AUTOMATIC SEGMENTATION OF THE SPINE FROM MR AND SYNTHETIC CT IMAGES

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Introduction

Subject-specific morphometric and finite element modelling studies of the spine often rely on CT scans, exposing subjects to harmful radiation. MR imaging does not expose the subject to radiation and is generally better suited for the visualization of soft tissues. With emerging deep-learning (DL) methods it is now possible to derive synthetic CT images from MR images to visualize bone [1]. Additionally, DL methods can be used for the automatic segmentation of various soft structures. The aim of this study was to train DL networks for the automatic segmentation of vertebrae, intervertebral discs (IVD), and nuclei pulposi (NP) based on MR images for the purpose of building biomechanical subject-specific spine models.

Materials and Methods

3D sagittal T1-weighted in-phase, out-of-phase, fat, water, and T2-weighted MR scans were taken from 13 adult volunteers (Fig. 1A; voxel size: 0.625×0.625×1 mm^3; field of view: 420×420×100 mm^3). For 4 volunteers additional T2-weighted scans were taken using compressed sensing, and a shortened sequence (Fig. 1C). Synthetic CT scans were generated from these images using a pretrained DL algorithm (Fig 1B; BoneMRI V1.5, MRIguidance). A DL network (nnU-Net) was trained on the in-phase, out-of-phase, fat and water scans of 6 subjects for automatic segmentation of the IVD [2]. The same network was trained on the standard 3D T2-weighted scans of 6 subjects for the segmentation of the NP. For segmentation of the vertebrae, a pretrained DL network was selected [3,4].

Using the newly trained and pretrained networks, validation was performed on 2 of the remaining subjects. For the NP, validation was also performed on the additional T2-weighted sequences.

Results

Validating the networks for the segmentation of the IVDs and vertebrae on a scoliotic subject (cobb angle ~30°) resulted in Dice scores of 0.93 and 0.96, respectively (Fig. 1D). For the segmentation of the NP Dice scores range from 0.86 to 0.94 for 4 subjects, with similar results for validation against the additional sequences (Fig. 1D).

Discussion and Conclusions

Synthetic CT imaging enables a unique segmentation of discs and vertebrae without the need for registering CT and MR images and avoiding radiation exposure. Training a DL network on high-resolution T2-weighted images resulted in good automatic segmentations, even on accelerated sequences. These segmentations are accurate enough to create subject-specific models.

References

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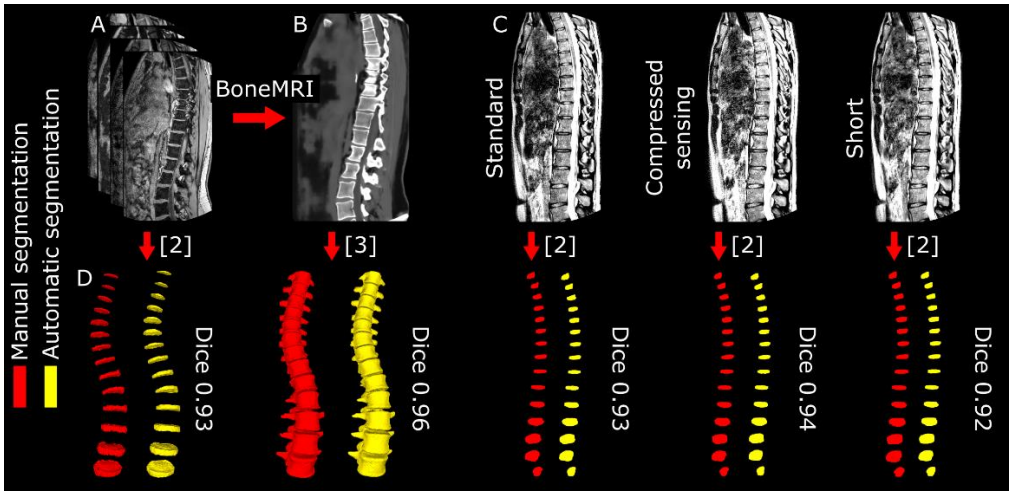

Figure 1: A) in-phase, out-of-phase, fat, and water MR images; B) Synthetic CT image; C) Various 3D sagittal T2-weighted images; D) Manual and automatic segmentations used for validation with the Dice score for each comparison.