# Structural Deformation Detection in Handy Skeleton

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**ABSTRACT**

The highest stats of hand fracture rate have steered to rigorous research in structural image analysis. Roentgen X-Ray gadget is frequently used to capture statuette of any bone in the physique. Bone fractures are a common torment in orthopedic wards swiftly. Only trained radiologists discern pathologies incorporating fractures with a relatively esteemed level of precision. However, studies investigate reader's precision have exposed that in a few cases the miss rate can be as immense when reading radiographs containing various abnormalities.

As a consequence, a computer aided detection system is forged in this paper, few image processing modus operandi are wielded such as thresholding, skeletonization, thinning algorithm, and medial axis transformation; various numerical equations are computed. Subsequently, processing of 100 images upshot 78% of accuracy in detection of ossification and deformity of hand bones by enumeration of fingers and angle between each phalanx.

**Keywords:** Keywords- GLCM; Binarization; Skeletonization

## 1 INTRODUCTION

Hand is a multi-fingered prehensile, appendage having five digits including one thumb and four fingers ,a total of 27 bones localized at forearm end. The main function of hand in human body is locomotion except other vertebrates. Hand fractures are frequent over widespread and lead to massive financial losses in terms of job loss, time off duty and its treatment. Hand fractures account to about 40% of overlying extremity fractures and 1.5% of all emergency wards visits. In combative athletes, the eminent extremity is motif to torque forces with axial filling over recursive bearing heavy weights. 25% of sprain in sports are analogous to the phalanges or wrist [1].

Skeleton malformation on the radio carpal joint physique is frequent in sportsmen as recurring loading and arising in range of 6 -13 fiscal years. Furthermore, it's more quotidian in female than in other sportsman [2].

The provocation of computer-aided diagnosis for constructing the system is to lessen human errors, the conduct of civilized artist can relinquish under sustainable levels if one is inattentive, overstretch, overburden, emotional psychotic and minimizing efforts and time associated with training and employing physicians.

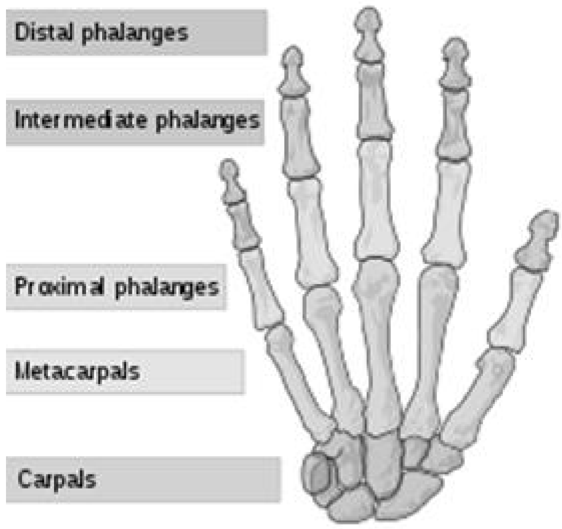



**Fig. 1.** Anatomical structure of hand

**Types of abnormality:**

Abnormality of hand can be categorized in multiple types like fractures, gaps, fading and dislocation.

i. **Dislocation and gaps in Phalanx:** Finger bones deviated from origin can cause dislocation and can have large gaps between bones.

ii. **Fracture in Phalanx:** It is categorized into four types.

iii. **Distal Phalanx:** It occurs at the fingertip, quotidian as tuft fracture correlated with a crush injury.

iv. **Fracture in Mallet:** It occurs due to axial load on the terminal finger.

v. **Fracture in Flexor Digitorum Profundus Avulsion Fractures:** It is caused from forced hyperextensions of a flexed DIP joint.

vi. **Middle and Proximal Phalanx Fractures:** It can be intra or extra articular where the first is complicated and can be gaps, dislocated. [2]

## 2 RELATED WORK

Diverse researchers have imparted in automatic fracture detection using disparate techniques. A thumbnail deliberation on the work done already on abnormality detection is yielded in this slice.

In paper [3], Al-Ayyoub Mahmoud have proffered a system which reflexively identifies cracking in phalanges practiced on radiographic images. The preprocessing includes removal of noise using salt and pepper noise to gray scale images. Further transformation function is formulated using median filter preserving edges and sharpness of structure. Sobel edge detector is pertained for edge detection. Weka's supervised attribute filter is appertained for feature extraction and selection which uses hill climbing with backtracking yielding 84 features, using GLCM. Quartet classifiers are used encompassing Decision Tree, Naive Bayes, Neural Network and Bayesian Networks, systems accuracy is increased using Bootstrap & Boosting. Thus, at the end k-fold cross validation is pertained for testing that results Bayesian Network with an accuracy > 91%.

In paper [4], G Manes has conferred to hinged upon region melding and cartilage extraction rules. Region melding is meshed in region and fringe boundary knowledge and crucially minimizes the aggregation of unnecessary regions imposition of bone extraction regulation. The bone extortion rules were grounded on the grey magnitude factors and admirably performed with large set of radiographs, skeleton's variant part with similar characteristics.

In paper [5], Zielinski,B has proposed in USA and Europe, from 11 to 14% of tenant encounter from rheumatoid arthritis. For diagnosis patient's hand x-ray is grabbed, but regular analysis is immensely tangled, hence it ought to be automated. Binarization and thinning is sufficiently used to find out the joint cavity widths and then analyze to obtained skeleton. Satisfactory results prevailed with 81% accuracy in the joint cavity width analysis.

In paper [6], Humyanchai has presented a method for automated femur bone fracture identification employing GLCM method. The method's ability is to group the availability and unavailability of cracked bone ground on the derived limited variable from the range of GLCM. The gateway value is fixes to 0.95 to bordering the existence and non-existence of bone fracture precision of algorithm is achieved at least 86% which outcomes to recognize it undoubtedly.

## 3 RESEARCH METHODOLOGY

The research methodology used for the development of computer aided diagnosis includes several image preprocessing steps.

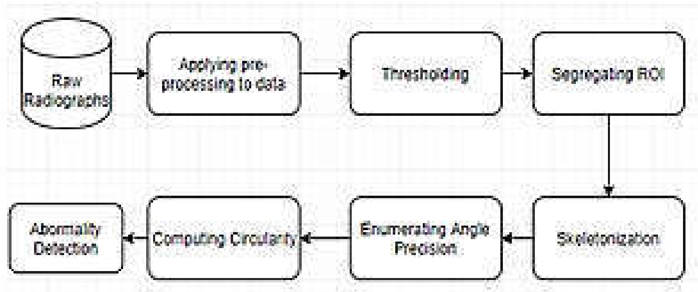



**Fig. 2.** Abnormality detection methodology

. The methodology rooted on following steps.

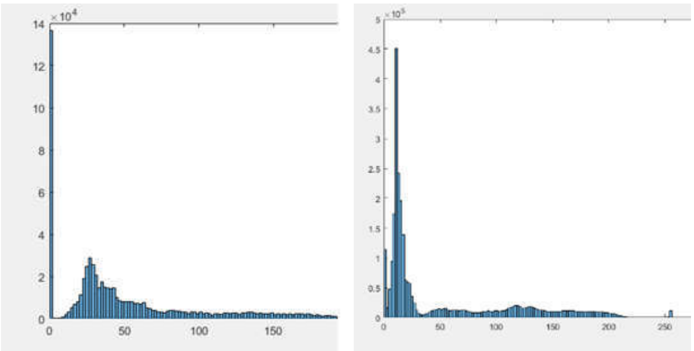
A pre-processing step is statutory to compose the image for analysis ahead; for example, to sharpen the image and removing tangential information from image and procuring supreme quality image. improving contrast, the removal of artifacts such as labels and noise. The detection of regions of interest of hand radiographs where major joint damage is located. A number of image segmentation and edge detection methods can be worn to ascertain the display of the pixels.

A. **Data Collection:** Hand radiographs dataset was employed for this experiment. The dataset is online hook-up [7]. The data set comprises of a total of 14656 images specifically 2185 hand radiographs aging from 8 to 45 years updating every four years. Each radiograph has a resolution up to 406 x 512 having anterior posterior, oblique view, lateral view of right or left hand being labeled on the corner of radiograph.

**B. Image Pre-processing:** X-ray radiographs were pre-processed. Pre-processing is basal step such as noise removal, fragmenting the labels of radiographs obtaining desired region of interest for future processing.

**(i) Thresholding:** It is the simplest way of fragmenting the unwanted region by erecting binary images It substitutes every pixel in a picture with absence of all color pixel bit if the intensity is compact scale than some permanent constant.

**(ii) Histogram:** Analyzation of apex, valleys and curvatures of the smoothness.



(a) (b)

**Fig. 3.** Histogram of normal image indicating the high peak as pixels of background and continuous connectivity values as hand region.

## C. Skeletonization

A technique for minimizing foreground zone in binary image to a skeletal stub. Fig:5 visualizes the implementation of skeleton function forming the branches in hand radiographs resulting to count total number of fingers in hand.

The actual radiograph is transformed into feature and non-feature bits which originated from objects boundary. The distance portray is formed where each bit defines the nearby distance region. Thus, local extremities are spotted and points of skeletal.

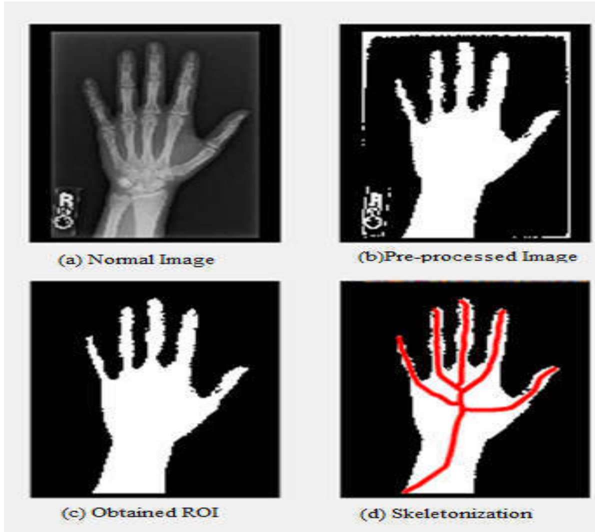



**Fig. 4.** Enumerating fingers in normal hand radiographs using skeleton function from a gravity point to tip of each fingers coordinates values. (a) represents the original normal x-ray radiograph (b) shows the preprocessed version of original x-ray radiograph (c) shows the segregation of the unwanted regions such as labels and borders and obtained ROI (d) represents skeletonization algorithm that selects the gravity point of the hand and directs the diverse branches for the normal hand.

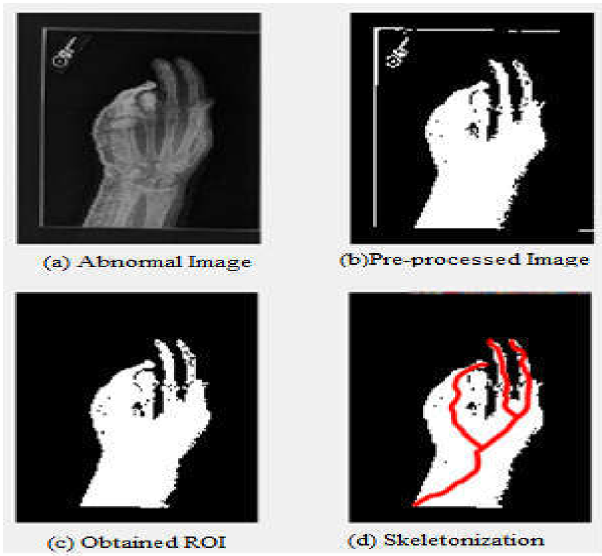


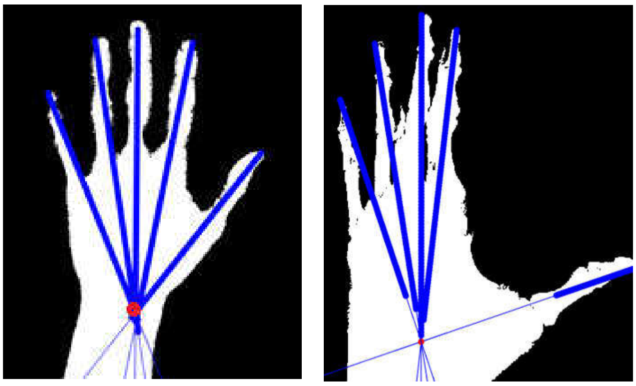

**Fig. 5.** Enumerating fingers in abnormal hand radiographs using skeleton function from a gravity point to tip of each fingers coordinates values. (a) represents the original abnormal x-ray radiograph (b) shows the preprocessed version of abnormal x-ray radiograph (c) shows the segregation of the unwanted regions such as labels and borders and obtained ROI (d) represents skeletonization algorithm that selects the gravity point of the hand and directs the diverse branches for the abnormal hand.

**Table -1** Enumeration of fingers in normal and abnormal hand

| Patient ID | No: of fingers in normal hand | No: of fingers in abnormal hand |
|---|---|---|
| P0121 | 5 | 3 |
| P0126 | 5 | 4 |
| P0122 | 5 | 5 |
| P0127 | 5 | 4 |

## D. Computing angles from referential point:

After enumerating fingers and finding n=5, the second step is taken to compute the angles of both normal and abnormal hand. According to hand human anatomy [8] the normal angle of thumb and the corresponding fingers such as index, middle, ring and small should form an acute angle. [10].



(a) (b)

**Fig. 6.** Referential gravity point to the phalanx tip coordinate selection (a)shows the center dot as the referential gravity point of normal hand and spreading towards the tip of each phalanx. (b) represents the center mark as the referential gravity point of abnormal hand and spreading towards the head of each phalanx.

## E. Computing circularity of hand radiographs:

Taking the starting points of each of the finger and making its mirror copy and finding the circularity of radiographs. The normal hand radiographs have the circularity 1 or near to one. The circularity near to 0 is indigent. Using the circularity formula, the results are computed.

circularity = (Perimeter .^ 2) ./ (4 * pi * area);

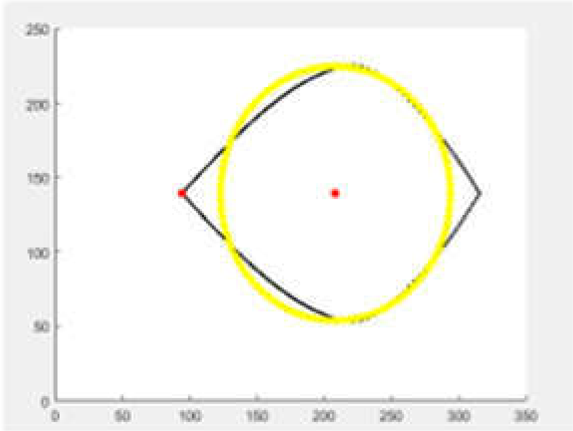



**Fig. 7.** Circularity of normal hand radiograph C=0.9

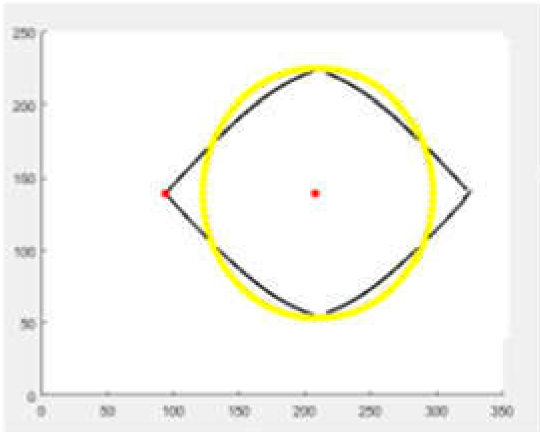



**Fig. 8.** Circularity of abnormal hand radiograph C=0.5

## 4 RESULTS AND DISCUSSION

Exploiting 100 images [7] and undertaking them from preprocessing to deformity identification underneath are the results. The computed circularity for normal hand is C=0.9 and abnormal resultant C=0.4. The angle from thumb reference point to the corresponding small phalanx is making an angle of 90 degrees not resulting to be an acute angle categorizes as abnormality of hand.

**Table 2.** Hand deformity results

| Gravity Position | Mean angle of normal image in degrees | Mean angle of abnormal image in degrees |
|---|---|---|
| Thumb to Index Finger | 26.7142° | 64.9119° |
| Thumb to Middle Finger | 37.6619° | 71.5575° |
| Thumb to Ring Finger | 46.5034° | 80.7804° |
| Thumb to Small Finger | 59.8484° | 90.7445° |

## V. CONCLUSION

There are many schemes to identify the malformation of medical images. This paper upshot to detect the deformity in handy skeleton. It was observed from hand anatomy [9] that the normal angle between each of the corresponding phalanx should make an acute angle. [10]

## References


1. Bak K, Boeckstyns M. Epiphysiodesis for bilateral irregular closure of the distal radial physis in a gymnast. Scand J Med Sci Sports 1997;7:363–6.
2. http://www.orthop.washington.edu/orthodev/drupal/sites/default/files/Abstract-Bodies-Orals.pdf
3. Hmeidi, Ismail & Al-Ayyoub, Mahmoud & Rababah, Haya & Khatatbeh, Zakaria. (2013). Detecting Hand Bone Fractures in X-Ray Images. 10.13140/RG.2.1.2645.8327
4. Zielinski, B. A fully-automated algorithm dedicated to computing metacarpophalangeal and interphalangeal joint cavity widths. *Schedae Informaticae*, 16, 47–67.
5. M. R. Zare, A. Mueen, W. C. Seng and M. H. Awedh, "Combined Feature Extraction on Medical X-ray Images," *2011 Third International Conference on Computational Intelligence, Communication Systems and Networks*, Bali, 2011, pp. 264-268.
6. Chai, H. Y., Wee, L. K., Swee, T. T., Hussain, S. (2011). Glcm based adaptive crossed reconstructed (acr) k-mean clustering hand bone segmentation. *Book GLCM based adaptive crossed reconstructed (ACR) k-mean clustering hand bone segmentation*, p. 192–197.
7. https://stanfordmlgroup.github.io/competitions/mura/
8. Schwarz, R. J., & Taylor, C. L. (1955). The anatomy and mechanics of the human hand. *Artificial limbs*, *2*(2), 22-35.
9. Napier, J. R. (1956). The prehensile movements of the human hand. *The Journal of bone and joint surgery. British volume*, *38*(4), 902-913.
10. Kamakura, N., Matsuo, M., Ishii, H., Mitsuboshi, F., & Miura, Y. (1980). Patterns of static prehension in normal hands. *American Journal of Occupational Therapy*, *34*(7), 437-445.