



## **Iterations on a Classic: A Novel Machine Learning Algorithm for the Establishment of Pediatric Bone Age Using Knee Radiographs**

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### **Introduction/Background**

It is common practice for orthopedic surgeons to obtain a radiograph of the left hand to estimate bone age for planning surgical interventions of the knee in pediatric patients, as those interventions are based on skeletal age rather than chronological age. We created a novel deep learning (DL) algorithm that determines skeletal age based on radiographs of the knee.

### **Methods/Intervention**

We identified a total of 7,336 radiographs of the knee acquired among 5,701 pediatric patients under 18 years of age, acquired between January 2018-January 2024. The images included a range of normal images and images with pathology. The following views were used to train (80% of total), tune (10% of total) and test (10% of total) the model: 1167 right 2 views, 1252 left 2 views, 768 right 3 views, 831 left 3 views, 1,282 right 4+ views, 1,280 left 4+ views. Patients with more than one study were placed in the same cohort in order to prevent data leakage. We developed a view-agnostic multimodal deep learning model using an intermediate fusion approach. Our model employed a 2D DenseNet121 as the imaging feature extractor and two shallow neural networks. The first shallow neural network transformed patient sex into the imaging feature space, while the second neural network merged and processed the imaging features along with the transformed sex features to predict bone age in months. We used mean squared error as the loss function and co-trained all the neural networks with the AdamW optimizer. The model's performance was evaluated on the test set using the mean absolute error (MAE) metric.

### **Results/Outcome**

The mean patient age was 13.4 years, with a STD of 3.5 years. The model showed a MAE of 9.7 months on the test cohort.

### **Conclusion**

A view agnostic multimodal DL algorithm can estimate bone age from radiographs of the knee, with higher accuracy than published references.

### **Statement of Impact**

This ML algorithm may enable clinicians to forgo the routinely obtained left hand radiograph for skeletal bone age.

### **Keywords**

Bone age; Regression algorithms; CNN