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Osteoarthritis detection system using transfer learning

Ibrahim siraj p[1], dr valsamma k m[2]
[1]pg scholar, dept. Of cse, royal college of engg. & tech., trissur, kerala, india
[2]professor, dept. Of cse, royal college of engg. & tech., trissur, kerala, india
***Email:** ibrahimsirajp@gmail.com [1], valsammakm@royalcet.ac.in[2]*

Abstract
Osteoarthritis is a degenerative joint disease that leads to cartilage deterioration, pain, stiffness, and reduced mobility, particularly in the knee joint. Early detection of osteoarthritis is important for preventing severe joint damage and improving treatment outcomes. Traditional diagnosis mainly depends on manual interpretation of knee x-ray images by radiologists, which can be time-consuming and may lead to variations in diagnosis. To address this challenge, this study proposes an automated osteoarthritis detection system using deep learning techniques. The proposed system utilizes the efficientnetb0 convolutional neural network model to analyze knee x-ray images and classify the severity of osteoarthritis. Image preprocessing techniques are applied to enhance image quality before training the model. The trained model categorizes knee x-ray images into three classes: healthy, moderate, and severe. A web-based application developed using python, django, and mysql allows users to upload knee x-ray images and obtain prediction results with confidence scores. In addition to automated detection, the system provides exercise recommendations, diet plans, and doctor appointment booking features to assist patients in managing osteoarthritis effectively. Experimental results show that the efficientnetb0 model achieves an accuracy of approximately 0.97, demonstrating its effectiveness for medical image classification and osteoarthritis detection.

***Keywords:** osteoarthritis detection, deep learning, efficientnetb0, knee x-ray classification, medical image analysis.*

1. Introduction
Osteoarthritis is one of the most common musculoskeletal disorders affecting millions of individuals worldwide and is a leading cause of disability among older adults. The disease occurs due to the gradual degeneration of cartilage that cushions the joints, leading to pain, stiffness, swelling, and limited joint movement. The knee joint is particularly susceptible to osteoarthritis because it supports most of the body's weight during daily activities such as walking, standing, and climbing stairs. As the condition progresses, the protective cartilage between bones gradually wears down, causing bones to rub against each other and resulting in severe joint damage and discomfort. Early detection of osteoarthritis is therefore essential to slow down disease progression and improve patient quality of life. In clinical practice, osteoarthritis is typically diagnosed using medical imaging techniques such as x-ray and magnetic resonance imaging. Among these methods, knee x-ray imaging is widely used due to its availability and cost-effectiveness. However, the manual interpretation of x-ray images relies heavily on the expertise of radiologists and may sometimes lead to subjective variations in diagnosis. With the rapid advancement of artificial intelligence and deep learning technologies, automated medical image analysis has emerged as an effective solution for improving diagnostic accuracy and efficiency. Deep learning models, particularly convolutional neural networks, have demonstrated strong capabilities in extracting meaningful features from images and performing accurate classification tasks. In this work, an automated osteoarthritis detection system is developed using the efficientnetb0 deep learning architecture to analyze knee x-ray images and classify them into healthy, moderate, and severe categories. The system also includes a web-based dashboard that allows users to upload x-ray images and receive automated diagnostic predictions along with additional healthcare recommendations.

2. Methods

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2.1.Convolutional neural network (cnn)

Convolutional neural networks (cnns) are widely used in deep learning for image classification and medical image analysis because of their ability to automatically learn hierarchical features from images. A cnn architecture typically consists of convolution layers, pooling layers, and fully connected layers that work together to extract meaningful[1] patterns from input images. The convolution layers identify important visual features such as edges, textures, and shapes, while pooling layers reduce the dimensionality of the feature maps and improve computational efficiency. The fully connected layer performs the final classification based on the extracted features. In this research, cnn techniques are applied to analyze knee x-ray images and detect patterns associated with osteoarthritis severity. The use of cnn enables the system to learn complex visual characteristics of medical images and perform accurate classification without requiring manual feature extraction[2].

2.2. efficientnetb0 architecture

Efficientnetb0 is a modern convolutional neural network architecture designed to achieve high accuracy while maintaining computational efficiency. The efficientnet model family uses a compound scaling method that simultaneously scales network depth, width, and input resolution in a balanced manner. This scaling strategy allows efficientnet models to achieve better performance compared to traditional cnn architectures with fewer parameters and lower computational cost. In this study, efficientnetb0 is used as the primary model for osteoarthritis classification because of its ability to extract meaningful image features effectively. The model is implemented using transfer learning, where pretrained weights[3] from large image datasets are utilized to improve feature learning. This approach helps the model adapt quickly to the task of analyzing knee x-ray images and detecting osteoarthritis severity levels.

2.3. dataset collection

The dataset used in this research consists of knee x-ray images representing different stages of osteoarthritis. These images are categorized into three classes: healthy, moderate, and severe. Each category represents a different level of cartilage damage and joint degeneration in the knee joint. The dataset is divided into training and validation sets to ensure that the model learns effectively while also being evaluated on unseen data. Proper dataset organization and labeling are important for enabling the deep learning model to correctly identify patterns that distinguish between the different osteoarthritis stages.

2.4.Image preprocessing

Image preprocessing is an essential step in preparing medical images for deep learning analysis. In this study, several preprocessing techniques are applied to improve the quality and consistency of the dataset. All knee x-ray images are resized to a fixed input dimension of 224 × 224 pixels to match the input requirements[4] of the efficientnetb0 architecture. Pixel normalization is applied to scale the intensity values within a consistent range, which helps stabilize the training process and improve convergence. These preprocessing steps allow the model to focus on relevant structural features in the x-ray images and improve the overall performance of the classification system[5].

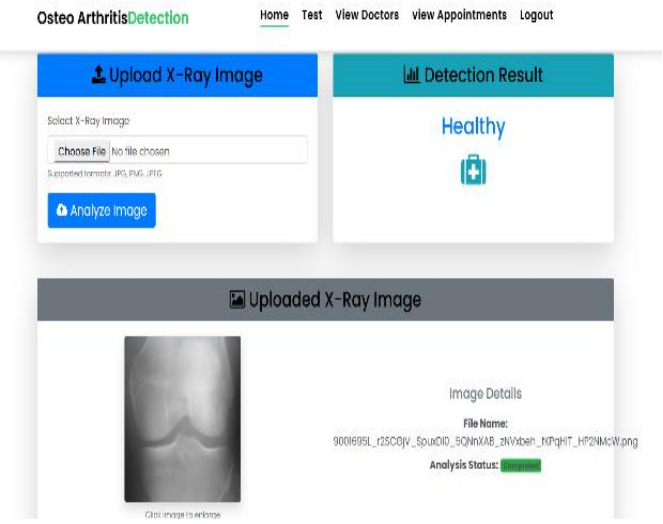

Figure 1 uploading x-ray

2.5.Model training

The efficientnetb0 model is trained using the prepared knee x-ray dataset to learn patterns

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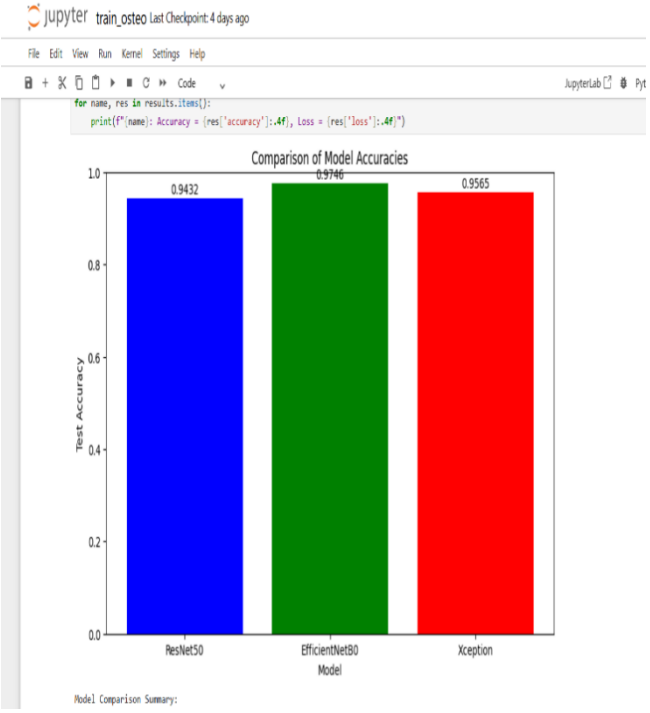
associated with osteoarthritis severity. During the training process, the dataset is fed into the model for multiple iterations known as epochs. In this study, the model is trained for 30 epochs to allow sufficient learning of relevant image features. The adam optimizer is used to update the model weights during training because it provides efficient and stable optimization for deep learning models[6]. The loss function used is sparse categorical cross-entropy, which measures the difference between the predicted class labels and the actual labels. As training progresses, the model adjusts its parameters to minimize prediction errors and improve classification accuracy[7].

Figure 2 model training

2.6.Model comparison and selection

To determine the most suitable model for osteoarthritis detection, three pretrained convolutional neural network architectures were evaluated: resnet50, efficientnetb0, and xception. Each model was trained using the same dataset, preprocessing techniques, and training parameters to ensure a fair comparison. After training, the performance of the models was evaluated using accuracy[8] and loss metrics. The results show that the resnet50 model achieved an accuracy of approximately 0.9432, while the xception model achieved an accuracy of around 0.9565. Among the evaluated models, efficientnetb0 achieved the highest accuracy of approximately 0.9746. The superior performance of efficientnetb0 can be attributed to its compound scaling approach, which improves feature extraction and classification capability. Based on this comparison, efficientnetb0 was selected as the final model for the osteoarthritis detection system[9].



2.7.Osteoarthritis detection and prediction

After the training and model selection process, the efficientnetb0 model is used for automated detection and prediction of osteoarthritis severity. When a knee x-ray image is provided as input, the system first applies preprocessing techniques to resize and normalize the image. The processed image is then passed to the trained efficientnetb0 model, which analyzes the visual features of the x-ray and predicts the severity level of osteoarthritis. The prediction results are classified into three categories: healthy, moderate, and severe. In addition to the predicted class label, the system also provides a confidence score indicating the reliability of the prediction result[10].

3. Results and discussion

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3.1. results

The performance of the proposed osteoarthritis detection system was evaluated using multiple deep learning architectures trained on the same knee x-ray dataset. The models considered in this study include resnet50, efficientnetb0, and xception, which are widely used convolutional neural network architectures for image classification tasks. All models were trained using identical preprocessing techniques and training parameters to ensure a fair comparison. The training process was conducted for 30 epochs using the adam optimizer and sparse categorical cross-entropy loss function. The experimental results indicate that each model demonstrated strong classification capability in detecting osteoarthritis severity from knee x-ray images. The resnet50 model achieved an accuracy of approximately 0.9432, while the xception model achieved an accuracy of approximately 0.9565. Among the evaluated models, the efficientnetb0 architecture achieved the highest classification accuracy of approximately 0.9746. The comparison results show that efficientnetb0 provides improved performance due to its efficient scaling mechanism and enhanced feature extraction capability. Based on these results, efficientnetb0 was selected as the final model for the osteoarthritis detection system.

4. Discussion

The results of this study demonstrate that deep learning techniques can effectively analyze knee x-ray images and detect osteoarthritis severity with high accuracy. The comparison of three different convolutional neural network architectures shows that efficientnetb0 outperforms resnet50 and xception in terms of classification accuracy and overall model efficiency. The improved performance of efficientnetb0 can be attributed to its compound scaling approach, which balances network depth, width, and image resolution, allowing the model to capture more informative image features. The high accuracy achieved by the model indicates that the proposed system can reliably classify knee x-ray images into healthy, moderate, and severe categories. Furthermore, the integration of the trained model into a web-based application enables real-time prediction and provides a user-friendly interface for healthcare professionals and patients. The system not only performs automated detection but also offers additional support features such as exercise recommendations, dietary suggestions, and doctor appointment booking, which can assist patients in managing osteoarthritis more effectively. These results highlight the potential of deep learning-based medical imaging systems to support clinical decision-making and improve early diagnosis of osteoarthritis.

Conclusion

This research presents an automated osteoarthritis detection system based on deep learning techniques for analyzing knee x-ray images. The proposed approach utilizes the efficientnetb0 convolutional neural network model to classify osteoarthritis severity into three categories: healthy, moderate, and severe. The model was trained for 30 epochs and compared with other deep learning architectures including resnet50 and xception. Experimental results demonstrate that efficientnetb0 achieved the highest classification accuracy of approximately 0.97, indicating its effectiveness in extracting relevant features from medical images. The trained model was integrated into a web-based platform developed using python, django, and mysql, allowing users to upload knee x-ray images and obtain automated prediction results. In addition to disease detection, the system provides supportive healthcare features such as exercise recommendations, diet plans, and doctor appointment booking options to help patients manage osteoarthritis more effectively. The proposed system therefore offers a reliable and efficient ai-based solution that can support healthcare professionals in early diagnosis and decision-making for osteoarthritis treatment.

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