result obtained by this algorithm.

II. RELATED WORK

Many researchers are working to model an efficient algorithm to detect fracture [1]. Here, brief literature is presented. Work by [2] Y Jia and Y Jiang, shows fractured bones of patient's arm within casting materials, and alignment between fracture bones. To segment the bone region a geodesic active contour model is used with global constrains. A priory shape is derived by maximum-likelihood function for each evolving process. Robust and accurate results were obtained by this method.

Morphological method has been proposed by [3] JIAN LIANG et al, to identify fracture in tibia bones where before segmentation, the original image is dynamically divided into several sub-images to detect smallest interval in target image. Obtained segmentation results are examined using statistical methods which will be used to compare defined stopping criteria of adjustment. Automatic thresholding technique Otsu is used for this. Morphology is applied on extracted segment to extract the target border and cover the boundary of fracture. The accurate location can be recognized by superposing the target border image and covering the extracted skeleton.

Automatically detecting fractures, by [4] Martin Donnelley et al., in long bones, edges are extracted from the x-ray image using a non-linear anisotropic diffusion method that assures no loss of important information about the boundary. For the better approximation of the edges of the long bone, Hough transformed is used with automatic peak detection. Centerline approximation, diaphysis segmentation and fracture detection are approximated by the extracted parameters in the segmented region. Neural Network techniques has been proposed by [5] Syiam et al. to detect fractures in long bone. An adaptive interface agent, called the AdAgen that collaborates with trained agents using neural network to build the software interface agent to detect fractures in long bone is used.

Various classifier have been proposed till date for classifying fracture based on one or more of the feature like shape parameter, appearance parameter, texture, gabor orientation, Markove Random Field(MRF) ,Intensity Gradient Detection(IGD) and Neck Shaft Angle.

[6] ZHENG wei et al. developed the automatic interpretation of fracture, in femur bones,by converting it to bone shape identification problem. The fracture location,the proximal, middle or the distal part of femur bone can be identified by shape of the bone segment.

DWT is applied by [7] Rebecca Smith et al. for fracture detection in pelvic ring. Prior automated region is segmented by DWT.The bone boundary can be highlighted by reconstructing image using same wavelet coefficient which will be followed by morphological operation on its binary image.The N8 connectivity is used to identify pixel location on boundary. Based on the number of interrupts on boundary suggest the types and number of fracture in bone.

Fuzzy function optimization is used to detect crack in the method developed by [8].The subset parameters of histogram is used as initial estimates and each pixel in the fuzzy region is classified as belongs to one of the sub-set by minimizing the fuzzy index. From the segmented three regions, the background and skin regions are removed for better detection of the crack in bone region

Automatic fracture detection in Femur bone using well know classifiers Support Vector Machine (SVM) and Neural Network were also been tested by [9]. Performance was compared with traditional classification system and result showed higher accuracy for detecting fracture.

III. METHODOLOGY

Based on literature surveyed we proposed an algorithm to detect fracture in leg's long-bone, tibia. Flow diagram is as shown in figure-1. X-ray images are used for testing purpose which we got from internet. Detail about each block is as under.

Preprocessing:

This stage usually important for enhancing the input image data for further processing because there at time of image capture there are several reasons to make image data corrupted. In presence of any type of noise it becomes very much difficult to extract the correct information or leads to the different results of subsequent stages. Below model shows the additive noise η (x, y) to original image f (x, y).

$$g(x, y) = f(x, y) + \eta(x, y) \quad (1)$$

where g (x, y) is the noisy image.

In the preprocessing task, 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 chooses 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.

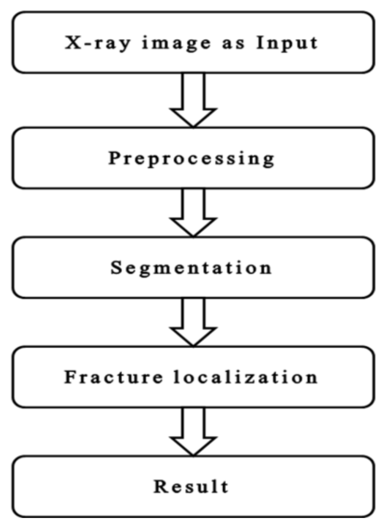

Figure-1 Proposed algorithm flow

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. In this work, σ=2 is taken. After filtering, this system is performed adjusting image brightness and colour to distinct the desired object or bone shape from the image. Then, the enhanced image is converted into the gray scale for detecting edges in segmentation part which also lessen the computation from 3D matrix to 2D. Figure-2 shows the results of image smoothing on an X-ray bone image.

Segmentation:

Image segmentation is the fundamental step to analyze 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 most widely used operations in applications that require determining objects' boundaries in an image. It is based on analyzing the changes in the intensity in the image. A famous canny edge detector is used for finding the boundaries of segments which outperforms than soblel, prewitt and Robert edge detector.

Canny Edge Detection: Canny edge operator is considered as superior edge detection operator among the available operators based on the experimental results[10]. It detects faint edges more efficiently even in noisy.

Test image 1

Test image 2

Test image 3

Test image 4

Figure-2 result of smoothing on test images

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. Algorithm steps are briefed below:

1. Smooth image with a Gaussian
2. Compute the Gradient magnitude using approximations of partial derivatives
3. Thin edges by applying non-maxima suppression to the gradient magnitude
4. Detect edges by double thresholding

Fracture localization:

Few procedures are used to detect the fracture in final stage. Very first, straight lines are extracted from the image which features are used to detect the fracture or non-fracture image. The Hough transform is used for identifying straight lines in a given image. It uses binary information of segmented image and tries to detect the points in same lines by

$$r = x \cos\theta + y \sin \qquad (2)$$

where, r (Distance) is the perpendicular line from origin to the test line, θ (Angle) is between the perpendicular line and the horizontal axis and then x,y are constants. A parameter space is used to map point of image space where intersection of any waves of two different points show that they are on a single line and can be linked. Here, linking of two lines is allowed upto 10 pixels. Finally, an accumulated cell with a local maximum of scores is selected, and its parameter coordinates are used to represent a line segment in the image space.

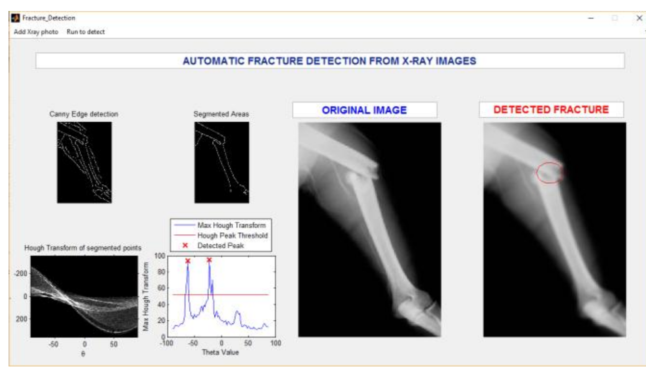

Figure-3 Fracture Detected

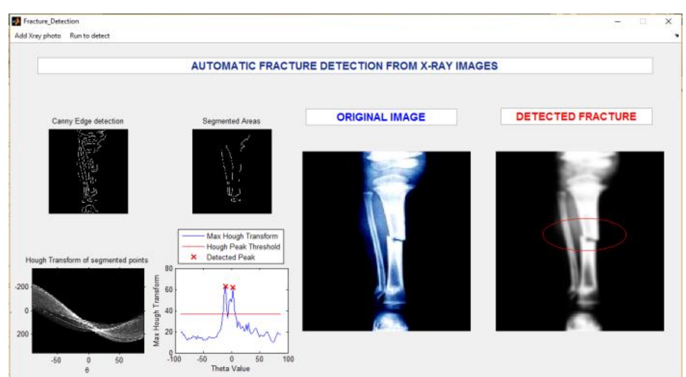

Figure-4 Fracture Detected

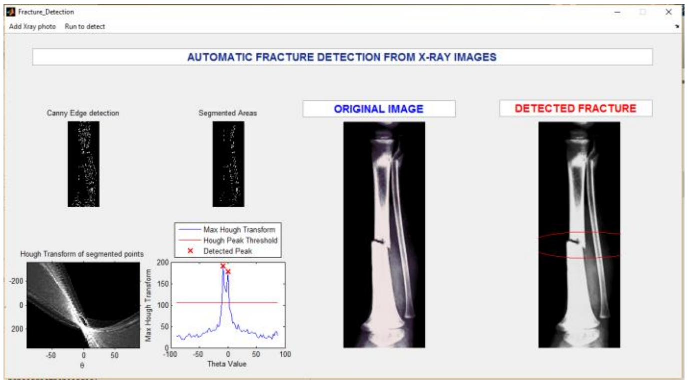

Figure-5 Fracture Detected

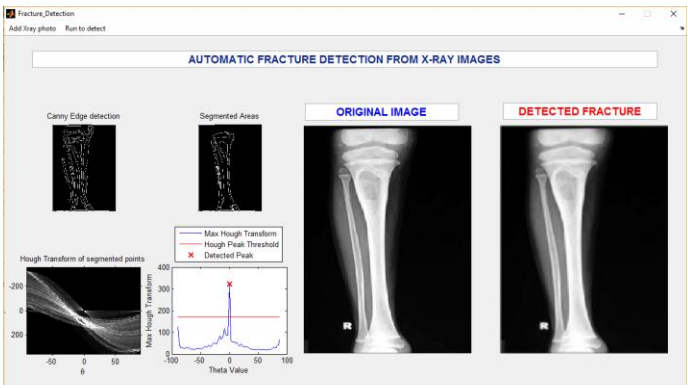

Figure-6 Fracture Not-Detected

IV. RESULTS AND DISCUSSION

Algorithm has been implemented using Matlab and its image processing toolbox. A complete GUI has been developed to show and compare the achieved result soothingly. We have worked on 12 images whereas result shown here are of the three fracture images and one non-fracture image. In the result snapshot we can see the original image and detected fracture in second image highlighted by red circle. Few intermediate results, canny edge detection, segmented areas, Hough transform parameter space and detected peak points in the graph as the fracture exist are also shown. Presentation of testing images and results are same in all four snapshots. We can see, if there is a two separate segment's peak available then only fracture can be detected as in figure 3-5 whereas only one peak shows no fracture in the image, shown in figure-6.Though we have tested the algorithm using other edge detection techniques and blind deconvolution techniques to remove noise in first preprocessing task but achieved results were not up to the mark as shown here.

V. CONCLUSION AND FUTURE SCOPE

A computer based automatic long-bone fracture detection techniques using X-ray/CT images have been shown in this work. Results achieved on three fracture and one non-fracture images are very accurate and shows it is the base of any other type of fracture detection technique in future. In the future work more robust algorithm to detect fracture in hand will be considered.

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REFERENCES

[1] Jacob, Nathanael E., and M. V. Wyawahare. "*Survey of Bone Fracture Detection Techniques*." International Journal of Computer Applications 71.17, 2013.
[2] Jia,Y.,and Y.Jiang. "*Active contour model with shape constraints for bone fracture detection*." International Conference on Computer Graphics, Imaging and Visualisation. IEEE, 2006.
[3] Liang, Jian, et al. "*Fracture identification of X-ray image*." International Conference on Wavelet Analysis and Pattern Recognition (ICWAPR), IEEE, 2010.
[4] Donnelley, Martin William. "*Computer aided long-bone segmentation and fracture detection*." Diss. Flinders University, Faculty of Science and Engineering, 2008.
[5] Syiam, Mostafa, Mostafa Abd El-Aziem, and Mohamed El-Menshawy. "*AdAgen: Adaptive Interface Agent for X-Ray Fracture Detection*." International Journal of Computing & Information Sciences 2.3, 2004.
[6] Wei, Zheng, and Zhang Liming. "*Study on recognition of the fracture injure site based on X-ray images*." 3rd International Congress on Image and Signal Processing (CISP), Vol. 4. IEEE, 2010.
[7] Smith, Rebecca, et al. "*Detection of fracture and quantitative assessment of displacement measures in pelvic X-RAY images*." International Conference on Acoustics Speech and Signal Processing (ICASSP), IEEE, 2010
[8] Linda, C. Harriet, and G. Wiselin Jiji. *"Crack detection in X-ray images using fuzzy index measure*." International Journal of Applied Soft Computing 11.4, pp.3571-3579, 2011
[9] M P Deshmukh, P. Deshmukh, "*Development of Automatic Fracture Detection System using Image Processing and Classification Methods for Femur Bone X-Ray Images*", International Journal of Computer Sciences and Engineering (IJCSE), Vol. 4, Issue.1, pp.56-60, 2016.
[10] Shrivakshan, G. T., and C. Chandrasekar. "*A comparison of various edge detection techniques used in image processing*." IJCSI International Journal of Computer Science Issues 9.5, pp.272-276, 2012.

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