University of Basel
Department of Biomedical Engineering

Project MIRACLE
Planning and Navigation
CIAN

Automated Bone Labelling and Segmentation in CT Scans Using Deep Learning

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Background

MIRACLE:

Minimally Invasive Robot-Assisted Computer-guided LaserosteotomE.

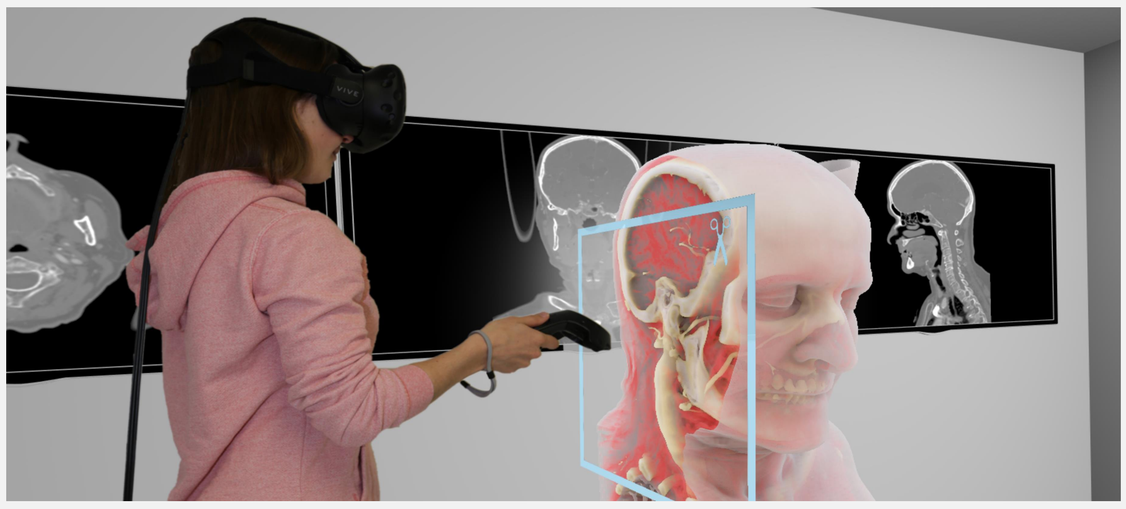
Building a robotic guided endoscope for minimally invasive bone cutting, using lasers.

Planning & Navigation group:

Work on preoperative planning as well as navigation during surgical procedures within MIRACLE.

SpectoVR:

Intuitive workspace for 3D medical data in Virtual Reality.



Motivation and Goals

Motivation:

Manual bone labelling takes a lot of time and work.

We want to automate the process to quickly locate and outline any bone in a CT scan.

Application:

Integration into SpectoVR for highlighting or hiding of specific bones.

For surgical planning and educational purposes.

Preprocessing of CT data for analysis of bone density and joint loading[2].

Methods and Challenges

Approaches:

We explore multiple machine learning algorithms for the task, notably 3D U-net [1] like Deep Learning algorithms that show high performance on volumetric medical data.

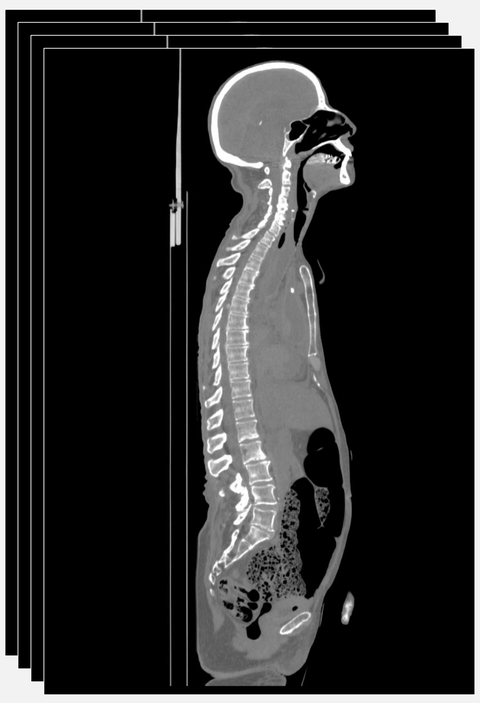
Challenges:

Scarcity of annotated training data; model is prone to overfitting.

Size of 3D scans; they don't fit into GPU memory at once. Subvolumes are easier to work with but lack global context.

Multitude of classes – there are roughly 200 bones in an adult body – with a high class imbalance.

Preliminary Results



Input

Bone Segmentation - Prediction

Further Ideas

Extensive data augmentation:

In addition to typical deep learning data augmentation such as shifting, scaling, rotating and deforming the training data, we generate artificial training data using an appearance model, an approach that has successfully been used for registration [3].

Co- and Pre-training:

We investigate the effects of co- and pre-training with openly available datasets that are segmented for different purposes.

References

[1] Ö. Çiçek, A. Abdulkadir, S. S. Lienkamp, T. Brox, and O. Ronneberger, "3D U-Net: Learning Dense Volumetric Segmentation from Sparse Annotation," in *Medical Image Computing and Computer-Assisted Intervention – MICCAI 2016*, vol. 9901, S. Ourselin, L. Joskowicz, M. R. Sabuncu, G. Unal, and W. Wells, Eds. Cham: Springer International Publishing, 2016, pp. 424–432.

[2] M. Müller-Gerbl, R. Putz, and R. Kenn, "Demonstration of Subchondral Bone Density Patterns by Three-Dimensional CT Osteoabsorptiometry as a Noninvasive Method for In Vivo Assessment of Individual Long-Term Stresses in Joints," *Journal of Bone and Mineral Research*, vol. 7, no. 52, pp. 412–418, 1992.

[3] H. Uzunova, M. Wilms, H. Handels, and J. Ehrhardt, "Training CNNs for Image Registration from Few Samples with Model-based Data Augmentation," in *Medical Image Computing and Computer Assisted Intervention – MICCAI 2017*, vol. 10433, M. Descoteaux, L. Maier-Hein, A. Franz, P. Jannin, D. L. Collins, and S. Duchesne, Eds. Cham: Springer International Publishing, 2017, pp. 223–231.

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