

Development of a Radiograph Database and Pretrained Deep Learning Model for Primary Bone Tumor Classification

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Abstract

Primary bone tumors are relatively rare, but delayed or inaccurate diagnosis of malignant lesions can substantially affect patient prognosis. Artificial intelligence has shown potential for assisting radiographic diagnosis; however, the development of robust diagnostic models is limited by the lack of dedicated, well-annotated bone tumor datasets and the relatively small number of malignant cases. This study aimed to construct a primary bone tumor radiograph database and develop a pretrained deep learning model for classifying normal bone images, benign bone tumors, and malignant bone tumors. We established the Bone Tumor X-ray Radiograph Dataset (BTXRD), an open-access dataset comprising 3,745 radiographs, including 1,879 normal images, 1,524 benign tumor images, and 342 malignant tumor images. All tumor radiographs were annotated with pathological categories, tumor subtypes, anatomical sites, bounding boxes, and segmentation masks. To improve classification performance under limited-data conditions, a ResNet-based musculoskeletal foundation model was first pretrained on approximately 40,000 radiographs from the MURA dataset and subsequently fine-tuned on BTXRD to develop the ResNet-FM classification model. A directly trained ResNet model without musculoskeletal pretraining was used as the comparator. Model performance was evaluated using five-fold cross-validation and an independent validation set. ResNet-FM consistently outperformed the directly trained model and achieved areas under the receiver operating characteristic curve of 0.845, 0.969, and 0.904 for benign tumors, malignant tumors, and normal bone images, respectively. Compared with the directly trained model, these values increased by 12.8, 7.2, and 7.7 percentage points, respectively. Explainability analysis further showed that ResNet-FM focused more accurately on tumor-related regions. The construction of BTXRD provides a standardized resource for bone tumor radiograph research, while musculoskeletal radiograph pretraining significantly improves the classification performance and interpretability of deep learning models. This approach may support more accurate and efficient radiographic assessment of primary bone tumors in clinical practice.

Keywords

Primary Bone Tumor, Radiography, Artificial Intelligence, Deep Learning, Transfer Learning, Image Classification