Using convolutional neural networks for vertebrae segmentation in spinal FUS treatment planning

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Introduction

- **Goal:** FUS therapy in spinal canal
  - CT-derived treatment planning to focus through bone

- Require quick *in vivo* spine segmentations of individual vertebrae for simulations during pig experiments
  - Currently too slow

- **My project:** fully automated segmentation with CNNs (U-NET architecture)

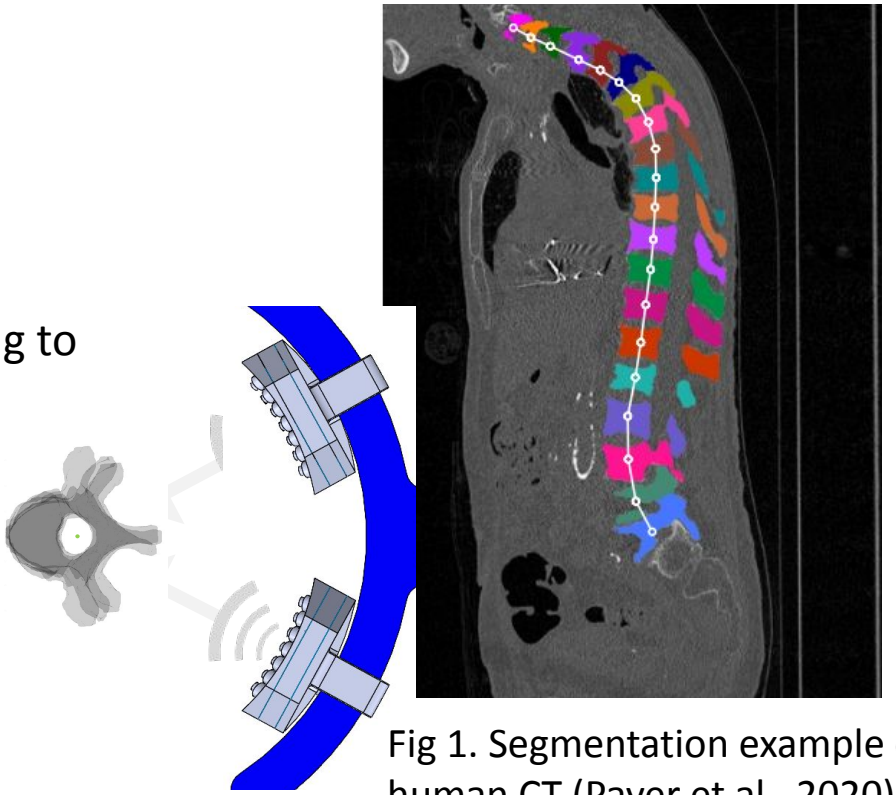


Fig 1. Segmentation example on human CT (Payer et al., 2020)

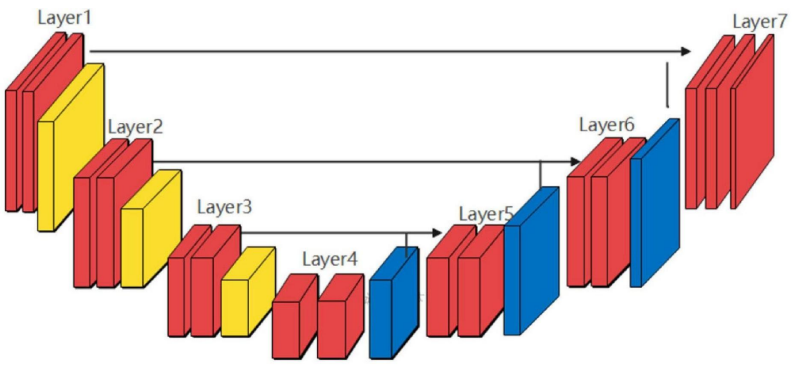


Fig 2. Diagram of a U-NET (Cai et al., 2022)

Experimental Workflow

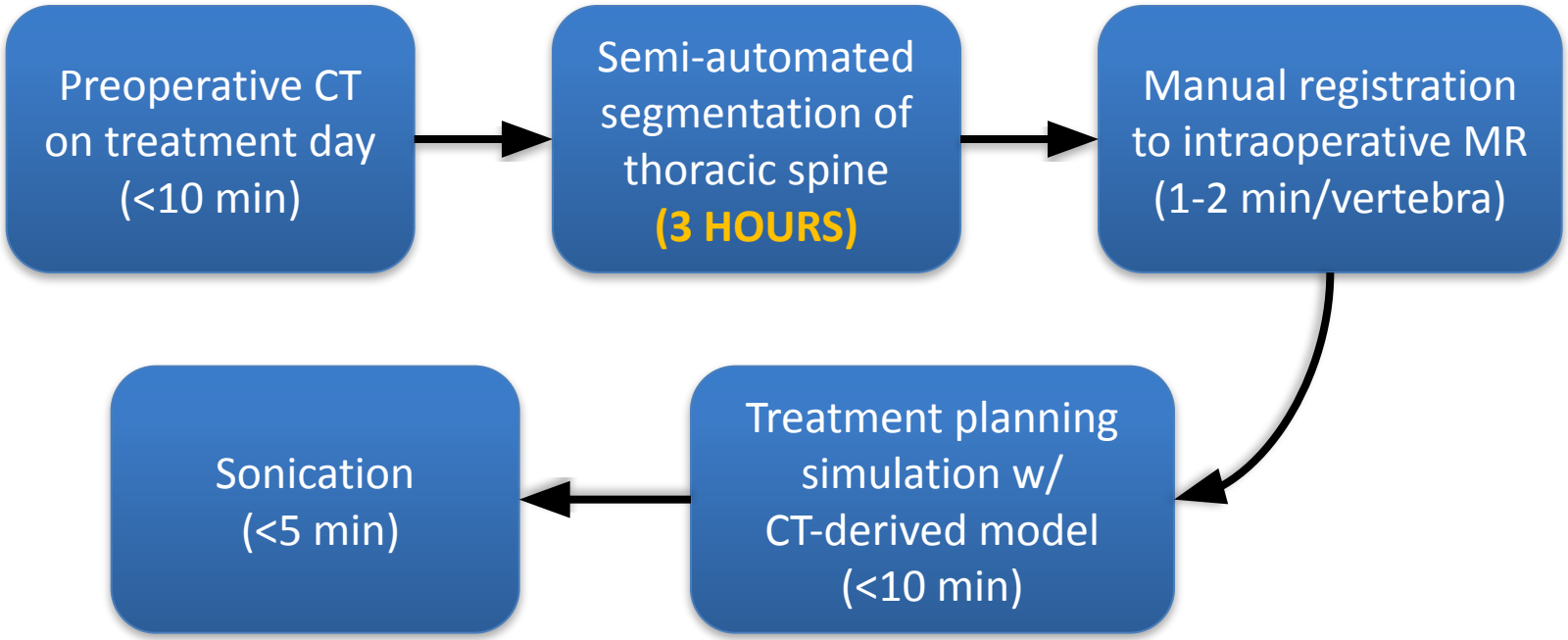


Fig 3. Flowchart showing the current workflow for porcine model spinal FUS experiments, with semi-automatic spine segmentation being the clear bottleneck for time.

Methods

- Implementation of Payer et al., 2020 (VerSe Challenge winner 2019-20)

- Three-step process
  1. Spine localization
  2. Vertebrae localization
  3. Vertebrae segmentation

- Trained on 107 human CTs, tested on 4 pig CTs

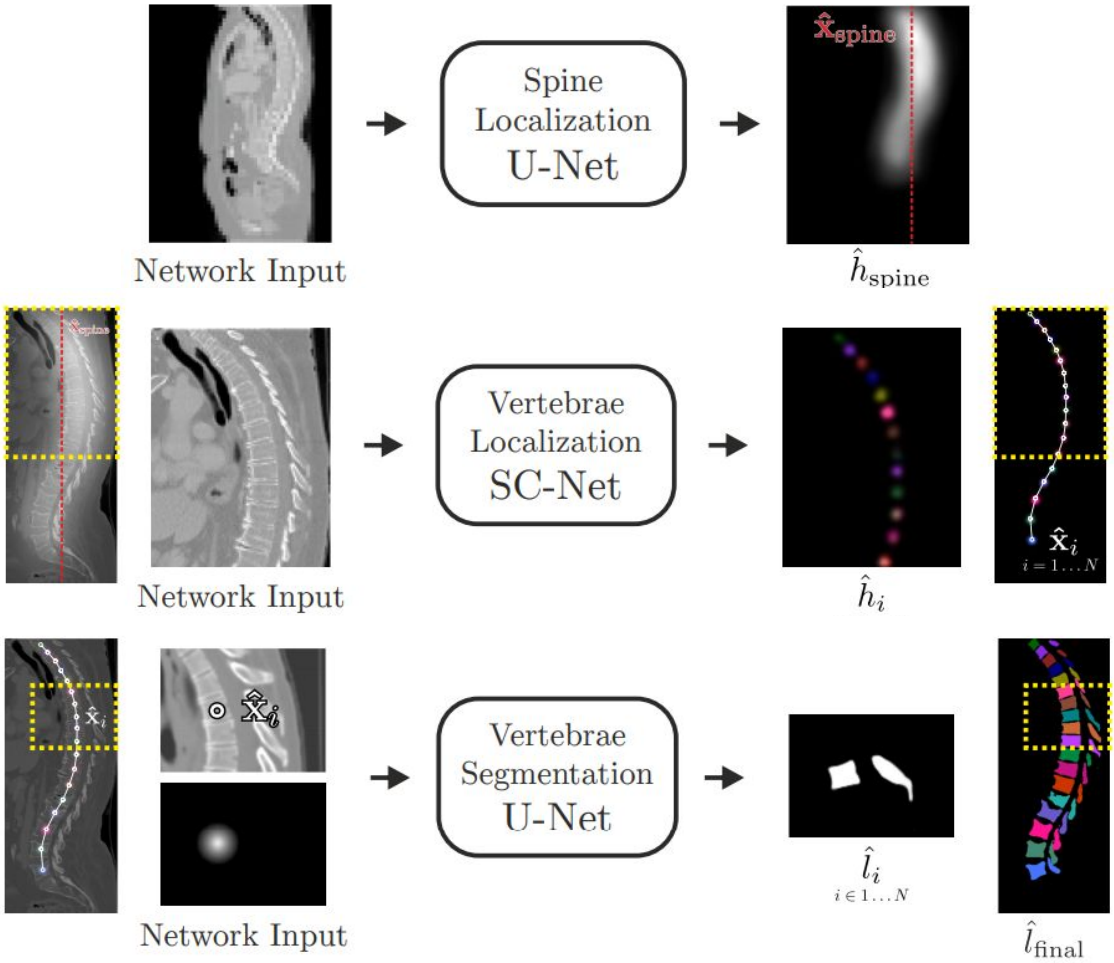


Fig 4. Visualizations of the inputs and outputs of the three implemented CNNs (Payer et al., 2020)

Results

- Inference process runs in ~5 minutes, accurate segmentation
- Issues in vertebrae localization (Step 2)
  1. Cutting off lumbar vertebrae
  2. Missing individual vertebrae
- **Solution:** manually input centroid positions between Steps 2-3

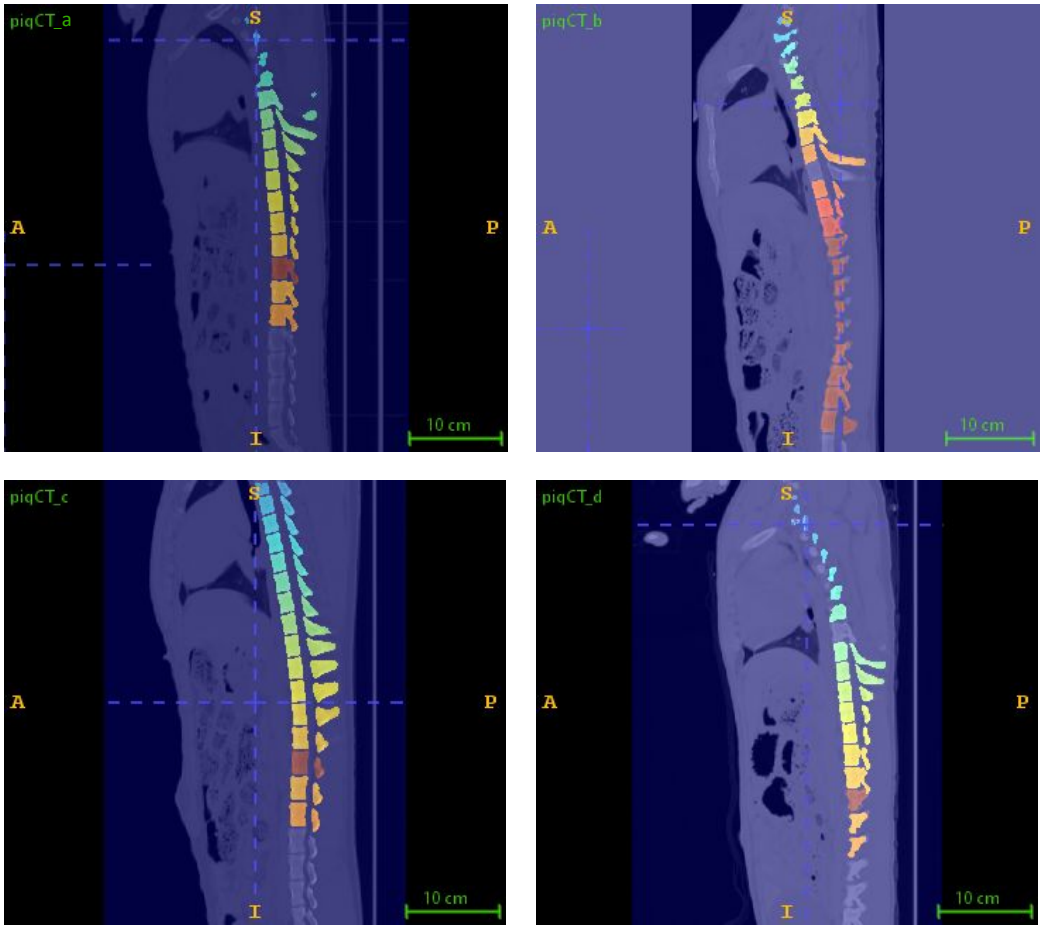


Fig 5. Sagittal views of vertebrae segmentation masks (with missing vertebrae) on slices from four pig CT images

Results (cont.)

- Manual input of centroids → full spine segmentation
- Additional 2-3 min per missing vertebrae

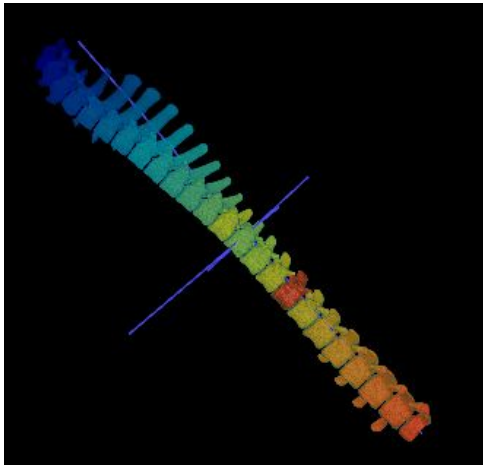


Fig 6. Volume rendering of segmented pig vertebrae

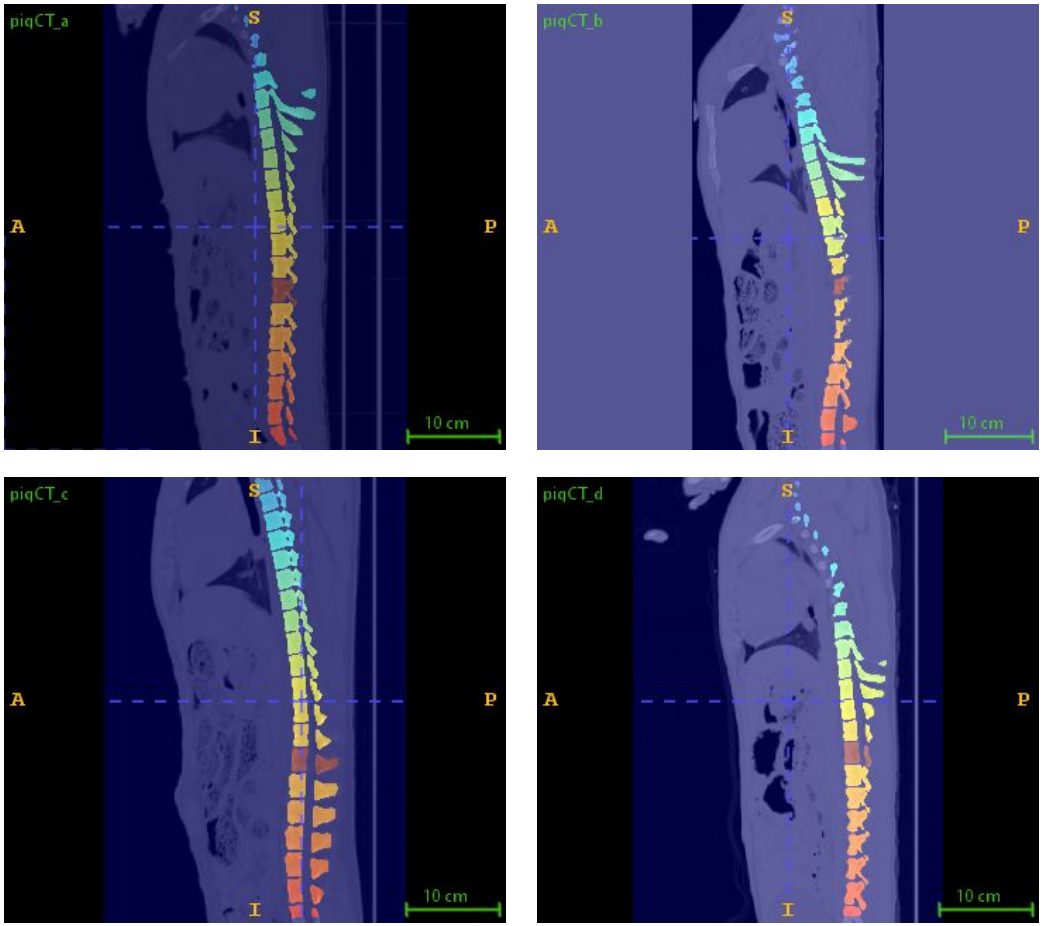
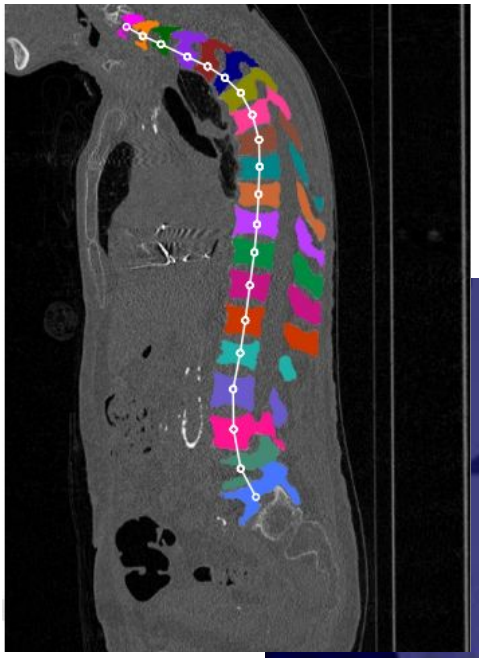
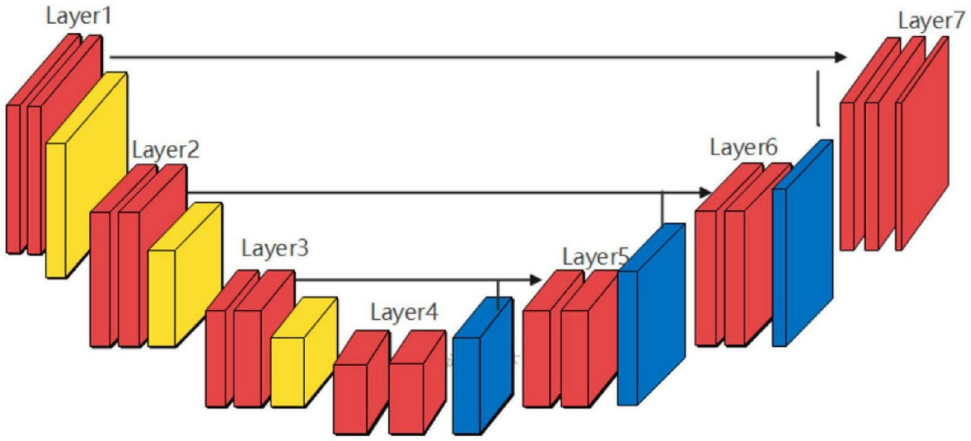


Fig 7. Sagittal views of vertebrae segmentation masks on slices from four pig CT images

Conclusion

- Successfully applied human CT-trained U-NET segmentation model to pig CTs
- Corrected missing vertebrae with minor manual input
- Accelerated segmentation method ready to be used in *in vivo* experiments





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Open Source Code

Payer, C., Štern, D., Bischof, H., & Urschler, M. (2020). Coarse to Fine Vertebrae Localization and Segmentation with SpatialConfiguration-Net and U-Net. *Proceedings of the 15th International Joint Conference on Computer Vision, Imaging and Computer Graphics Theory and Applications - Volume 5: VISAPP*, *5*, 124–133. doi:10.5220/0008975201240133

Image of U-NET

Cai, S., Wu, Y., & Chen, G. (2022). A Novel Elastomeric UNet for Medical Image Segmentation. *Frontiers in Aging Neuroscience*, *14*. doi:10.3389/fnagi.2022.841297