Efficient Bone Fracture Detection And Classification Using Machine Learning Approaches

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Abstract— Machine Learning (ML) techniques have emerged as a viable option for X-ray screening. Fracture detection is a significant part of muscular X-ray image test. Automatic fracture detection for patients in distant regions helps paramedics in making an early determination and starting prompt medical consideration. In this paper we propose a leg and hand bone fracture detection and classification using k-nearest neighbor (KNN), Support Vector Machine (SVM), Artificial Neural Network (ANN), and Convolutional Neural Network (CNN) classifiers. Also the performance comparisons are carried out for four classifiers. The classification accuracy of the proposed model is 98.39%. The result obtained demonstrates that the effectiveness of CNN classifier as compare to other three classifiers. The performance of CNN classifier is superior.

Keywords— Artificial Neural Network, Bone fracture, Convolutional Neural Network, hand bone, leg bone, k-nearest neighbors, Support Vector Machine, and X-ray image.

Introduction
Nowadays medical image processing is a logical research area that is acquiring far reaching acknowledgment in the medical care industry because of advancement in technology and software. Fracture occurs when a heavy force disburse against a bone is tough than the bone can structurally resist. Among the various diseases, detection of bone fracture and its treatment, which affects many people, is becoming increasingly important in today's culture. Bone fracture is a common problem in most developed countries, and the number of fractures is increasing rapidly. Bone fracture can happen because of a basic mishap or various kinds of diseases. Subsequently, speedy and exact determination is basic to the accomplishment of any endorsed
treatment. In practice, specialists and radiologists rely heavily on X-ray images to determine whether or not a fracture has occurred, as well as the precise location of the fracture. Manual evaluation or a traditional X-ray framework for fracture detection is a time-consuming and labor-intensive measure. An exhausted radiologist discovered that among sound images, he missed a fracture image. The PC vision framework will help screen X-ray images for suspicious cases and alert specialists. Contingent upon the specialists alone for a particularly basic matter has caused deplorable blunders and thus, the possibility of programmed determination strategy has consistently been an engaging one. The bones have various sorts of components, which incorporate; comminuted, compound, greenstick, oblique, spiral, and transverse. Any work to recover and show the images should go through Picture Archives and Communication System (PACS) equipment [4]. With the improvement of personal computers (PC) abilities and capacities, medical imaging has fostered the expected way to deal with the test of conclusion of images. X-ray images can't be perused and perceived by a radiologist with an open eye because of essence of intrinsic commotion. By creating medical imaging arrangement, it is trusted that, this will offer help to radiologists in recognizing bones fractured irregularities and decrease time spent in its understanding[5].In orthopedic treatment, fracture classification assumes an imperative part in order of bone and it is fundamental for doctors to decide the seriousness and course of treatment of the injury. The life structures of human bones have various components in nature which relies upon its area, types and fracture-lines [6]. The center of this exploration is to carry out frameworks that identify bones fracture in X-ray images dependent on arrangement from the reception of two classifiers. This will facilitate the method for diagnosing patients for fracture injury and assists with taking out inessential medical techniques.

In this paper, detection of fractured bones of leg and hand on X-ray images categorization is implemented. The focus of this study is to provide solution to the challenges of detecting fracture or non-fracture bone images. The pre-processing was applied to enhance, highlights the edges in the image and to get rid of noise without losing the relevant features. The two-way segmentation is used to sharpen the image using entropy and edge detection techniques and Hough transformation and canny edge detector were used to extract the image features. Finally, the four classifiers are employed to performance classification of leg and hand bone fractures.

The objective of this research work is to detect fracture or non-fracture and classify the type of fracture in x-ray images of the leg and hand bone. Four classification approaches are used to identify fracture or non-fracture and characterize fracture types. In this work, oblique displaced, spiral, greenstick, comminute, traverse and linear are characterized as the six fracture types. Finally, system outputs are assessed by two execution evaluation strategies. The first is execution assessment for fracture or non-fracture (typical) conditions utilizing four potential results like True positives (TP), True negatives (TN), false positives (FP) and False negatives (FN). The subsequent one is to investigation for exactness of each fracture type inside blunder conditions utilizing the Kappa appraisal strategy. The programming used to carry out the framework is MATLAB. The analysis results show that the CNN approach achieved a better accuracy. The
The developed system can detect fracture in bones, which is a way to assist doctors and radiologists in fast and accurate diagnosis.

The remaining paper is arranged as follows: section II presents the related works to our work, section III presents about the method used to develop detection system, section IV describes the results of simulation evaluation and discussion, finally the section V describes about the conclusion, future work and references.

- **Related work**
  Yangling Ma et al [2021] proposed the novel two-stage system of crack-sensitive CNN for detection of fractures in the X-ray images of bone. They utilized the 1052 images, out of this 526 fractured images and remaining images are non-fractured. The results have shown the accuracy of 90.11% and 90.14% F-measure. The performance of proposed system outperform over existing two-stage systems [7].
  A. Oyeranmi, et al [2020] has proposed the use of KNN and SVM classifiers for detection of fracture in X-ray of bone Images and Categorization. They carried out the evaluation of developed system using TP, TN, FP and FN as possible outcomes. The simulation result has been shown the improved classification accuracy 90 % and the Kappa accuracy of 83% [8].
  Alice Yi Yang et al [2019] has investigated schemes for detection of bone fracture on the basis of two lines: Standard and the Adaptive Differential Parameter Optimized (ADPO) for fractured lines detection from the bone X-ray images. The ANN classifier is employed and there are two evaluations used to evaluate both the system as a whole and the ANN. The Standard Scheme has an average accuracy of 74.25 percent, while the average accuracy of ADPO is 74.4 percent. This scheme is preferred but further improvement can be done with detected contours and extracted features [9].
  W. W. Myint et al [2018] has investigated and developed the system for detection of lower leg bone fracture and its classification. They employed Decision tree and KNN classifier and harris corner algorithm for fracture location. The system is designed using MATLAB tool and evaluations are conducted with the use of TP, TN, FP, and FN possible outcomes, as well as Kappa assessment method. For fracture type classification, the system achieves an accuracy of 82% [10].

- **Proposed Method**
The schematic representation in Fig. 1 depicts the five steps of analysis that would be applied to the x-ray images stored in the database.

- **Acquisition of x-ray images**
The standard input x-ray images used were downloaded from internet. All input X-ray images were stored for training dataset and serve as input data to features extraction stage.
• **Pre-processing**
  The pre-processing is by smoothing and removing noise of the image edges [11]. In this step, the X-ray image in RGB format is converted into a grey scale image for better processing and less computation time.

• **Segmentation**
  The segmentation process is applied by entropy and canny edge methods [12] where image gray-zones are extracted from the x-ray image. The aim at identifying points in the x-ray image at which the x-ray image brightness changes sharply or has discontinuities, at such points a line is draw to represent the change in brightness this helps the Hough Transform to figure out if there is a break in the bone or not.

Fig. 1. Various steps for fracture detection and classification

• **Feature Extraction:**
  The Hough transform was used to determine whether or not a break point exists in the uploaded x-ray image, and a circle was drawn at the breakpoint [13] [14]. Because it combines the basic features of the bones, the Hough transform algorithm is useful for identifying lines or detecting the radius of fracture. A line in the image space is mapped to a point in the parameter space. For classifying fracture and non-fracture image types, these extracted features are fed into the four classifiers.

The algorithm for Hough transform steps are as follows
• Create a 2Darray corresponding to a discrete set of values for $\rho$ and $\theta$. Each element in this array is often referred to as accumulator cell.
For each pixel (x, y) in the image and for each chosen value of Ѳ, compute ρ from equation (1) and write the result in the corresponding position (ρ, Ѳ) in the accumulator array.

The highest peak value in the (ρ, Ѳ) array will correspond to the most relevant lines in the image.

**Classification:**
The final step was to categorize fracture bone types using classifiers such as KNN, SVM, ANN, and CNN [15] [16]. These classifiers were chosen primarily for their ability to reduce training time while increasing classification accuracy.

**Simulation Evaluation Results**
The software tool used to implement proposed method is MATLAB R2018a. The performance evaluation of fractured and non-fractured bone with 300 X-ray images of leg and hand bones for training with four performance metrics: accuracy, precision (P), specificity (SP) and sensitivity (SE) providing four possible outcomes TP, TN, FP and FN. The Number of Bone Facture Detected is 249 and number of Bone Facture Not Detected is 51. In simulation the classifiers were used to detect different fracture types such as Oblique, Displaced, Spiral, Greenstick, Comminuted, Traverse and Linear.

**Hand bone X-ray image**
The input image is hand bone x-ray image and after execution the bone fracture type detected is spiral. The results are presented in figure 2 to figure 11.

![Original image and spiral image](image1)
![Hough area detection of image](image2)

Fig. 2. Original image and spiral image  Fig. 3. Hough area detection of image
Fig. 4. Hough Transform image: circular detection

Fig. 5. Recognition rate of training set

Fig. 6. Total loss functions

Fig. 7. Performance of network
Figure 8. Training state of the network

Figure 9. Receiver operating characteristic (ROC) curves for four classifiers

Figure 10. Error histogram
The accuracy obtained for four different classifiers is shown in table 2. We see that the accuracy of CNN classifier is superior over other three classifiers.

Table 2 classifier accuracy

<table>
<thead>
<tr>
<th>Classifier</th>
<th>Accuracy</th>
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<tbody>
<tr>
<td>KNN</td>
<td>54.66</td>
</tr>
<tr>
<td>SVM</td>
<td>65.59</td>
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<tr>
<td>ANN</td>
<td>81.99</td>
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<tr>
<td>CNN</td>
<td>98.39</td>
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The 300 images used for training and testing the proposed systems were collected from the [https://www.kaggle.com/srinivasvishe7/fracture](https://www.kaggle.com/srinivasvishe7/fracture) database.

Out of 300 images 120 are testing images and 180 training images
- **Leg bone image**
The input image is leg bone and after execution the bone fracture type detected is greenstick. The results are presented in figure 12 to figure 16.

**Fig. 12. Original image and green stick image**

**Fig. 13. Hough area detection of leg bone image**
Fig. 14. Hough Transform image: circular detection

![Hough Transform image: circular detection](image)

Fig. 15. Error histogram

![Error histogram](image)

Fig. 16. Confusion matrix

![Confusion matrix](image)

Table 3 performance metrics

<table>
<thead>
<tr>
<th>Classifier</th>
<th>Accuracy</th>
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<tbody>
<tr>
<td>KNN</td>
<td>52.87</td>
</tr>
<tr>
<td>SVM</td>
<td>63.44</td>
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<tr>
<td>ANN</td>
<td>79.30</td>
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Accuracy Sensitivity F-measure Precision Specitivity

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<td>96%</td>
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http://www.webology.org
Table 4 classifiers accuracy

The accuracy obtained for four different classifiers is shown in table 4. Using KNN, SVM, ANN classifiers in classification and testing phase the overall accuracy is 52.87, 63.44, 79.30 but using CNN in the testing phase of this system the overall accuracy is 95.16. Hence CNN classifier outperforms.

- CONCLUSION

We have implemented and simulated the fracture detection of leg bone and hand bone and its classification using MATLAB tool. Four different classifiers were utilized for classification of bone fracture and their performances have been investigated. The simulation results have shown that CNN classifier outperforms over other classifier.

In the future, we plan to develop an automated software system suggesting the course of action based on the type of fracture.

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Conflict of interest The authors have no conflicts of interest to declare.

- REFERENCES


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