Automatic Detection of fracture in femur bones using Image Processing

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Abstract— The femur is the enlarged and the vigorous bone in the human body, ranging from the hip to the knee. This bone is responsible for the creation of Red Blood Cell in the body. Since this bone is a major part of the body, a method is proposed through this paper to visualize and classify deformities for locating fractures in the femur through image processing techniques. The input image is preprocessed to highlight the domain of interest. In the process, the foreground which is the major domain of interest is figured out by suppressing the background details. The mathematical morphological techniques are used for these operations. With the help of basic morphological operations, the foreground is highlighted and edge detection is used to highlight the objects in the foreground. The processed image is classified using the support vector machine (SVM) to distinguish fractured and unfractured sides of the bone.

Keywords— Feature extraction, Image enhancement, Image edge detection, Image classification, Morphological operation, Support Vector Machine.

I. INTRODUCTION

The Digital Image Processing is growing tremendously and becoming an essential part of medical field due to its enhancement in technology and as well as cheaper microprocessor. It plays a key role in manipulation of image, and extracting as much knowledge as possible from the Image with the help of different algorithms. It gives quick and accurate diagnosis result. One of the standards are used to store, exchange & transmit biomedical image is DICOM. Various instruments are used to capture the biomedical image in which X-ray is used mainly for bone fracture Detection due to their high speed, inexpensive, and ease of use. The invention of X-ray was done by Wilhelm Roentgen in 1895, medical imaging has developed at a magnifying degree of rate and has become the essential diagnostic device in today's healthcare. As a role of ease and computer image processing technologies, digital X-ray imaging appliance are being frequently used in various medical applications. So, this work is mainly focused on manipulation of X-ray images of several types of femur bone, which helps in detecting the bone fracture easily as well as accurately. The femur fracture is classified into 3 sections: the shank of the bone, the head/neck of the bone (the prime end, adjacent the pelvis), or the subjacent end immediate the patella. Fracture occurs when a heavy-force expend against a bone is stronger than the bone can structurally withstand. Several hair line & minor fractures may get un-noticed in the X-ray image by the Doctor. In such cases Digital Image Processing helps doctor to determine those errors by providing clear and crystal view of the image to the doctor. So this proposed approach used image processing as a significant tool to detect those minor fracture efficiently. There are several challenges for identifying the fracture such as noise reduction, Feature Extraction, Classification. In [7] the author conferred the filtering algorithm which will impoverish Gaussian noise. The noise extent is determined from noisy image; it replaces the focus pixel by the mean value of the total sum of the neighboring pixels created on a threshold value. Another problem faced during preprocessing is salt and pepper noise, which was untangled by [8] to eliminate salt and pepper noise while introducing K-fill algorithm grounded on the count of black or white pixels in a 3 × 3 window. Assuming that the images are ruined by the noise demonstrated as a sum of two arbitrary processes: Poisson and Gaussian, this methodology permits to mutually evaluate the scale criterion of the Poisson element and the mean and variance of the Gaussian one. Lastly, [10] introduce the problem related to image augmentation and speckle reduction by means of filtering technique. The next step is feature extraction. There are different techniques which can be used such as Canny Edge Detection and Sobel Edge Detection. In [10] the author stated that the Sobel Edge Detector uses mainly 2 masks horizontal and vertical. These masks are generally used in 3×3 matrices. Specifically, In MATLAB the matrices which have 3×3 dimensions are used which results in smoothing effect of random noise of image. The edge seems thick and bright as it is differential of two rows and two columns. Another research done in [11] proposed a system for fracture detection in femur bones based on calculating the neck-shaft angle of the femur. Final step is Classification. In [12] proposed that SVM can be used for classification. It is a binary classification technique. By using combination of three classifier advances the total accuracy compared to a singular classifier. To capitalize this observation, [13] proposes to use a hierarchical SVM classifier system for the detection of fracture in femur bones. Hierarchical classifiers being used and the classification problem is tiered into smaller sub-problems. There have been several papers [5] [14] [15] addressing the problem of detecting fractures in long bones which helps us to learn and implement this algorithm.

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TABLE 1.
RESEARCH QUESTIONS ON LITERATURE REVIEW

ID	RESEARCH QUESTIONS
RQ1	What are the strategies used in processing the Image?
RQ2	Why Sobel edge detection is used in this approach?
RQ3	Why SVM classifier is used?
RQ4	How we can improve the accuracy of result?

II. METHODOLOGY

The femur bone is a sophisticated part of body so an approach is being made through this paper in which the bone deformities is visualized through an algorithm using image processing as a tool. This approach is focused on locating minor or hair line fracture in the femur through image processing techniques. The input image is processed to highlight the regions of interest. In the process, the foreground which is the major region of interest in this process is figured out by suppressing the background details. The mathematical morphological techniques are useful for these type of operations. With the help of basic morphological operations like *opening and using edge detection* the foreground objects are highlighted. Then the image is classified using the SVM into two sides of image (fractured and unfractured). The techniques used are preprocessing, feature extraction and image classification. The flowchart of algorithm is shown in Fig. 1. The paraphrase of techniques is below:

A. Preprocessing

The unwanted feature of image like Noise are removed from the image and some modification like improving contrast is done so as to obtain the image which can be used for further feature extraction.

In this approach, median filter and average filter used for removal of noise from the given image. The value of the output pixel for both filter equals to the mean of the pixel magnitude in the neighborhood around the equivalent input pixel. The median filter gives the magnitude of an output pixel equals to the median value of the neighborhood pixels, rather than the mean. The median is very less subtle than the mean to extreme magnitude and known as outliers. Therefore, Median filtering is more effective to eliminate the outliers deprived of decreasing the image sharpness [3].

For image enhancement, logarithmic operator is used. Here the arithmetic operation is used to enhance the contrast of the image. The contrast of brighter region is scaled down using logarithmic operator. This is given by equation:

$$V = J * log(1 + e); \quad (1)$$

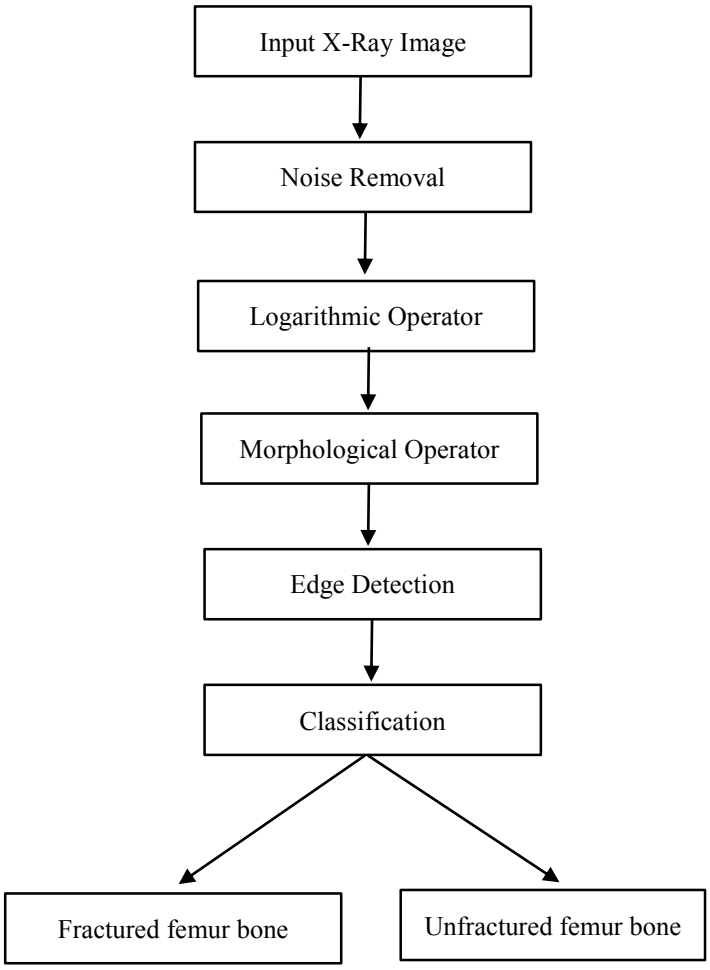

Fig. 1. Flowchart of proposed approach

Where J is the factor, e is the image to which enhancement has to be done. Here the factor J is decided empirically to get a required level of enhanced image.

Then the feature extraction of preprocessed image is done. Here the foreground is figured out by suppressing the background. For this morphological operations (erosion and dilation) and sobel edge detection technique is used.

B. Morphological Operations

These are the processing operations that route set of image grounded on shapes [3]. For producing an output image of the similar size it applies a constituting element to an input image. In such operation, the magnitude of each pixel in the output image is established through the comparison of the equivalent pixel in the input image with its neighbors. By selecting shape and size of the neighboring pixel, a morphological operation which is subtle to precise and exact shapes in the input image is created. The predominantly used morphological operations are – erosion and dilation.

In erosion, where output image pixel magnitude is the least of all the pixel's magnitude in the neighborhood. The pixels

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

S_x

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

S_y

Fig. 2. Sobel convolution kernels

ahead the image border are assigned the supreme value that can be given by the data type.

In dilation, where output image pixel value is the maximum of all the neighborhood pixels. The pixels beyond the image border are assigned the minimum value that can be given by the data type.

C. Image Edge Detection

The approach is to detect the edge of the bone in the input processed images. The edge of femur bone is detected so that its background is distinguished, to extract clear edge of bone. Edge detection technique that can be used are canny edge detection, Gaussian edge detection and Sobel edge detection. In proposed approach best result is obtained using sobel edge detection. The Sobel operator [4] [5] [10] performs a 2-D spatial gradient measurement on an image and emphasizes the regions of high spatial frequency that correspond to edges. It is mainly used to find the approximate absolute gradient magnitude at every point in given input grayscale image. The operator consists of a pair of 3×3 convolution kernels as shown in fig. 2. One kernel is as shown and the other is rotated by 90°. These are used to respond maximally to edges running vertically and horizontally relative to the pixel grid, one kernel for each of the two perpendicular orientations. The preprocessed image is applied over kernel and each orientation produces a separate measurement of the gradient component (call these *Sx* and *Sy*). They constitute all together to evaluate the absolute value of the gradient at every point and their orientation. The gradient value is given by:

$$|S| = \sqrt{{S_x}^2 + {S_y}^2} \tag{2}$$

An approximate value is computed using given formula:

$$|S| = |S_x| + |S_y| \tag{3}$$

And the angle of orientation of the edge which give rise to the spatial gradient which is given by:

$$\theta = \arctan\left(S_y / S_x\right) \tag{4}$$

B_1	B_2	B_3
B_4	B_5	B_6
B_7	B_8	B_9

Fig.3. Pseudo-convolution for computation of approximate gradient magnitude

In this case, orientation referred to mean that the direction of maximum contrast from black to white bound from left to right on the image, and other angles are evaluated anti-clockwise.

Often, this absolute value of pixel is the output user visualize, the two gradient components are computed conventionally and they are added in a single pass into the input image using the pseudo-convolution operator shown in Fig. 3.

The approximate magnitude using kernel is given by:

$$|S| = |(B_1 + 2 \times B_2 + B_3) - (B_7 + 2 \times B_8 + B_9)| + |(B_3 + 2 \times B_6 + B_9) - (B_1 + 2 \times B_4 + B_7)| \tag{5}$$

This detection technique gives a sharp edge of bone of processed image and then image is classified using classifiers.

D. Image Classification

The processed X-ray image is classified into fractured and un-fractured using image classification. The collection of 30 X-ray image is used as data set to classify the data. The images are processed and then classification is done using SVM. In [2] it is defined that, the SVM classifier is the binary classifier and is one class classifier. It performs binary classification and regression estimation task, minimizes the error and provide effectiveness in classification so it is very efficient to use. Here the classification is supervised and has two data set one is training dataset and other is test dataset. Training dataset train the support vector machine for the classification and the test dataset test the classification accuracy. In this approach two data set is used to classify the biomedical processed image into fractured and un-fractured. The training data sets are separable and if one set of data set is 'A' and other is 'B' so they are separated by constructing hyperplane which is given by:

$$X'W = \gamma \tag{6}$$

so that one half contains mostly point 'A' and other one half contains point 'B'. So these satisfy the equation give below:

$$VW > b\gamma - b \text{ and } BW < b\gamma + b \tag{7}$$

Where 'V' denotes the matrix corresponding to all X in class A; 'B' denote a matrix for data in B and 'b' is the vector of all 1's. The above equation (7) will have the smallest generalization error. The data set is classified and training set is used to analyze the classified data.

III. RESULTS AND DISCUSSION

Fig. 4. Median and Average Filter used for noise removal

Fig. 5. Showing the images before[left] and after[right] implementing Logarithmic Operator.

Fig. 6. Erosion [left] and Dilation [right] of X-ray images.

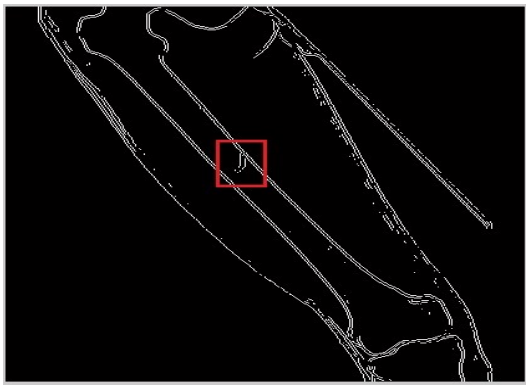

Fig. 7. Proposed method detecting fracture.

Fig. 8. Canny edge detection used in processed X-ray image.

TABLE II. RESULT AFTER CLASSIFICATION OF PROCESSED IMAGES

S. No.	No. of images in Training data set	No. of images in Testing data set	Accurate Result	Percentage Accurate Result
1.	30	15	13	86.6 %
2.	30	10	8	80 %
3.	30	24	21	87.5

This approach proposed the algorithm for automatic detection of fracture in femur bone so as to facilitate more accurate and broad classification. This work is done using explicit coding in MATLAB. Initially, the X-ray image is stored in RGB, so conversion is done to grayscale prior to image pre-processing stage. The collection of 30 X-ray images is taken from radiograph film resolution (2592x1944) which also taken as training data for classification. This approach is developed for detection of fracture in femur bone using modified version sobel edge detection and result is compared with other edge detection techniques.

In pre-processing the input X-ray image containing noise is removed using median and average filter as shown in fig. 4. Then this image is processed using logarithmic operator where contrast of foreground is improved to a required level as shown in fig. 5. The morphological operators (erosion and dilation) is used as shown in fig.6 to process the image and the sobel edge detection is used as an approach to get clear edge of the bone as shown in fig. 7. The result is compared with other edge detection techniques like canny which is shown in fig. 8, the canny edge detection can detect bone edge accurately but failed to detect fracture edges. The result of classification of images is shown in table 2. The accuracy of classification on average is about 84.7%, which can be improved using an intense training data set, which will support SVM to classify more accurately.

This approach has following advantages:

1. Filter is used for noise removal which will enhance the image and eliminate the noise pixel.
2. Logarithmic operator is used to get clear and enhanced foreground.
3. The modified sobel edge detection gives clear bone edge and radius bone structure.

IV. CONCLUSION

The fracture in femur bones is very common and is rapidly increasing case in many of the countries. In context of medical science, it is very important to have accurate detection of minor fracture in a bone. So in this approach the classification of fractured and un-fractured bone is done. For which image processing techniques is used which involve preprocessing, feature extraction and classification. The median and average filter is used to get the noise free image and then Logarithmic operator is used for image Enhancement whose factor is evaluated empirically. The morphological operation is performed to processed image and then edge detection technique is used (Sobel filter) to distinguish edges from the image in feature extraction. The sobel edge detection technique gives clear fractured edge but the canny edge detection detects bone edge accurately but not fractured edge. Then the processed image is given as input for classification using SVM where the image is classified into fractured or un-fractured. The dataset is used to train the SVM and used set of processed image to test the accuracy of that. In proposed approach, the accuracy is 84.7% but it can be improved more by using an intense training set of image.

V. IMPLICATIONS OF FUTURE RESEARCH

The future scope of automatic fracture detection using image processing are characterized in the following category:

1. As the medical area is very sophisticated so to improve the accuracy, intense training set can be provided to improve result.
2. The more complex algorithm can be implemented to show the shape, area and complexity of fracture.
3. Artificial intelligence can be used to improve the result and to analyze the characteristics of fracture and its cure.
4. Data mining techniques can be used after detection of fracture to give more classification of fracture and cure which will be extracted from prior knowledge.
5. Through some improvement in above approach it can also be used for fracture detection in other long bones.
6. The factor in Logarithmic operator can be decided automatically through some statistical operators.

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