Assessment of bone age using artificial intelligence in children and adolescents across different ethnicities

Ladkat Arnav, Goel Pranay, Lars Sävendahl, Tim Aeppli, Oza Chirantap and Khadilkar Anuradha

email address: arnav.Ladkat@gmail.com

Introduction

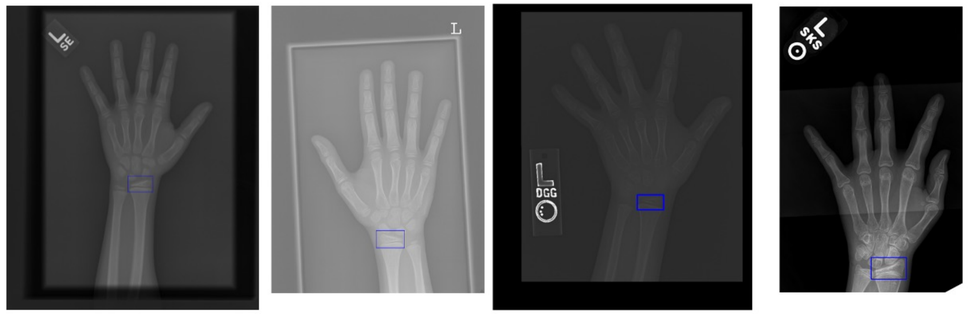
- There are several methods for bone age assessment (BA), such as the Greulich-Pyle and Tanner-Whitehouse. However, these are time-consuming, require expertise, and can be subjective. Systems using artificial intelligence (AI) to assess BA from hand radiographs are likely to be objective and efficient.
- This study aims to develop, validate, and test the efficacy of an AI-based segmentation system for isolating and identifying individual bones in an X-ray image used to identify an individual's bone age.
- The system is evaluated against the differences in exposure in the Images, age, ethnicity, the image's orientation, and the presence of overlapping bones in the X-ray.

Methods

- The Radial Epiphysis is a vital bone that helps determine a child's bone age, we focus on reliably segmenting the portion of the X-ray image that contains the radial epiphysis.
- An AI System using Convolutional Neural Networks(CNNs) segments the Radial Epiphysis from an X-ray image . A "benchmark" dataset is defined, including the Radiological Society of North America (RSNA) data for boys between 9 and 14 years of age.
- We use 250 randomly chosen images from the benchmark dataset to annotate and label the Radial Epiphysis; 200 of these images are used for Training and 50 are used for validation of the model. The model uses a Resnet34 architecture.

Results

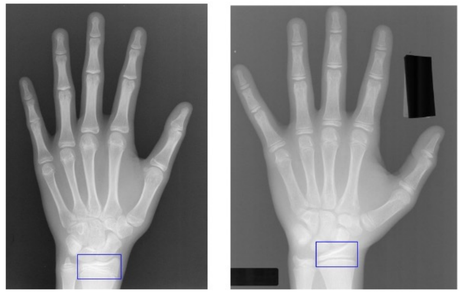
- The Segmentation model locates the ROI (Region of Interest), i.e., the Radial Epiphysis, and generates a Bounding box around it.
- A custom pixel to pixel matching accuracy algorithm gives us a training accuracy of 99.85% and a validation accuracy of 99.71 percent, which gives us excellent results on all the images from the benchmark dataset.
- The segmentation results are shown in the images below, denoted by a blue bounding box created by the model around the Radial Epiphysis.



(i) M - 108 (ii) F - 78 (iii) M - 52 (iv) F - 174

(F,M) : Female, Male. :- Number corresponds to months

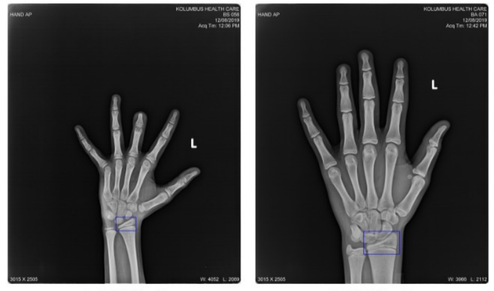
Fig A: Results on the RSNA Dataset



(v) ASF-13 [years] (vi) BLKM - 13 [years]

[ASF : Asian Female, BLKM : Black Male]

Fig B: Results on the UCSD Dataset



(vii) BS 58 - Ff (viii) BA 71 - M

Fig C : Results on the Indian Dataset [Pune]

Results

- The Segmentation model's robustness is verified against X-ray Images from:
  1. RSNA dataset that are outside of the benchmark dataset [Fig. A : (ii) ,(iii) and (iv)]
  2. UCSD: Digital Hand Atlas [Fig. B]
  3. Indian dataset (Pune Bone Age Dataset) [Fig. C]
- As observed in Fig A : (ii),(iii), and (iv), the model responds well to change in the orientation of the hand , flipped images and changes in exposure of the image. Images with an overlap in Radial epiphysis bones are also segmented without any discrepancies.
- The model performs accurately on X-rays from all ethnicities from the UCSD dataset, including the X-ray images of Indian Children [Fig. B and C]
- The Model Performs Satisfactorily on X-rays of subjects below 60 months of age even though there is a gap between approximately four years between the training data and set of images below 60 months of age.

Conclusions

We have shown that the model successfully segments the radial epiphysis in the real-world scenarios evaluated in the study. Our literature survey for this study finds that the study is the first to use isolated bones to evaluate bone age using an automated system; this marks an important benchmark in automated bone age assessing systems. We plan to use this segmentation model to assess bone age in a new hybrid method.

References

1. Halabi SS, Prevedello LM, Kalpathy-Cramer J, et al. The RSNA Pediatric Bone Age Machine Learning Challenge. Radiology 2018; 290(2):498-503.
2. https://www.rsna.org/education/ai-resources-and-training/ai-image-challenge/RSNA-Pediatric-Bone-Age-Challenge-2017
3. Gertych, Arkadiusz et al. "Bone age assessment of children using a digital hand atlas." *Computerized medical imaging and graphics : the official journal of the Computerized Medical Imaging Society* 31 4-5 (2007): 322-31 .

No Conflicts of Interest