Artificial Intelligence for Automated Segmentation of CT Scans of Intra-Articular Fractures

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Purpose: Artificial intelligence (AI) is believed to change the scope of medicine, as the introduction of smartphones changed our day-to-day life. In orthopaedic trauma, AI shows promising results and already performs on a human level in recognizing fractures on plain radiographs taken in the emergency department of patients with wrist , hand, and ankle injuries with 83% accuracy. To the best of our knowledge, AI has not been studied in the setting of more advanced imaging (ie, CT). The purpose of this study was to evaluate accuracy of a first AI algorithm to automatically segment and reconstruct CT scans into 3-dimensional (3D) surface rendered models.

Methods: All CT scans were manually segmented and reconstructed into 3D surface rendered models according to current standards and served as the reference standard for the current study. The AI algorithm automatically segmented all 348 2D CT scans by using 2 AI deep-learning algorithms into 3D surface rendered models. The deep-learning model for automatic segmentation consisted of two 2D convolutional neural networks: 1 segmentation model and 1 shape model. Both of them used a popular U-Net architecture for segmentation, which is structured in an hourglass shape with an encoder and decoder part. Because the details of raw predictions were too crude for our medical application, we used another neural network on top in order to refine edges of the bone predictions. The refinement architecture was motivated by Deep Image Matting. To get the final result, we used another U-Net network as a shape model, motivated by Anatomically Constrained Neural Networks. The goal of this autoencoder model was to learn an internal representation of the anatomic shape of segmentation masks and use it as a regularization of our segmentation model. Accuracy of 3D-CT surface rendered models of the respective intra-articular fractures using automated segmentation were compared to the manually segmented Q3DCT models, serving as a reference standard for all consecutive cases according to the Jaccard index.

Results: In total, 346 of 348 CT scans were automatically segmented and reconstructed into Q3DCT models of intra-articular fractures (99%). In 2 cases, the deep-learning algorithm could not reproduce a 3D model. According to the Jaccard index, the AI deep-learning algorithm (Healthplus.ai) had an accuracy of 93% compared to manual for the remainding 346 cases.

Conclusion: Our AI algorithm could automate segmentation of 2D-CT images and reconstruct 3D surface rendered models in 99% of cases with 93% accuracy. However, additional research with thousands of cases are needed to further "feed" the algorithm in order to increase accuracy. These results are a promising first step in this field. However, additional research with thousands of cases are needed to further "feed" the algorithm in order to increase accuracy.