

Fully Convolutional Neural Network for accurate segmentation of Digestive Organs, Veins and Tumors With Hepatic Cancer in CT Data with strong class imbalance and noisy labelling.

Efficient and accurate 3D organ and vein segmentations from contrast-enhanced computed tomography (CT) images are an important prerequisite for planning of surgical interventions for hepatic diseases. However, inhomogeneous appearances, ambiguous boundaries, and large variance in shape and intensities of digestive organs often make it a challenging task. The existence of organ abnormalities and the extreme variation in spatial scale within organs, veins and tumors poses further difficulty. This study aims to address these challenges, by proposing a single fully automatic 3D segmentation method based on state-of-the-image segmentation models (DeepLab[1]) adapted to the context of medical image segmentation for the segmentation of 4 anatomical organs, 3 veins and tumors. We harness the rich visual representations from Deep convolutional neural networks and use it to analyse slices of volumetric medical images. With dilated convolutions[2] and residual blocks[3] as the essential building blocks, we propose a high-resolution, fully convolutional network for volumetric image segmentation. The networks have been pre-trained on Imagenet and are fine-tuned on medical data using a multiclass transfer layer with with nine target classes, namely Pancreas, Liver, Stomach, Gall Bladder, Artery, Portal Vein, Superior Vena Cava, Tumor and Background. We adapt fully convolutional networks[4] and fine-tune their representations to the spatially dense task of segmentation. An important care is taken to solve the problem of strong class imbalances in the dataset, which we address by relating prior class data distributions to the loss function.

The models are tested on the IRCAD dataset, consisting of 927 CT scans and their corresponding human annotated segmentation masks, which represent a large dataset of more than 12,0000 image slices. This dataset is skewed with 83% of the voxel representation from Liver and the rest from the other classes. The dataset is also weakly annotated, with missing ground truth masks of some organs. However, our network learns low level priors from the existing segmentation annotations and is still able to account for the presence of organs, even when the ground truth mask is missing. Our best performing model, reached mean dice of 81.0%, and 68.6 % accuracy in the multi-class configuration with computation times below 100s per volume.

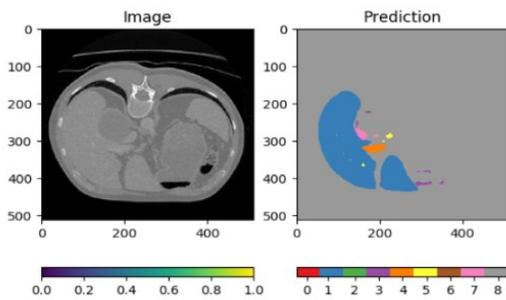


Fig1: Fine Level Organ, Vein and Tumor Predictions

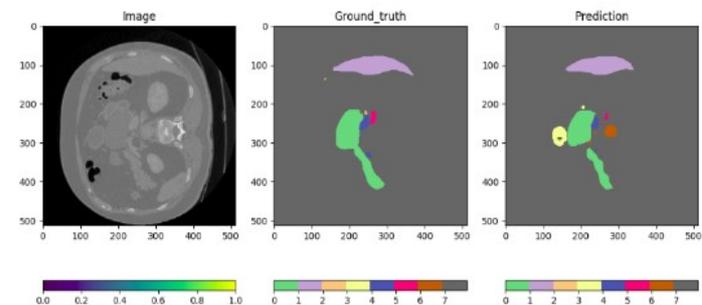


Fig 2: Prediction of organs such as Pancreas(yellow), which were missing in the ground truth mask.

[1] Chen, Liang-Chieh, et al. "DeepLab: Semantic image segmentation with deep convolutional nets, atrous convolution, and fully connected crfs." arXiv preprint arXiv:1606.00915 (2016).

[2] Yu, Fisher, and Vladlen Koltun. "Multi-scale context aggregation by dilated convolutions." arXiv preprint arXiv:1511.07122 (2015).

[3] He, Kaiming, et al. "Deep residual learning for image recognition." Proceedings of the IEEE conference on computer vision and pattern recognition. 2016.

[4] Long, Jonathan, Evan Shelhamer, and Trevor Darrell. "Fully convolutional networks for semantic segmentation." Proceedings of the IEEE Conference on Computer Vision and Pattern Recognition. 2015.