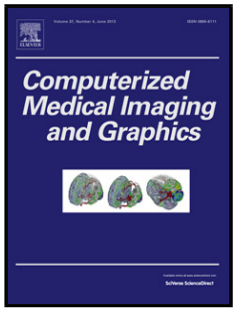

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Intraoperative margin assessment of human breast tissue in optical coherence tomography images using deep neural networks

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Abstract

Assessing the surgical margin during breast lumpectomy operations can avoid the need for additional surgery. Optical coherence tomography (OCT) is an imaging technique that has been proven to be efficient for this purpose. However, to avoid overloading the surgeon during the operation, automatic cancer detection at the surface of the removed tissue is needed. This work explores automated margin assessment on a sample of patient data collected at the Pathology Department, Severance Hospital (Seoul, South Korea).

Some methods based on the spatial statistics of the images have been developed, but the obtained results are still far from human performance. In this work, we investigate the possibility to use deep neural networks (DNNs) for real time margin assessment, demonstrating performance significantly better than the reported literature and close to the level of a human expert. Since the goal is to detect the presence of cancer, a patch-based classification method is proposed, as it is sufficient for detection, and requires training data that is easier and cheaper to collect than for other approaches such as segmentation. For that purpose, we train a DNN architecture that was proved to be efficient for small images on patches extracted from images containing only cancer or only normal tissue as determined by pathologists in a university hospital. As the number of available images in all such studies is by necessity small relative to other deep network applications such as ImageNet, a good regularization method is needed. In this work, we propose to use a recently introduced function norm regularization that attempts to directly control the function complexity, in contrast to classical approaches such as weight decay and DropOut.

As neither the code nor the data of previous results are publicly available, the obtained results are compared with reported results in the literature for a conservative comparison. Moreover, our method is applied to locally collected data on several data configurations. The reported results are the average over the different trials. The experimental results show that the use of DNNs yields significantly better results than other techniques when evaluated in terms of sensitivity, specificity, F1 score, G-mean and Matthews correlation coefficient. Function norm regularization yielded higher and more robust results than competing regularization methods.

We have demonstrated a system that shows high promise for (partially) automated margin assessment of human breast tissue, Equal error rate (EER) is reduced from approximately 12% (the lowest reported in the literature) to 5% – a 58% reduction. The method is computationally feasible for intraoperative application (less than 2 seconds per image) at the only cost of a longer offline training time.

Keywords: Breast cancer, Margin assessment, Optical Coherence Tomography (OCT), Deep Neural Network (DNN), Regularization, Function norm

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