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HYBRID DEEP LEARNING AND OPTIMIZATION STRATEGIES FOR ACCURATE BONE FRACTURE DIAGNOSIS IN MEDICAL IMAGING

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ABSTRACT:
Deep Learning is an emerging technology which evolves in machine learning. Automated machine tools and developed technology in hospitals helps to recover many patients. Deep learning concept is inbuilt with many algorithms which help to train the input data set into different layer of perceptron. Computers have been shown to be valuable in every facet of human life, from banking, online shopping, communication, medical, education, research and development. It is used to help doctors and hospitals for their patients, a lot of innovative technical resources have been developed. This technique is extremely helpful for several applications like biomedical, security, satellite imaging, personal image, medicine, etc. Bone fracture is one of the most ordinary problems in mortals because of accidents or other causes. Breaking bones can occur in our body, such as the wrist, heel, ankle, hip, rib, leg, chest, etc. Fractures cannot be seen with the naked eye, so X-ray / CT images are used to detect them. But sometimes these images lack sufficient detail for diagnosis, image processing plays an important role in detecting bone fractures. Because the typical scanner for X-rays produces a fuzzy picture of the bone component in issue, surgeons risk making an inaccurate diagnosis of bone fractures when they utilize it. Various stages such as pre-processing, edge detection, feature extraction and machine learning classifications, constitute the backbone of this system, with the end goal of making surgeons lives easier.

KEYWORDS: Bone Fracture, Pre-processing, Edge Detection, Feature Extraction, Segmentation, Harris Corner, Canny Edge Detection

1. INTRODUCTION:

The human body contains 206 Bones. The ability to move the body is provided by bone. The human body frequently experiences bone fractures. Bone fracture can occur due to a simple accident or different types of diseases. Fractures commonly happen because of car accidents, falls or sports injuries, low bone density and osteoporosis, which cause weakening of the bones. Doctors use X-Ray to identify the fractured bone. The normal technique takes time and requires expertise. The manual fracture detection method takes a long time and has a high chance of error. Therefore, it is necessary to create an automated system to identify the fractured bone. The system can identify major and minor bone fractures. Based on the type of fracture, this system involves fracture detection.

2. LITERATURE REVIEW:

In this work, we have conducted a comprehensive literature review, including everything from traditional approaches to state-of-the-art procedures.
In [1] proposed a transfer learning, Faster R–CNN deep learning model for fracture detection and classification with Region Proposal Network (RPN). In addition, the author retrained the model's top layer on 50 x-ray images using the inception v2 (version 2) network architecture. This model was trained in 40 k steps and halted when the loss was just 0.0005. The suggested model for detection and classification was evaluated by the author. In terms of classification and detection, this technique has an overall accuracy of 94%.

In the study [14] long bone fracture or non-fracture classification was accomplished by first using the Bang of Words (BoW) model for feature extraction and then training the model with the Support Vector Machine (SVM) machine learning technique. Additionally, the suggested approach has a detection rate of 78% for transverse and oblique fractures, respectively.
Another study [17] proposed these steps: pre-processing, feature extraction and classification for their workflow. After that, the processed picture is used as input for classification using SVM, which has an accuracy of 84.7%.
Study [8] proposed a meta classifier that combines decision tree (DT) and neural network (NN) to obtain better accuracy. Several distinct processing steps, including pre-processing, segmentation, edge detection, and feature extraction, are utilized. The meta classifier has an accuracy of 85%, and the processed pictures will be further categorized into fractured and non-fractured bone.
Study [18] demonstrates that the Canny Edge Detection technique is the best algorithm for edge detection. It takes a greyscale picture (X-ray image) as input, analyzes it, and outputs an image with intensity discontinuities.
This study [12], The identification of lower leg bone (Tibia) fracture types is being explored utilizing various image processing approaches. The goal of this project is to detect fracture or non-fracture and characterize the type of fracture in an x-ray picture of the lower leg bone (tibia). The tibia bone fracture detecting system is created in three stages. To categorize fracture types and find fracture sites, they use pre-processing, feature extraction, and classification. During the pre-processing stage, Unsharp Masking (USM) and Harris algorithm have been used for sharpening and corner detection. Simple Decision Tree (DT) is utilized for fracture or not classification, while K-Nearest Neighbor (KNN) is used for fracture type classification. The four fracture types are characterized in this study as Normal, Transverse, Oblique, and Comminute. For fracture type classification, the method achieves an accuracy of 82%.
In another study [19] proposed CNN algorithm with SFCM (Spatial Fuzzy C-Means). Median filter and Discrete Wavelet Transforms (DWT) are used as pre-processing steps. It uses features like homogeneity, entropy, contrast, correlation coefficient, and energy with the accuracy of 78%.
In the study [20], suggested hybrid approach is particularly effective in identifying paediatric ulna and radius fractures. The author used a 2D sliding window to get the local Shannon entropy for each pixel in the image. This research achieved the accuracy of 91%.
Another study [21], approach to X-ray image processing was developed, which makes use of the Local Binary Pattern (LBP) feature extractor and the Support Vector Machine (SVM) classification technique. The implementation of pre-processing techniques to enhance image quality is also an important addition. The outcomes demonstrate that the CLAHE pre-processing approach achieves an accuracy of 80% in classification.
In [22], to distinguish between fractured and healthy bone, a deep neural network model was created. Due to the little data available, the deep learning model becomes overfit. So, the size of the dataset has been increased by the use of data augmentation methods. A total of three experiments were conducted utilizing the SoftMax and Adam optimizers to assess the efficacy of the model. As for its classification abilities, the suggested model scores a very respectable 92.44%.
In another study [23], A comparison can also be made between the proposed method and the Harris corner detection method. For automated bone fracture identification, BPNN combined with Canny edge detection and conservative smoothing achieves the highest accuracy (91%).

3. OBJECTIVE:
The goal of this research is to create a program that can help doctors to determine whether bone has been broken or not easily and quickly. The main aim is to save time for patients, to lower the workload of doctors by screening out the easy case and to reduce human errors.

4. EXISTING SYSTEM:

There are different types of medical imaging tools are available to detecting different types of abnormalities such as X-rays, 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 uses x-ray images to determine whether a fracture exists, and the location of the fracture. 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.

5. DISADVANTAGES OF EXISTING SYSTEM

Depending on the human experts alone for such a critical matter can cause intolerable errors

6. PROPOSED SYSTEM

The X-ray/CT images are obtained from the hospital which contains normal as well as fractured bones images. In the first step, apply pre-processing techniques such as RGB to grayscale conversion and enhance them by using filtering algorithm to remove the noise from the image. Edge detection methods are used to detects the edges in images and segmented the image.

Feature Extraction methods are used to converts each image into a set of features by using techniques such as Harris Corner Detection. Finally, we build the classification algorithm based on extracted features. Performance metrics for the proposed system are evaluated.

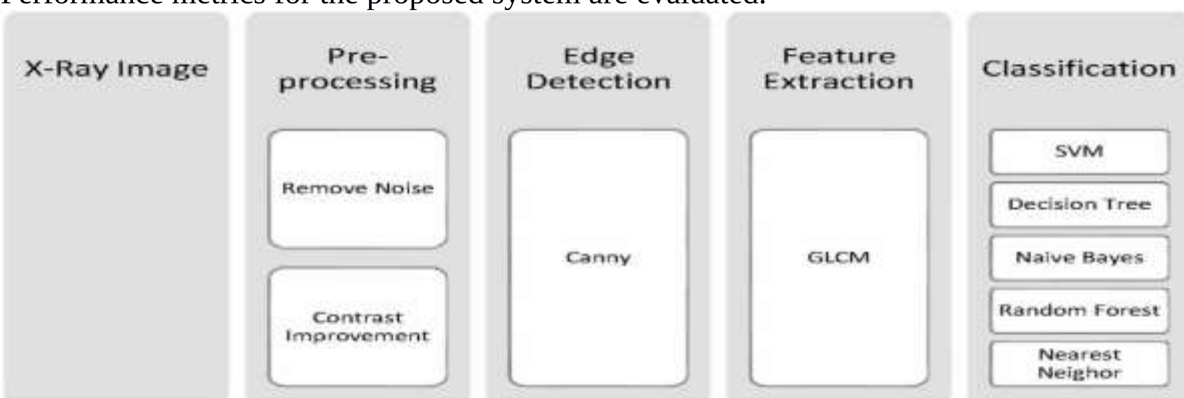

Figure 1: Block Diagram for Proposed System

The bone fracture detection system consists of four main modules, which are pre-processing, edge detection, feature extraction, and classification.

7. PRE-PROCESSING

This stage consists of the procedures that enhance the features of an input X-ray image so that the result image improves the performance of the subsequent stages of the proposed system. In this work, the main procedures for image enhancement are noise removal, adjusting image brightness and color adjustment. Noise can be defined as unwanted pixel that affects the quality of the image. Gaussian smoothing filter is a filter for removing noise draw from a normal distribution. A Gaussian filter is parameterized by σ, and the relationship between σ and the degree of smoothing is very simple, σ implies a wider Gaussian filter and greater smoothing. After filtering, this system is performed adjusting image brightness and color to distinct the desired object or bone shape from the image. The adjusted image is converted into the gray scale image to speed up processing time and less computation.

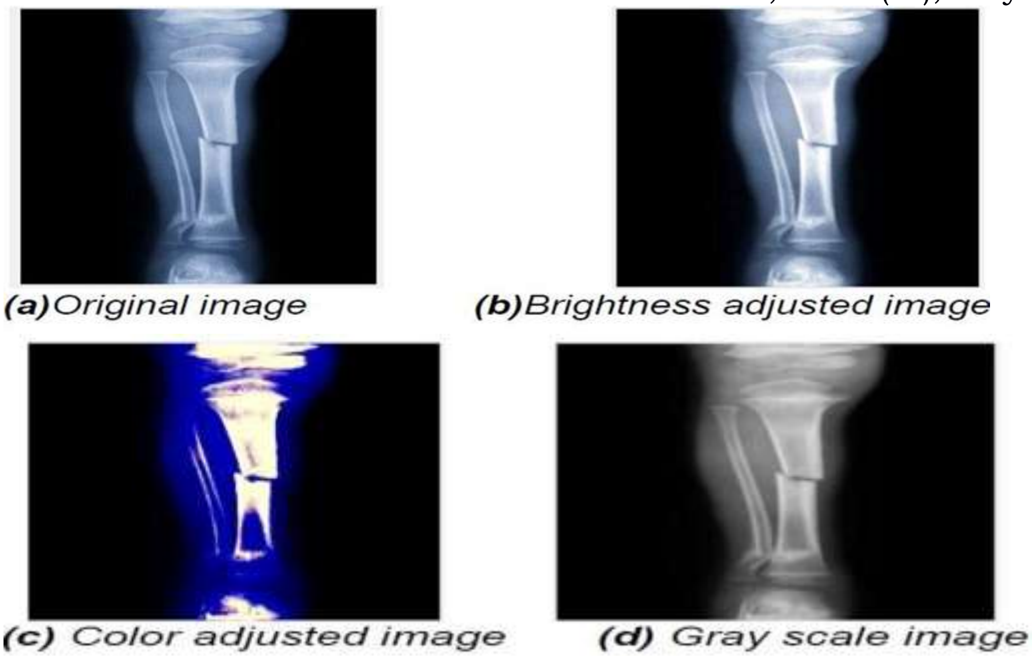

Figure 2: Results of Image Pre-processing

8. EDGE DETECTION

In image processing especially in computer vision, the edge detection treats the localization of important variations of a gray level image and the detection of the physical and geometrical properties of objects of the scene. It is a fundamental process detects and outlines of an object and boundaries among objects and the background in the image. Edge detection is the most familiar approach for detecting significant discontinuities in intensity values. Edges are local changes in the image intensity. Edges typically occur on the boundary between two regions. The main features can be extracted from the edges of an image. Edge detection has major feature for image analysis. Edge detection is used for object detection which serves various applications like medical image processing, biometrics etc. Edge detection is an active area of research as it facilitates higher level image analysis. There are three different types of discontinuities in the grey level like point, line and edges. Spatial masks can be used to detect all the three types of discontinuities in an image. There are many edge detection techniques in the literature for image segmentation. The most commonly used discontinuity-based edge detection techniques are reviewed in this section.

Those techniques are

- Roberts edge detection
- Sobel Edge Detection
- Prewitt edge detection
- Canny Edge Detection
- LoG edge detection

8.1. ROBERTS EDGE DETECTION

It performs a simple, quick to compute, 2-D spatial gradient measurement on an image. This method emphasizes regions of high spatial frequency which often correspond to edges. The input to the operator is a grayscale image the same as to the output is the most common usage for this technique. Pixel values in every point in the output represent the estimated complete magnitude of the spatial gradient of the input image at that point.

-1	0
0	+1

G_x

0	-1
+1	0

G_y

8.2. SOBEL EDGE DETECTION

The Sobel method of edge detection for image segmentation finds edges using the Sobel approximation to the derivative. It precedes the edges at those points where the gradient is highest. The Sobel technique performs a 2-D spatial gradient quantity on an image and so highlights regions of high spatial frequency that correspond to edges. In general, it is used to find the estimated absolute gradient magnitude at each point. in n input grayscale image. In conjecture at least, the operator consists of a pair of 3x3 complication kernels as given away in under table. One kernel is simply the other rotated by 90^o. This is very alike to the Roberts Cross operator.

8.3. PREWITT EDGE DETECTION:

It is used to estimate the magnitude and orientation of an edge Prewitt is a correct way. Even though different gradient edge detection wants a a quite time-consuming calculation to estimate the direction from the magnitudes in the x and y-directions.

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

G_x

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

G_y

8.4. CANNY EDGE DETECTION:

Canny Edge detection technique is one of the standard edge detection techniques to find edges by separating noise from the image before find edges of the images. Canny method is the best method without disturbing the features of the edges in the image afterwards applying the tendency to find the edges and serious value for threshold

The algorithmic steps are as follows:

Convolve image f(r, c) with a Gaussian function to get smooth image

f^(r, c). f^(r, c) =f(r,c) *G(r,c,6) ---□ 1

Apply first difference gradient operator to compute edge strength then edge magnitude and direction are obtained as before.

Apply non-maximal or critical suppression to the gradient magnitude.

Apply threshold to the non-maximal suppression image.

8.5. LOG EDGE DETECTION:

The LoG of an image f (x,y) is a second order derivative which has two effects, it will smooth the image and it computes the Laplacian , which yields a double edge image. Locating edges then consists of finding the zero crossings between the double edges. The digital implementation of the Laplacian function is usually made through the mask below,

$$\nabla^2 f = \frac{\partial^2 f}{\partial x^2} + \frac{\partial^2 f}{\partial y^2}$$

0	-1	0
-1	4	-1
0	-1	0

G_x

-1	-1	-1
-1	8	-1
-1	-1	-1

G_y

The Laplacian is generally used to found whether a pixel is on the dark or light side of an edge. This section presents the relative performance of various edge detection techniques such as Robert Edge Detector, Sobel Edge Detector, Prewitt Edge Detector, LoG Edge Detector and Canny Edge Detector. The objective is to produce a clean edge map by extracting the principal edge features of the image. The original image and the image obtained by using different edge detection techniques are given below in the figure

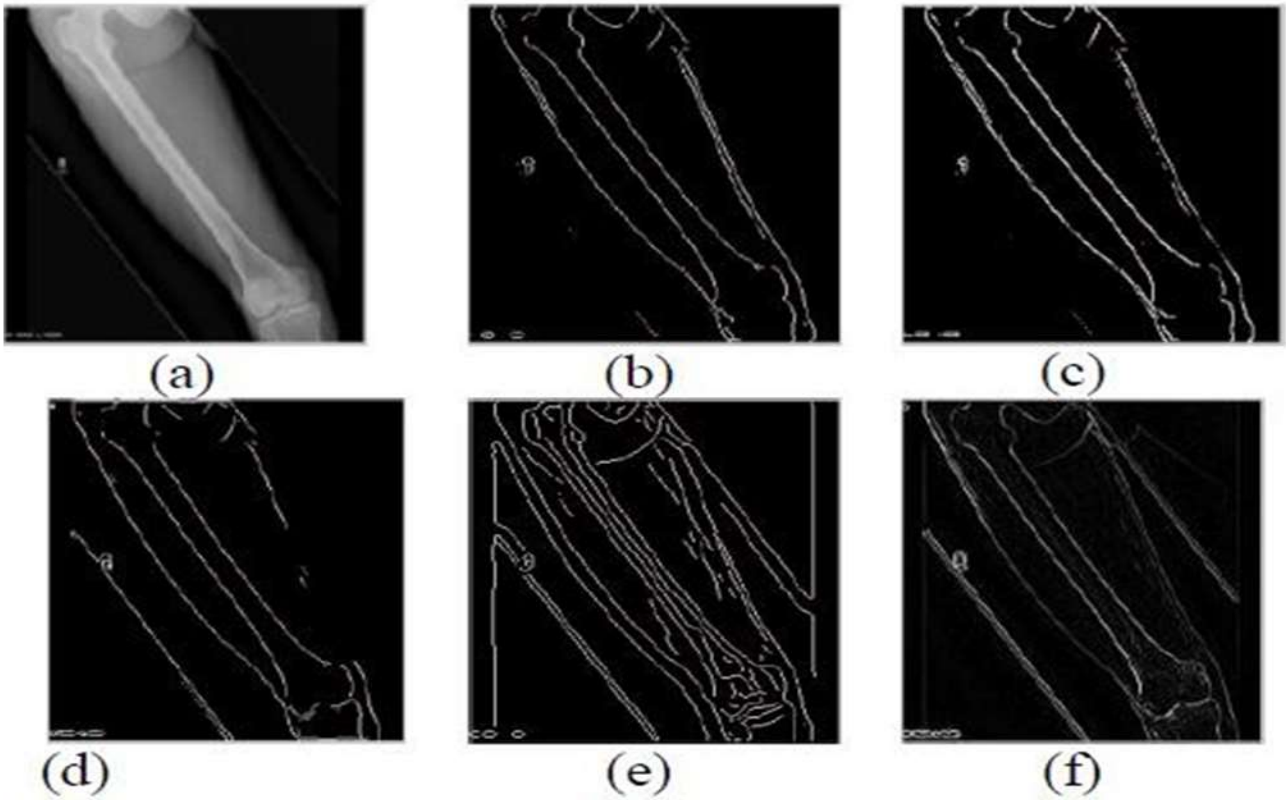

Figure 4: (a) Original X-Ray input image and corresponding resultant edge detected images by using (b) Roberts, (c) Sobel, (d) Prewitt, (e) Canny, and (f) Laplace second order difference operators.

Robert, Sobel and Prewitt results actually deviated from the others. LoG and Canny produce almost same edge map. It is observed from the figure Canny result is far better to the other results.

Comparison of Edge Detection Methods

Method	**It works on**	**Results**
Roberts Edge Detection Method	It works for 2-D spatial gradient measurement on an image.	It emphasizes regions of high spatial frequency
Sobel Edge Detection method	It works for the edges at those points where the gradient is highest.	It highlights regions of high spatial frequency that correspond to edges
Prewitt Edge Detection Method	It works for estimating the magnitude and orientation of an edge	It estimates the direction from the magnitudes in the x and y-directions.
Canny Edge Detection Method	It is used to find edges by separating noise from the image before find edges of the images	It estimate without disturbing the features of the edges in the image , to find the edges and serious value for threshold

LoG	It is used to found whether a pixel is on the dark or light side of an edge	It estimates the relative performance of various edges such as horizontal , vertical and diagonal edges.

9. FEATURE EXTRACTION:

Feature Extraction plays an important role in the area of image processing. Feature extraction techniques are applied for classifying and recognition of images. Feature define the behavior of an image, in terms of storage taken, efficiency in classification and in time consumption. The technique of extracting the features is useful when you have a large data set and need to reduce the number of features without losing any relevant information. Feature extraction reduce the amount of redundant data from the data set.

9.1. HARRIS CORNER DETECTION:

It is used to identify the corners in an image this Harris corner detection is used which acts as an operator [14]. When the 2 edges interact, the point can be considered as edges where there is a variation in the brightness of an image [16]. The following steps represent the process involved in bone fracture detection. The first step is to identify which window produces a large variation of intensity when moved in the direction of x and y axes. In the end, a fracture is detected from the x-ray image of the fractured bone. The below figure clearly shows how the fractures are detected by using Harris corner detection. This Harris corner detection technique itself identifies the fracture which need not be trained by any classifier.

Harris corner is a detection algorithm considering the local gradient in the horizontal and vertical directions of each point around it. The aim is to find out the value of the image having different intensity on both directions.

$RH = \det(M) - k * trace2\ (M)$

Note: RH = the value of Harris detector

k = constant sensitivity of Harris corner detector method

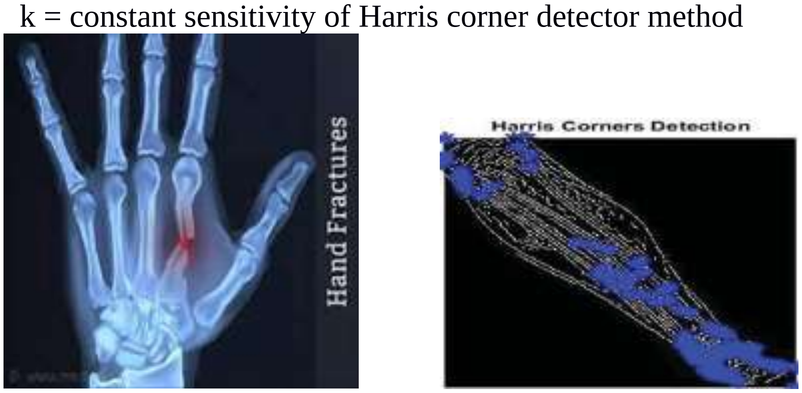

Figure 5 a. Original image b.: Harris Corner detection

9.2. MULTI LAYER PERCEPTRON:

Multilayer Perceptron (MLP) classifier is used to train the image that extracted its features by two algorithms, which are the Histogram Oriented Gradients (HOG) and local binary pattern (LBP) algorithms. LBP descriptors efficiently capture the local spatial patterns and the gray scale contrast in an image. The HOG descriptor focuses on the structure or the shape of an object. It is better than any edge descriptor as it uses magnitude as well as angle of the gradient to compute the features.

Figure 6: a. Original image b. Multilayer Perceptron

9.3. SURF Speeded-Up Robust Features Based BPNN:

The SURF method (Speeded Up Robust Features) is a fast and robust algorithm for local, similarity invariant representation and comparison of images. It can be used for tasks such as object recognition, image registration, classification, or 3D reconstruction.

Figure 7 a. Original image b. SURF

10. COMPARISON OF RESULTS:

From the 600 collected images,400 are fractured and 200 are non-fractured bone images. Out of 400 fractured bone images 200 are used for testing and 200 are used for testing and in similar way out of 200 normal images 130 are used for training and 70 are used for testing. Table.1 shows the performance measures of different fracture detection techniques. Our work is compared with MLP based BPNN(Back Propagation Neural Network) and SURF with BPNN.MLP based BPNN gives an accuracy of 86%, sensitivity of 88% and the specificity of 87%,and SURF with BPNN gives an accuracy of 86%, sensitivity of 83% and the specificity of 81%.The proposed method has accuracy of 95%, the sensitivity of 91% and the specificity of 90%.The overall performance measure of Proposed method gives better accuracy compared to other techniques which prove to be the better method for computerized bone fracture detection.

Methods	**Accuracy**	**Sensitivity**	**Specificity**
Harris Corner	95%	91%	90%
MLP based BPNN	86%	88%	87%
SURF+BPNN	86%	83%	81%

Table 1 :Performance Measures

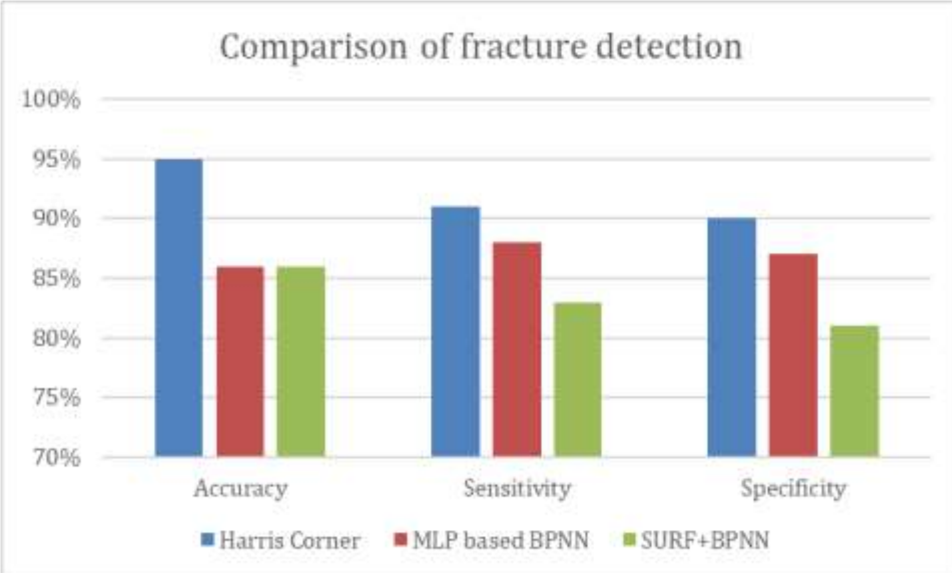

Figure 6: shows the comparative analysis of different fracture detection techniques

11. CONCLUSION:

The proposed system has a better capacity to detect the fractures in an X-ray image of bones. This work not only detects the fractured more accurately but also differentiates non-fractured bones very accurately. The qualities of the images are improved only after the pre-processing functions processed successfully in the input image. The fully automatic detection of fractures in bone is an important but difficult problem. According to the test results, the system has been done to detect the bone fracture. A conclusion can be made that the performance of the detection method is affected by the quality of the image. The better the image quality, the better the result system got. In future work, focusing on other works like detecting on smaller bone, ankle fractures, etc. may be considered.

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