A HYBRID MACHINE LEARNING APPROACH FOR BONE FRACTURE DETECTION IN RADIOGRAPHIC IMAGES

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ABSTRACT

Accurate detection and classification of bone fractures from radiographic (X-ray) images is essential for clinical diagnosis, emergency treatment planning, orthopedic workflows, and automated medical decision support systems. Manual diagnosis is often challenging due to overlapping anatomical structures, subtle fracture lines, variable image quality, and inter observer differences among radiologists. Traditional machine-learning approaches rely on handcrafted features, which often fail to generalize across diverse fracture types and imaging conditions. This survey paper reviews existing fracture detection methodologies and evaluates deep-learning-based classification models. Special emphasis is given to the model, a hybrid transfer learning architecture that integrates Dense Net's feature reuse with Inception's multi-scale pattern extraction. Its architecture, workflow, accuracy, and clinical applicability are thoroughly discussed. Bone fractures are among the most common global health problems and require rapid and accurate diagnosis to prevent complications and reduce healthcare costs. Traditional diagnostic methods rely on the manual examination of X-ray images by experienced radiologists, a process that is time-consuming and prone to human error, especially in emergency departments with high patient volumes. This study proposes a lightweight hybrid approach that integrates deep learning–based feature extraction with classical machine learning algorithms for automatic bone fracture detection. These findings confirm that combining deep feature extraction with ensemble learning can effectively support automated diagnostic systems for bone fracture detection, enabling healthcare professionals to make faster and more reliable decisions.

Keywords: *Bone fracture detection, Medical imaging, Radiographs, Transfer learning, hybrid transfer learning*

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. Bones are the main concrete parts in the human body and bone fracture is the familiar trouble in human body. The fracture may cause due to the pressure applied to a bone or may be due to any other diseases x-ray imaging technique is very useful in detecting the fracture. In this technique the image is first captured using X-ray then it is processed by using one of the image processing techniques like edge detection, image enhancement, segmentation etc. Here in this paper edge detection method is used for processing x-ray images. The image database size is getting increased day by day. This happen due to the development in technology and by increase in various high speed internets, increase in capacity and various storage devices creates the need of development in image retrieval systems. In earlier cases images were manually annotated and texts, keywords and tags then they were used to describe it that is known as metadata. The manual annotation becomes difficult in case of large datasets that results in increase of cost, time and also there is need of large amount of manual labour. Two different users can choose different words to describe the image characteristics that results in irrelevant retrieval results. If it is done through computer known as Digital image processing and analysis. Computer algorithms are used to process images in digital image processing. Digital image processing has numerous recompense compared to analog image processing. In an image processing procedure, the put in is an image and its output image is an improved high quality image as per the methods used. Digital image processing generates a greater amount of algorithms where input data are incorporated.

LITERATURE REVIEW

Elchin Asgarov (2024) heart disease is one of the most important problems the world faces. It is an ongoing problem and it is leading to the cause of death globally. To solve this issue, predicting early heart disease is important. This research focuses on supervised machine learning techniques as a potential tool for heart disease prediction. This study has done a comprehensive review of 30 articles published between 1997 to 2023 about machine learning techniques to predict heart disease. The common problem is that authors use different data sets, and different numbers of parameters to train and test these models. These two factors could affect the model's accuracy. To compare different models, I only used articles that analyze more than one method using the same data to prevent bias. Some traditional machine learning methods such as Artificial Neural Network, and K-Nearest Neighbor demonstrated significant variation in accuracy, occasionally reaching as high as 100% but sometimes falling below 60% in specific situations which is inconsistent.

Muhammad Azam Zia (2023) Human bones are the hard organs that protect vital organs such as the heart, lungs, and other internal organs. Fractures of the bones are a prevalent issue among humans. Bone fractures may develop from an accident or another circumstance when there is great pressure on the bones. It may be difficult and time-consuming to determine the site of a fracture in a patient who is suffering discomfort. The manual examination of

fractures during radiological interpretation is a time-consuming and error-prone process. This may result in erroneous detection, poor fracture healing, and an extensive procedure. So, this research proposed an effective approach to rectifying bone fractures with the inclusion of the latest technologies. The solution is proposed by employing a Deep learning model. Moreover, a novel concept of classification is also incorporated. Firstly; the MURA dataset was collected from Stanford. Secondly; The proposed model used techniques like DCNN (Deep Convolution Neural Network) and use Alex Net model. Bones are classified into fractured or non-fractured through a classification approach. The proposed model was created using Google Colab.

Turgay Celik (2022) Synopsis Mineral Resources estimation plays a crucial role in the profitability of the future of mining operations. The conventional geo-statistical methods used for grade estimation require expertise, understanding and knowledge of the spatial statistics, resource modelling, geology, mining engineering as well as clean validated data to build accurate block models. However, the geo-statistical models are sensitive to changes in data and would have to be rebuilt on newly acquired data with different characteristics, which has proved to be a time-consuming process. Machine learning methods have in recent years been proposed as an alternative to the geo-statistical methods to alleviate the problems these might suffer from in Mineral Resource estimation. In this study, a systematic literature review of machine learning methods used in Mineral Resource estimation is presented. The results, based on 31 research studies, show that the machine learning-based methods have outperformed the conventional grade estimation modelling methods.

Dac Nhat Nguyen (2021) Artificial lift plays an important role in petroleum industry to sustain production flowrate and to extend the lifespan of oil wells. One of the most popular artificial lift methods is Electric Submersible Pumps (ESP) because it can produce high flowrate even for wells with great depth. Although ESPs are designed to work under extreme conditions such as corrosion, high temperatures and high pressure, their lifespan is much shorter than expected. ESP failures lead to production loss and increase the cost of replacement, because the cost of intervention work for ESP is much higher than for other artificial lift methods, especially for offshore wells. Therefore, the prediction of ESP failures is highly valuable in oil production and contributes a lot to the design, construction and operation of oil wells. The contribution of this study is to use 3 machine learning algorithms, which are Decision Tree, Random Forest and Gradient Boosting Machine, to build predictive models for ESP lifespan while using both dynamic and static ESP parameters.

Palwinder Kaur (2020) There is increase in size of image acquisition and data storage methods and also there is increase in database of images. Earlier textual description and manual annotation of images were used for retrieval of images that was a time consuming task. The need of the hour is to manage the large collections through efficient systems called content-based image retrieval systems. In this case visual contents of the image like shape, arrangement and color of the objects is present in the images are also considered along with the associated data with the

image. As compared to other conventional method of image retrieval these systems are more efficient and fast. In this study we have proposed a new system in which features are extracted using Gabor filtering which are further optimized using lion optimization. In the end the classification is done using SVM for cuckoo search optimization and decision tree method for lion optimization. The proposed method is tested in terms of various parameters that show improved results are achieved using Lion optimization as compared to cuckoo search optimization.

Effects Of Misdiagnosed Fractures

When the fractures are not properly diagnosed, it will cause major effects in human body. Many misdiagnosed fractures damage the blood vessels and cause bleeding within the body or from an open wound. A dislocated hip or knee can disrupt blood flow to the leg. Therefore the tissues in the leg will not able to get enough blood and it die. If the tissues die the part of the leg have to be cut off. When fracture occurred the nerves are stretched, bruised, or crushed. Thus misdiagnosis of fracture causes nerve damage. Fat embolism is another major problem in misdiagnosis. Because sometimes fat is released from the bone's interior. This fat may travel through the veins, lodge in the lungs, and block a blood vessel. As a result, the body does not get enough oxygen, and people may become short of breath and have chest pain. In order to overcome this misdiagnosis of fractures, three general approaches for medical image segmentation, namely, manual segmentation, semi-automatic segmentation and automatic segmentation are used.

Cad For Fracture Detection

The Computer-Aided Diagnosis (CAD) is used to diagnose the fractures by a radiologist who utilizes the output of a computerized analysis of the medical images as a second opinion when making the diagnosis. This provides image interpretation by improving the accuracy and consistency of radiological diagnosis and also by reducing the image reading time. Medical images in their raw form are represented by arrays of numbers in the computer, with the numbers indicating the values of relevant physical quantities that show contrast between different types of body tissue. Processing and analysis of medical images are useful in transforming raw images into quantitative information to aid diagnosis, and in integrating complementary data from multiple imaging modalities. One fundamental problem in medical image analysis is image segmentation, which identifies the boundaries of objects such as organs or abnormal regions (e.g. tumors) in images. Having the segmentation result makes it possible for shape analysis, detecting volume change, and making a precise radiation therapy treatment plan.

Fracture Types

The dynamic organ which gives the shape of the human body, permitting the motor function and locomotion, enabling respiration, creating marrow-derived cells, caring vital organs and playing a key role in homeostasis is called skeletal system. In the human body the bones are having constant changes which remodels according to the ever-changing atmosphere. The human body normally has two hundred and six bones. They are described by their shapes. It can be classified based on the shapes as long bones, short bones, flat bones, irregular bones, and sesamoid bones. The

Long bones provide the structural support to our skeleton, which are longer than they are wide. Examples of longer bones are femur, thigh bone. Short bones are wider but not so long. Tarsal in the foot and carpals in the hand are examples for short bones. The ankle, wrist etc are made up of shot bones. Flat bones are flat and provide a flat surface for the muscle to attach. The best example for flat bones is libs. The oddly shaped bones are called irregular bones, which doesn't falls in any category.

Edge Detection Of Femur Bone In X-Ray Images – A Comparative Study Of Edge Detectors

Analysis the performance of Laplace operator in comparison with other edge detection methods, namely, Roberts, Sobel, Prewitt, and Canny's operators, which are applied to the X-ray images of femur bones. They observed that Robert cross gradient operator is very quick to compute. The resultant image is very similar to the one obtained by Sobel operator but quality of edge pixels are found to be degraded due to lot of jerky effect on edges. The Sobel operator is slower than the Roberts operator and its performance is poor than the Prewitt operator. From the experimental results, they observed that the Laplace operator gives better edge detection results than the other methods in the investigation of X-ray images of femur bones, which has significance to medical and forensic experts.

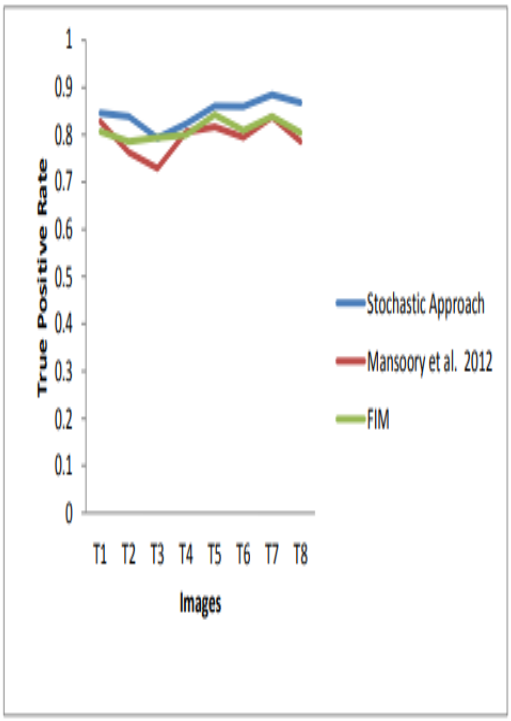
METHODOLOGY

This work presents the detailed image processing procedure including the grid formation, local there sholding, threshold value interpolation, segmentation using fuzzy index measure, background removal, and morphological filtering for the determination of infestation sites of a crack in X-ray image. The image processing procedure was tested with X-ray images of several types of crack bones. Additional tests and analyses were performed using the developed algorithm on the X-ray images obtained with different image acquisition parameter. The atlas-based approach for automatic segmentation of femurs in X-ray images will produce the consistent sets of edge segments registers the whole atlas to the image under joint constraints. A novel cracking automatic detection approach based on segment extending for complex pavement images proposed to identify cracks correctly and entirely.The prediction methodology of Finite-Element Analysis (FEA) based on J-integral value estimation is used to investigate the interfacial fracture opportunity of low-k packages. Various paths with an integral contour surrounding the crack tip are considered to avoid a misunderstanding of the cracking energy. The accuracy assessment for object based image segmentation is analyzed using different objects. The measures are shown to be an intuitive, useful technique for consistency checking different segmentation results and assessing segmentation accuracies among a large set of disparate segmentation results.

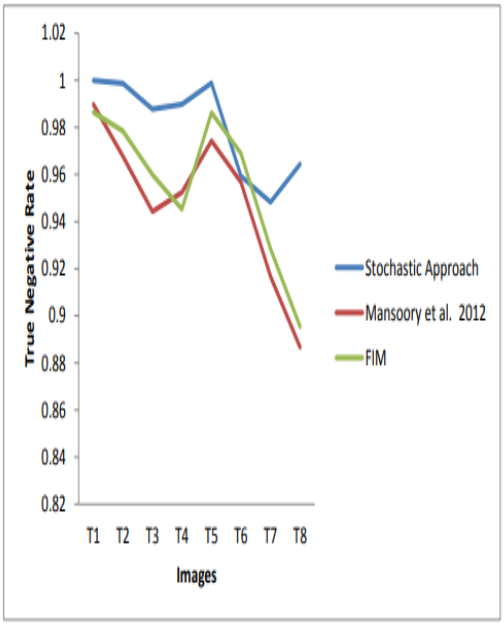
RESULTS AND DISCUSSIONS

The Fracture diagnosis, evaluation of skeletal, bone densitometry and hip replacement are done based on the results of X-ray images. The automatic detection of crack improves the timeliness and accuracy of diagnosis. The accuracy of detection of hairline breakage is very important now-a-days because the misdiagnosis of fracture leads to very serious problems for the patient. Any misdiagnosis of fracture causes neurovascular damage, soft tissue damage,

blood loss, localized contamination and infection. Though there are lots of methods applied for detecting fractures on bone images, these are not sufficient to give accurate result.

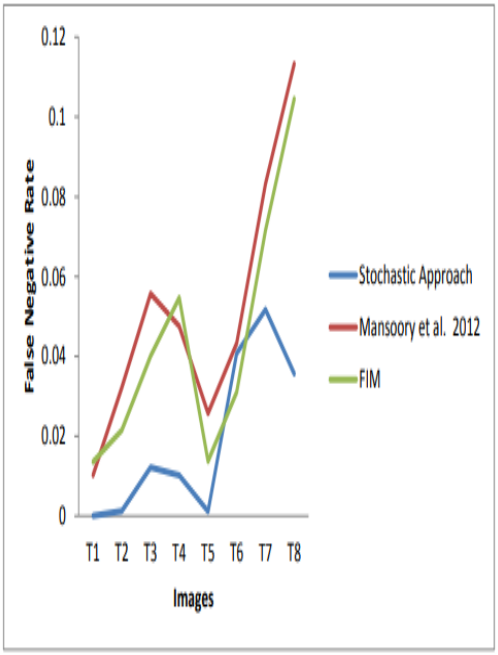


Graph 1 True Positive rate comparison of stochastic approach with & Mansoory et al. 2012 FIM

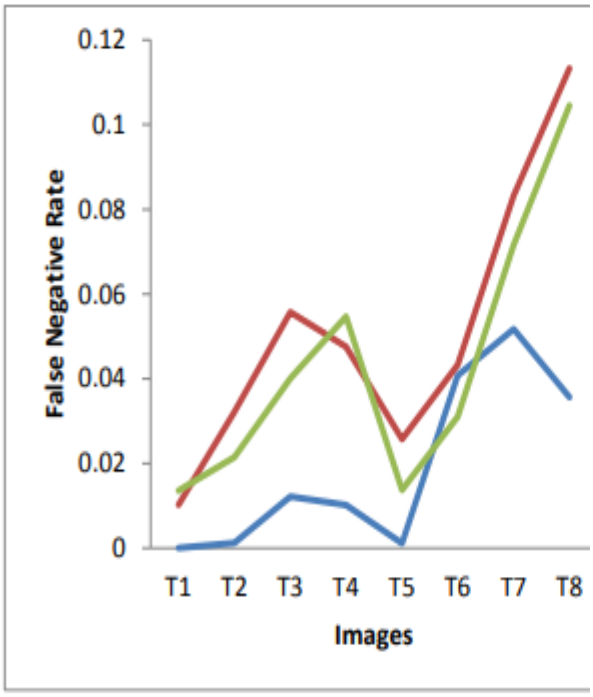


Graph 2 True Negative rate comparison of stochastic approach with & Mansoory et al. 2012 FIM

The Overall True Positive Rate (Sensitivity) is 0.8467 and the overall True Negative Rate (Specificity) is 0.9809. The graphical chart which shows the comparison of true positive rate and true negative rate with other techniques is given in Graph 1 and Graph 2. On seeing the results, it can be known that the proposed method detects crack well than the other methods.



Graph 3 False Negative Rate Comparison of stochastic approach with & Mansoory et al. 2012 FIM



Graph 4 False Negative Rate

Comparison of stochastic approach with & Mansoory et al. 2012 FIM

The overall accuracy rate of the stochastic approach is very high (98%) when compared with the other techniques. The average false positive rate is 0.1533 and false negative rate is 0.0191 which is low when compared to the other techniques from Graph 3 and Graph 4. Therefore the error rate in fracture diagnosis is very low when compared with the other methods.

Receiver Operating Characteristic (ROC) Curve Analysis is important for medical diagnosis. In this the segmentation results of the proposed work are compared with other standard techniques by calculating the True Positives (TP), True Negatives (TN), False Positives (FP) and False Negatives (FN). The True Positive Rate (TPR) or the Sensitivity, and the False Positive Rate (FPR) or 1-specificity is calculated for the sample images. Graph7.6 shows an ROC curve with Sensitivity vs 1-Specificity for all patients. The results also demonstrate that our new proposed technique has the ability to detect crack well when compared with the other techniques.

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