Detection of Bone Fracture using Image Processing Methods

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ABSTRACT
The bone fracture is a common problem in human beings occurs due to high pressure is applied on bone or simple accident and also due to osteoporosis and bone cancer. Therefore the accurate diagnosis of bone fracture is important aspects in medical field. In this work X-ray/CT images are used for bone fracture analysis. The aim of this project is to develop an image processing based efficient system for a quick and accurate classification of bone fractures based on the information gained from the x-ray / CT images. Images of the fractured bone are obtained from hospital and processing techniques like pre-processing, segmentation, edge detection and feature extraction methods are adopted. The processed images will be further classified into fractured and non-fractured bone and compare the accuracy of different methods. This project is fully employed MATLAB 7.8.0 as the programming tool for loading image, image processing and user interface development. Results obtained demonstrate the performance of the bone fracture detection system with some limitations and good accuracy of 85%.

General Terms
Medical imaging, Biomedical Engineering

Keywords
Bone fracture, noise removal, segmentation, classification.

1. INTRODUCTION
Bones are the solid organs in the human body protecting many important organs such as brain, heart, lungs and other internal organs. The human body has 206 bones with various shapes, size and structures. The largest bones are the femur bones, and the smallest bones are the auditory ossicles. Bone fracture is a common problem in human beings. Bone fractures can occur due to accident or any other case in which high pressure is applied on the bones. There are different types of bone fracture occurs are oblique, compound, comminuted, spiral, greenstick and transverse.

There are different types of medical imaging tools are available to detecting different types of abnormalities such as X-ray, Computed Tomography (CT), Magnetic Resonance Imaging (MRI), ultrasound etc. X-rays and CT are most frequently used in fracture diagnosis because it is the fastest and easiest way for the doctors to study the injuries of bones and joints. Doctors usually uses x-ray images to determine whether a fracture exists, and the location of the fracture.The database is DICOM images. In modern hospitals, medical images are stored in the standard DICOM (Digital Imaging and Communications in Medicine) format which includes text into the images. Any attempt to retrieve and display these images must go through PACS (Picture Archives and Communication System) hardware.

2. EARLIER WORK
There are several algorithms were developed for bone fracture detection. In this section a broad overview of the literature is presented, starting with papers that Vijaykumar V at al.[1] presented a filtering algorithm for Gaussian noise removal. First estimating the amount of noise from the noisy image, then replace the center pixel by the mean of the sum of the surrounding pixels based on a threshold value. Compared to other filtering algorithms such as mean, alpha-trimmed mean, Wiener, K-means, bilateral and trilateral, this algorithm gives lower Mean Absolute Error (MAE) and higher Peak Signal-to-Noise Ratio (PSNR).

Generally the DICOM images are corrupted by the salt and pepper noise. Al-Khaffaf H at al [2] proposed an extension of the K-fill algorithm to remove salt and pepper noise based on the number of black or white pixels in a 3 × 3 window. Assuming that the images are corrupted by the noise modeled as a sum of two random processes: a Poisson and a Gaussian, this approach allows them to jointly estimate the scale parameter of the Poisson component and the mean and variance of the Gaussian one. Finally, Zain, M. L. at al [3] addressed the problem of image enhancement and speckle reduction using filtering technique. The following step is feature extraction method. Chan, K.-P.at al [4] proposed a method of feature selection by using three different methods such as wavelet and curvelets transform. Haar method gives the highest accuracy value compared with other two methods. Tian, T. proposed a system for fracture detection in femur bones based on measuring the neck-shaft angle of the femur. In follow-up works, Lim, S. E at al [6], Yap, D. at al [7] and Lum, V. L. F at al [8] proposed to use Gabor, Markov Random Field, and gradient intensity features extracted from the x-ray images and fed into Support Vector Machines (SVM) classifiers. They observe that the combination of three SVM classifiers improves the overall accuracy and sensitivity compared to using individual classifiers. Based on this observation, He at al. [9] proposed to use a "hierarchical" SVM classifier system for fracture detection in femur bones. Mahendran, S. at al [10] proposed a fusion classification technique for automatic detection of existence of fractures in the Tibia bone. The authors start with preprocessing steps such as of binary conversion, edge detection, noise removal and segmentation. For the classification step, he use the three common classifiers, such as feed forward back propagation Neural Networks (NN), Support Vector Machines (SVM) and Naive Bayes (NB), using a simple majority vote technique. The following step is the segmentation process. Chai, H. Y. at al [11] propose GLCM based method is proposed to segment the x-ray image of the hand and separate the bone regions from the soft tissue regions. Authors start with preprocessing techniques such as binary conversion and edge detection techniques. Followed by k-means segmentation and GLCM method for feature extraction. Hao, S. at al [12] proposed an automatic segmentation method of in x-ray hand images. They start with detecting the edges of the image, then automatically determining the region of interest and finally segmenting the image to extract the carpal bones only. Bielecki, A. at al [13] proposed an automated algorithm to compute the joint width in the x-ray images of the hand.

In this work, it is tried to automatic classification of bone fracture using image processing methods based on information gained from X-ray/ CT images with good accuracy and first time tried to all the types of bone fracture without concentrate on particular type of fracture. And also tried for CT images with some limitation.

3. PROPOSED METHOD

The X-ray/CT images are obtained from the hospital that contains normal as well as fractured bones images. In the first step, applying preprocessing techniques such as RGB to grayscale conversion and enhance them by using filtering algorithm to remove the noise from the image. Then it detects the edges in images using edge detection methods and segmented the image. After segmentation, it converts each image into a set of features by using some feature extraction technique. Then we build the classification algorithm based on extracted features. Finally, the performance and accuracy of the proposed system are evaluated. The flow diagram of proposed system for detecting the bone fracture in X-ray/CT images is shown below in Fig 1.

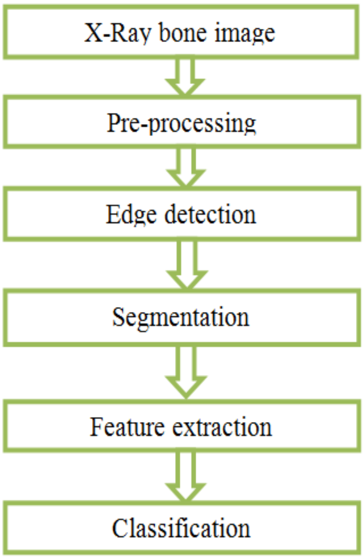


Fig.1.The flow diagram of steps in detecting the bone fracture in X-ray/CT images

3.1 Image Pre-processing

In computer-aided diagnosis of the medical images, image processing tools for noise removal, image segmentation and feature extraction play a important role in the success of such systems. The X-ray/CT images are obtained from the hospital that contains normal as well as fractured bones images. In the first step, applying preprocessing techniques such as RGB to grayscale conversion and remove the noise from the image by using the median filter.

3.2 Noise Removal

Noise can be defined as unwanted pixels present in the image that degrade the quality of the image. It can be written as:

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

Where f (x, y) is the noisy image, g (x, y) is the original image and η (x, y) is the noise present in the image.

There are different types of noise present in the image are Gaussian noise, Salt and pepper noise etc. Salt and pepper is one of the common types of noise present in x-ray images. This is generally caused by a failure in capture or transmission that is appearing in the image as light and black dots. It can be removed by applying mathematical transformation on the images. It preserves the edges while removing noise. The median filter is a nonlinear digital filtering technique, used to remove noise such as salt and pepper noise.

3.3 Edge Detection

Edge detection is an important operation in image processing, that reduce the number of pixels and save the structure of the image by determining the boundaries of objects in the image. Edge detection is the method of identifying points in a digital image at which the image brightness changes sharply or, more formally, has discontinuities. The points at which image brightness changes sharply are typically organized into a set of curved line segments termed edges. There are two general approaches to edge detection that are commonly used are: gradient and Laplacian. Gradient method use the first derivative of the image, and the Laplacian method use the second derivative of the image to find edges. In our method use sobel edge detector and it is a gradient family.

3.4 Segmentation

Segmentation is the process of dividing the given image into regions homogenous with respect to certain features as color, intensity etc. It is an essential step in image analysis and locates object & boundaries (lines, curves etc). The K-means clustering technique is used in this work. The purpose of this algorithm is minimizing an objective function, which is absolute difference function. In this algorithm distance is squared or absolute difference between a pixel and cluster center is calculated. The difference is typically based on pixel intensity, color, texture and location. The quality of the solution depends on the initial set of clusters and value of k. After the segmentation crop the image and the area of fracture with some limitation.

3.5 Feature Extraction

Feature extraction is the main step in various image processing applications. Gray-Level Co-occurrence Matrix is used for feature extraction and selection. GLCM was defined by Haralick et al. in 1973.GLCM is main tool used in image texture analysis. Textures of an image are complex visual patterns that are composed of entities or regions with sub-patterns with the characteristics of brightness, color, shape, size, etc. GLCM is a statistical way to indicate image texture structure by statistically sampling the pattern of the grey-levels occurs in relation to other grey levels. We use the Gray Level Co-occurrence Matrix (GLCM) method to extract textural features such as entropy, contrast, correlation, homogeneity.

3.6 Classification

Classification is a step of data analysis to study a set of data and categorize them into a number of categories. Each category has its own characteristics and the data that belong to such category have the same properties of this category. In proposed method, different types of classifier are used such as decision tree (DT) and neural network (NN) and meta-classifier. Based on the GLCM textural features, classifiers classify the given image into fractured and non-fractured image. not ragged.

4. RESULT AND ANALYSIS

The results of preprocessing, edge detection is shown in Figure 2. Figure 2(a) shows input x-ray image of fractured femur bone. Figure 2(b) shows edge detected image and 2(c) shows processed output image. The GLCM features are calculating for the segmented image and based on these features find whether fracture exists or not. The proposed method has been tested on set of X-ray/CT images consisting of fractured and normal images. The dataset consists of totally 40 images, 20 fractured images and 20 non-fractured images. After the feature extraction the images are classified into normal and fractured images based on GLCM features. The performance of the proposed system is evaluated in terms of accuracy, sensitivity and specificity. The analysis is with respect to the observer. In this work, there are only four possible outcomes of applying the classifier on any instance. These outcomes are

- True Positive (TP) which refers to the fractured images that are correctly labeled as fractured.
- True Negative (TN) which refers to the normal (non-fractured) images that are correctly labeled as normal (non-fractured).
- False Positive (FP) which refers to the normal (non-fractured) images that are incorrectly labeled as fractured.
- False Negative (FN) which refers to the fractured images that are incorrectly labeled as normal (non-fractured).

The performance of the proposed system is evaluated in terms of accuracy, precision, sensitivity and specificity.

Accuracy= (TP+TN)/(TP+TN+FN+FP).

Precision= TP/(TP+FP)

Sensitivity= TP/(TP+FN)

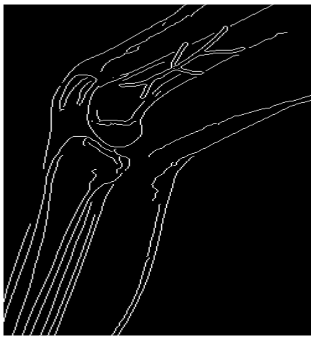
Specificity= TN/(TN+FP)

The accuracy of the classifier decision tree (DT) and neural network (NN) is 53.25%, 75% and 50% respectively. Therefore combined the above classifier into one called meta-classifier and obtain the Accuracy is 85%, Precision is 76.9%, Sensitivity is 100% and Specificity is 70%.

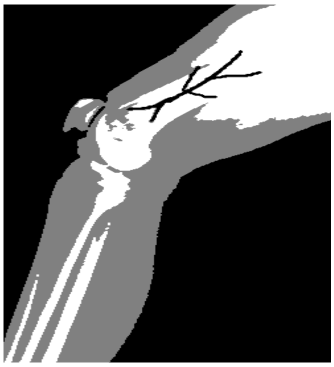
5. CONCLUSION

A computer based analysis techniques for the detection of bone fracture using X-ray/CT images has been presented in this work. It starts from the preprocessing to remove the noise and edge detected by using sobel edge detector. After the segmentation the area of the fracture is calculated. The method has been tested on a set of images and results have been evaluated based on GLCM features. Analysis shown that results obtained are satisfactory and accuracy of this method was 85%.The limitation of this method is ,in CT and some cases of X-ray images very difficult to find the area of fracture, In future work is, it is fully implemented to CT images and also classify the type of fracture is occurs.

(a)



(b)



(c)

Fig.2 Results of image processing steps (a) input image (b) edge detected image (c) output image

6. ACKNOWLEDGMENTS

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