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# OSTEOSCAN AI: A DEEP LEARNING-BASED WEB APPLICATION FOR DETECTING OSTEOPOROSIS AND OSTEOPENIA WITH CHATBOT SUPPORT AND DYNAMIC HOSPITAL SUGGESTIONS

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**ABSTRACT:** Osteoporosis and osteopenia are progressive bone diseases that often go undetected until a serious fracture occurs. Early diagnosis is essential for effective treatment and prevention. This project presents OsteoScan AI, a deep learning-based web application designed to classify bone X-ray images into Normal, Osteopenia, or Osteoporosis categories using a custom-trained convolutional neural network (CNN).

The system features a user-friendly interface that allows users to upload X-ray images and input their location. Upon prediction, the system provides Grad-CAM visualizations for explainability, suggests nearby hospitals for medical consultation, and recommends a personalized diet chart based on the diagnosis. Additionally, an integrated chatbot assists users with common queries about bone health, lifestyle modifications, and application usage.

Developed using technologies such as Python, Flask, PyTorch, HTML/CSS, and JavaScript, this application aims to make AI-driven bone health assessment more accessible, interpretable, and supportive. OsteoScan AI is a step toward bridging the gap between early diagnosis and timely medical care, especially in resource-limited areas.

***KEYWORDS:*** Osteoporosis, Osteopenia, X-ray Classification, Deep Learning, CNN, Grad-CAM, Explainable AI, Chatbot, Hospital Recommendation, Diet Suggestion, Flask, PyTorch, Medical Image Analysis, Preventive Healthcare.

## I. INTRODUCTION

Osteoporosis and osteopenia are common yet often overlooked bone conditions that gradually weaken bone density, increasing the risk of fractures and long-term health complications. These diseases are typically asymptomatic in the early stages, making early detection difficult but critically important. Traditional diagnostic methods, such as DEXA scans, are not always accessible or affordable, especially in rural or resource-limited areas.

To address this challenge, OsteoScan AI is developed as a web-based diagnostic tool that uses deep learning to analyze bone X-ray images and classify them into Normal, Osteopenia, or Osteoporosis categories. The system enhances interpretability using Grad-CAM visualizations, which highlight the areas of the X-ray that influenced the model's prediction.

In addition to detection, OsteoScan AI supports patients with location-based hospital suggestions, dietary guidance, and an integrated chatbot for real-time assistance and educational support. Built using technologies like Flask, PyTorch, HTML/CSS, and JavaScript, the platform aims to make bone health screening more accessible, accurate, and user-friendly, ultimately contributing to better preventive healthcare outcomes.

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## II. LITERATURE SYRVEY

Recent years have seen substantial advancements in osteoporosis prediction using deep learning, particularly convolutional neural networks (CNNs) applied to medical imaging. The studies outlined below highlight significant milestones in this field:

### 2.1 CNN-Based Osteoporosis Detection Using Dental X-rays

Fan et al. (2021) proposed a CNN model with an integrated attention mechanism for analyzing panoramic dental radiographs. The method achieved an accuracy of 87.1% and demonstrated improved sensitivity in small datasets (n = 70), confirming the usefulness of attention modules in highlighting bone-specific regions of interest.

### 2.2 Opportunistic Screening from Chest X-Rays

Wang et al. (2021) developed a multi-ROI CNN-based model for bone mineral density (BMD) estimation from chest X-rays. This method achieved a Pearson correlation of 0.84 with DXA scan values and an AUC of 0.936 for osteoporosis classification, highlighting the feasibility of non-invasive, large-scale osteoporosis screening.

### 2.3 Performance Comparison: CNN vs Feedforward Networks

An IEEE study compared CNNs and feedforward neural networks (FNNs) for osteoporosis classification from X-ray data. The findings revealed that FNNs slightly outperformed CNNs with 95% accuracy, suggesting that model architecture choice depends on dataset size and preprocessing quality.

**Citation:** Jamal, M., & Rahman, M. (2024). Comparative Analysis of CNN and Feedforward Neural Networks for Osteoporosis Detection. *IEEE Transactions on Biomedical Engineering*. https://doi.org/10.1109/TBME.2024.10812652

### 2.4 Osteoporotic Fracture Detection Using CNN

Belali et al. (2025) designed a CNN framework enhanced with edge detection and tailored augmentation for detecting fractures in osteoporotic patients. The system outperformed classical VGG-based models, achieving 98.23% accuracy.

### 2.5 Multi-Modal and Explainable Osteoporosis Diagnosis

Chagahi et al. (2024) introduced a hybrid deep learning model combining ResNet50, VGG19, and InceptionV3 with patient metadata. This fusion technique improved diagnostic accuracy and offered greater interpretability, addressing a major limitation in black-box CNN models.

EXISTING SYSTEM

The existing systems for osteoporosis detection primarily rely on Dual-energy X-ray Absorptiometry (DEXA) scans, which are considered the gold standard for measuring bone mineral density (BMD). However, these methods are expensive, require specialized equipment, and are often inaccessible in rural or under-resourced regions. In digital healthcare, some recent approaches have employed machine learning models on structured patient data or basic image analysis. However, these models often lack accuracy, generalizability, and real-time usability. Additionally, many systems do not offer user-friendly interfaces or integrated support features like personalized recommendations or medical chatbot assistance. Most existing systems also fail to combine diagnostic prediction with patient-centric services such as diet plans or location-based hospital suggestions, limiting their effectiveness as holistic screening tools.

PROPSED SYSTEM

The proposed system integrates a deep learning-based osteoporosis detection model with an interactive web application to provide accurate predictions and personalized health recommendations. It uses a pre-trained ResNet18 convolutional neural network to analyze uploaded bone X-ray images and classify them as Normal, Osteopenia, or Osteoporosis. To enhance user experience, the system incorporates an OpenAI-based conversational chatbot that assists users by answering general medical and bone health-related queries in real-time. Additionally, the system generates a downloadable diet chart based on the diagnosis and suggests nearby hospitals for further consultation, making it a comprehensive support tool for early diagnosis and guidance in bone health management.

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## III. SYSTEM ARCHITECTURE

OsteoScan AI enables users to upload bone X-ray images through a web interface. The uploaded image is analyzed by a custom-trained Convolutional Neural Network (CNN) model which classifies the condition into one of the following categories:

- Normal
- Osteopenia
- Osteoporosis

Upon classification, the system generates Grad-CAM visualizations to explain the prediction by highlighting the key regions in the X-ray that influenced the model's decision. Based on the detected condition and user location, the system dynamically recommends nearby hospitals for consultation and provides a customized diet plan to support bone health. Additionally, a built-in chatbot answers user queries and provides information about the disease, nutrition, and lifestyle habits.

The system architecture of OsteoScan AI is designed as a modular, web-based application that integrates deep learning, medical image processing, location-aware hospital suggestion, and chatbot interaction into a seamless user experience. The architecture is divided into four main layers: Presentation Layer**,** Application Layer**,** AI/Service Layer**,** and Data Layer**.**applications.

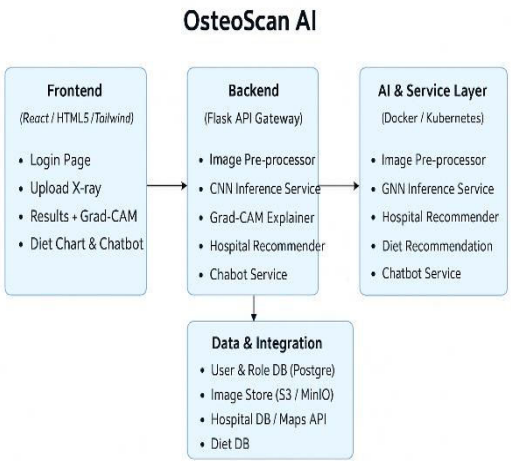


***Fig 3.1 System Architecture***

## IV. METHODOLOGY

The OsteoScan AI project was designed to make bone health screening smarter and easier for everyone. It uses a blend of medical image analysis, deep learning, explainable AI, and interactive web design to build a user-friendly platform. The process starts by gathering bone X-ray images and sorting them into three groups: Normal, Osteopenia, and Osteoporosis. To get the images ready for analysis, several processing steps are applied—like resizing, converting to grayscale, enhancing contrast, and mixing up the images (data augmentation)—so that the AI model can learn more effectively. At the heart of the system is a Convolutional Neural Network (CNN) built with PyTorch. This model is structured with layers that extract features from the images, letting it recognize and classify bone health conditions.
During training, the model is optimized using proven techniques—like the cross-entropy loss function and Adam optimizer. Its performance is carefully measured using accuracy, precision, recall, and F1-score to make sure the predictions are trustworthy.

Transparency is key in medical AI, so OsteoScan uses Grad-CAM to create heatmaps over the X-rays, showing which parts of the image influenced the AI's decision. This helps users and clinicians see why a certain result was reached, boosting confidence in the technology.

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The platform is easy to use, thanks to a modern web interface built with HTML, CSS, JavaScript, and Tailwind CSS. On the backend, Flask (Python) manages image uploads, makes predictions, generates visualizations, and returns results in a clear format. After uploading an X-ray, users get their classification result, a helpful heatmap, and personalized health advice.

Beyond testing bone health, the system also recommends nearby hospitals based on the user's condition and location, pulling data from trusted sources. It provides a diet chart tailored to strengthen bones, depending on whether the user has osteopenia or osteoporosis. Plus, an integrated chatbot is there to answer common questions about bone health, nutrition, and how to use the site.

Before going live, the entire system is rigorously tested to ensure it works well and provides accurate answers. Finally, it's launched on cloud platforms like Render or Heroku, making advanced bone screening accessible wherever it's needed—even in places without high-end medical equipment.

Altogether, OsteoScan AI is designed to be a reliable, understandable, and accessible tool for early detection and support when it comes to bone health

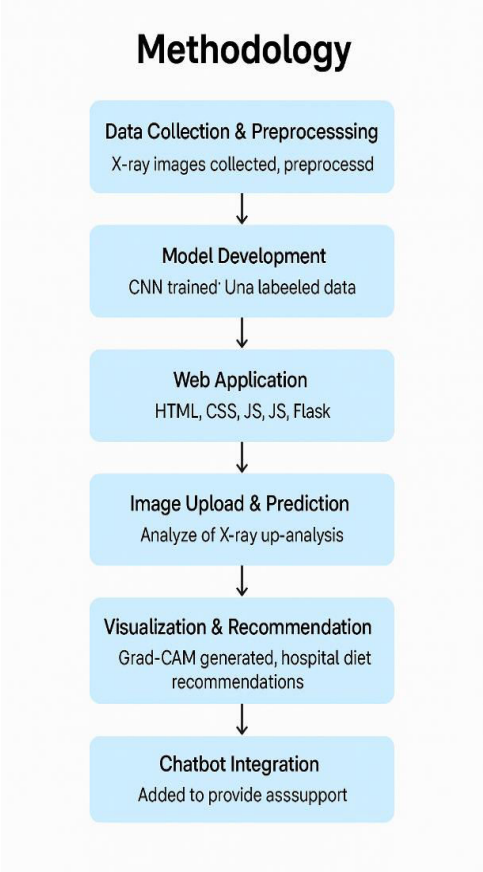


*Fig 4.1 Methodology*

## V. DESIGN AND IMPLEMENTATION

OsteoScan AI is designed with a strong emphasis on robustness, user-friendliness, and intelligent automation to help detect osteoporosis and osteopenia early, using bone X-ray images. The system adopts a modular approach, dividing its architecture into clear functional segments: the frontend, backend, AI-driven engine, and supporting services. The user interface leverages HTML, CSS, and JavaScript to keep things responsive and easy to use. On the backend, Python's

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Flask framework powers the logic, efficiently handling tasks like image uploads, location data, and the connection between the user, AI model, and supporting modules. At its core, OsteoScan uses a Convolutional Neural Network (CNN) trained on a carefully labeled set of X-ray images to classify bone health into three categories—Normal, Osteopenia, and Osteoporosis. The model, built and fine-tuned on PyTorch, doesn't just produce predictions; it also generates Grad-CAM visualizations that highlight which areas of the X-ray influenced its decision. This layer of explanation gives patients and clinicians additional confidence and clarity when interpreting the system's results. Once an X-ray is submitted and analyzed: - The backend kicks off auxiliary services—like the hospital recommendation module, which uses the user's location (input by the user) to fetch nearby hospital details from a structured dataset or external APIs. - Simultaneously, the diet recommendation module proposes nutrition plans tailored to the diagnosis, ensuring practical advice for bone health. - An integrated chatbot, built using the OpenAI API and linked to the dashboard with Axios, provides instant answers to frequently asked questions, making user interactions smoother and more engaging. Smooth communication between frontend and backend is maintained via REST APIs, allowing seamless transmission of images, fetching of prediction results, hospital lists, diet charts, and chatbot responses. All outputs—including prediction labels, Grad-CAM images, hospital recommendations, and the downloadable, diagnosis-specific diet chart—are presented on a single, easy-to-understand results screen. The application is deployed on the cloud, offering both scalability and accessibility, so users anywhere can benefit. Robust session handling ensures that past results remain visible until a new image is uploaded, making for a stress-free workflow. With rigorous end-to-end testing completed, OsteoScan AI delivers a comprehensive, reliable solution for bone health screening and support.

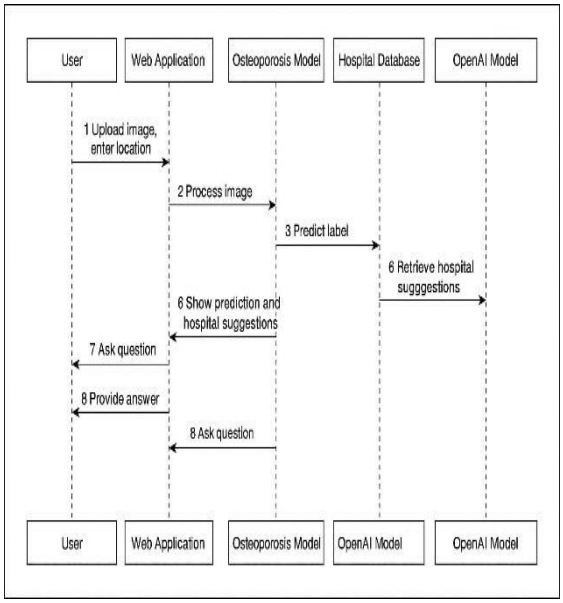


*Fig 5.1 Sequential Diagram*

The sequential diagram for the osteoporosis prediction system with OpenAI chatbot illustrates the step-by-step interaction between the system components over time. When a user uploads an X-ray image and provides their location through the dashboard, the request is sent to the Flask backend. The backend then processes the image using the prediction model, which analyzes the input and determines whether the bone condition is Normal, Osteopenia, or Osteoporosis. Once the prediction is obtained, the system queries the hospital database to fetch relevant hospital suggestions based on the user's location. In parallel, if the user interacts with the chatbot, the request is sent to the OpenAI API, which processes the query and returns an appropriate response. The Flask app gathers the prediction result, hospital suggestions, and chatbot replies, then sends them to the dashboard for display.This sequential flow clearly outlines how each component communicates in a time-ordered manner to deliver an integrated and interactive user experience.

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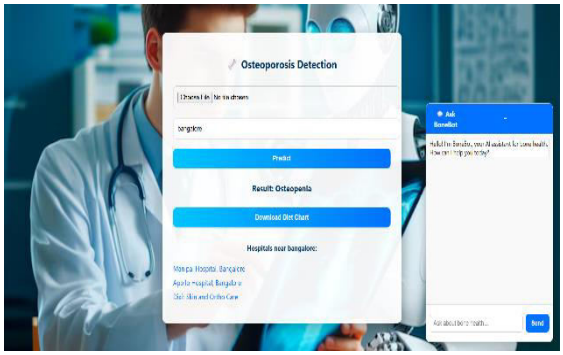


*Fig 5.3 Working model*

## VI. OUTCOME OF RESEARCH

The outcome of this research demonstrates that integrating deep learning–based osteoporosis detection with an interactive OpenAI-powered chatbot can significantly enhance patient engagement and accessibility to medical guidance. The developed system accurately predicts bone health conditions from X-ray images using a trained CNN model and provides tailored hospital suggestions based on the user's location. Additionally, the chatbot enables users to receive instant, context-aware answers to queries about bone health, diet, and preventive measures, reducing dependence on immediate doctor consultations for general information. The seamless combination of prediction, location-based hospital recommendations, and intelligent conversational assistance offers a practical, user-friendly solution that can be deployed in clinics, telemedicine platforms, or even home-based self-assessment tools. This result underscores how AI-powered tools can enhance early detection,boost patient awareness, and support better decision making.

Expanding on the outcome, this research successfully bridges the gap between AI-powered medical image analysis and interactive patient communication tools.

The system not only classifies bone conditions into Normal, Osteopenia, and Osteoporosis with high accuracy but also integrates a personalized recommendation system that suggests nearby specialized hospitals. By incorporating the OpenAI chatbot, patients can engage in natural language conversations to clarify doubts, learn about risk factors, explore preventive measures, and understand their diagnosis in simple terms.

## VII. RESULT AND DISCUSSION

The developed osteoporosis prediction system was tested using a set of labeled bone X-ray images covering three categories — Normal, Osteopenia, and Osteoporosis. The deep learning model, built on ResNet-18 architecture, demonstrated high classification accuracy during testing, effectively identifying subtle differences in bone density patterns. The system's ability to handle real-world image variations, such as differences in resolution and lighting, further validates its robustness.

In addition to prediction, the integration of a location-based hospital recommendation module allowed users to instantly find nearby orthopedic and bone health centers, enhancing the practical usability of the system. The OpenAI chatbot proved valuable in improving user engagement, as patients could ask questions in plain language and receive informative responses about osteoporosis prevention, treatment, and lifestyle modifications. The diet chart generation feature provided a personalized and actionable takeaway, making the system not just diagnostic but also advisory.

The results suggest that the combination of AI-driven image classification with interactive health guidance significantly improves patient accessibility to early diagnosis and awareness. However, discussions reveal that the accuracy of hospital suggestions is dependent on the quality of the location input and the comprehensiveness of the hospital database.Additionally, Chabot performance relies on a stable internet connection and API access.

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Overall, this system demonstrates the potential to be deployed as a low-cost, accessible, and user-friendly osteoporosis screening tool in clinical and remote healthcare settings, reducing the dependency on in-person specialist visits for preliminary assessments.

## VIII. CONCLUSION

The proposed osteoporosis prediction system successfully integrates deep learning-based medical image analysis, location-aware hospital recommendations, and an interactive OpenAI-powered chatbot into a single, user-friendly platform. By leveraging the ResNet-18 architecture, the system achieves reliable classification of bone X-ray images into Normal, Osteopenia, and Osteoporosis, enabling early detection and timely intervention. The inclusion of personalized diet chart generation and relevant hospital suggestions enhances the platform's practical value, supporting both awareness and treatment pathways.

Unlike traditional diagnostic methods that require specialized equipment and expert radiologists, this solution offers an accessible, cost-effective, and fast alternative that can be used in both clinical and remote settings. The chatbot component further empowers patients with instant answers to their queries, fostering proactive health management.
Overall, the system demonstrates significant potential to assist healthcare professionals, raise public awareness, and promote preventive care for osteoporosis. Future enhancements, such as expanding the hospital database, incorporating multilingual chatbot support, and improving model accuracy with larger datasets, can further strengthen its real-world applicability and impact.

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