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Enhanced Computer Aided Bone Fracture Detection Employing X-Ray Images by Harris Corner Technique

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***Abstract*—Rapidly creative innovations are emerging day by day in various fields, particularly in restorative condition. Bone fracture is one of the most common human problem and happens when the high pressure is applied to the bones, or simply because of accidents. High precision diagnosis of bone fracture is an important feature in the medical profession. Owing to fewer physicians, remotely based hospitals cannot have any of the equipment to diagnose fractures. X-ray scans are used to assess the fractures. These X-rays are one of the less expensive techniques for identification of fractures. Harris corner based detection algorithm is proposed to extract features from the image and the extracted features from this algorithm can identify edges, fractures and corners present in the image.300 different X-ray images are collected from Osmania hospital, Hyderabad. Proposed method gives an accuracy of 92% which is better in recognizing fracture compared to the existing methods.**

Keywords—Gaussian filtering, Canny edge segmentation, Fracture detection, Harris corner detection.

I. INTRODUCTION

Every year, traumatic fractures of bones contribute to permanent disability and sometimes contribute to the cause of death. In remote areas and hospitals, the implementation of this project helps the people to detect the fracture of bones without the need for orthopedicians.When bone fracture combined with other injuries in the body, for example, an abdominal injury combines with bone fracture, the chances of increasing the mortality rate is high, traumatic bone fracture in certain regions can result in severe hemorrhage, Multiple Organ Disability Syndrome (MODS), nerve injury and various other damages to internal organs. Bones, the rigid tissues are the strong organs that form the skeleton of the human body and protecting various body parts like lungs, heart, brains and other internal parts. The human body is comprised of approximately 206 bones each with its own size, Structure, and shape. The largest and the second-largest bones are the femur bones and the leg bone. The two bones tibia and fibula makes the leg bone. Auditory ossicles are the smallest bones present in the human body. Humans suffer from bone fractures more frequently. Accidents and excessive pressure on the bones leads to bone fractures. Comminuted, open, stable and transverse are the various kinds of bone fractures. Different imaging tools like x-rays, computed tomography (CT), Ultrasound etc., are available to detect various abnormalities in the human body. X-rays and CT rays are most widely used to detect bone fractures in the body because they are the most efficient and fastest way for the doctors to study bone and joint abnormalities and fractures. The medical images are now stored in DICOM format, and are retrieved and displayed using PAC (Picture Archives and Communication) hardware. Due to less resolution of image elements, different bone structures and visual characteristics of bone fracture locations and other various reasons, automatic fracture detection is not easy to achieve. Fracturing detection and computerized detection in bone from X-ray images makes an orthopedician to work better and helps to cure the fractured system. The isolation of fracture features as well as fracture rearrangement measurements are all very crucial for assisting orthopedicians in making faster and accurate decisions.

II. LITERATURE SURVEY

There were several algorithms developed to extract and detect the fracture of bones. A comprehensive overview of the literature is given in this section. The algorithms such as mean, alpha-trimmed mean, wiener, bilateral techniques give less precision for removing noise from the image. Ryder[1] referenced the presence of bone fracture by observing acoustic pulses as they pass along a bone. Neural networks is used by kaufman[2] to analyse mechanical vibrations in a bone, and electrical conductivity was measured by Chauhan[3] and singh. Unfortunately, all the techniques are not so accurate for classification and localisation of bone fractures and as a result they are not used in a clinical setting. A visual interpretation of x-ray contains classification from bone to bone and edge to edge. In order to detect the bone fracture a model-based methodology segmentation specially designed for long-bones by EL-Kwae[4], bone age estimation method by Niemiezer[5] tells us spatial variation, a bone is modelled with centroid and calculated weighted distances from centre to boundary, for positive match the distance between the small bone and long bone must be less but they did not present any results, however, this showed anatomical variation. In addition, they also only show detection of fracture of a single bone within an image, without any consecutive segmentation. There are different filtering methods presented such as Gaussian noise removal technique that removes the extra noise in the image and replaced with bright pixels surrounding it, this method gives a lower mean absolute error and high peak signal to noise ratio compared to other filtering methods. Joseph et al proposed classification on vertebral body compression fractures of bones. Oishila Bandyopadhyay[6] et al done the research to detect bone cancer from the X-ray based on geometric approach.

III. METHODOLOGY

The input x-ray image is collected, and the pre-processing is done on that image by using Gaussian Filtering to remove noise in the image. This gives the noise less image and now the segmentation using canny edge detection is applied to find the edges in the image. From this Canny edge image, the feature extraction is done by using Harris Corner Detection method which results in the fractured / non-fractured image as shown in fig.1.

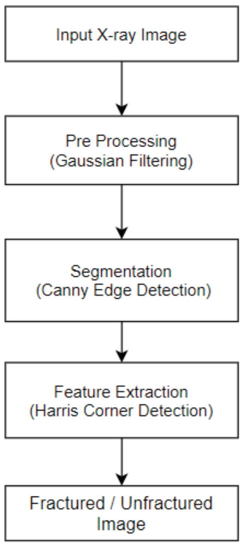

Fig.1. Block diagram of the Proposed Model

A. Filtering

The X-ray images or the CT images that we collected from hospitals contain normal and fractured bone images too. Initially, we need to apply some pre-processing techniques such as filtering and different enhancement techniques to remove noise from the images[9] This step comprises the techniques that improve the quality of an input X-ray image so that the image obtained improves the attainment of the further stages of the methodology[11]. The image suffers from noise due to poor illumination, capturition, and electronic sensor data.

Noise in the original image can be defined as an unwanted element of the image. This can be written as f(x, y)=a(x, y)+b(x, y) where f(x, y) is the noisy picture, a(x, y) is the original picture and b(x, y) is the noise in the picture. Noises that we often see are Gaussian noise, salt, and pepper noise, etc. There are various filters for eliminating noise from the images.

1) Gaussian filter

Such filters are used by adding a blur or mask on the image to eliminate the noise present in the original image. This is identical to a mean filter using a different kernel showing the type of a bell-shaped hump. The kernel has properties given below.

1-D filtering condition can be written as: $G(x)=\frac{1}{\sqrt{2\pi\sigma}} e^{-(\frac{x^2}{2\sigma^2})}$, Where σ stands for standard deviation of the Gaussian distribution. The larger the value of σ indicates wider Gaussian and more smoothening.

2-D filtering condition can be written as: $G(x)=\frac{1}{2\pi\sigma^2} e^{-(\frac{x^2+y^2}{2\sigma^2})}$, where σ denotes the width of the Gaussian. These filters are separable and work very accurately for removing unwanted image elements from the images. Gaussian filters are generally symmetric in two dimensional and variance σ is used to control their smoothening degree. We can use Gaussian filters for unsharp masking i.e. edge detection.


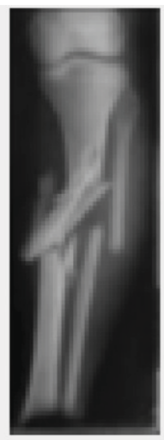

Fig.2. Original Image Fig.3. Gaussian Filtered Image

Fig.2 represents the original image and fig.3 shows the filtered noise less image after implementing Gaussian filter.

B. Segmentation

Segmentation subdivides an image into constituent regions or objects which means partitioning the original image into multiple segments or different regions[7]. The goal of segmentation is to extract more features and information from the image and analyse it in a more meaningful and easier manner. It takes the Pre-processed digital image as an input and gives the attributes of an image as output which is used for feature extraction and object recognition. This is the process of assigning a label to each pixel in an image such that the pixels with the same label share certain characteristics. There are many approaches for image segmentation, but we have used the Edge-based segmentation method which is more suitable for bone fracture detection.

Edge-based segmentation also known as edge detection is a process of locating the edges of an image. Edges usually correspond to points in the image where the grey value changes from one pixel to the other. From these edges, we can extract the features which give the information related to the image as it was discovered that the most important information lies in the edges of an image. Canny Edge Detection is used to get optimal results when compared with other operators like sobel[8].

1) Canny Edge Detection

In Canny Edge detection technique, first the noise is reduced from the image by applying gaussian filter on the original image. Edges are identified by using some threshold values which represents the minimum threshold and maximum threshold values[min, max]. If a pixel gradient is greater than the maximum threshold then that pixel is considered to be a point on the edge. If a pixel gradient is lesser than the minimum threshold then that pixel cannot be a point on the edge[15]. If it is in between both the threshold values, then it is considered as a point on the edge only when it is connected to a pixel that is already on the edge or else it is rejected[13]. By using this, we can form the edges on the image and the final result is the binary image with thin edges.


Fig.4. Gaussian Filtered Image Fig.5. Canny Edge Image

Here, we have taken the Gaussian Filtered image shown in fig.4 and implemented Canny Edge detection which gives the Canny Edge image as shown in fig.5.

C. Feature Extraction

In this paper, Harris Corner Detection algorithm is used as the feature extraction technique. This technique is used to extract the important features from the image. It was first published in 1988 by Chris Harris and Mike Stephens. It is an operator for corner detection which is widely used in machine learning algorithms to identify corners[14]. This algorithm can detect the edges, flat area and corners present in the image which helps in identifying whether bone is broken or not[12]. A corner is a point that can be viewed as a two-edge intersection, where an edge reflects a sudden change in brightness of the image. Corners are where a slight location shift will lead to a significant change in intensity both vertical and horizontal axes. The detection of bone fracture is involved in the following steps:

The first step is to identify which window produces large variation of intensity when moved in the direction of x and y axes.

$$E(u,v) = \sum_{x,y} w(x,y)\,[I(x+u,y+v) - I(x,y)]^2$$

E (u,v) be the difference between the original and shifted window.

I_x and I_y are the pixel intensities at x and y axes.

U and v are the derivatives of I_x and I_y. Which means shifting the window to new location (u,v).

We need to optimize E (u, v) for corner detection, because the above formula takes longer, so after expanding the above formula by applying the Taylor series method we get,

$$E(u,v) = \sum_{(x,y)} w(x,y)[I(x,y) + I_x u + I_y v - I(x,y)]^2$$

$$E(u,v) = \sum_{(x,y)} w(x,y)[I_x^2 u^2 + I_y^2 v^2 + 2 I_x I_y uv]$$

Taking u, v out and rewriting in matrix notation

$$M = w(x,y)\begin{pmatrix} \sum_{(x,y)} I_x^2 & \sum_{(x,y)} I_x I_y \\ \sum_{(x,y)} I_x I_y & \sum_{(x,y)} I_y^2 \end{pmatrix}$$

The next step is to identify the suitable window. It was estimated that suitable corners can be identified with the help of above M value (matrix of eigen values). Thus R value is calculated for each window.

$$R = det(M) - k(trace(M))^2$$

Where det=λ, λ_2 and trace=$\lambda_1 + \lambda_2$

Here $\lambda,, \lambda_2$ are eigen values of M and k is constant value between 0.04-0.06.

From the above calculated R value it is easy to identify the corner, edge, flat area in the image. There are 3 rules to follow when classifying any corner or flat or edge.

- If λ1 and λ2 are small then R will be small, the region is flat.
- If λ1>>λ2 or vice versa then R<0, the region is edge.
- If λ1 and λ2 are large and λ1~λ2 then R is large, the region is a corner.

IV. RESULTS AND DISCUSSION

Finally, the output is obtained as either the bone is fractured or not. If corners or edges are present, then it is said as the bone is broken. If it is flat, then bone is not broken.


Fig.6. Canny Edge Image Fig.7. Harris Corner Detected Image

Here we have taken the Canny Edge image shown in fig.6 and implemented the Harris Corner Detection and finally we have detected the fractured part successfully, as shown in fig.7, here the fractured part is clearly viewed.

A. Comparison between Results

TABLE I. PERFORMANCE MEASURES

Methods	Accuracy	Sensitivity	Specificity
Harris Corner	0.92	0.88	0.85
Hough Transform	0.89	0.86	0.81
GLCM	0.82	0.83	0.8

From the 300 collected images, 30 from each type of X-Rays is used for training and remaining 20 from each type of X-Rays is used for testing. The table 1 interprets various performance measures like accuracy, sensitivity, specificity and the corresponding values of three algorithms Harris Corner, Hough Transform[10] and Grey Level Co-occurrence Matrix (GCLM).

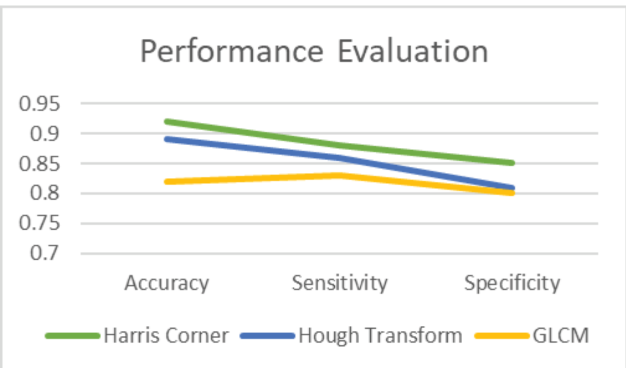

Fig.8. Performance Evaluation between various methods

The performance evaluation between various methods states that Harris Corner detection method gives better results with accuracy of 92%, sensitivity of 88% and specificity of 85% because it includes methods such as Gaussian Filtering for noise removal and Canny Edge for segmentation when compared with the other two methods i.e., Hough Transform, Grey Level Co-occurrence Matrix (GCLM) as shown in fig.8.

V. CONCLUSION

The Proposed system has the capability of pre-processing and identifying the fracture and non-fracture bone x-ray images for effective dissemination. The X-ray images used for this experiment were collected from Osmania hospital, which includes both fractured and non-fractured images. The input image is pre-processed with Gaussian filter in order to remove noise. When the pre-processed image is given as an input to canny segmentation, it identifies the edges based on threshold values. Further, Harris Corner Detection method is used to extract the important features from the image and identifies and localize the bone fractures from the extracted features with an accuracy rate of 92%. While the other two methods Hough transform and the Grey Level Co-occurrence Matrix (GCLM) gives an accuracy rate of 87% and 82% as shown in fig.8. In comparison with the above two methods Harris Corner method performs better with a recognition rate and can be used as an effective tool for localization and bone fracture detection.

REFERENCES

[1] D. Ryder, S. King, C. Olliff, and E. Davies, A possible method of monitoring bone fracture and bone characteristics using a non-invasive acoustic technique, International Conference on Acoustic Sensing and Imaging (1993), pp. 159–163.

[2] J. Kaufman, A. Chiabrera, M. Hatem, N. Hakim, M. Figueiredo, P. Nasser, S. Lattuga, A. Pilla, and R. Siffert, A neural network approach for bone fracture healing assessment. IEEE Engineering in Medicine and Biology 9, 23 (1990).

[3] V. Singh and S. Chauhan, Early detection of fracture healing of a long bone for better mass health care, *Annual International Conference of the IEEE Engineering in Medicine and Biology Society* (1998), pp. 2911–2912.

[4] E. A. El-Kwae, A. Tzacheva, and J. F. Kellam, Model-based bone segmentation from digital X-ray images, *Second Joint EMBS/BMES Conference*, Houston, Texas, USA (2002), pp. 2529–2530.

[5] K. Doi, Computer-aided diagnosis in medical imaging: Historical review. *Current Status and Future Potential* 31, 198 (2007).

[6] Bandyopadhyay, Oishila, A. Biswas, and B. B. Bhattacharya, Automated analysis of orthopaedic X-ray images based on digital-geometric techniques. ELCVIA: Electronic Letters on Computer Vision and Image Analysis 15, 7 (2016).

[7] Lai, Jiing-Yih, T. Essomba, and P.-Y. Lee, Algorithm for segmentation and reduction of fractured bones in computer-aided preoperative surgery, Proceedings of the 3rd International Conference on Biomedical and Bioinformatics Engineering, ACM (2016).

[8] C. I. Gonzalez, P. Melin, J. R. Castro, and O. Mendoza, An improved sobel edge detection method based on generalized type-2 fuzzy logic. *Soft Computing* 20, 773 (2016).

[9] Zeelan Basha, C. M. A. K., Maruthi Padmaja, T., & Balaji, G. N. (2018). Automatic X-ray image classification system. In Smart Innovation, Systems and Technologies (Vol. 78, pp. 43–52).

[10] McDonagh, John, and G. Tzimiropoulos, Joint face detection and alignment with a deformable Hough transform model, *European Conference on Computer Vision*, Springer International Publishing (2016).

[11] C. Sbarufatti, M. Corbetta, M. Giglio, and F. Cadini, Adaptive prognosis of lithium-ion batteries based on the combination of particle filters and radial basis function neural networks. *J. Power Sources* 344, 128 (2017).

[12] G. N. Balaji, T. S. Subashini, and N. Chidambaram, Detection of heart muscle damage from automated analysis of echocardiogram video. *IETE Journal of Research* 61, 236 (2015).

[13] M. L. Giger, Computer-aided diagnosis in medical imaging-A new era in image interpretation, World Markets Research Centre, Tech. Rep.(2000).

[14] K. Doi, Current status and future potential of computer-aided diagnosis in medical imaging. *British Journal of Radiology* 78, S1 (2005).

[15] Basha, C. Z., Sricharan, K. M., Dheeraj, C. K., & Ramya Sri, R. (2018). A study on wavelet transform using image analysis. International Journal of Engineering and Technology (UAE), 7(2), 94–96.