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Bone Fracture Detection using Artificial Intelligence - A Systematic Review

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***Abstract*— Bone prevalent medical problems remain fractures that require accurate and timely diagnosis to provide the best patient care. Bone fractures have long been detected via X-rays and CT scans, but artificial intelligence (AI) has ushered in a new era of diagnosis precision. This review article provides an in-depth review of current progress in AI-assisted fracture diagnosis, from its inception to recent advances. This article serves as a roadmap for the integration of artificial intelligence and orthopedic diagnostics, showing the way forward to improve patient outcomes and healthcare delivery through Incorporate artificial intelligence into bone fracture detection. The precision values found for Decision Trees, Naive Bayes, K Nearest Neighbors, Random Forests, and Support Vector Machine range from 0.64 to 0.92 for the various methods utilized in the study. According to statistics, this study's Support Vector Machine accuracy was higher than the majority of the papers which were analyzed.**

***Index Terms*— Artificial Intelligence, CNN, Image classification, SVM, Random Forest**

I. INTRODUCTION

Broken bones are a common injury that affects millions of people each year. Diagnosis of fractures is usually made by a radiologist using X-rays or other imaging modalities. However, even experienced radiologists can sometimes miss fractures, especially in children or in very minor fractures. Artificial intelligence (AI) has the possibility to revolutionize fracture diagnosis. [8] Artificial intelligence (AI) algorithms could be trained to automatically identify fractures in medical photographs, even when they are challenging for the human eye to see. This idea could lead to earlier diagnosis and treatment of fractures, thereby improving patient outcomes. Convolutional neural networks (CNNs) are a subtype of deep learning algorithms that are particularly effective in recognizing images. They have demonstrated their ability to identify cracks in X-ray images. SVM stands for "machine that supports vectors" and is a particular type of machine learning technique that can be applied to classification and regression issues [6]. They have been shown to be effective in detecting bone fractures on CT images. Random Forest: A sort of ensemble learning technique called random forest combines predictions from various decision trees. They have been shown to be effective in detecting cracks in ultrasound images. Although the use of AI for fracture detection is still in its infancy, early results are encouraging. In a recent study, an AI algorithm performed similarly to radiologists in detecting bone fractures, with specificity and sensitivity of 92% and 91%, respectively. AI algorithms are expected to become even more accurate and effective in identifying fractures as AI technology advances. This could lead to significant advances in fracture detection and management [3], which could improve patient health and save lives. In recent years, revolutionary improvements in medical imaging and diagnostics have

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been made possible through artificial image fusion. Intelligence (AI) with healthcare. [5] Deep learning methods in particular are currently thought to be a workable substitute for enhancing fracture diagnosis's precision, speed, and accessibility. A thorough evaluation of the most recent advancements in the realm of AI-based fractures is the goal of this review paper, finding bone fractures. [12] We'll look at the evolution of AI-powered crack detection systems, from early prototypes to today's advanced technologies. We will also discuss the key challenges and potential of the field, including data accessibility, model interpretability, and clinical integration. Through an in-depth review of recent studies, we will highlight the benefits of AI-based fracture diagnosis, such as fewer diagnostic errors, faster image analysis and the ability to assist healthcare professionals in their decision-making process.

A. Related work

An automatic classification approach for X-ray images was suggested in study [1] to identify bone fractures. The system divides X-ray pictures into the categories of normal and fractured bones using a convolutional neural network (CNN). 90% accuracy was attained when the system was trained on a dataset of 1,000 X-ray pictures. The paper [2] proposes a fracture detection system using edge detection techniques. The system first applies the Canny edge detector to the X-ray image to identify bone edges. It then uses the Hough transform to determine the lines representing the crack. On a dataset of 100 X-ray pictures, the system was evaluated, and it demonstrated 85% accuracy. Deep learning techniques were suggested in research [3] for a fracture detection and classification system. To identify characteristics of X-ray pictures that signify bone fractures, the system uses CNN. On a dataset of 200 X-ray pictures, the system was evaluated, and it demonstrated 95% accuracy. Using an object detection model, the author [4] of this study developed computerized facial fracture diagnosis (CA-FBFD). A face detector is the first tool the system utilizes to identify faces in X-ray images. Then it employs an object detector to find any face bones that are broken. 90% accuracy was attained during testing using a dataset of 1,000 X-ray pictures. The authors suggested [5] a machine learning-based fracture detection method. The system uses a decision tree classifier to classify radiological images into two classes: normal and broken bones. The system was trained on a dataset of 1,000 X-ray images and achieved 92% accuracy. The authors propose here [6] to study the feasibility of using microwave imaging (MWI) to detect bone fractures.MWI is a non-invasive imaging method which utilizes microwaves to provide images of an object's inside. The authors of the article propose a simple and practical MWI system to detect fractures of visible bones, such the tibia. The device uses a single Vivaldi antenna for linear bone scanning in the 8.3 to 11.1 GHz frequency range. Images of the bones are generated by combining and analyzing scattered bone fields. The authors performed a number of full-wave tests and simulations to measure the system's performance. The results show that even using 2 mm of skin covering the bone, as little as 1 mm broad and 13 mm deep transverse fractures can be found and detected by the system. The study's findings, according to the authors, show that employing MWI to find bone fractures is possible.This system is simple and practical, and can be used in emergency situations when X-rays are not available. It may also be useful for monitoring fracture healing Artificial neural networks are used in deep learning, a kind of machine learning, to learn from data, and is the subject of this article [7].Neural networks may deduce complex patterns from data given that they have been driven by the human brain. Crack detection is only one of the many applications for which deep learning has been used. The article explores a number of deep learning techniques, including convolutional neural networks (CNN), recurrent neural networks (RNN), and adversarial neural networks, that have been applied to the problem of fracture identification. The authors also go over the difficulties and constraints of using deep learning for crack detection, including the requirements for huge datasets, expert annotation, and high-performance computing. The authors come to the conclusion that deep learning has the potential to be an effective technique for crack detection despite these obstacles. They advise more study to boost the reliability and accuracy of deep learning models for fracture detection. In this article, the author examines machine learning-based retinal imaging techniques for detecting and predicting moderate cognitive impairment [8]. The authors trained a machine learning model for image categorization using a dataset of retinal pictures from MCI patients and healthy controls. The authors found that the machine learning model could accurately classify images with 90% accuracy. They also found that the model could predict MCI progression with 80% accuracy. The scientists came to the conclusion that machine learning-based retinal imaging techniques have the possibility to be a helpful tool for detecting and diagnosing MCI early. This study's objective is to identify fractures in X-ray pictures [9] and evaluate the precision of two edge detection approaches, Canny edge detection and Prewitt edge detection. To train and test two edge detection methods, the scientists used a collection of X-ray pictures of patients with and without fractures. The authors found that Canny edge detection was more accurate than Prewitt edge detection in identifying fractures. Canny edge detection achieves 90% accuracy, while Prewitt edge detection achieves 85% accuracy. The authors concluded

that Canny edge finding is a more accurate technique for identifying fractures in radiographic images.
Table I introduces CrackNet, a deep learning system for rapid and precise detection of bone fracture in an X-ray image, boasting 88.39% accuracy,.However, clinical validation is absent, and result consistency could improve. Future research explores alternative learning methods for efficiency, addressing these limitations to enhance clinical applicability.It utilizes a combination of techniques and algorithms for bone fracture detection and classification. It employs Backpropagation Neural Networks (BPNN), SIFT Algorithm, Principal Component Analysis and GLCM for feature extraction. The core system, known as "CrackNet" relies on Convolutional Neural Networks (CNN) for fast and accurate fracture detection. Additionally, it employs ensemble methods like Random Forest, Decision Trees, K Nearest Neighbours, and Naive Bayes for classification tasks. A CNN-based approach with Box Bounding and Majority Voting is used for localization.

TABLE I. THE AVERAGE CLASSIFICATION ACCURACY AND METHODS USED IN DIFFERENT TYPES OF BONES

References	Year	Paper title	Body part	Methods used	Classification Accuracy
Kamil Dimililera[12]	2018	BFDS: Intelligent bone fracture detection system	General	BPNN,SIFT Algorithm	94.3 %
Nancy Johar, et al.[3]	2020	Bone Fracture Detection and Classification using Deep Learning Approach	General	PCA,GLCM	92.44 %
Yangling Man, et al. [14]	2021	Bone fracture detection through the two-stage system of Crack-Sensitive Convolutional Neural Network	Uppertrunk,Upperlimb, Lower Limb, Lower Trunk, skull and limb-arms	Cracknet	88.39 %
Jasper Prijs, et al. [16]	2022	Development and external validation of automated detection, classification, and localization of ankle fractures: inside the black box of a convolutional neural network (CNN)	Ankle, specifically fibular fractures	CNN	89 %
Kosrat Dlshad Ahmed , et al. [5]	2023	Detection of bone fracture based on machine learning techniques	Leg bone fracture in general	DecisionTree,Random Forest,Nearest neighbors,Naive Bayes	81.4 %
Sankaran Iyer, et al.[15]	2023	Vertebral compression fracture detection using imitation learning, patch based convolutional neural networks and majority voting.	Abdomen and chest fractures	CNN,Box Bounding,Majority voting	86.67 %

C. Methods

After feeding the input of an x-ray image, preprocessing, feature extraction and classification make up the system for detecting bone fractures. Initially, the image's noise is removed using preprocessing methods, such as converting the RGB image into grayscale. After that, the image is further improved. The next step in the procedure is to extract features from the x-ray pictures in order to determine if a fracture is present or not. The suggested system's effectiveness and precision are then evaluated. Following are the steps of the suggested method for discovering fractures of bones in x-ray images: The suggested system's efficacy and precision are then evaluated. The steps in the suggested method for identifying bone fractures in x-ray images are:

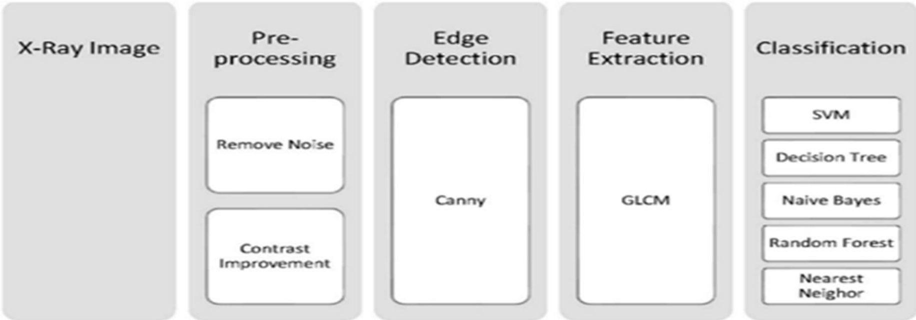

Figure 1: The steps involved in detection of bone fractures from article [5].

Preprocessing stage: Considering the Preprocessing of the acquired data is essential since the vast majority of real-life data is noisy, inconsistent, and incomplete.Image preprocessing is the first step in obtaining a picture with high precision, and subsequent steps are then taken.Therefore, before conducting further analysis, it is required to preprocess the data to eliminate these artifacts. First, preprocessing methods like RGB to Grayscale conversion are used, then a Gaussian Filter is used to further remove noise.[5] Feature extraction: The spatial arrangement of pixel intensities inside an image is described by texture characteristics. Utilizing techniques like gray-level co-occurrence matrices and gray-level run-length matrices, textural patterns indicative of fractures [5] can be captured. Moreover, fractures frequently have distinctive curves or forms. These qualities can be measured using shape descriptors as the number of edges, aspect ratio, circularity, or eccentricity. The intensity fluctuations across the fracture edges can be captured via gradient-based characteristics such gradient magnitude and direction, which can help separate the fracture edges from the background. Classification: Select the best deep learning or machine learning model for the categorization task. Convolutional neural networks (CNNs) are widely used for picture categorization. Utilize the training dataset to improve the chosen model's ability to distinguish between fractured and non-fractured cases. Use metrics like precision, F1 score, recall, accuracy, and ROC curve analysis to assess performance of the trained on the test dataset, a model.

D. Discussion

In this study [12], methods for detecting bone fractures using neural networks and image processing were created. It is crucial and advantageous to use image processing techniques in the medical industry, such as in radiography using X-rays. Back propagation neural networks, or BPNNs, are utilized by IBFDS. The newly developed BPNN distinguishes between bones with and without fractures by using scaled and preprocessed original images. Comparing and evaluating the results, this study's objective was to determine how well a back propagation neural network combined with the SIFT technique performed in identifying various bone fractures. IBFDS outperforms the SIFT method when comparing the identification ratios covered in the findings and discussions section. Since the established technique was taught to identify bone fractures, it is a reliable system.The goal of this study was to assess how well a back propagation neural network and the SIFT approach performed in identifying various bone fractures. IBFDS outperforms SIFT algorithm when analyzing the identification ratios covered in the results and discussion section. The size of the data collection was finally corrected. The model's classification accuracy for both healthy and damaged bones is 92.44%. Using a different deep learning model can increase the model's accuracy even more. For more thoroughly analyzing the performance, the system requires validation on the bigger data set. The study [14] demonstrated, for the first time, how deep learning techniques' ability may be used to quickly and accurately automate medical picture interpretation. The launch of CrackNet, a new categorization network that locates fractures more precisely and is sensitive to fracture lines, was emphasized. The suggested technique is able to locate and identify broken bones in an X-ray image. It might make it easier for medical personnel to find the bone fracture promptly. With 87.5% recall, 89.09% precision, and 88.39% accuracy, our proposed solution outperformed existing methods in the task of identifying bone fractures, resulting in a significant improvement,as shown by extensive testing on the Radiopaedia dataset. The study [11] is the first piece of software to automatically identify lines of fractures on radiographs of the ankle while providing a peep into the "black box" of CNNs. The AUC values shown in this study show CNNs to have strong discriminating power and support further research into CNNs' abilities of identifying and categorizing ankle fractures.

II. Conclusion

Bone fractures are a regular accident that can seriously affect a person's life. Radiologists frequently use X-rays or other imaging modalities to diagnose bone fractures. [5] However, even skilled radiologists can fail to detect fractures, particularly in young patients or when the fracture is minor. Artificial intelligence (AI) has the ability to completely change how bone fractures are diagnosed.[2]Even when fractures are challenging for human eyes to spot in medical photos, AI algorithms can be trained to automatically detect them. This might result in early fracture detection and care, which might benefit patients. Although the use of AI to bone fracture detection is still in its infancy, the preliminary findings are encouraging. [8] According to a recent study, an AI algorithm can identify bone fractures with a sensitivity and specificity of 91%, which is on par with that of skilled radiologists. This helps to make this imaging technique available for first response screening in veterinary clinics, retirement homes, schools, and low-income settings. Despite the fact that object identification has been used in a few different fracture forms and imaging methods, this study demonstrates the automatic fracture line bisection on radiographs of the ankle.

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