Detection of Bone Fracture in X-Ray Images Using Image Processing

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***Abstract* – Bone fracture is a medical condition where the bone is fractured. Fracture may be caused due to stress or impact of force on the bone. Image processing became a part of this world in every field like medical, etc. It also developed in medical applications to provide analysis of human body. Many digital images has been taken from the patients like X-ray, Computerized Tomography (CT), Ultra Sonography (US), Magnetic Resonance Imaging (MRI). This Project analyse the X-ray image of natural leg bone and fractured leg bone using image processing. Image Classifier algorithm is used to detect fracture of leg by using MATLAB software. Classifiers like Support Vector Machine(SVM) and Artificial Neural Network(ANN) are used. Experimental results are obtained with better accuracy for the processed images.**

***Keywords* – X-ray image, MATLAB software, Support Vector Machine, Artificial Neural Network**

I. INTRODUCTION

Image processing became a part of this world in every field like medical, etc. It also developed in medical applications to provide analysis of human body. Many digital images has been taken from the patients like X-ray, Computerized Tomography (CT), Ultra Sonography (US), Magnetic Resonance Imaging (MRI). The huge data are collected from various resources with the help of digital image processing such as digital camera, scanner and through internet. Hence this will increase the retrieval of image in rapid manner in the application of art, architecture, crime areas, etc. It is also helpful for the medical applications also. Through these images, it is helpful for the diagnosis for physicians and research in medical. It is the very easiest way to know the problem of patient's body parts and location.

Human body consists of 206 bones. The rigid structure in human body is called bones. It will protect the parts like brain, lungs, heart and internal organs. The bone fracture is usually detected using X-ray. This makes medical field to process the data easily and detect fractured bone automatically for the physicians. It is caused by applying force to the human body or by accidents.

Though, it is common problem in human beings and classified in various ways. They are periprosthetic fracture: weakness of bone, traumatic fracture: due to sustained trauma caused by road accident, fall; Pathologic fracture: due to disease, weak the bones caused by osteoporosis.

In recent days, the database of medical images in hospitals are stored in DICOM images. DICOM (Digital Imaging and Communications In Medicine) in which it includes text to images. It is displayed or retrieved using PACS (Picture Archives and Communication Systems).

This paper analysis the natural leg bone images and fractured leg bone images using classifiers through pre-processing and feature extraction. The classifier used for detection of bone fracture is hybrid algorithm. They are SVM (Support Vector Machine) algorithm and ANN (Artificial Neural Network). These algorithms will automatically detect the fractured bone rapidly with accuracy for physicians in hospitals.

II. RELATED 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.

III. BONE AND FRACTURE TYPES

1. BONE

Bones have different size and shapes which has hard organ in the part of human body and animals. It protects the body, produces red blood cells and white blood cells, provides support and structure to the body. Therefore, it is strong and hard to the humans. There are 206 bones in humans. The figure 3.1 shows the human skeleton system consists of bones.

2. FRACTURE TYPES

The different types of fracture are: simple fracture, compound fracture, hairline fracture, greenstick fracture, complicated fracture, avulsion fracture, comminuted fracture, compression fracture. These fractures are explained below.

Simple Fracture

It is also called as closed fracture. Simple fracture does not penetrate the skin when bone is broken.

Compound Fracture

The bone is broken in such a way that the bone fragments project by the skin. It can be also called as open fracture.

Hairline Fracture

This fracture is caused by running or jogging. It is occurred due the force or stress exerted on the foot of the legs.

Greenstick Fracture

Greenstick fracture is occurred when the bones bend and cracks. There will be no separate pieces of broken bones.

Complicated Fracture

It is caused by the injury or damages in the fracture bones are surrounded by the supporting bones. Complicated fracture is occurred in the arteries of heart.

Avulsion Fracture

Avulsion fracture is occurred in knee and shoulder joints in human body. Structures are anchored by the muscles of the bone are called tendons. It is said to be type of connecting tissues.

Comminuted Fracture

This kind of fracture requires more time to cure where the bones is broken into small pieces. It is called as comminuted fracture.

Compression Fracture

This kind of fracture occurs commonly to the aged people. Compression fracture is caused due to the bones pressing each other.

IV. PROPOSED WORK

The Fig.1 shows the system flow diagram that has been implemented to get results of fractured bone and non-fractured bone using classifier algorithms such as SVM (Support Vector Machine) and ANN (Artificial Neural Network). It is done using MATLAB software to obtain fractured bone or not. Input image is taken as X ray image to process the data. The input x-ray image is pre-processed. The input x-ray image RGB, so it is converted to greyscale. Then noise of the image is removed, and image is enhanced and sharpened. The image is then segmented, and features are extracted. The image is then classified as fractured and non-fractured image and the result is obtained.

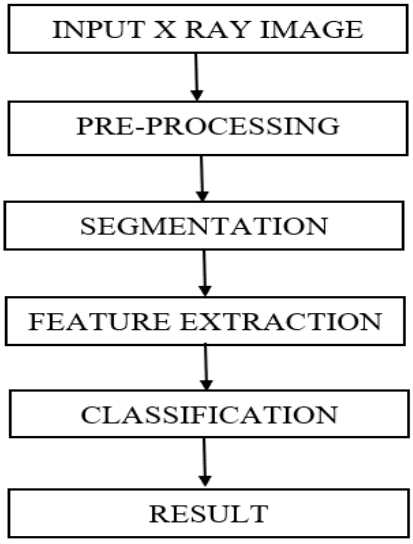

Fig.1. Block Diagram of Bone Fracture Detection

Input x-ray Image

The first step of the proposed work is image acquisition. The input image used is x-ray image to find the bone fracture. Data is obtained from Digital x-ray images. Recent, x-ray image machine can support both format such as DCIOM and JPG format. In which, JPG image is processed without conversion from DCIOM. The image format can be JPG, JPEG, PNG, etc. Using this format images are acquired to process. For further process, it does not require to enhance the x-ray image by pre-processing after this step. The figure shows the fractured bone and non-fractured bone respectively.

Image Pre-processing

It is the second step in the detection of bone fracture using image processing technique. The success of diagnosing the fractured bone and non-fractured bone is by achieving eliminating noise, segmenting the images and feature extraction for the x-ray images. The input images are processed from the image acquisition. This step consists of converting RGB (Red Green Blue) image to the grayscale image to speed the processing time. Then this grayscale image is processed to remove noise from the image. As it contains noise while image transmission. Gaussian noise is used for image smoothening. Larger sigma provides larger filter to smoothening. Removing unwanted pixels in an image is called denoise. Then denoised image is processed with canny operator to find the edges of the image. It gives wide ranges of edges than other edge detecting operators.

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 Canny edge detector and it is a gradient family.

Segmentation

Images are divided into different parts or regions and are extracted as region of interest (ROI). This is known as segmentation. The region of interest is selected based on the problem being solved.The success or failure of computerized operation is determined by segmentation technique. The algorithm used should have good accuracy to the segmented image. Several methods of segmentation include OTSU, k means, SVM, etc. The segmentation technique in which pixels in same group have same greyscale is the best for segmentation technique. SVM is used for segmentation process.

Feature Extraction

The important step is feature extraction to extract the images to get useful information. Collecting the set of pixels from the dividing the images. It will help to identify the Region of Interest (ROI). Input image is enhanced to protect information of the protenious pixels before coloured from the background. It is used to reduce effects of illumination and distinguish between diseased and non-diseased leaf colour, resulting colour pixels are clustered to acquire group of colors in the image. Feature extraction is based on specified threshold value, that is computed for corresponding pixel value. In this project we used Hough transform to detect bone fracture.

Hough Transform

Hough transform was developed by Paul Hough, which can be used to find lines in an image is shown in fig.2. It is a robust method to detect from an edge lines in an image using image extraction technique. Therefore, it is an automated identification for detecting bone fracture in an image because edge detector is imperfect. Due to the missing of pixels in required curves and noise is also obtained in edge detection. Hough transform solve this problem to extract images from pre-processing image. Hough transform uses two-dimensional array which is called accumulator. To detect a line from an image is described by

$$r = x \cos \theta + y \sin \theta$$

r = distance between the origin and closest point on straight line

θ = angle between the origin and x- axis

In two-dimension space (r, θ) is called as Hough space.

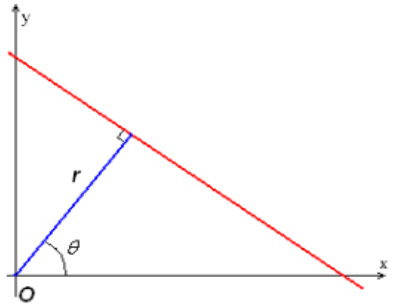

Fig.2. Parametric representation of Hough Transform

Classification

In Machine Learning, many classifiers are used to categories the data from many data sets. Individual categories has its own specifications that categories are belonging to the same category with same characteristics. In this proposed method, we used two classifications called SVM and ANN. The data are classified based on the classifier used to find fractured bone and non-fractured bone from the feature extraction of Hough Transform.

Support Vector Machine (SVM)

SVM or Support Vector Networks shown in the Fig.3 are supervised learning model which are associated with learning algorithms. The Analyzed data used for classification and analysis. SVM models are the representation of the examples as points in space, mapped so that these examples of the different categories are divided by a clear gap that is as wide as possible. SVM can efficiently perform a non linear classification by using the algorithm called Kernel Trick in addition to performing the linear classification. SVM allows to classify data which are linearly separable for non-linear classification, Kernel Trick can also be used.

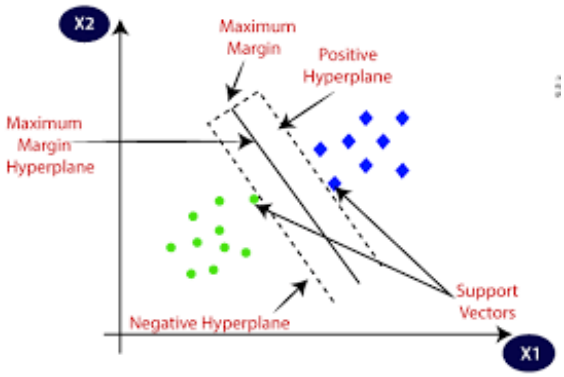

Fig.3. Support Vector Machine

Artificial Neural Network

Artificial neural networks (ANN) are a form of computing inspired by the functioning of human brain and nervous system. ANN have been used to carry out cognitive tasks performed naturally by the brain, including face recognition, learning to speak and understand a language, identifying handwritten characters, and determining that a target seen from different angles is in fact the same object. However, the number of uses for ANN is increasing rapidly, and in recent years they have been successfully used for the prediction of emotions from facial expressions. ANN are a type of parallel computer, which differ from conventional computers in the way they process information. The operation of conventional computers is controlled by a single central processing unit (CPU), which holds the computer's memory and processes information in a sequential manner. Parallel computers, on the other hand, consist of a number of smaller processing elements (PE), that are linked together.

V. RESULT AND ANALYSIS

The input x-ray image is first pre-processed and the noise is removed using Gaussian filter. The fig.4 shows the denoised image of input x-ray image. Then edge detection is performed using canny operator. The figu.5 shows the edge detected image. The image is segmented and features are extracted. Then the image classified using Support Vector Machine and Artificial Neural Network. 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.

Fig.4. Denoised image of input x-ray image

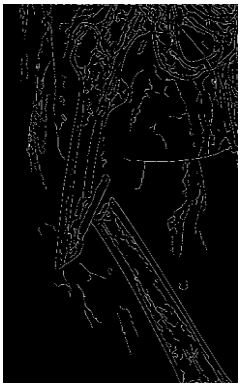

Fig.5. Edge detected image using canny operator

Fig.6 (a)

Fig.6(b)

Fig.6(a) The input X-ray image
Fig.6 (b). The output image with fracture indicated

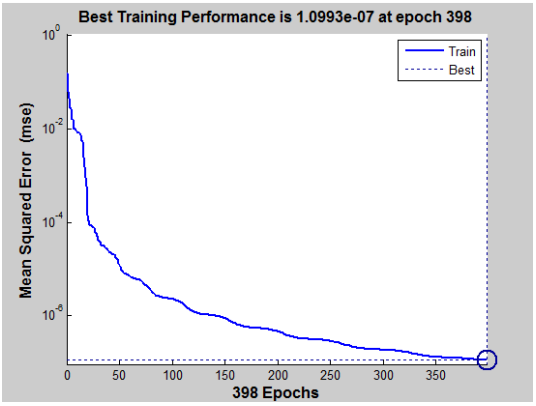

Fig.7. The performance graph with mean square error

To analyse the performance of the proposed system, it has been tested on 10 fractured bone images. Out of these, fracture was identified in 6 images of bone. In the result snapshot we can see the original image Fig.6(a) and detected fracture in second image highlighted by red circle Fig.6(b). The Fig.7 shows the mean square error of ANN showing the best performance. Thus the fracture is detected.

VI. Conclusion

Bone fracture using X-ray images has been presented in this work. It starts from the pre-processing to remove the noise and edge detected by using Canny 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 Hough Transform features. The results obtained shows that the algorithm is executed with better accuracy and performance. In future work it can be developed for more complex medical images such as CT and Ultrasonic images

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