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# Bones of Fragility: Diagnosis of Osteoporosis Fracture using Image-based Techniques and Convolutional Neural Networks

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**ABSTRACT:** Osteoporosis is a medical condition characterized by weakened bones, which can lead to an increased risk of fractures. It occurs when the body loses bone mass and/or makes too little bone, making the bones fragile and more likely to break. Osteoporosis Diagnosis is the approach that utilizes Convolutional Neural Network for detecting and classifying the bone fracture. The method consists of preprocessing followed by feature extraction based on CNN model.

The objective of this abstract lies on the characterization of osteoporosis disease using Fractal Analysis of X-ray Images. Convolutional Neural Networks (CNNs) have several advantages over traditional systems, particularly in tasks related to image and video processing are Feature learning, Robustness to variations, Spatial hierarchy of features, Scalability and generalization. Overall, the advantages of CNNs make them a powerful tool for a wide range of applications in computer vision, image and video processing, and artificial intelligence.

In conclusion, the Convolutional Neural Network is a promising approach for enhancing early detection of osteoporosis. The system has the potential to improve the accuracy of fracture diagnosis, and ultimately improve patient outcomes. Further research is needed to validate the system's performance in healthcare and investigate its potential impact on patients.

**KEYWORDS:** Osteoporosis, Weaken bones, Convolutional Neural Network (CNN), feature extraction, Characterization, Deep Learning.

## I. INTRODUCTION

Osteoporosis is a bone disease in which the bone mass is reduced and bone tissue deteriorates, which therefore leads to an increased risk of fractures. It is a common condition, particularly in postmenopausal women and older adults, and can have a significant impact on quality of life.

The human skeleton is constantly undergoing a process of remodelling, where old bone is broken down and replaced with new bone tissue. In osteoporosis, the rate of bone breakdown outpaces the rate of bone formation, resulting in a loss of bone density and increased risk of fractures, particularly in the hip, spine, and wrist.

Risk factors for osteoporosis include age, gender, family history, low calcium and vitamin D intake, smoking, excessive alcohol consumption, and the use of certain medications, such as corticosteroids. Osteoporosis is often referred to as a "silent disease" because it often has no symptoms until a fracture occurs, which can have serious consequences, including chronic pain, disability, and loss of independence.



The diagnosis of osteoporosis is typically made using bone mineral density (BMD) testing, which measures the density of bones in the hip and spine. Treatment options for osteoporosis include lifestyle modifications, such as regular exercise and a healthy diet, as well as medications to prevent bone loss and promote bone formation.

Osteoporosis is a major public health concern, with an estimated 200 million people affected worldwide. Early detection and treatment of osteoporosis are essential in reducing the risk of fractures and improving outcomes for individuals with this condition.

Osteoporosis is characterized as a medical condition that affects the bones, and thus makes them weak and brittle. It is characterized by a loss of bone density, which can increase the risk of fractures. Osteoporosis is more common in older people, especially women, but it can affect anyone at any age.

Symptoms of osteoporosis may include: Back pain, Loss of height, Stooped posture and Bone fractures that occur easily or without significant trauma. The exact cause of osteoporosis is not fully understood, but several factors can increase the risk of developing the condition. These risk factors include: Aging, Family history of osteoporosis, Low levels of calcium and vitamin D, Hormonal changes (such as menopause), Sedentary lifestyle, Smoking and excessive alcohol consumption

There is no cure for osteoporosis, but there are several treatments available that can slow down the progression of the disease and help reduce the risk of fractures. These treatments may include: Calcium and vitamin D supplements, Medications that slow down bone loss and increase bone density, Exercise and physical therapy to improve bone strength, balance and Lifestyle changes such as quitting smoking, reducing alcohol intake.

Preventing osteoporosis in the first place is also important. This can be done by: Consuming a diet rich in calcium and vitamin D, engaging in regular weight-bearing exercise (such as walking or weightlifting), Avoiding smoking and excessive alcohol consumption and getting regular bone density tests to monitor bone health.

## II. LITERATURE SURVEY

The research paper titled “Osteoporosis Diagnosis using Fractal Analysis and Support Vector Machine” authored by Abdessamad Taфраouti, Mohammed EI Hassouni was published in the 10<sup>th</sup> International Conference on Signal-Image Technology and Internet-based systems in 2014. The paper presents a Machine Learning based approach for classification based on Fractal Analysis of X-ray images. The author employed Fractional Brownian Motion Model and Support Vector Machine was used as classifier to distinguish between Osteoporotic patient and control cases. The study reported promising results with an accuracy classification rate of 95% offers a good discrimination OP patients and CC subjects.

The research paper titled “Current and Emerging Diagnostic Imaging-Based Techniques for Assessment of Osteoporosis and Fracture Risk” authored by Anu Shaju Areeckal (Student Member, IEEE), Suman David S., (Senior Member, IEEE) was published in the IEEE in the year 2018. The state-of-the-art and advantages in imaging techniques for diagnosis of bone disease i.e., osteoporosis and the fracture risk assessment have been explored in this paper. This paper presents a review of segmentation methods used to segment the ROI and texture analysis methods used for classification of healthy and osteoporotic subjects.

The research paper titled “Osteoporosis Classification Using Texture Features ” authored by Farhan Riaz, Rehan Nemati, Ali Hassan in the 32<sup>nd</sup> International Symposium on Computer Based Medical Systems (CBMS) in the year 2019. The focus is on simultaneously extracting the discriminative patterns in all the orientations and scales. Gabor filters are useful in yielding a scale and orientation sensitive analysis and LBPs are useful for quantifying microstructural changes in the images hence we have proposed an approach that is based on a combination of multi resolution Gabor filters and 1DLBP features. The proposed method shows good classification results with an overall accuracy of about 72.71%.

The research paper titled “Detection of Osteoporosis in Lumbar Spine[L1-L4] Trabecular Bone: a review article” authored by Kavita Avinash Patil, K.V. Mahendra Prashanth, A Ramalingaiah in the International Journal of



Research in orthopaedics in the year 2021. This paper focuses on bone mineral density(BMD) standards obtained through a variety of scientific methods experimented from different skeletal regions. It also focuses on advance technologies in imaging systems and fracture probability analysis of osteoporosis detection. The segmentation techniques explored to examine osteoporosis in particular region of the image and further significant attributes are extracted using different methods to classify normal and osteoporosis bones.

The research paper titled “Machine Learning Solutions for Osteoporosis-A review” authored by Julien Smets, Enisa Shevroja, Thomas Hugle in the Journal of bone and Mineral Research in the year 2021. This paper studies a systematic search in PubMed and Web of Science resulted in 89 studies for inclusion in the review. These covered 1 or more of 4 main areas in osteoporosis management: bone properties assessment(n=13), osteoporosis classification(n=34), fracture detection(n=32), risk prediction(n=14). A 12-point checklist was used to determine reporting and methodological quality. Efforts taken to develop Machine Learning based models for identifying fracture risk factors and improving the fracture predictions are additional features of research.

### III. PROPOSED METHODOLOGY

To develop and evaluate the performance of the Osteoporosis Disease Detection and Classification utilizing the Convolutional Neural Network (CNN), the following methods are used:

**Data Collection:** The data collection module involves the acquisition of the X-ray image dataset, which includes both normal and osteoporosis bone images. The dataset was collected from Kaggle, a popular platform for sharing datasets and code related to machine learning.

**Data Pre-processing:** The pre-processing module involves the preparation of the collected data for training the CNN model. This module includes several steps, such as image resizing, normalization, and filtering. Image resizing is used to reduce the size of the images to make them easier to process, and normalization is used to standardize the pixel values of the images. Filtering is used to remove any noise or unwanted features from the images that could affect the accuracy of the model.

**Model Training:** The training module involves the use of a CNN model to learn the features of the pre-processed images and classify them as normal or osteoporosis. The CNN model consists of several layers, such as convolutional layers, pooling layers, and fully connected layers. The model is trained on the pre-processed data using an optimizer and loss function to minimize the error between the predicted and actual labels of the images.

**Model Testing:** The testing module involves the evaluation of the trained model on a separate set of data to assess its accuracy in detecting osteoporosis. This module includes several performance metrics, such as accuracy, precision, recall, and F1-score. These metrics are used to evaluate the performance of the model and determine if it is suitable for deployment.

**Web Application Development:** The web application development module involves the creation of a user-friendly interface using Flask, SQLite3, HTML, CSS, and Bootstrap. Flask is a popular web framework for building web applications using Python, SQLite3 is a lightweight database management system, and HTML, CSS, and Bootstrap are used for the design and layout of the web application. The web application allows healthcare professionals to upload X-ray images and get a prediction of whether the bone density is normal or osteoporosis.

Overall, the proposed system uses image processing and CNN algorithms to detect osteoporosis in X-ray images, and a user-friendly web application to make it easy for healthcare professionals to assess the bone density of their patients.



#### IV. SYSTEM ARCHITECTURE

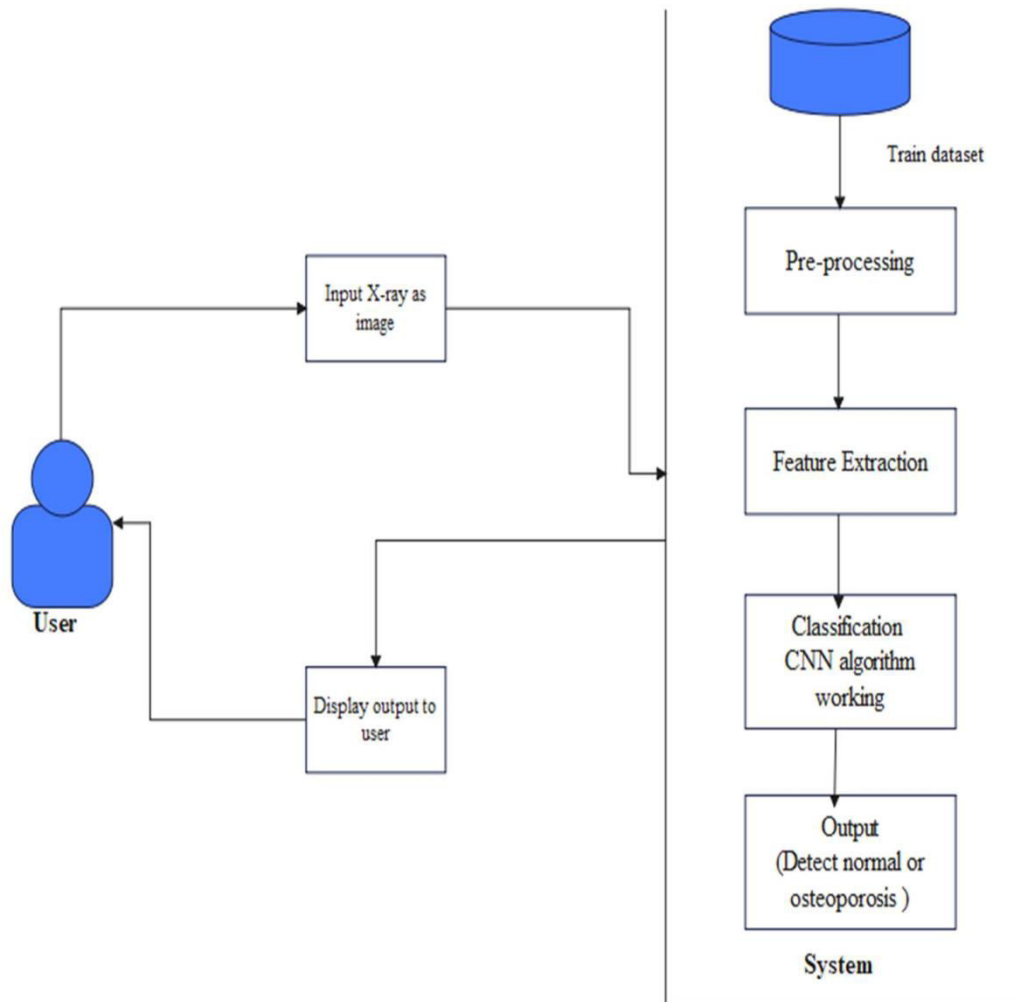


Fig 1: System Architecture

#### V. ALGORITHM USED

Convolutional Neural Networks (CNNs) are a type of deep learning algorithm that are particularly useful in image recognition tasks, such as detecting osteoporosis from X-ray images. The main advantage of CNNs is that they are able to learn and extract features directly from raw image data, without the need for manual feature extraction. The structure of a CNN typically consists of the following components:

1. Input layer: The first layer of the network that takes in the input image. Each pixel in the input image is represented as a neuron in this layer.
2. Convolutional layer: This surface applies a set of filters to the input image to take out features such as edges, corners, and other visual patterns. The filters slide over the input image in a process called convolution, and produce a feature map for each filter.
3. Activation layer: After the convolutional layer, an activation function such as ReLU (Rectified Linear Unit) is

applied to the feature maps to introduce non-linearity into the network.

4. Pooling layer: This layer reduces the dimensionality of the feature maps by down sampling them. The most common type of pooling is max pooling, where the maximum value in each pool is retained.

5. Fully connected layer: This layer takes the flattened output from the previous layers and applies a set of weights to produce the final output. This is alike to traditional neural network.

6. Output layer: The final layer of the network that produces the classification output. The number of neurons in this layer is equal to the numeral of classes in the classification problem.

In summary, the input image is passed through a series of convolutional, activation, pooling, and fully connected layers to produce the final output. Using Convolutional Neural Networks (CNNs) for osteoporosis detection using image- based techniques offers several benefits, including:

1. Increased accuracy: CNNs can detect subtle changes in bone density and structure that may not be apparent to the human eye. This can result in higher accuracy in osteoporosis detection, which can be crucial for early diagnosis and treatment.

2. Efficiency: Image-based osteoporosis detection using CNNs can be more efficient than traditional diagnostic methods, which can be time-consuming and costly. Automated image analysis using CNNs can significantly reduce the time required for diagnosis and treatment.

3. Non-invasive: Image-based osteoporosis detection using CNNs is non-invasive and does not require the use of radiation or invasive procedures, making it a safer option for patients.

4. Personalized treatment: CNNs can be trained to identify specific patterns in bone density and structure, which can help physicians develop personalized treatment plans for patients with osteoporosis.

5. Scalability: Image-based osteoporosis detection using CNNs can be easily scaled to handle large amounts of data, making it suitable for use in clinical settings and large-scale research studies.

## VI. RESULTS AND DISCUSSION

After Pre-processing the X-ray images of normal as well as abnormal i.e. osteoporotic images the results obtained are:

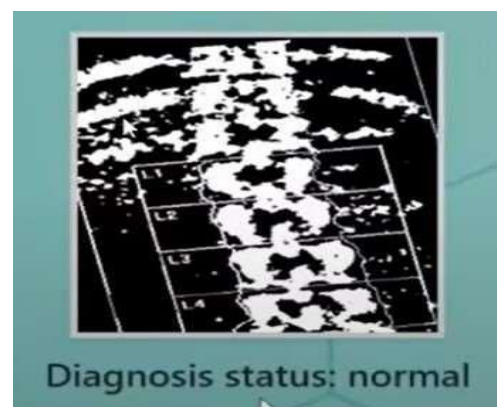
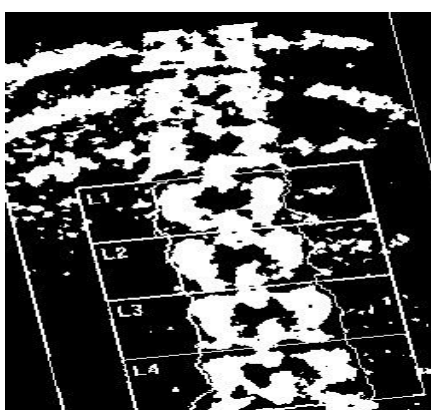


Fig 2: Normal

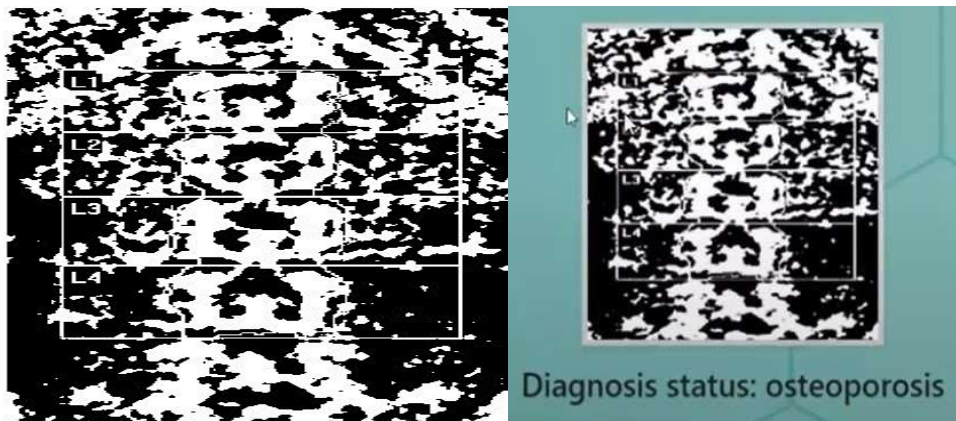


Fig 3: Osteoporosis

All the research papers mentioned above propose different approaches for detecting osteoporosis and classifying X-ray images into normal and osteoporosis using different algorithms like Convolutional Neural Networks, Support Vector Machine, Regression and various Machine Learning as well as Deep Learning Techniques.

The research paper published by Abdessamad Tafraouti, Mohammed El Hassouni and Hechmi Toumi were based on characterization of osteoporosis disease using fractal analysis of X-ray images. The SVM used as a parametric to determine linking two populations mixed of Osteoporotic Patients (OP) and Control Cases (CC). This approach offers good discrimination between OP patients and CC subjects giving an accuracy of 95%.

The research paper proposed by Anu Shaju Areeckal, Michel Kocher and Suman David S., used quantitative imaging techniques such as Dual X-ray Absorptiometry (DXA), Quantitative Computed Tomography (QCT), High Resolution peripheral QCT (HR-pQCT), Quantitative Ultra Sound (QUS), Magnetic Resonance Imaging (MRI), Digital X-ray Radiogrammetry (DXR), Radiography for diagnosis of Osteoporosis. The segmentation techniques used are edge detection methods, region growing methods, deformable models and Deep learning methods.

## VII. FUTURE SCOPE

X-rays have traditionally been used as a diagnostic tool for osteoporosis, particularly in assessing bone mineral density (BMD) and identifying fractures. However, recent advancements in imaging technology have opened up new possibilities for the detection, prevention, and management of osteoporosis based on X-rays.

One area of future research is the development of machine learning algorithms to analyze X-ray images and automatically detect signs of osteoporosis. By training algorithms on large datasets of X-ray images, it may be possible to develop more accurate and efficient methods for detecting osteoporosis at an earlier stage, when preventative measures are more effective.

Another promising area of research is the use of X-ray imaging to monitor the progression of osteoporosis and the effectiveness of treatment. By tracking changes in bone density over time, clinicians can assess the effectiveness of treatments such as medications and lifestyle modifications, and adjust treatment plans as needed.

In addition, X-ray technology may also be used to develop new therapies for osteoporosis. For example, researchers are exploring the use of low-intensity pulsed ultrasound (LIPUS) as a non-invasive treatment for osteoporosis, which works by stimulating bone formation. X-ray imaging can be used to monitor changes in bone density and structure following LIPUS treatment.



Overall, X-ray imaging has the potential to play an important role in the detection, prevention, and management of osteoporosis, and future research in this area may lead to new and more effective approaches for addressing this common and serious health condition.

### VIII. CONCLUSION

The detection and analysis of osteoporosis fracture using deep learning, machine learning, and convolutional neural networks (CNNs) has shown promising results in recent studies. The use of these techniques in combination with medical imaging has the potential to improve early detection and treatment of osteoporosis fractures. Deep learning algorithms such as CNNs have been used to detect osteoporotic fractures from X-ray and with high accuracy. Machine learning models have been used to predict the risk of fracture and the progression of osteoporosis. These techniques have the potential to provide physicians with valuable diagnostic tools and personalized treatment plans for patients with osteoporosis. Overall, the combination of medical imaging and deep learning techniques has the potential to revolutionize the diagnosis and treatment of osteoporosis fractures. With further research and development, these techniques may become an essential tool in the fight against this common and debilitating condition.

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