# A flexible framework for machine learning-based image segmentation – case study using mouse tibia microCT

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## Aims

Image segmentation is an essential part of quantification and targeted analysis, yet it remains a time-consuming and often subjective task. Machine learning approaches using neural networks (NN) have proven useful for many segmentation tasks, and have the potential to yield substantial time saving, but software is generally custom and application specific. We describe a generalized framework for training of a modified U-net architecture [1] and use in a workflow-based software. This framework has been successfully used for MRI and PET segmentation tasks. The framework was further tested using ex vivo microCT of mouse femur and tibia provided by Skyscan.

## Method

An interface to Tensorflow [2] and the U-net-based NN were created via Python (Keras) and R in the Java-based software PMOD (Figure 1). Image data was preprocessed and transferred to Tensorflow for training of the NN. 2D sections of the femur/tibia with gold-standard reference segmentation result were used for training. The samples and training parameters were prepared in a database using built-in functionality. The resulting model weights were returned to PMOD for use in prediction.

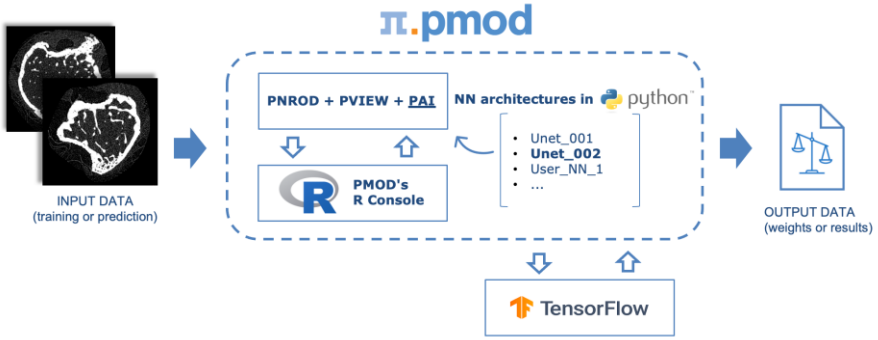


Figure 1: illustration of the architecture used for machine learning in PMOD.

## Results

The trained model successfully segmented the trabecular bone region without substantial inclusion of cortical bone or spurious background inclusion. An example of the resulting volumes-of-interest (VOIs) is shown in Figure 2. We will perform standard analysis using the segmentation outcome in data withheld from training to provide further validation.

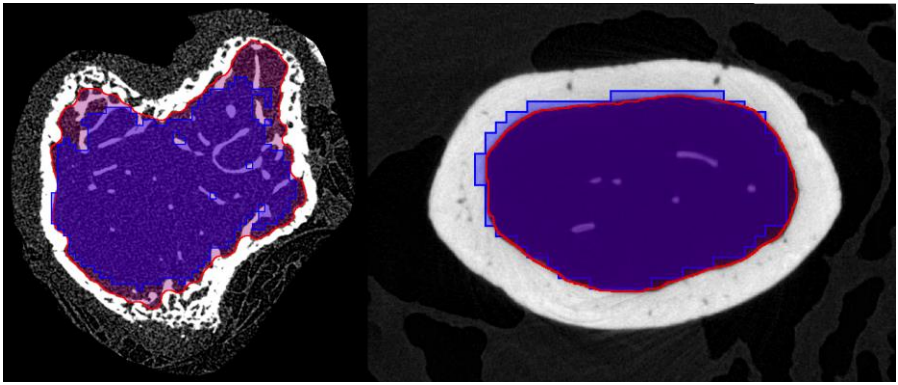

Figure 2: early examples of NN-based segmentation result (blue) on mouse tibia right metaphysis, with reference manually-adjusted segment (red) for comparison. The NN used for this example was trained on 2D sections from a mouse femur.

## Conclusion

The flexible framework for NN-based segmentation could be directly adapted from MRI and PET tasks to microCT. Existing software tools and GUI made data preparation and pre-processing straightforward. The trained model was successfully deployed and prediction is rapid on standard laptops with Win/MacOS/Linux. Accuracy will be improved by retraining with additional data and may be made more generalizable by including data from differing imaging protocols and vendors.

## References:

[1] Isensee F., Kickingereder P., Wick W., Bendszus M., Maier-Hein K.H. (2018) Brain Tumor Segmentation and Radiomics Survival Prediction: Contribution to the BRATS 2017 Challenge. In: Crimi A., Bakas S., Kuijf H., Menze B., Reyes M. (eds) Brainlesion: Glioma, Multiple Sclerosis, Stroke and Traumatic Brain Injuries. BrainLes 2017. Lecture Notes in Computer Science, vol 10670. Springer, Cham. https://doi.org/10.1007/978-3-319-75238-9_25

[2] Martín Abadi, Ashish Agarwal, Paul Barham et al. TensorFlow: Large-scale machine learning on heterogeneous systems, 2015. Software available from tensorflow.org.