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A Robust Approach For Detection of the type of Fracture from X-Ray Images

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Abstract: A bone is broken or a fracture in bone happens when an external force applied upon the bone is more than what the bone can tolerate or bear. As a result, the shape and strength of the bone is disturbed which causes excruciating pain on the bone and ends up in the loss of functioning of the bone. In some instances there will be bleeding around the injured site. The modern developments in medical imaging contributes a lot in examining the fractures in different kinds and classes of bones found in the body of the patient without much difficulty. Segmentation of an image involves a process called edge detection. The purpose of segmentation is to modify the representation of an image into fragments that is bits and pieces that are more important, useful and easier to analyse. To identify the edges, this function scans for regions in the image where the change of intensity occurs rapidly. Edge detection returns a binary image containing ones where edges are found and zeros in all other places. Different edge detection methods exist like Sobel operator, Prewitt operator, Laplacian of a Gaussian and Canny. These techniques can be applied on X-Ray medical images. Quality metrics like mean and standard deviation are applied to analyze, compare and evaluate the results. The process of detecting the type of fracture has to be done with a great precision. To improve these quality metrics,a novel edge detection algorithm is proposed and the accuracy is measured for this cause.

Keywords: Fracture detection, Bone segmentation, Edge detection, Fracture classification.

I. INTRODUCTION

A bone fracture happens when a force exerted against a bone is more than that the bone can bear. As a result, the shape and strength of the bone is disturbed which causes excruciating pain on the bone and ends up in the loss of functioning of the bone. Fractures are detected using X-ray images. There are numerous types of x-ray images. Some of them are simple x-ray images, microscopic images, angiograms, fluoroscopic images and mammography images. Normal or ordinary x ray imaging of bones is commonly adopted by doctors for diagnosing and for treatment of bone disorders. X-ray imaging technique is helpful to doctors in various instances. Some of them are

- *Diagnosis of fracture and treatment:* Being the quickest and simplest approach for the doctors to analyse the injuries of bones and joints. X-ray images are most frequently used in fracture diagnosis. Normally doctors apply X-ray imaging techniques and approaches to diagnose whether a fracture exists or not. It is also helpful to the doctors to locate the position and of fracture and to treat it effectively. This technique is also helpful to the doctors to ensure whether the injured bones and joints have recovered or not and also to study the extent of recovery.

- *Bone density test:* Various approaches are existing to measure the density of bone, but at present, the most widely used X-ray based technique is DEXA (Dual Energy Xray Absorptiometry). The testing of bone density is otherwise known as bone densitometry is used to measure the content of minerals especially calcium content of the bones. Doctors often use this technique to diagnose osteoporosis, a condition that often affects women after menopause but may also be found in men and rarely in children. This test can also assess an individual's risk for developing fractures.

- *In replacement of hip joint:* In Hip replacement treatment technique the hip joint is replaced with a metal implant. A plastic cup or a plastic and metal cup is used to replace the hip socket. X-ray imaging technique of the hip helps the doctors in hip replacement surgery.

So, the application of the accurate segmentation procedure comes not only in diagnosis of the type of fracture but also in all the other above mentioned processes.

In order to obtain accuracy and precision in diagnosis, a medical imaging should have a quality image, and also an accurate interpretation of an image by a skilled reader. Over the last hundred years, the field of radiology has grown as a result of advancement in imaging innovation.

Due to the advanced facilities we have today, to a great degree astounding pictures are handled for examination. However, the methods of interpretation by applying Computer Technology have only recently begun to benefit this cause.

II. TYPES OF FRACTURE

Bone fractures in human are of several types. Depending on the impact of the force, Some of the fractures are more severe than others. Sometimes the specific bone involved, and the age of the person and general health conditions

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also determine the severity. Commonly bone fractures include the hip, wrist and ankle. Fractures in hip occur most often in aged people.

The different types of fracture that can occur include:

- *Simple fracture* – otherwise called closed fracture – This is caused when a broken bone does not penetrate the skin.
- *Open (compound) fracture* – The bone breaks such that bone fragments project through the skin. In cases, the wound may penetrate down to the broken bone. This type of fracture is called open or compound fracture. Infection and external bleeding are common to occur.
- *Hairline fracture* – This type of fracture is occurring due to stress exerted in the foot or lower leg caused by activities such as jogging or running.
- *Greenstick fracture* – This kind of fracture occurs when the bone bends and cracks. There is no breaking completely into separate pieces. This type of fracture occurs most commonly in children because their bones are soft and more flexible than adult bones.
- *Complicated fracture* – This fracture occurs when supporting bones surrounding the fracture are also damaged and injured. This may result in injury to the arteries, veins and nerves. There may also be injury to the bone lining.
- *Avulsion fracture* – Muscles are anchored to the bone by structures called tendons. These are said to be a type of connective tissue. Powerful muscle contractions can cause the tendon to come out free, leading to pull out pieces of bone. This type of fracture is more common in the knee and shoulder joints.
- *Comminuted fracture* – In this type the bone is shattered into small pieces and this kind will take more time to heal.
- *Compression fracture* – This type of fracture occurs when two bones are pressed against each other. The bones of the spine,(vertebrae) can have this type of fracture. Aged people with osteoporosis have higher risk of developing this kind of fracture.

III. EXISTING APPROACHES

The various fracture detection techniques and approaches that are proposed already can be broadly categorized into transform based approaches and classification based approaches. These can detect femur bone fractures by computing the angle between the shaft axis and the ankle axis. Due to the reason that the approach involving separate exclusive classifiers tend to interfere with one another, a combined approach is adopted. The combined approach increases the accuracy and also the sensitivity considerably. According to [1], first pre processing techniques like Contrast enhancement, Homomorphic filtering are used. Enhancing various regions of the original image contrast is used in this approach. The fundamental idea is to improve the image gray level dynamic range. In other words, the original image is enhanced by increasing the intensity of two dynamic range between the values. This is achieved using contrast enhancement. Homomorphic filter is one of the the frequency domain approaches whereas the image brightness range compression and contrast for the image enhancement are spatial domain approaches. Each pixel in the image space(spatial domain) is transformed suitably into a corresponding parameterized curve of the parameter space(Non- spatial domain). Each transformed pixel value in the parameter space is considered as a candidate point for representing a line and hence they are accumulated in a cell of an accumulator. At the end of the process, the accumulator cell with the value of local maximum is chosen and its corresponding coordinates are used to represent a line segment in the original image space.

In [5], Y Jia and Y Jiang present a method that produces the outlines of fractured bones in an X-ray image of the vicims's arm or leg within casting material, and displays out the alignment between the fractured bones. An active contour model is adopted, selecting suitable global constraints is used to segment the bone. Prior shapes are collected and used in the formulation of the global constraint of the model. A maximum-likelihood function is derived to provide feedback for each iterating process. Experimental results show that the method produces the outlines of the fractured bones on the low contrast X-ray images robustly and accurately. According to [2], The medical images of X-Ray have been taken as input images. The experimenters have applied different edge detection techniques such as Sobel, Prewitt, Canny, Log, Zerocross & Roberts. According to [3], It has been proved that the performance of fracture detectors can be improved both in terms of accuracy and sensitivity by combining classifiers (Lim et al., 2005; Chen et al., 2004).Motivated by this fact, the present work uses a novel classifier fusion algorithm to identify and detect fractures from DRD. This paper uses the texture features for fracture detection. The texture features used are GLCM Mean, GLCM Variance, Energy, Entropy, Homogeneity,Gabor Orientation, Markov Random Field(MRF) and Intensity Gradient Direction (IGD). According to [4], the fracture detection is performed using active contour model and canny edge detection.

In [6], Jian Liang et al. have proposed morphological method to identify fractures in tibia bones. Before segmentation process , the original input image is divided into several sub-intervals to help in finding out the smallest interval within the target. The small regions are then automatically thresholded using the Otsu method. To promote the accuracy of segmentation and to avoid over or under segmentation, the segmentation result obtained is examined using statistical method. Depending on the test results the segmented image is adjusted. After the second time segmentation is applied, the steps of verification and adjustment are required to be repeated until the test result conforms with any one of the terminating conditions. When the segmentation is completed, the target image will no long have tough areas. This is followed by

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mathematical morphology to extract the target border area and the boundary of fractures. Then by superposing the target border image, the exact location of fractures can be detected.

The method of automatically detecting fractures in long bones was developed by Martin Donnelley et al. The edges are extracted first from the x-ray image using a non-linear anisotropic diffusion method. This smoothens the image without losing important information about the boundary locations within the image. Then, a modified Hough transform with automatic peak detection is used to determine the parameters for the straight lines that best approximate the edges of the long bones. The parameters used to approximate the long bone edges are then used for centre-line approximation, diaphysis segmentation and fracture detection in the segmented region. Zheng wei et al. deal with the problem of automatic interpretation of fracture injury site in femur bones by converting it to bone shape identification problem. Depending on the shape of the bone segment, the fractures locations can be identified as - the proximal, middle or the distal part of femur bone. The approach involves performing vertically integral projection for each pre-processed bone region in X-ray images and combines the projection curves. After this is completed, the Muller AO coding standing for the fracture injure site is judged based on analysis of subsection variances of curves. If the variance ratio is found to be larger than a fixed value, the program outputs a numeric code one, if the variance ratio is less than a fixed value, the program output a numeric code three. Otherwise, the program output a numeric code two. Then the fracture injury site is automatically interpreted according to the code matching rules.

The paper also introduces a procedure for crack detection in X-ray image, which is based on the minimization of a fuzzy measure. The image histogram is divided into three fuzzy sub-sets using iterative approach to obtain subsets parameters. The obtained parameters were used as initial estimates and each pixel in the fuzzy regions were classified as belonging to one of the sub-sets by minimizing the fuzzy index. After segmenting the image into three regions, the background and skin regions are removed to detect the cracks in the bone region.

A binary image thus obtained contains cavities or holes. A hole-filling step combined with the morphological operation is then applied to the binary image to fill these holes and create a temporary image. The temporary image is subtracted by the original binary image to isolate the small holes. Morphological filtering functions, usually erosion followed by dilation, are then applied to screen noise and other undesirable spots using the iteration number as an operational parameter. The morphological operation can eliminate or maintain the spots on the image according to their area size. This is done to identify possible infestation sites among small spots segmented from the binary image. The output of this process is a binary image containing the crack.

IV. PROPOSED TECHNIQUE

Step 1 : Preprocessing

Since the X-ray images, may be susceptible to noise, we need few preprocessing steps. As in most of the approaches, contrast stretching and homomorphic filtering are used. Then as a novel idea, the image is binarized and the intensity values are inverted, i.e. black pixels are made white and white pixels are made black. This is done for the sake of accuracy.

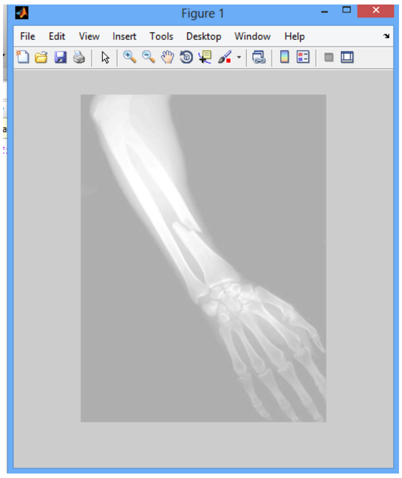

Fig. 1. X-ray image input

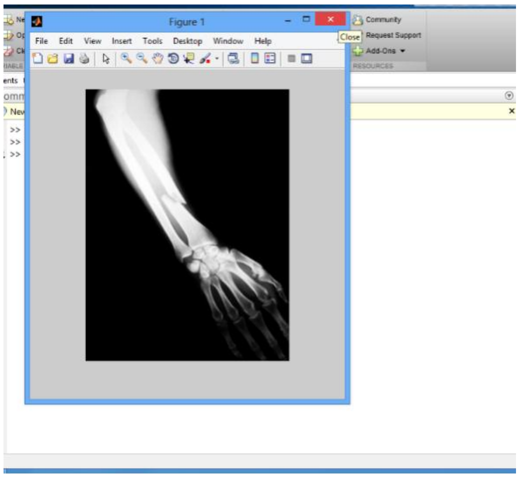

Fig. 2. X-ray image after preprocessing

Step 2: Fracture detection

An innovative idea is proposed for detecting the fractures. The binary image is exposed to hole filling and all small insignificant blobs are removed with mean thresholding. Now the image is scaled to an arbitrary standard size chosen as 256 x 256. The image is scanned over for the largest blob. The width of this blob is measured. A rectangular window of height and width same as the width of the measured blob is scanned over the image. If there occurs any white space within the black space inside the window, then fracture is detected. To make the process more accurate, different such sample windows are taken and trained using a neural network. Thus this can be used to predict future inputs. Edge detection features can also be used. Instead of Canny, a novel edge detection algorithm is used. The image is represented as a binary

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tree with each node its pixel value. The tree is traversed from bottom to up and the cascade-cut algorithm is applied to it. The nodes are cutoff at the point where there is a sharp change in intensity, which are candidate edge points. From these cut-off portions the edges are formed.

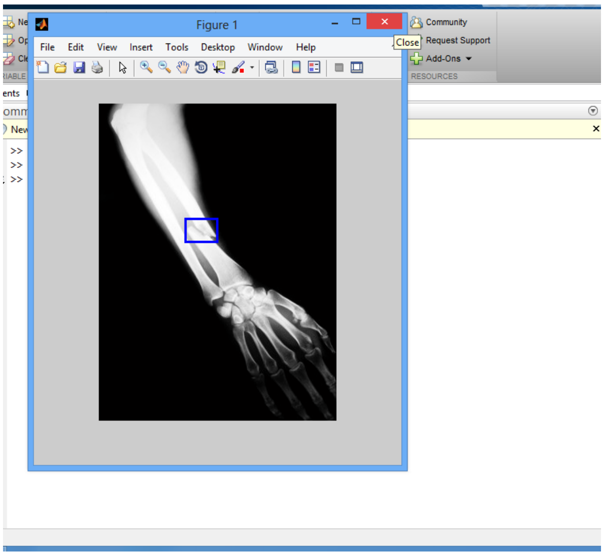

Fig. 3. Fracture detected

Step 3: Type of fracture

Once fracture has been detected, the next step is to analyse and detect the type of fracture. For this, a blend of bounding box and convex hull based approach is used. A rectangle is bounded over the largest black area possible. The bounded region is cropped and saved as a new image. The intensity values are again inverted, , i.e. black pixels are made white and white pixels are made black. Now the image is resized to 64 x 64 and shape features are extracted. Also statistical features are included. Samples of these images are used to train a neural network classifier which can be used to predict the type f fracture in future.

V. IMPLEMENTATION

The system has been implemented and tested out in MATLAB. All the modules – preprocessing, fracture detection and fracture type detection are tested out for accuracy.

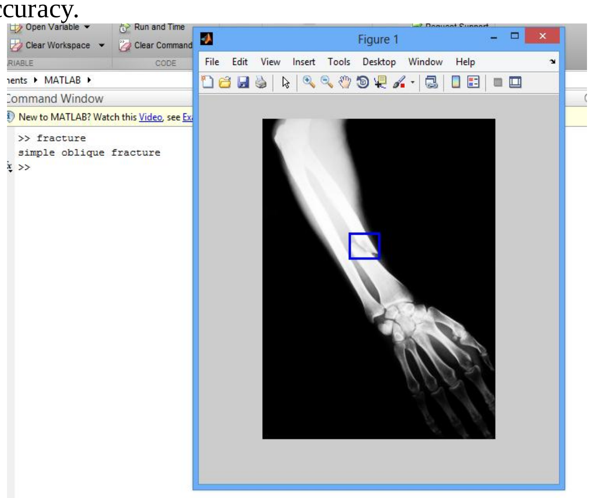

Fig. 4. Output

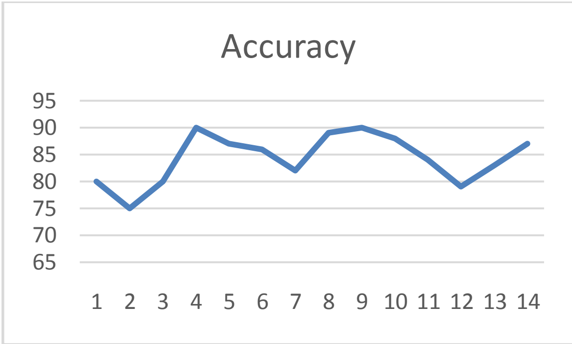

Fig. 5. Accuracy of the proposed approach

VI. CONCLUSION

Thus an innovative approach to detect fractures and the type is proposed. When X-ray images are examined manually, it's a time consuming process and also it is prone to errors. And so there is a great need for the development of automated techniques and methods to verify the presence or absence of fractures. This automated system involves steps such as acquiring the image. To make these images accurate one or more steps of preprocessing are applied to get rid of noise and blur in the image. The existing scheme is modified by a better segmentation and edge detection algorithm to improve efficiency. From these results, diagnosing fracture and its type can be done effectively.

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