Machine Learning for the Identification of Bone Deformities

Mohammed Aslam Khan [1], Mohd Yaseen Ahmed [2], Syed Safadar Hussain [3], Khutaija Abid [4]

[1, 2, 3] B.E. Student, [4] Assistant Professor,
Department of IT, Lords Institute of Engineering and Technology,
Hyderabad, Telangana, India.

Published in IJIRMPS (E-ISSN: 2349-7300), Volume 11, Issue 1, (January-February 2023)

Abstract
The success of machine learning algorithms in medical imaging has boosted the demand for models that have been artificially trained to function more rapidly and effectively in the medical profession. In this paper, a method for identifying bone fractures using machine learning algorithms is presented, which can help to lighten the workload of orthopedics. Instead of spending hours in radiology departments, the substantial application of machine learning in this era of huge medical data will make it possible to obtain information from the available X-ray images. The imaging techniques described in this study can quickly determine whether a bone fracture has occurred in a human body after an X-ray has been obtained.

Keywords: Medical Field, Orthopaedics, Machine Learning, X-ray, Bone Fracture, Image Pixels, Image Soothing, Edge Detection, Ridge Regression, Pickle Library, Image Reshaping, Feature Vectors

1. Introduction

Humans frequently experience bone fractures due to accidents, falls, diseases that result in pathological fractures, wounds to the skin below, hairline fractures, etc. the complexity of bone structure and how different fractures seem depending on where they are. Therefore, it is challenging to precisely identify and locate the fractures as well as to assess the injury's severity. An important contribution to helping doctors diagnose patients more quickly and accurately and arrange patient care is the automatic detection of fractures in X-ray pictures [1]. In the field of medical science, the use of digital images for disease diagnosis is currently very common. One of the most common and efficient non-invasive medical monitoring techniques is the use of Roentgen radiation for radiograph (X-ray image) capture, which enables the detection of fractures, bone abnormalities, and other disorders [2]. To identify the fracture X-rays and CT scans are used but these cannot always detect the exact location of the fracture [3], [4]. Hence the involvement of machine learning and artificial intelligence would have a great impact on the outcomes and the fracture can be accurately diagnosed. X-ray imaging technique is often used by orthopedic doctors for fracture detection [5].

Using machine learning tools, we can inventively extract information about the human body conveniently and economically [6]. It is possible because of both hardware and software advancements and the development of existing technology. We know that a single method cannot be applied to all parts of the body,

but experimenting with new technology that would be capable of identifying the fractures in our body using one method [7].

The proposed Computer-Aided Diagnosis (CAD) system is a different method to tackle this problem. Artificial intelligence (AI) and machine learning (ML) techniques are revolutionizing several industrial and research fields so it can be applied to the medical sector as well [8], [9]. This system is an AI and Machine Learning based analysis system. It is applicable to all age groups of men, women and children [10] It provides a summarized and evaluated results of any detected deformity or fracture based on the X-ray images [11]. Implementation of an image processing based efficient system to accurately detect the fractures in the whole human body is the aim of this project and this paper gives details about the techniques used thereby making this a novelty of the work proposed.

2. Problem Statement

Bone fracture and deformity detection has received a lot of attention. Fractures cannot be seen with the naked eye, hence they are found with X-ray/CT imaging. However, these X-ray images could occasionally be too finely detailed for the human sight. The human eye may frequently miss the many bone fractures, making thorough and effective therapy challenging. Consequently, the goal is to create an intelligent categorization system that can recognize and emphasize bone fractures. This can be done by developing a Computer-Aided Diagnosis (CAD) system that can quickly analyse the input medical images, primarily X-ray images, and assist radiologists or orthopedics in detecting bone fractures.

3. Literature Survey

We have researched and examined the various research techniques by doing searches in the Scopus and Medline databases. Numerous methods, including classification, regression, clustering, K-means clustering, CNNs (Convolutional Neural Networks), ANNs (Artificial Neural Networks), and others, can be used to detect fractures [12].

In [13] CNN is used to identify bone fractures, according to a research paper. The technology here is a very delicate and precise CAD system [14]. In this, an X-ray image is used as the input, and discontinuities are found using a contour-based approach for identification purposes [15]. We had a good concept of which method to use for the article based on the efficiency of each methodology and the accuracy found.

The poll also revealed information about the target factors that should be taken into account. We attempted to create a novel and effective method that can be utilized in the department of orthopedics and radiology using the survey data and its constraints.

The bone fracture is a common problem in human beings which occurs due to simple accident or a high pressure applied on bone or due to osteoporosis and even due to bone cancer. Fractures is usually defined as a cracks in bones which is basically a medical condition when there is a break in the continuity of the bone. Hence accurate diagnosis of bone fracture is very important aspect in medical science.

The field of computer-aided diagnosis is highly known and well-liked. The system that can accurately and efficiently identify any sort of problem. The use of least resources is highly favored and advised.
One sort of such system is medical image processing, which can analyze and detect any kind of disorder based on some feature extraction methods from the image by various types of improvement techniques

after removing noise. An X-ray image's fracture status has previously been determined using a binary classification approach.

A. Quantitative Analysis and Fracture Detection of Pelvic Bone X-ray Images

A proposed automatic hierarchical system for bone fracture detection in X-ray images. The fracture is found using the Gray level co-occurrence matrix. The results show potential for clinical use and show that the suggested approach may accurately and automatically detect both large and minor fractures. Additionally, statistical findings show that the suggested procedures are superior to alternative techniques. The creation of a system like this for detecting long-bone fractures. This project used MATLAB 7.8.0 (.r2009a) exclusively as the programming language for loading images, processing images, and creating user interfaces. With some restrictions, the results collected show that the pelvic bone fracture detection system performs as expected.

B. Automatic Identification of Fracture Region within Bone in X-ray Image

One of the common problem in human beings is bone fracture which occurs due to high pressure applied on bone or simple accident. It may also be due to bone cancer and osteoporosis. Hence the accurate diagnosis of bone fracture is very important aspects in medical field. In this paper X-ray images has been used for bone fracture analysis.

The aim of this paper is to develop a processing technique for identification of fracture region within bone in X-ray image which was obtained from medical institute. Result obtained demonstrates the performance of processing technique.

C. Fracture Detection in X-ray Images through Stacked Random Forests Feature Fusion

We present a generalized bone fracture detection method that is applicable to multiple bone fracture types and multiple bone structures throughout the body. The method uses features extracted from candidate patches in X-ray images in a novel discriminative learning framework called the Stacked Random Forests Feature Fusion. This is a multi-layer learning formulation in which the class probability labels, produced by random forests learners at a lower level, are used to derive the refined class distribution labels at the next level. The candidate patches themselves are selected using an efficient sub window search algorithm.

D. Bone Fracture Detection from X-ray Image of Human Fingers using Image Processing

Orthopaedics deals with surgery and treatment of the human musculoskeletal system. Orthopaedics deals with surgery and treatment of the human musculoskeletal system issues. Orthopaedic doctors are always interested to take an X-ray image of injured parts of patient’s body for better diagnosis. In an X-ray imaging, electronic radiation is passed in the human body for capturing bone images. After X-ray image retrieval, a doctor examines X-ray image manually. It is not that easy to detect most of the major diseases/issues related with the bones just by visualizing an X-ray image, although in some cases, it is possible, but till that time, diseases may reached towards next or serious stage for example bone fracture. The main problem with X-ray images is that they may be blurred, out of focus, improperly bright and noisy, which makes examination more difficult. One of the solutions to all above problems can be computerized image processing of human being’s X-ray images. In this research paper, we have presented an algorithm to detect bone fracture from X-ray images of human fingers using image processing.

4. Proposed System

The entire process of detection of fracture mainly deploys the ridge regression model and the method of edge detection [16]. The main advantage of using a ridge regression model is that despite being almost similar to linear regression it introduces a small bias which can prove to give better predictions in long term applications. Another important concept used in the procedure of detection is edge detection which involves automatic identification of the boundaries present between objects. This segregation of boundaries benefits in breaking up the image into separately examinable areas. Also, ridge regression gives better performance against data which does not have a pattern similar to the data used for training the model due to the diversity present in the images of the dataset. Thus, a ridge regression model coupled with edge detection gives us the desired outcome

The initial and most basic step involves importing the different libraries for creation and proper designing of the model. The libraries used in the model of the given work are NumPy, Pickle, OpenCV 2, Tensorflow, Scikit-Learn and similar libraries. Different regressors imported are K-neighbour, Decision Tree, Random Forest Classifier and similar. The python pickle module is useful in performing the function of converting the data into a byte stream and vice versa. In other words the python object structure is serialized and de-serialized so as to save it to the disk.

For the model in this work two lists were created, one for training and another for testing respectively. For the first set of labels, the corresponding model returns a NumPy array used for training. This is followed by usage of pickle library which performs its functions as mentioned above and stores the images to the file or database. Similarly, as depicted in Fig. 1 all the images in the dataset are reshaped in the same format. These lists are then converted into input and output arrays for both training and testing arrays.

An X-ray image is taken as input for detection of fractures. Manual edge detection and median filter smoothing are performed on the images. Image smoothing helps to reduce the noise present in the input image and thereby makes the image sharper which helps to improve it.

Once image smoothing is performed, the distances or gaps present in the image are measured and the coordinates are then plotted on a graph. The graph has the image pixels on the x-axis while the distances present in the image are measured along the y-axis. The distances which cross the threshold of the normal distances usually present in the crevices of the bone structures are highlighted by the model as such unusual large distances or big gaps denote presence of fractures. There is also a possibility that an X-ray image might have more than one fracture in the bone. The given model is capable of detecting multiple fractures in the bone structure as well.

One more important factor to be taken into consideration is the size of the 1-D array created from the flattening of the feature vectors of the images present in the dataset. Image thresholding is performed and an optimum value of pixel size is fixed. So, an optimal size was chosen for the images of the dataset and the dataset was customized accordingly.

It provides a summarized and evaluated results of any detected deformity or fracture based on the X-ray images. Implementation of an image processing based efficient system to accurately detect the fractures in the whole human body.

An X-ray image is taken as input for detection of fractures. Manual edge detection and median filter smoothing are performed on the images.

5. Input and Output Design

5.1. Input Design

Input design is a link between the information system and the user. It comprises the developing specification and procedures for data preparation and those steps are necessary to put transaction data in to a usable form for processing can be achieved by inspecting the computer to read data from a written or printed document or it can occur by having people keying the data directly into the system.

The design of input focuses on controlling the amount of input required, controlling the errors, avoiding delay, avoiding extra steps and keeping the process simple. The input is designed in such a way so that it provides security and ease of use with retaining the privacy. Input Design considered the following things:

(1) What data should be given as input?
(2) How the data should be arranged or coded?
(3) The dialog to guide the operating personnel in providing input.
(4) Methods for preparing input validations and steps to follow when error occur.

Objectives

Input Design is the process of converting a user-oriented description of the input into a computer-based system. This design is important to avoid errors in the data input process and show the correct direction to the management for getting correct information from the computerized system.

5.2. Output Design

A quality output is one, which meets the requirements of the end user and presents the information clearly. In any system results of processing are communicated to the users and to other system through outputs. In output design it is determined how the information is to be displaced for immediate need and also the hard copy output. It is the most important and direct source information to the user. Efficient and intelligent output design improves the system's relationship to help user decision-making.

(1) Designing computer output should proceed in an organized, well thought out manner; the right output must be developed while ensuring that each output element is designed so that people will find the system can use easily and effectively. When analysis design computer output, they should Identify the specific output that is needed to meet the requirements.
(2) Select methods for presenting information.
(3) Create document, report, or other formats that contain information produced by the system.

The output form of an information system should accomplish one or more of the following objectives.

- Convey information about past activities, current status or projections of the future.
- Signal important events, opportunities, problems, or warnings.
- Trigger an action.
- Confirm an action.

It is achieved by creating user-friendly screens for the data entry to handle large volume of data. The goal of designing input is to make data entry easier and to be free from errors. The data entry screen is designed in such a way that all the data manipulates can be performed. It also provides record viewing facilities.

When the data is entered it will check for its validity. Data can be entered with the help of screens. Appropriate messages are provided as when needed so that the user will not be in maize of instant. Thus the objective of input design is to create an input layout that is easy to follow.

6. Result and Analysis

As proposed above, the given set up shall give outputs in the form of highlighted fractures present in the X-ray image. The algorithm is explained in Figure 1 step wise. The output is achieved in Figure 2 where multiple overlapping fractures are detected. the area having fracture is highlighted with green rectangles. In Figure 3, Y-axis is the distance between bone edges and X-axis denotes pixels of the image. We can easily understand that the first spike in the graph corresponds to the first fracture. The middle spike is due to the presence of a fracture in the middle region of the calf. Thus, the constant region seen in the end is because of the multiple fractures present in that region of the input image.

Figure 1: Fracture Detection (1)

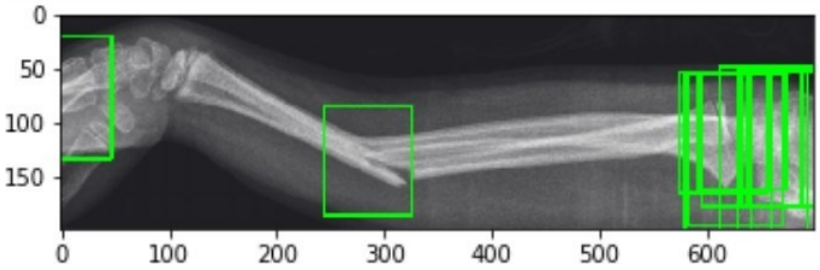
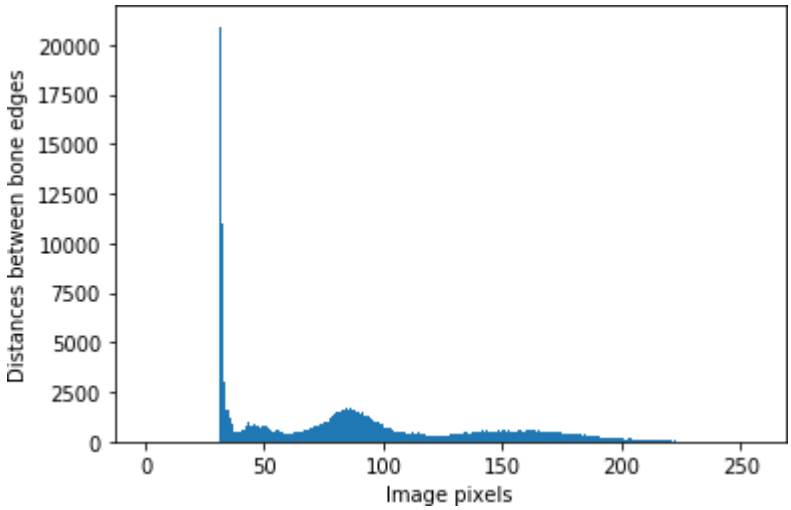


Figure 2: Edge Detection Graph (1)



In Figure 3, the deformity is identified in almost every area of the bone. In this case, the distance between the bone edges is less and multiple overlapping fractures are present which leads to broadly varying spikes in its respective graph as seen in Figure 4.

Figure 3: Fracture Detection (2)

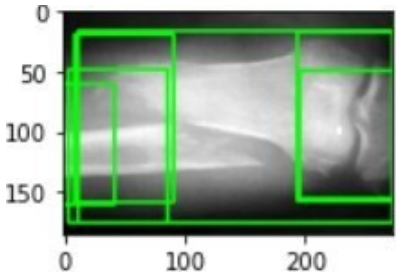
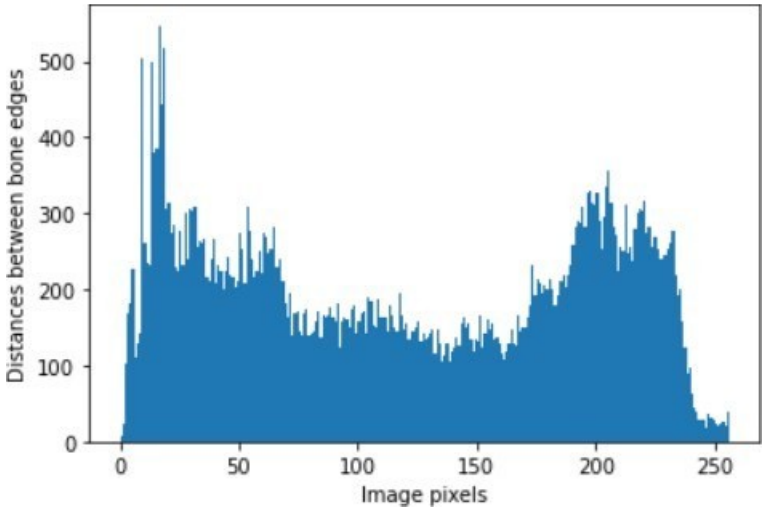


Figure 4: Edge Detection Graph (2)



7. Conclusion

In this Paper, a convenient bone deformity identification method is introduced. The automatic detection of any deformity, overlapping cracks in any part of the human body is an essential task. Here the overlapping cracks are easily detected which might go unnoticed manually. Some key points are taken into consideration while detecting like bone alignment, the gap between different bones, etc. Initial prior work on the detection of fractures is focused on conventional machine learning processes consisting of pre-processing, feature extraction, and author integral steps. Ridge regression is used here to carry out the deformity identification. Here we are identifying multiple fractures in the same area. This Computer-Aided Diagnosis (CAD) system is a convenient way of deformity identification as it is feasible as well as efficient and helps the orthopedics as well.

8. Future Scope

As we know, bones are one of the most integral parts of the body, and treating them when fractured is even more crucial, and implementing such techniques would reduce the workload in the orthopedic department and give accurate information and results. The current limitation of the proposed work is the absence of its collaborative functioning by direct deployment in the X-ray machines. Hence, the future works possible for this project include the deployment of the model in the X-ray/CT scan machines itself so that whenever the bone area is scanned the results will be obtained to the patient in a few seconds. Along with this, the current work confines itself only to identification of the fracture.

References

[1] R. Vijayakumar and G. Gireesh, "Quantitative analysis and fracture detection of pelvic bone x-ray images", in 2013 fourth international conference on computing, communications and networking technologies (ICCCNT). IEEE, 2013, pp. 1–7.

[2] A. Ghosh and S. Saha, "Automatic identification of fracture region within bone in x-ray image", in 2018 2nd International Conference on Electronics, Materials Engineering & Nano-Technology (IEMENTech). IEEE, 2018, pp. 1–7.

[3] Y. Cao, H. Wang, M. Moradi, P. Prasanna, and T.F. Syeda-Mahmood, "Fracture detection in x-ray images through stacked random forests feature fusion", in 2015 IEEE 12th international symposium on biomedical imaging (ISBI). IEEE, 2015, pp. 801–805.

[4] S. Manoharan, "Improved version of graph-cut algorithm for CT images of lung cancer with clinical property condition", Journal of Artificial Intelligence, vol. 2, no. 04, pp. 201–206, 2020.

[5] A.K. Bharodiya and A.M. Gonsai, "Bone fracture detection from x-ray image of human fingers using image processing", in Emerging Trends in Expert Applications and Security. Springer, 2019, pp. 47–53.

[6] Y. Dong, Y. Pan, J. Zhang, and W. Xu, "Learning to read chest x-ray images from 16000+ examples using CNN", in 2017 IEEE/ACM International Conference on Connected Health: Applications, Systems and Engineering Technologies (CHASE). IEEE, 2017, pp. 51–57.

[7] V. Kajla, A. Gupta, and A. Khatak, "Analysis of x-ray images with image processing techniques: A review", in 2018 4th International Conference on Computing Communication and Automation (ICCCA). IEEE, 2018, pp. 1–4.

[8] A.Y. Yang, L. Cheng, M. Shimaponda-Nawa, and H.-Y. Zhu, "Long-bone fracture detection using artificial neural networks based on line features of x-ray images", in 2019 IEEE Symposium Series on Computational Intelligence (SSCI). IEEE, 2019, pp. 2595–2602.

[9] S. Bulut, A. Özçinar, Ç. Çiftçioğlu, and A. Akpek, "A new algorithm for segmentation and fracture detection in x-ray images", in 2015 Medical Technologies National Conference (TIPTEKNO). IEEE, 2015, pp. 1–4.

[10] V.L. Thing, "IEEE 802.11 network anomaly detection and attack classification: A deep learning approach", in 2017 IEEE Wireless Communications and Networking Conference (WCNC). IEEE, 2017, pp. 1–6.

[11] C. Basha, M. Padmaja, and G. Balaji, "Computer aided fracture detection system", Journal of Medical Imaging and Health Informatics, vol. 8, no. 3, pp. 526–531, 2018.

[12] M. Deshmukh and P. Deshmukh, "Study of automatic fracture detection system using classification methods: A review", International Journal, vol. 5, no. 12, 2015.

[13] U. Raghavendra, N.S. Bhat, A. Gudigar, and U.R. Acharya, "Automated system for the detection of thoracolumbar fractures using a CNN architecture", Future Generation Computer Systems, vol. 85, pp. 184– 189, 2018.

[14] O. Bandyopadhyay, A. Biswas, and B.B. Bhattacharya, "Long-bone fracture detection in digital x-ray images based on digital-geometric techniques", Computer methods and programs in biomedicine, vol. 123, pp. 2–14, 2016.

[15] K. Dimililer, "IBFDS: Intelligent Bone Fracture Detection System", Procedia computer science, vol. 120, pp. 260–267, 2017.

[16] A. Sungheetha and R. Sharma, "GTIKF- Gabor-Transform Incorporated K-Means and Fuzzy C Means Clustering for Edge Detection in CT and MRI", Journal of Soft Computing Paradigm (JSCP), vol. 2, no. 02, pp. 111– 119, 2020.