Learned CT Reconstruction and Segmentation

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Abstract: Applying neural networks to Inverse Problems is a very active area of research, and many different algorithms have been proposed. A common ground for all these techniques is that in order to perform supervised learning, a loss function on the network output has to be specified. Until now this loss has been chosen to be the L2 error between the ground truth and the network output. Especially in medical imaging, this choice of loss functional comes with severe disadvantages, as the L2-norm has a tendency to blur out edges and fine structures. On the other hand, neural networks have also been very successfully applied to image segmentation and image classification.

In our work, we combined these two algorithms to a single one. We first reconstruct the picture from measurements and then segments or classifies it. This joint approach has been known to be successful for classical non-learning-based methods, and comes with two main advantages. Firstly, training the combined architecture end-to-end yields segmentation results that are superior to what can be achieved when performing both tasks separately. Secondly, the segmentation algorithm serves as implicit loss functional for the reconstruction algorithm, leading to an improved visual quality of the key features of the image in comparison to L2 loss.

We built on a learned iterative algorithm[1] used for reconstruction in computed tomography. We combined this with a learned segmentation algorithm based on the U-Net[2] architecture and jointly trained these algorithms on reconstruction and segmentation of medical CT data. The results showed a clear improvement over results obtained by training the algorithms separately or with L2 loss.

Motivated by advances in the machine learning community, adversarial loss functions have been proposed for loss quantification in medical imaging. We will present some very recent applications of those to inverse problems and show computational results obtained on our images with this method.

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[1]Solving ill-posed inverse problems using iterative deep neural networks; J. Adler and O. Öktem; arXiv:1704.04058

[2]U-Net: Convolutional Networks for Biomedical Image Segmentation; Olaf Ronneberger, Philipp Fischer, Thomas Brox; arXiv:1505.04597