

Bone Fracture Detection using Image Segmentation

Tanudeep Kaur¹, Anupam Garg²

¹Student, Department of CSE, Bhai Gurdas Institute of Technology, Punjab, India

²Assistant Professor, Department of CSE, Bhai Gurdas Institute of Technology, Punjab, India

^{1,2}Sangrur, Punjab, India

Abstract— The fracture can occur in any bone of our body like wrist, ankle, hip, rib, leg, chest etc. The Fracture cannot detect easily by the naked eye, so it is seen in the x-ray images. This Paper represents the fracture detection of the bone x-ray images by using the segmentation, Fuzzy c-means, and Multilevel wavelet algorithms. Bone Fracture detection has become a research area in the medical imaging system. An efficient algorithm is proposed for bone fracture based on thresholding and fuzzy c-mean segmentation and morphological operators. In the base paper [1], the fractured portion is selected manually to overcome this drawback, the proposed method detect the bone fracture automatically. The result shows that the proposed method of fracture detection is better. The results show that algorithm is 89.6% accurate and efficient.

Keywords — Image Segmentation Methods, Edge Detection, Fractured X-Rays Images, Fuzzy C-Means, Hough Transform and Multilevel Wavelet.

I. INTRODUCTION

The fracture may define as a crack or break in the bone [8]. Bone is made up of cells, protein fibers, and minerals. In our body when the several bones are joined together then it makes a skeleton of the body. Skeleton provide support to the body shape, and also protect the organs of the body, to provide attachments and movement of the muscles, and also to produce red blood cells. With the help of the bones, we can run, jump, sit, stand, walk, kneel, grasp, and lift. Bones also protect our internal organs from the potential damage. The fracture can occur in any bone of the body like wrist, ankle, hip, rib, leg, chest, etc. In the children, broken bones are very common. In children, the fractures are easily recovered than the adults. The broken bones can recover within 28 to 56 days and also it may depend on the person age and health and type of fracture. A fracture can be crosswise, lengthwise, in several places, or into small or two or more pieces. Typically, a bone fracture can be occurred by the force or pressure or fall from vehicles etc. Mostly the doctors can examine the fractures easily and take X-rays of the injury. Sometimes a fracture is not clear in the X-ray images like in the wrist, hip, and stress fractures. To find the fracture doctor performs

the several tests, like ultrasound, MRI, Computed tomography, Endoscopy, Medical photography or a bone scanning [17].

The [1], detect the appearance of rheumatoid arthritis. The first step is to denoise the image; by using the median filter the noise is removed. The next step is to normalize the image through the histogram smoothing and used the segmentation by using the thresholding. Then, the morphological operation of dilation and erosion is used to the removal of the bone area named as a region of interest. The next step is boundary detection, to find the edges of the bones by using the canny edge detection method. If the values of a diagnosis are above than a specific range than rheumatoid arthritis can be positive. For the classification, the Neural Network is used. The input image is pushed into the BMD Block, and then all the steps are performed on the input image. Then extract the GLCM features of the input image. Then the values are calculated by using the neural network and then classify whether the input image is infected or not [1].

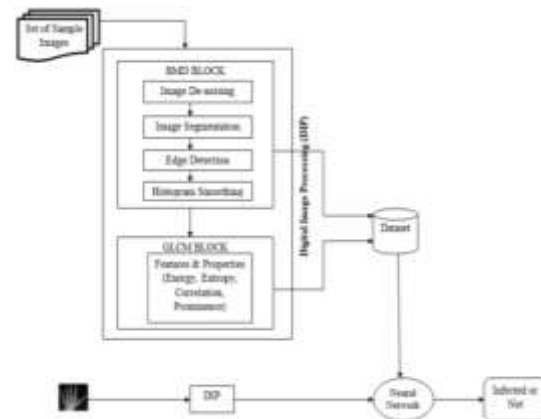


Fig. 1 Block Diagram [1]

II. RELATED WORK

SP. Chokkalingam and K. Komathy [1] implemented a new scheme to diagnose the presence of rheumatoid arthritis by a series of image processing techniques. The system can be enhanced by the improvement of the edge detection and find better segmentation technique. The Gray level co-occurrence matrix (GLCM) features are Mean,

Median, Energy, Correlation, Bone Mineral Density (BMD) etc. After finding all the features, it can be stored in the database. The dataset is trained with inflamed and non-inflamed values and with the help of classifier i.e. neural network.

Cephas Paul Edward V et al. [2] introduced automated techniques and methods to verify the presence or absence of fractures. The system involves steps such as acquiring the image. To make these images accurate one or more steps of pre-processing are applied to remove the noise and. The existing scheme is modified by a better segmentation and edge detection algorithm to improve efficiency.

Snehal Deshmukh et al. [3] conclude that the Canny Edge detection can be used in detecting fractured bones from x-ray images. According to the test result that has been done to detect the bone fracture, a conclusion can be made that the performance and accurate of the detection method affected by the quality of the image. The better the image quality, the better result system got.

Hs Rathode and Wahid Ali [4] proposed an algorithm for Automatic tumor detection that is based on segmentation using Daubechies Wavelet and Fuzzy C-Means (FCM) Clustering. The segmented portion showing the tumor area in pixels and the time elapsed to detect and calculate the area in seconds. The algorithm developed is accurate and fast to detect and quantify the tumor.

B Patel et al. [5] presented a breast tumor representation and removes the noise by using the fuzzy c mean algorithm and DWT. Discrete wavelet transform (DWT) is used to extract high- level details from MRI images. The processed image is added to the original image to get the sharpened image. Then Fuzzy C- means algorithm is applied to the sharpened image in which the tumor region is located using the thresholding method.

Swathika.B et al. [6] discussed the diagnosis of radius bone fracture detection in X-ray images. Canny edge detection is applied after finding morphology gradient. The morphological gradient technique removes noise, enhances image details and highlights the fracture region. The processed image output show that the proposed technique provides efficient fracture detection when compared with other edge detection methods.

R.Aishwariya et al. [7] proposed the technique that detect the boundaries of objects in noisy images using the information the fracture detection on the x-ray images is founded. The proposed technique for the canny edge detector in the x-ray image locates the edges and using the boundary detection, the system which detects the fracture automatically. The boundary detection techniques also implemented in the models are Active Contour Model, Geodesic Active Contour Model and compare the accuracy of detecting is analysed and tested.

III. PROPOSED METHOD

The proposed methodology contains the following steps that are shown in the following block diagram:-

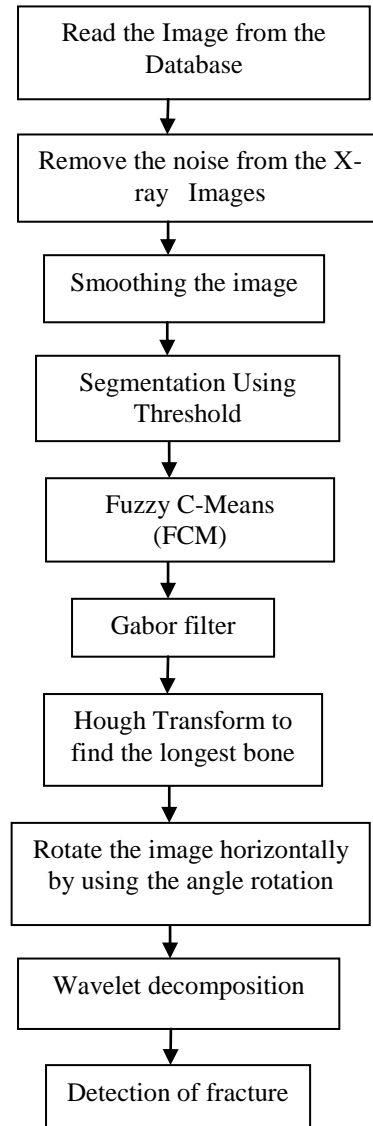


Fig 2: Steps of Bone Fracture Detection

In the [1], the fracture part of bone is selected manually by using the Region of interest (ROI).With the help of GLCM features like Mean, Skew, standard deviation, entropy, perimeter, bone mineral density calculates the value and if the area is larger and BMD value is more than 0.550 then the results are non-inflamed, else the results are inflamed. The main drawback of the [1] is that it may select the region of interest manually; to overcome this drawback in the proposed method the region of interest is selected automatically. In the proposed method the work is focused on the fractured bone images. So proposed method is focus on the

improved detection of bone fracture by using the various techniques. Fig 2 shows the flow chart where the steps were taken is shown. Fig 3 shows the original image that is taken from the database. Then resize the image and converting it into the grayscale image and then enhances the contrast of the gray scale image by using the contrast-limited adaptive histogram equalization.

On the basis of the performance metrics, the wiener filter[17] gives the better results as compared to median and the Gaussian filter the results as shown in table 4.1 and table 4.2. In the table 4.1 the images of the proposed filter are better than the median and the Gaussian filter So in the proposed method the wiener filter is used to remove the noise from the images as shown in figure 4.



Fig 3: Input Image

Fig 4: Denoise Image

Table 4.1 Results of Filters

Image Name	Org. Image	Proposed filter	Median filter	Gaussian filter
3.jpg				
6.jpg				
10.jpg				
12.jpg				
15.jpg				

Table 4.2 Performance Metrics of the filters

Input Image	PSNR			MSE		
	P.F	M.F	G.F	P.F	M.F	G.F
3.jpg	55.2	55.2	55.1	0.19	0.19	0.20

6.jpg	59.7	59.7	59.6	0.07	0.07	0.07
12.jpg	58.0	58.0	57.8	0.10	0.10	0.11
15.jpg	56.1	56.1	56.0	0.16	0.16	0.16

Where, P.F. = Proposed filter, M.F. =Median filter, G.F. = Gaussian filter, PSNR=Peak-signal-to-noise ratio, MSE= Mean squared error.

In the table 4.2 the results shows that proposed filter shows the better results than the median and the Gaussian filter, because the PSNR value is high and MSE value is less as compared to median and Gaussian filters.

The next step is smoothing the image by using the cumulative and probability distribution. Then segmented the image by using the thresholding. Then used the morphological operations, the structuring element is used to as an input image, and creating the output image of the same size. The morphological operations is used the erosion and dilation .Erosion removes the pixels from the boundaries while dilation adds pixels to the boundaries Fig 5 shows the morphological image.

Apply the Fuzzy C-Means algorithm to segment the image. In the FCM data set is grouped into the clusters and every data point in the data set belongs to every cluster to a certain degree. If the data is same the points belong to one cluster and if different then data points belong to different clusters. Fig 6 shows the FCM segmented image.



Fig 5: Morphological Image

Fig 6: FCM Image

Then uses the Gabor filter, it is a linear filter and all filters are generated from wavelet by performing dilation and rotation. In the proposed method the Gabor filter is used to find the edge detection and it will produce the thick edges. For the thin edges use the morphological operations to thin the object lines. It removes the pixels and the object connected to a stroke. Fig 7 shows the image of thinning after applying the Gabor filter.

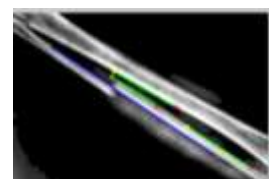


Fig 7: Thinning Image Fig 8: Hough Transform

Fig 8 shows the Hough transform. Hough transform is used to find the longest line in the bones. To detect the lines in images, firstly the image is binarised using thresholding and then the Hough accumulator is used to find a minimum line length, and the line gap. The longest line is represented by a blue line.

After finding, the longest line rotates the image horizontally by using the angle rotation method. Fig 9 shows the image rotation.

```

Angle = - (90-(atan2 (slope taken)))
      If slope taken <=0
      Angle= -atan2 (slopetaken)
      End
If slopetaken>0 & abs (slopetaken) <.2
      Angle= 90+angle1
      End
    
```



Fig 9: Rotated Image Fig 10: Fracture Detected

Then multi-level discrete wavelet transform with zero padding extension mode is applied. Biorthogonal discrete wavelet transform with 'zpd' mode is applied for the decomposition. Extract all level approximation and detail coefficients and then reconstruct the approximation and detail. The fractured portion is detected and segmented from the rotated image as shown in fig 11.

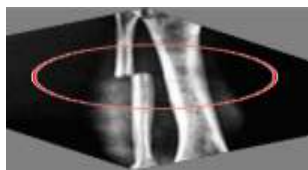


Fig 11: Bone Fractured Detection

Fig.12 shows the design and implementation of the proposed method. The GUI of the proposed method may contain the 8 axes that is used to display the image and there are 9 push buttons, by clicking the push button the image is displayed on the axes.

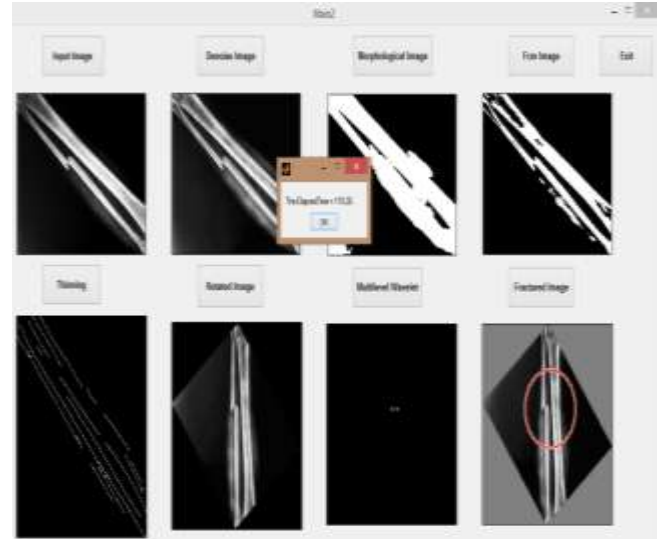


Fig 12 GUI Layout of Fracture Detection

Algorithm for Bone Fracture Detection

Input: Fractured Bone X-Ray Images I.

Output: Fractured Detection Image Y.

Begin:

Step1: Input Fractured X-Ray Image I.

Step 2: Apply the wiener filter to denoise the input image I. i.e. wiener2 (I, [m n]), where size m-by-n to estimate the local image mean and standard deviation.

Step 3: Apply the probability of each occurrence [1]. i.e. probf (value+1) = freq (value+1)/num of pixels.

Step 4: Apply the cumulative distribution probability of each pixel [1].

Step 5: Apply the Segmentation using the threshold on the input image H [1].

Step 6: Apply the morphological operations [1]: i.e.1.) hnew1 = imerode (HHH, se), where erodes the gray-scale image HHH, returning the eroded image hnew. The argument se is a structuring element object returned by the strel function.

2.) hnew = imdilate (hnew1, se1), where dilates the gray-scale, binary, or packed binary image hnew1, returning the dilated image, hnew. The argument se1 is a structuring element object, returned by the strel function.

Step 7: Apply the Fuzzy C-Mean [9] i.e. [center, U, obj_fcn] = fcm (data, cluster_n) where,

1. data: data set to be clustered; each row is a sample data point
2. cluster_n: number of clusters (greater than one)
3. center: matrix of final cluster centers where each row provides the center coordinates.
4. U: final fuzzy partition matrix
5. obj_fcn: values of the objective function during iterations

Step 8: Apply the Gabor Filter [10] i.e. [gb] =g_f (sigma, orient, wavel, phase, aspect) where,

1. sigma : standard deviation of Gaussian envelope, this in-turn controls the size of the result
2. orient : orientation of the Gabor from the vertical
3. wavel : the wavelength of the sin wave
4. phase : the phase of the sin wave
5. aspect : aspect ratio of Gaussian envelope (0 = no modulation over "width" of sin wave, 1 = circular symmetric envelope)

Step 9: Apply the Hough Transform [11]. To find the longest bone in the image. i.e. [H, T, R] = Hough (BW, 'RhoResolution', 0.5, 'Theta Resolution', 0.5);

1. RhoResolution — it is the Spacing of Hough transforms bins along the axis of rho, it may be specified as a real, numeric scalar between 0 and norm exclusive.
2. Theta Value for the corresponding column of the output matrix H, specified as a real numeric vector within the range [-90, 90]

Step 10: Apply the angle rotation [12]. Find the slope $m = \frac{y_2 - y_1}{x_2 - x_1}$, and then find the angle by using the slope.

$$\text{Angle} = - (90 - (\text{atand}(\text{slope taken})))$$

If slope taken <= 0

$$\text{Angle} = -\text{atand}(\text{slope taken})$$

End

If slope taken > 0 & abs (slope taken) < .2

$$\text{Angle} = 90 + \text{Angle}$$

End

Then rotate the image using the imrotate function. i.e. B=imrotate (A, angle, bilinear), Rotates image A by angle degrees in a counter clockwise direction around its center point.

Step 11: Apply the wavelet decomposition [13]. Wave2 dec is used.

$$[C, S] = \text{wavedec2}(X, N, 'wname')$$

The wname is Bior 6.8 filter with order 6 in decomposition and order 8 in reconstruction, no. of decomposition [15]. The fractured portion is detected.





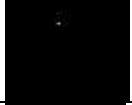








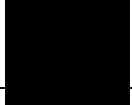

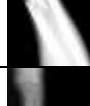
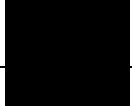


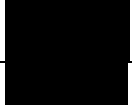


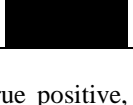
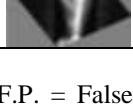
Step 12: Compute the performance parameters namely Precision, Recall and Accuracy [41].

End.

IV. RESULTS

Fracture detection algorithm is applied on 126 fractured database images. Mostly The database contains the fractured images of leg, arm, knee, elbow and thigh. The Wavelet decomposition results computed as shown in the figures 3-12 and the rest of images results as shown in Table 4.3. The efficiency and the accuracy of the algorithm is 89.6 %. The precision of the proposed algorithm is 93.1 % and the Sensitivity of the fracture detection is 95.5%.

Table 4.3 Result of Fractured Images

S.No.	Input Image	Multilevel Wavelet	Fractured Image	Elapsed Time
T.P.				15.57
T.P				15.30
F.P.				12.42
F.P.				9.57
F.N.				12.07
F.N.				12.07
T.N.				12.00
T.N.				12.46

Where T.P. = True positive, F.P. = False positive, F.N. = False negative, T.N. = True negative

IV. CONCLUSION AND FUTURE WORK

A wavelet approach used to detect Fracture detection region on the X-Ray images. Multilevel wavelet is used to find the fracture from the x-ray bone images; it may detect only the fracture portion. Results suggest that the method is capable of detecting fracture detection with 93.1% positive predictive value and the sensitivity of the proposed fracture detection algorithm is 95.5%. The Accuracy and efficiency of the fracture detection algorithm is 89.6%. There are some limitations that it finds the fracture only the horizontal images. In the future algorithm can be modified or applied on the different dataset and also the algorithm is used for the short bone x-ray images to detect the fracture and also in the hand, rib, hip, back bones etc. The algorithm is used on the upper end and lower end of the bone images. To overcome the limitation algorithm used on the vertical and diagonal images.

V. REFERENCES

- [1] Chokkalingam, SP. and Komathy, K. (2014). “*Intelligent Assistive Methods for Diagnosis of Rheumatoid Arthritis Using Histogram Smoothing and Feature Extraction of Bone Images*”. World Academy of Science, Engineering and Technology International Journal of Computer Information Systems and Control Engineering, Vol. 8, Issue .5, pp.834-843.
- [2] Edward V, Cephas Paul. and Hepzibah S, Hilda. (2015) , “*A Robust Approach For Detection of the type of Fracture from X-Ray Images*”, International Journal of Advanced Research in Computer and Communication Engineering, Vol. 4, Issue No. 3, pp.479-482.
- [3] Deshmukh, Snehal., Zalte, Shivani., Vaidya, Shantanu. and Tangade, Parag. (2015), “*Bone Fracture Detection Using Image Processing In Matlab*”, International Journal of Advent Research in Computer and Electronics (IJARCE), pp. 15-19.
- [4] Rathode, Hs. and Ali, Wahid. (2015), “*MRI Brain Image Quantification Using artificial neural networks – A Review Report*”, ISOI Journal of Engineering and Computer science, Vol. 1, Issue No. 1, pp. 48-55.
- [5] Patel, Brijesh B., Shah, Brijesh N. and Shah, Vandana. (2013), “*Breast tumor representation & noise removal using Fuzzy c-mean algorithm and DWT*”, International Journal of Computer Trends and Technology (IJCTT), Vol. 4, Issue No.5, pp. 1111-1114.
- [6] B.Swathika.,K.Anandhanarayanan.,B, Baskaran. and R, Govindaraj. (2015), “*Radius Bone Fracture Detection Using Morphological Gradient Based Image Segmentation Technique*”, International Journal of Computer Science and Information Technologies, Vol.6, Issue No.2, pp. 1616-1619.
- [7] Aishwariya, R., Geetha, M.Kalaiselvi. and Archana, M. “*Computer- Aided Fracture Detection Of X-Ray Images*”, IOSR Journal of Computer Engineering, pp.44-51.
- [8] Marshall, S.T. and Browner, B.D. (2012) [1st. Pub. 1956]. “*Chapter 20: Emergency care of musculoskeletal injuries*”. In Courtney M. Townsend Jr. Sabiston textbook of surgery: the biological basis of modern surgical practice. Elsevier. pp. 480–520. ISBN 978-1-4377-1560 6. (Wikipedia)+
- [9] Makhalova Elena (2013), “*Fuzzy C – Means Clustering in Matlab*”, The 7th International Days of Statistics and Economics, Prague, pp. 905-914.
- [10] Kaur, Harpreet. and Kaur, Lakhwinder. (2014), “*Performance Comparison of Different Feature Detection Methods with Gabor Filter*”, International Journal of Science and Research (IJSR), Vol.3, Issue No. 5, pp. 1880-1886.
- [11] Donnelley, Martin. and Knowles, Greg. “*Computer Aided Long Bone Fracture Detection*”, IEEE, pp. 175-178.
- [12] Palanichamy, Jaganathan. and Marimuthu, Rajinikannan. (2013), “*A Novel Image Alignment and a Fast Efficient Localized Euclidean Distance Minutia Matching Algorithm for Fingerprint Recognition System*”, IJAIT.
- [13] Rathode, Hs. and Ali, Wahid. (2015), “*MRI Brain Image Quantification Using artificial neural networks – A Review Report*”, ISOI Journal of Engineering and Computer science, Vol. 1, Issue No. 1, pp. 48-55.
- [14] Al-Ayyoub, Mahmoud. and Al-Zghool, Duha. (2013), “*Determining the Type of Long Bone Fractures in X-Ray Images*”, WSEAS Transactions on Information Science and Applications, Vol. 10, Issue No. 8, pp-261-270.
- [15] Hiremath, P.S. and T.Akkasaligar, Prema. “*Comparison of Wavelet Based Despeckling of Medical Ultrasound Images*”, Advances in Computer Vision and Information Technology, pp-1026-1033.
- [16] Dwivedi, Ashutosh., Soni, Pratik.and Verma, Virendra k. (2015), “*Comparative Analysis of Image De-noising with Different Filters in Wavelet Domain*”, International Journal of Engineering Trends and Technology (IJETT),Vol.24,Issue No. 2,pp-77-81.
- [17] <http://www.doctorsalami.com/>