

Simplified Access to AI Methodology

Artificial Intelligence (AI) methods have become a success story and are now part of daily experience. They have also successfully been applied in many domains of biomedical research. However, the setup and use of AI toolkits is a task requiring a lot of methodological insight as well as specialized IT expertise.

The aim of PAI is to drastically lower the entry barrier to the AI methodology for researchers analyzing biomedical images. PAI is designed as a framework, which allows users to develop their tailored AI-based image analysis solution leveraging their own training data while fully working within the familiar PMOD environment.

PAI drastically lowers the entry barrier to AI-based image analysis.

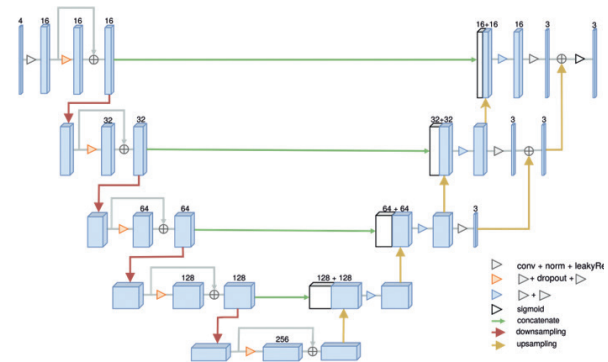
Segmentation Framework

PAI currently supports segmentation and classification tasks. For segmentation, users can easily set up training data sets consisting of image pairs, namely the input image (or several matched images with different contrasts) and the segmented object(s). They then select a neural network configuration and start the training process. As the training set should be sufficiently large and training will require heavy processing, the use of cloud-processing is an option which is already accounted for. Training result is a neural network which is ready to be used for the prediction, i.e. the fast, unsupervised segmentation of input images. A similar approach is supported for classification tasks.

Using PAI, segmentation tasks can be automated based on sufficiently large sets of segmentation examples.

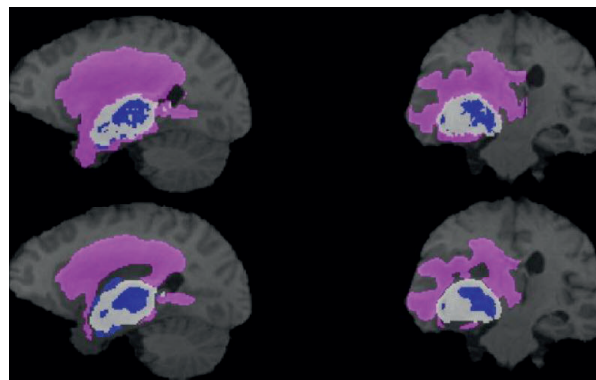
Tumor Segmentation Case Study

The example below illustrates an AI-based tumor segmentation resulting in three segments (necrotic non-enhancing tumor, Gd-enhancing tumor, edema). The upper row shows the manually segmented ground truth, the lower row the segmentation obtained from PAI using a network trained on more than 300 such data sets.

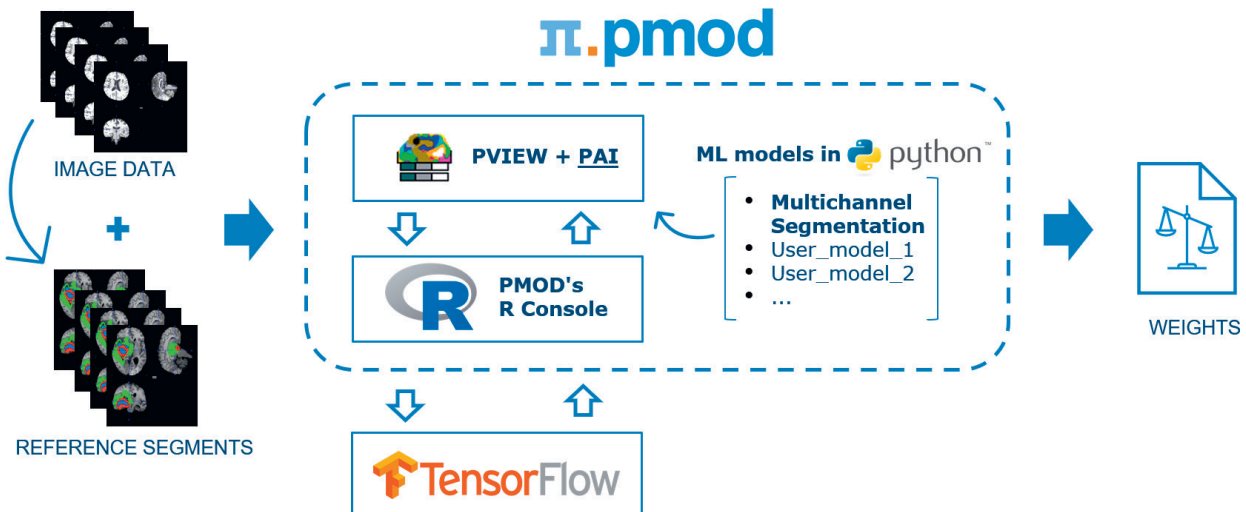


Neural network structure for tumor segmentation from MR images.

Users can develop AI-based segmentations working fully in PMOD.



Ground truth (top) and result of AI-based tumor segmentation (bottom). BraTS data courtesy of MICCAI.



Software Infrastructure

PAI uses the PMOD viewing tool for preparation of the training data and using the trained neural network for predictions. For the actual AI processes the best-in-class tools Python and TensorFlow are leveraged through the PMOD R console. Consequently, a PMOD installation has to be extended with the corresponding libraries.

As AI is developing rapidly, PMOD defines the toolkit versions which are compatible with a PAI version.

Hardware Infrastructure

PAI users have to be aware that the training of neural networks with a sufficient amount of data is a computational challenge and therefore not possible on personal computers. It requires at least a multicore workstation with large RAM and NVIDIA CUDA GPU, or alternatively a cloud computing solution.

PAI has proven to work efficiently on the Amazon AWS in various instance configurations. However, once a network has been trained, it can easily be deployed and used for prediction on any standard computer with sufficient RAM.

Data Preparation

A significant and crucial part of developing an AI solution is the collection and preparation of the training data. For image data, preparation includes bringing them into the same matrix dimensions and normalizing the value range. Furthermore, for the supervised learning approach implemented in PAI, each image must be paired with its corresponding teaching content.

Data preparation is supported by a dedicated training set editor in the viewing tool. It allows specifying the image preprocessing functions such as interpolation to a common resolution and cropping of the target area, and supports pairing the images with their teaching content.

As reliable AI solutions require hundreds of training data sets, auxiliary tools have been developed in PMOD to reduce the amount of manual preparation work.

When applying a prediction to an input image, it has to be similar to the training data. Furthermore, the same preprocessing steps need to be applied, which however occurs transparently for the user.

Neural Networks

Note that PAI is not an AI solution for a specialized purpose. Rather, it is intended as a framework which allows users to develop novel AI solutions based on their own data and a chosen neural network architecture.

The specification of neural networks for PAI is based on the Keras API for TensorFlow. It requires programming of the network structure in Python and embedding the code appropriately within the PAI framework. Added networks are detected and will be immediately accessible for new developments.

The PMOD distribution includes several trained networks with different architectures. They are working examples, but should be considered as illustrative case studies because they only have been trained with limited data sets. The applications encompass segmentations of deep nuclei in human MR brain images, of myocardium in cardiac cine MRI, of trabecular bone in CT images, as well as the positive/negative classification of human amyloid PET images.

Training

Once the training data has been prepared, a selected neural network can be trained in runs of a certain batch size. The number of epochs to perform is a parameter of the process and may depend on the behavior of the loss function as the training proceeds. A manifest file records the details of the training progress such that the training can be performed in batches and additional training data can be integrated as it becomes available.

Prediction

In the viewing tool a trained network can be applied for data consistent with the training data. The required pre-processing steps will automatically be performed before the network applies its prediction, resulting in a content type for which it has been trained for. In the case of the example brain segmentation network, it will generate a contour representing the tumor. Prediction is very fast, and because a trained network can be deployed to any computer equipped with PAI, a working solution can easily be made widely available.