UNet, a powerful tool for Ultrasound Image Analysis

Previously, deep learning for segmenting arteries in ultrasound images has been a big challenge. In this thesis, the newly developed convolutional neural network, UNet, was used to segment the main artery in our neck, the common carotid artery (CCA). The results show that UNet can be a powerful tool in image analysis within biomedical engineering.

Rupture of plaque in the CCA can result in stroke, which was the second leading cause of death in 2016 according to WHO[1], and is therefore of substantial focus in biomedical research. At Lund University, research on the CCA is being conducted and the researchers use ultrasound imaging to study the CCA. Extracting the location of the artery from the images is currently done manually, which is very time-consuming and an automatic way is desired. The purpose of this thesis is to see if deep learning can be used to automate this procedure.

Using deep learning, a way to train artificial neurons using statistics, we can teach a computer to study the images instead. Using a newly developed deep learning network called UNet, introduced at the University of Freiburg, the work in this thesis shows that it is possible to automatically segment out the CCA in the images making it easier for further processing in the research.

UNet is what is called a convolutional neural network, that has three steps, input, feature learning, and classification. In the input step, a training set consisting of ultrasound images of the CCA and their corresponding segmentation is given. This step provides a random image from this dataset to the feature learning step and its true segmentation to the classification step.

The purpose of the feature learning step is for the network to find which features that represent CCA-pixels in the images. The features are extracted by filters that are composed of trainable artificial neurons. These neurons can form any filter possible and are therefore extremely flexible. The extracted features are passed to the classification step. This also uses artificial neurons but to classify the pixels into two "classes", CCA or not CCA, forming a segmentation. Which "class" that is assigned to a pixel depends on the probability that the features, extracted by the filters, are a CCA-pixel or not.

After the image's pixels are classified by the network, they are compared to their true class from a manually outlined ground-truth. The network's neurons are trained using this comparison and are tweaked to minimize the error between the segmentations.

After detailed ultrasound examination of the CCA in four healthy volunteers, in total 249 images with corresponding manual expert segmentations were used to test UNet's capabilities. With a training dataset of less than 200 images, UNet manage to segment out an average of 87% of the CCA's area on a test dataset containing around 50 images of an unbiased patient's CCA.

Master Thesis *Segmentation of the Common Carotid Artery from Ultrasound Images*

[1]W. Johnson, O. Onuma, M. Owolabi, and S. Sachdev. Stroke: a global response is needed.

using UNet by Oskar Friberg, Faculty of Engineering, Lund University (LTH)