

Title: Interpretable Deep Learning for Musculoskeletal Radiograph Classification: Optimizing CNN Architectures with Explainable Insights

Author names: H. G. S. I. Bandara, A. W. M. A. S. Wanninayaka, Risath Athamlebbe, M. N. M. Aashiq & Rahimi A. Rahman

Abstract: X-ray radiography, in the form of medical imaging, exists the basis for the diagnosis of musculoskeletal disorders. However, manual interpretation by radiologists is not only time-consuming but also inconsistent, thus automated deep learning-based classification becomes inevitable. This study indeed applies Convolutional Neural Networks (CNNs) to classify musculoskeletal radiographs from the MURA dataset which contains 5,107 X-ray images. To evaluate and validate the performance of the four deep learning models VGG19, Xception, MobileNetV2, and ConvNeXtBase, the following classification performance measures were used: Recall, Precision, and F1-score. Among these models, MobileNetV2 turned out to be the best baseline with an F1-score of 0.92. The application of hyperparameter optimization with the increased learning rate, dropout, and L 2 regularization has resulted in the score increase to 0.94. The preprocessing techniques included auto-orientation, resizing, and data augmentation (which consisted of blurring, rotation, shearing, and adding noise) and all these contributed to the model's generalize ability. To strengthen clinical validity, the interpretability methods Local Interpretable Model-Agnostic Explanations (LIME), Saliency Maps, and Gradient-weighted Class Activation Mapping (Grad-CAM) were combined to facilitate the visual representation of the model's focus on clinically relevant anatomical structures. These techniques corroborated the model's attention to the joint and bone areas, corresponding to the radiology proficiency. The fine-tuned MobileNetV2 model together with interpretability has a high accuracy and computational efficiency property, thus being clinically appropriate for the support of radiologists. This method keeps improving diagnostic accuracy, decreases workload, and propels AI-based medical image analysis for the identification of musculoskeletal disorders.

Keywords: Deep learning, Musculoskeletal system Visualization, Accuracy, Computational modeling

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