Deep Neural Networks for Biomedical Image Analysis

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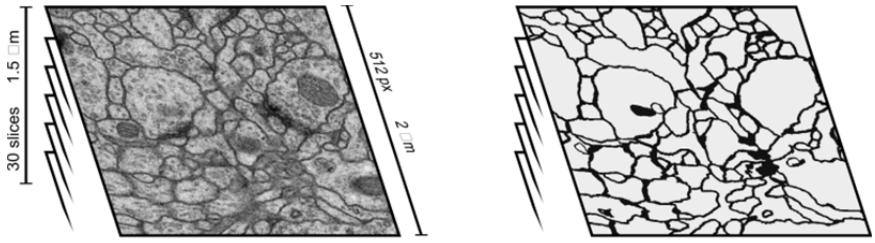
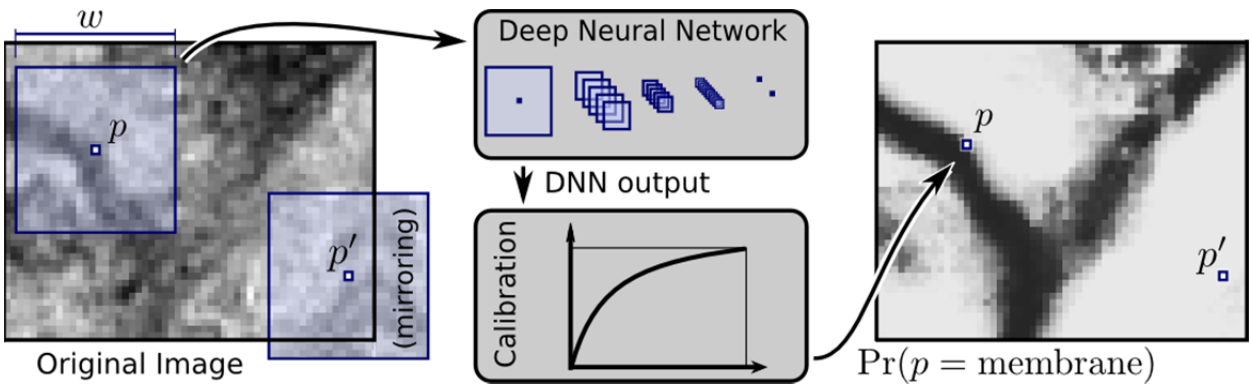
Abstract

GPU-optimized DNNs excel on general visual pattern recognition tasks. Our technique does not make use of expert human knowledge to define relevant features nor to design ad-hoc pre- or post-processing algorithms: instead, the system only exploits the information present in the labeled training set. DNNs are fast and extremely accurate, making them perfectly suited for bioinformatics. Here we present our results on three different problems.

Neuronal membrane segmentation

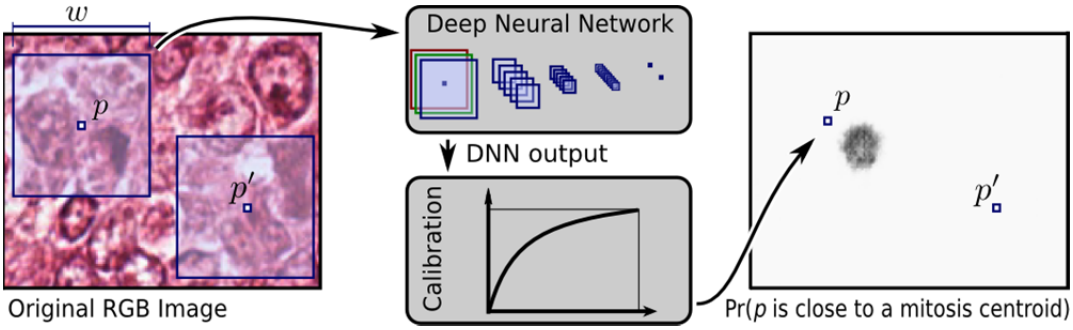
We address a central problem of neuroanatomy, namely, the automatic segmentation of neuronal structures depicted in stacks of electron microscopy images. This is necessary to efficiently map 3D brain structure and connectivity. To segment biological neuron membranes, we use a special type of DNN as a pixel classifier. Our method (Ciresan et al., NIPS 2012) makes it possible to automatically segment and reconstruct the neuronal connections in large sections of brain tissue for the first time. This will help bringing a new understanding of how biological brains work.



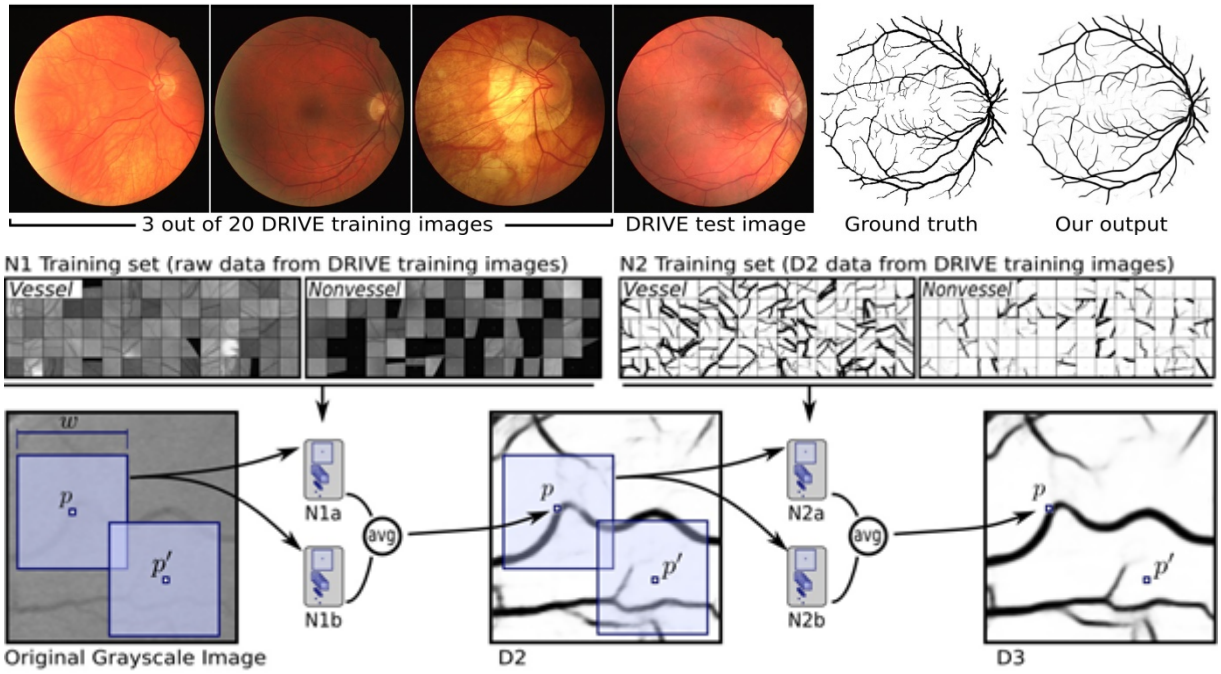


Mitosis detection

The number of mitotic figures visible in histology sections is an important indicator for cancer screening and assessment. Normally, the count is performed manually by histologists, but automating the process could reduce its time and costs, and minimize errors. Our approach (Ciresan et al., MICCAI 2013) for mitosis detection based on DNNs outperformed all competitors on the first public annotated dataset of breast cancer histology images.



Retinal blood vessel segmentation is a challenging and interesting pattern recognition problem, which has been subject of a large amount of research due to its clinical relevance. By leveraging state-of-the-art deep learning techniques, we developed a complete segmentation pipeline for retinal vessels which matches or even outperforms competing algorithms when tested on standard benchmarks.



D. Ciresan, A. Giusti, L. M. Gambardella, J. Schmidhuber - Deep Neural Networks Segment Neuronal Membranes in Electron Microscopy Images, NIPS 2012

D. Ciresan, A. Giusti, L.M. Gambardella, J. Schmidhuber - Mitosis Detection in Breast Cancer Histology Images using Deep Neural Networks, MICCAI 2013