Automatic Identification of Fracture Region within Bone in X-ray Image

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***Abstract*— One of the common problem in human beings is bone fracture which occurs due to high pressure applied on bone or simple accident .It may also be due to bone cancer and osteoporosis. Hence the accurate diagnosis of bone fracture is very important aspects in medical field. In this paper X-ray images has been used for bone fracture analysis. The aim of this paper is to develop a processing technique for identification of fracture region within bone in x-ray image which was obtained from medical institute. Result obtained demonstrates the performance of processing technique.**

Keywords—image processing; pre-processing; connected component;thresholding,erosion,dilation,edgedetection,skeleton,end point detection and traversal,detection of gradient.

I. Introduction

In imaging science, image processing is the way of processing images with the help of mathematical operations by using any form of signal processing technique. Here the input is an image or a series of images or a video, such as a photograph or video frame; and the output of image processing may be either an image or a set of properties or parameters extracted from the image [1].

Medical image processing(MIP) is a part of digital image processing in which the visual representations of the interior of a body is created for medical analysis and intervention. Medical image processing is also used for visual representation of the function of some organs or tissues [2]. Medical image processing also helps to maintain a database of normal anatomy and physiology so that abnormalities can be identified and a corrective measurement can be taken as per the requirement. [3].

Following are the list of application of MIP:

1. Identification of bone fracture
2. Cancer cell detection
3. Detection of Hemorrhages in Diabetic Retinopathy
4. Tumor detection

Unique challenges in medical image processing:

1. Medical image should always be stored and processed in lossless format
2. Erroneous diagnostics and its legal implication [4].

II. Literature Review

Bone is a living, growing tissue which is mostly made of two materials: collagen (protein) and calcium (mineral), this combination makes human bone strong and flexible enough to hold up under stress[5].

The bone fracture is a common problem in human beings which occurs due to simple accident or a high pressure applied on bone or due to osteoporosis and even due to bone cancer. Fractures is usually defined as a cracks in bones which is basically a medical condition when there is a break in the continuity of the bone. Hence accurate diagnosis of bone fracture is very important aspect in medical science.

Different types of medical imaging tools are available for detecting different types of abnormalities or physiological disorder such as Computed Tomography (CT), X-ray, ultrasound, Magnetic Resonance Imaging (MRI)etc [7]. Among all of them X-rays and CT are most frequently used in fracture diagnosis as this are fastest and easiest way to study the injuries of bones and joints. However doctors usually use x-ray images to determine the existence of a fracture and further to determine the proper location of the fracture [8].

Due to the nature of X-Ray image restoration, some image preprocessing techniques are necessary to eliminate the noise and image artifacts. The image pre-processing steps are including binary conversion, fine ppapers elimination and bone shaft detection[9][10]. . In order to detect the fracture bone, edge of bone features appears as a vital rule for the classification task. A wide conventional of edge detector have been considered, such as Sobel and Canny techniques [11][12].

In this paper the X-ray images are obtained from the medical institute which contains fractured bones images. In the first step, pre-processing techniques has been applied by converting the RGB image to grayscale image. Then the edges are detected in images using sobel edge detection methods and segmentation of the image was done. After segmentation, morphological image processing technique has been applied and noise removal was performed by applying filtering . Finally, the noise are removed and the accuracy as well as the performance of the system are evaluated.[13].

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Classification, which is also known as pattern recognition is defined as a task that involves construction of a procedure that maps the data into one of the several predefined classes. This is also called as discrimination or supervised learning or prediction [14] .The collection of features arranged in row-wise fashion is the input data for a classification task which is also called records. Each record, also known as an example or instance, is characterized by a tuple (X, y) where X is the set of attribute and y is a special attribute, which is designated in the class label. This special attributes are also known as category or target attribute [15].

A classification technique which is also called a classifier is a systematic approach to receive a input dataset and built a classification model. Examples of classifiers are Decision Tree Classifiers, Neural Networks, Support Vector Machines, Rule-Based Classifiers etc. Each technique established a learning model which will describe the best relation between the input data set and the set of attributes [16]. The model generated by the learning algorithm should correctly predict the class labels and also fit the input data well. Therefore, the models should accurately predict the class labels of previously unknown records. Hence the main objective of the learning algorithm is to build the models with, good assumption technique. [17].

Computer aided diagnosis is a well known and popular research area. The system which has the ability to diagnose any type of disorder with high accuracy and minimum resources are highly desirable and recommended. Medical image processing is one type of such system which has the ability to analysis and detects any type of disorder based on some feature extraction methods from the image by different type of enhancement technique after removal of noise. Previous work has been done using binary classification model to determine the existence of fracture in a x-ray image. [18].

The aim of this paper is basically to determine the fracture and location of bone fracture based on the information received in x-ray image. The general methods of the proposed system is mentioned as follows: The process starts by collecting some fractured as well as normal bone x-ray images and filtering the image for enhancement and removal of noise . Then the edge detection has been done in each images. In the next stage each image has been concerted as a set of feature by using different transformation technique such as wavelet and curvelet transformation. The next step is to generate the best classification model after studying the relationship between the set of feature extracted and the set of inputs .The last step is the testing phase where the accuracy and performance of the proposed system has been tested and evaluated [19].

III. DATABASE PREPEARATION

X-ray bone images are collected from different medical institute and we have created one database with the values of extracted features of the selected images. The objective of this paper is to identify the fracture zone or to identify the risk of fracture exist in the given dataset.

Table1: Image Details

Sl No	Name of Bone	Size of Image	Bit Per Pixel
1	Femur	1024×1024	24
2	Radius & Ulna	1280×1039	24
3	Tarsus & Metatarsus	1272×800	24
4	Femur	484×672	24

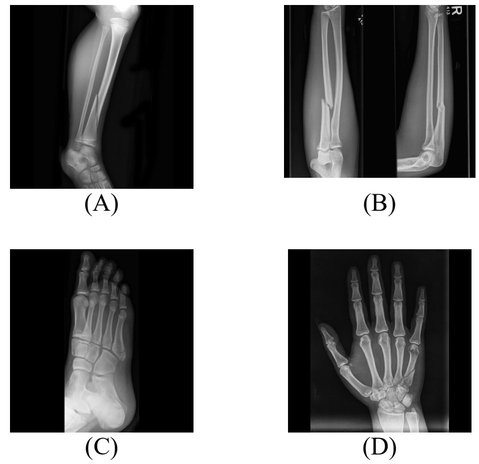

Figure 1: Image Dataset (A) Bone 1 (B) Bone 2 (C) Bone 3 (D) Bone 4

IV. PRESENT WORK

For implementing the whole concept the flow chart describe below the procedure step by step:

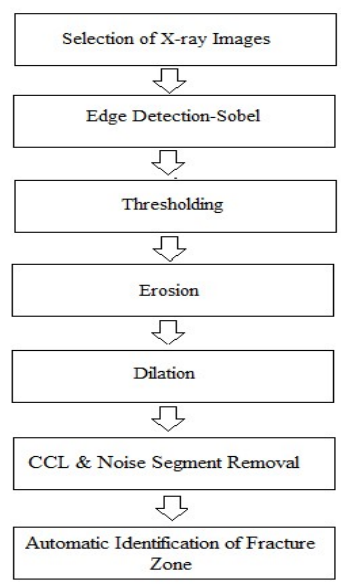

Figure 2: The flow chart describes the x-ray image processing.

A. Edge Detection

In image processing edge detection is a basic technique. The edges of image hold many information of the image which is important during feature extraction. The edge of the image describe about the shape, size and texture of the original images. The edge of the image is that particular point where

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the grey value of the image moves from the lowest value to highest value or from highest value to the lowest value and the edge is the centre of transition.

The edge detected image returns the output image of grey value and it gives the bright spot at the edge and dark area other than the edge. Hence the output image establishes a slope of grey level or rate of change of grey level in the image. The slope cannot have a negative value , it should be positive or zero and it has the maximum value at the edge. This is why the edge detection method is also called image differentiation method [20].

Two basic rules have been followed to consider the mask. The first one is that the sum of all the numbers in the mask should be zero. If a 3 x 3 area of an image contains a constant value means there will be no changes in the grey level then according to the definition of edge detection there will be no edges found. The result of convolution of the area with the mask should be zero. If the sum of all numbers of the mask is zero then convolution of the mask with the constant value area will give a perfect result of zero. And the second rules is that the mask should amplify the slope of the edge[20].

1	2	1
0	0	0
-1	-2	-1

2	1	0
1	0	-1
0	-1	-2

1	0	-1
2	0	-2
1	0	-1

0	-1	-2
1	0	-1
2	1	0

-1	-2	-1
0	0	0
1	2	1

-2	-1	0
-1	0	1
0	1	2

-1	0	1
-2	0	2
-1	0	1

0	1	2
-1	0	1
-2	-1	0

Figure 3: Sobel Mask for Edge Detection

The total convolution operation performed the convolution eight times each for one particular direction. First objective is to determine the correct mask means to determine the proper mask for convolution which is called as set up of masks. Then the convolution is performed with the mask eight times along the entire image array. In each step it is checked that the value of the convolution is greater than the maximum value or not and accordingly the image array has been changed.

B. Thresholding

After convolution during edge detection thresholding of output image is generally done. Edge detection result the slope of changes of grey level from zero to the maximum value. The variation of slope is determining the edge of the image. An edge which changes a longer value will be stronger than the edge which changes a small value such as edge from 10 to 200 is stronger than the edges which changes from 20 to 70. The output received after convolution will determine the strength. During thresholding it may happen that the stronger edges will reflect as darker and the weak edge will not appear at the output stage. So, thresholding will lower the noise level at the output of the edge detection technique. The detected edges and the convolution functions will pass through a threshold value. Suppose if the threshold = 10, the performed convolution function will go through the threshold parameter and if the pixel value is more than that it will set to the maximum level and if the pixel is lower than the threshold parameter it will be discarded and set as zero[20].

C. Erosion

In morphological image processing erosion is a fundamental operation through which all other basic morphological operations are evaluated. When the technique has been invented it has been applied it in binary images however later on it has been also applied in the grey scale images.

0	1	0
1	1	1
0	1	0

Figure 4: Mask for Erosion

The erosion operation will solve the problem with edge detection by eliminating the thin line which can be treated as noise and it is also used for thinning the required edges. Erosion method studies the entire pixel which are turned on and turned off the pixels which has maximum neighbor having zero value. Hence it will perform the work like the Gaussian filter or the Median filter [20]. In this paper a 3x3 mask has been considered for erosion and the mask used for erosion is defined as:

Here the mask is multiplied by the pixel and if the value exceed a certain number then the pixel is sustain otherwise the pixel is discarded. By erosion noise is removed after thresholding and it removes extra edges and thinning thick edges. There is no certain limit of removal extra edges and the number which is compared with the multiplied value can be selected as per the experiment and image category.

D. Dilation

The dilation operation is the opposite of erosion operation which make image thicker than before. The erosion and dilation operation is the basic theory behind the closing and opening methods. Dilation makes the image thicker by adding a value to the pixel which has marked as zero previously, if the minimum number of neighbors of that pixel is having a value of zero. There are two techniques for dilation. One is thresholding and another is dilation through mask .Here the 2nd methods has been used. The loop in the dilation method counts the value of all the neighbor pixel of the particular pixel which has been marked as zero previously. After counting if the value exceeds a certain level then the particular pixel is marked with some value [20]. In this work a 3x3 mask has been considered for dilation and the mask used for dilation is defined as:

0	1	0
1	1	1
0	1	0

Figure 5: Mask for Dilation

Here the mask is multiplied by the pixel and if the value exceed a certain number then the pixel is sustain otherwise the pixel is discarded. By dilation the required information which has been discarded during erosion and required for further processing can be regained and it increase the thickness of edges as per the requirement. There is no certain limit of regaining the edges and the number which is compared with the multiplied value can be selected as per the experiment and image category.

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Properties of binary erosion & dilation operator

1. The method is translation invariant.
2. The method is increasing in nature.
3. The method is commutative.
4. Sometimes it is extensive in nature.
5. It is associative.
6. It is distributive over set union.

E. Connected Component Labeling(CCL)

CCL or connected component labeling is an algorithm in graph theory where all the components which are connected to each other are categorized with one particular label [21].In this paper 8 connected component labeling method are used where all the 8 neighbor components connected with the particular pixel are matter of concern. In a 2D image the forward scan and assignment technique is used where scanning is done from left to right and from top to bottom. During scanning of each pixel the neighbors of the mask are also scanned to determine the label of the particular pixel.

1. During scanning if the particular pixel is background pixel then o changes will occur.
2. During scanning if the particular pixel belongs to the object and both the minimum and maximum value is zero then the label should be increased.
3. During scanning if the particular pixel belongs to the object and the minimum and maximum value are different then minimum value should be assigned with the particular pixel and the label to be increased accordingly [22].

In this paper pass algorithm is used for 2D grey images. Here all the foreground pixels is first denoted by the character'.'.Then during scanning of each pixel the first foreground pixel is labeled and denoted by some character other than '.'.Then all the neighbor foreground pixels is labeled by the same character. After completion of labeling of one foreground portion the same process is repeated to all the foreground portions and each portion is labeled by different character. The outcome of CCL has been consumed in a dat file and stored.

F. Noise Removal in CCL

Counting the no of objects present in a particular image is a major feature extraction method which is communing used in image processing. This connected component labeling can be done in three ways which are 4 –component labeling, 6-component labeling and 8-component labeling. After connected component labeling the salt and pepper noise can be removed by noise removal technique. This technique can be used in any type of images irrespective of its size, shape and texture. After CCL the number of objects found in a particular image can be counted along with the individual no of pixel in each object. The object with less no pixel compare to a certain parameter can be treated as noise and may be eliminated to improve the system performance and accuracy [21].

However the noise removal technique is a process oriented task and can give better performance where the speed of the processor is high.

G. Skeleton:

In image processing an important technique to represent the structural shape of an object in a region is to create a graph of the same. This can be done through skeletonizing algorithms. There are basic two methods of creating the skeleton of an image which are successive thinning and medial axis transformation [22].

Thinning is basically erosion of an object until it becomes one pixel wide. However medial axis transformation find the points which form the line down from the centre i.e. the medial axis of the object. This process can be understood by the Euclidian distance which is the shortest distance of a pixel of an image from the edge of that image.

In this paper the thinning algorithm has been followed for skeletonization. In this algorithm the boundary points are iteratively deleted until the object becomes one pixel wide. However during iterative deletion the following points have been taken care:

a) The continuity of the image has been maintained.

b) The end point kept intact and not deleted.

c) The algorithm is protected from too much erosion of the image.

Here one pixel is compared with its 8 neighbor pixel and that has been marked as (P_1).

P_9	P_2	P_3
P_8	P_1	P_4
P_7	P_6	P_5

Figure 6: 3×3 matrix of pixel

The algorithm is performed in two steps:

Step1:

1. $2 \leq N(P_1) \leq 6$ where $N(P_1) = P_1 + P_2 + P_3 + \ldots\ldots\ldots + P_9$
2. $T(P_1)=1$ where $T(P_1)$ is the no of 0-1 transition in a complete rotation of neighbors in clock wise direction.
3. $P_2.\ P_4.\ P_6=0$
4. $P_4.\ P_6.\ P_8=0$

If all the above points are satisfied then the flag of point P_1 is marked for deletion.

Step 2:

In step 2 the point no 1 & 2 will remain unchanged and point no 3 and 4 are modified as follows:

3. $P_2.\ P_4.\ P_8=0$
4. $P_2.\ P_6.\ P_8=0$

Now the one iteration of the thinning algorithm consists of following four steps:

1. Apply step 1.
2. Delete the flag which are marked in step 1.
3. Apply step 2.
4. Delete the flag which are already marked in step 2.

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Finally the process is continued iteratively until the image become one pixel wide.

H. End point traversal,gradient calculation and comparison:

In this paper the no of end points along with the co-ordinate of end points has been detected after skeletonization. Now in each end point the average gradient has been detected by traversing upto 5th pixel level from the end point and taking the average gradient of all points. After gradient detection the each end point is compared with other and the particular end point is flagged if the following two points are satisfied:

1. The end point remains within a certain distance from another end point.
2. The gradient value of the end point is within a certain limit with the gradient of another end point.

If both the points mentioned above are satisfied then the end point is marked with a circle and considered as a fracture region in bone image.

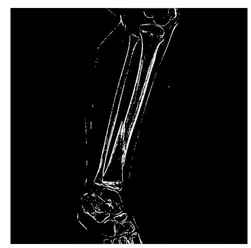
V. RESULT AND DISCUSSION

The above steps has been followed for the dataset received from different medical institute and result obtained for bone 1, bone 2, bone 3 & bone 4. In this paper pre-processing of images and connected component labeling (CCL) of images has been performed and finally fracture region within the bone has been identified. The required region of the image is reconstructed after removal of noise. In all the above techniques, it can be concluded that some images which are not corrupted by noise have given better performance. Hence the accuracy and performance varied depending on the input image quality. Here along with the fracture zone some other zone has been marked as fracture which can be ignored by further modification of the algorithm. The stepwise outputs of the algorithm for the four images are shown in Figure 7.

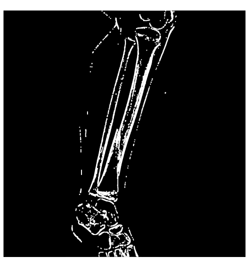
Bone 1: Original

Bone 1: Edge Detection

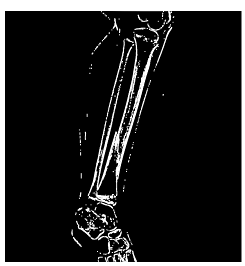
Bone 1: Thresholding



Bone 1: Erosion



Bone 1: Dilation



Bone 1: CCL & Noise Removal

Bone 1: Skeleton

Bone 1: Fraction Detection

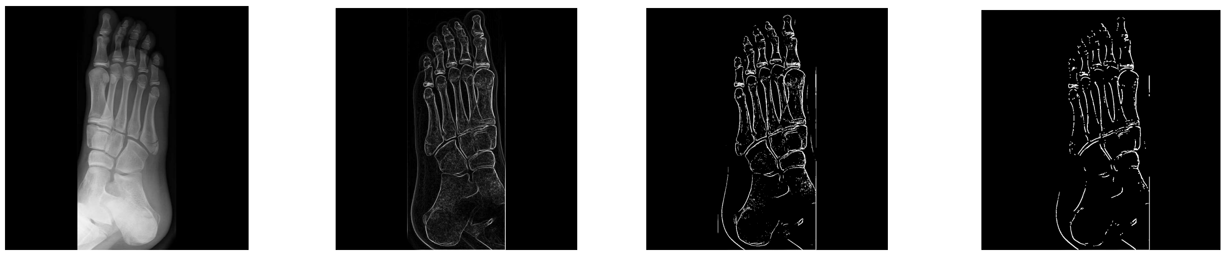
Bone 2: Original

Bone 2: Edge Detection

Bone 2: Thresholding

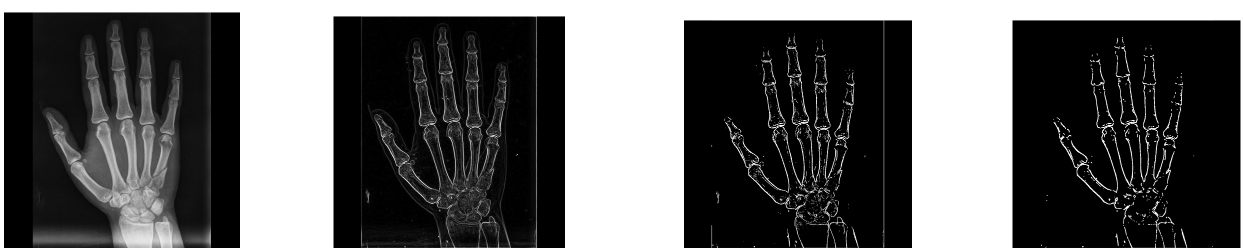
Bone 2:Erosion

Bone 2: Dilation | Bone 2: CCL & Noise Removal | Bone 2: Skeleton | Bone 2: Fraction Detection

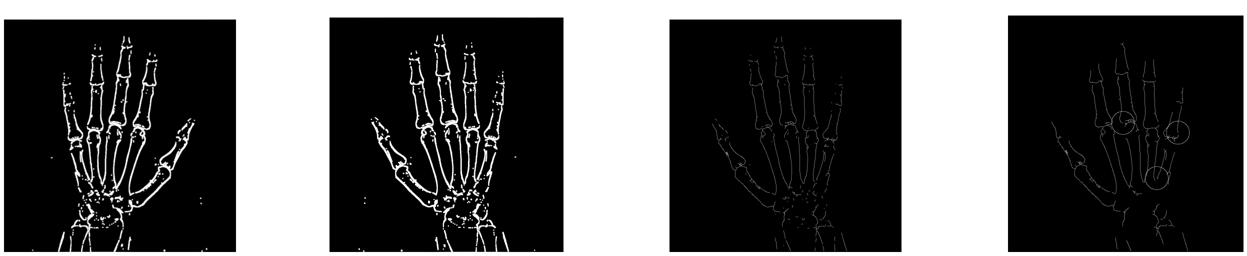


Bone 3: Original | Bone 3: Edge Detection | Bone 3: Thresholding | Bone 3: Erosion

Bone 3:Dilation | Bone 3: CCL & Noise Removal | Bone 3: Skeleton | Bone 3: Fraction Detection



Bone 4: Original | Bone 4: Edge Detection | Bone 4: Thresholding | Bone 4: Erosion



Bone 4:Dilation | Bone 4: CCL & Noise Removal | Bone 4: Skeleton | Bone 4: Fraction Detection

Figure 7: Stepwise output for four x-ray image

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