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Simultaneous Automatic Carpal Bone Segmentation on Wrist AP and Lateral Images Using Deep-Learning Model Trained With Digitally Reconstructed Radiographs From CT

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Abstract:
***Purpose:** Accurate bone segmentation is essential for the quantitative measurement of various orthopedic parameters. However, determining the precise boundary of small carpal bones on plain radiographs is challenging due to the overlap of structures. Digitally reconstructed radiography (DRR) is a synthetic X-ray generated from CT by projecting 3D volumetric data onto a 2D plane. In this study, we trained a deep-learning model using DRRs to simultaneously segment carpal bones on the wrist anteroposterior (AP) and lateral images.
***Methods and Materials:** One hundred and thirty-six patients who underwent wrist CT were included in this study, and four bones (distal radius, distal ulna, scaphoid, and lunate) were manually segmented on the CT images using a threshold-based semi-automated method. DRRs were generated from the CT images using volume rotation and ray casting methods, and a corresponding 2D mask for the DRR images was created by the maximum intensity projection method from the bone segmentation mask. We obtained both AP and lateral training data simultaneously from the same CT segmentation data. An ensemble model of UNet++ and Multi-Scale Attention Network (MANet) was trained and evaluated using 10-fold cross-validation. The performance of the segmentation model was evaluated using the Dice similarity coefficient (DSC) and intersection over union (IoU).
***Results:** The deep learning model demonstrated excellent performance in segmenting carpal bones on the AP images, with mean DSC and IoU scores of 0.97 and 0.93 for the distal radius, and 0.93 and 0.87 for the distal ulna, respectively. The segmentation accuracy for the scaphoid and lunate were also relatively high on the AP images, with mean DSC scores of 0.91 and 0.88, and mean IoU scores of 0.83 and 0.78, respectively. On lateral images, the deep-learning model also showed good performance for distal radius and ulna, with a DSC of 0.96 and an IoU of 0.92 for the distal radius, and a DSC of 0.90 and an IoU of 0.82 for the distal ulna. However, the deep learning model showed slightly lower performance for scaphoid and lunate, with a DSC of 0.83 and 0.88, and IoU of 0.71 and 0.79, respectively.
***Conclusions:** In conclusion, the deep-learning model trained on DRRs demonstrated excellent segmentation performance of carpal bones on AP images. However, the segmentation model showed slightly lower performance on lateral images, especially for small bones such as scaphoid.
***Clinical Relevance/Application:** The deep-learning based bone segmentation model developed in this study can potentially facilitate the quantitative evaluation of various orthopedic parameters that rely on accurate bone segmentation, such as bone mineral density, joint space width, and bone alignment.

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Has this work been previously presented or published?: No
2nd Format Opportunity: Yes, I would be interested if accepted to showcase my work in an additional format (2 meter Hardcopy Backboard).

Attached Files: DRR WRIST SEGMENTATION (PDF, 108387 bytes)

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