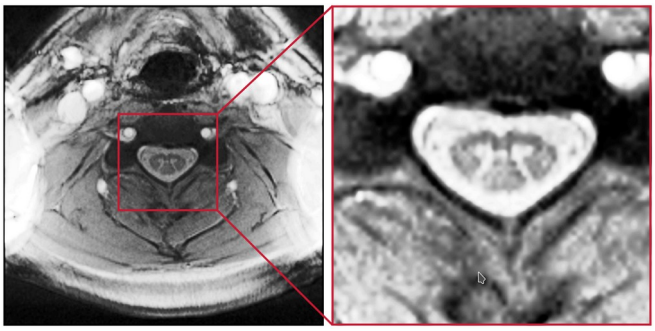
University of Basel

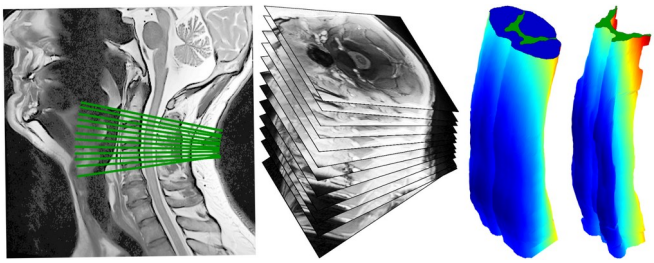
Department of Biomedical Engineering

Segmentation and Quantification of Spinal Cord Gray Matter–White Matter Structures in MRI

This thesis (1) focuses on finding ways to differentiate the gray matter (GM) and white matter (WM) in magnetic resonance (MR) images of the human spinal cord (SC).



Full view on an exemplary axial AMIRA image and a zoomed view of the SC's cross section.



The AMIRA imaging protocol with 12 axial slices perpendicular to the SC, the resulting stack of slices, and 3D visualizations of the segmented SC and GM.

The aim of this project is to quantify tissue loss in the GM and WM compartments to study their implications on the progression of the disease multiple sclerosis. To this end, we propose segmentation algorithms that we evaluated on MR images of healthy volunteers.

Segmentation of GM and WM in MR images can be done manually by human experts, but manual segmentation is tedious and prone to intra- and inter-rater variability. Therefore, a deterministic automation of this task is necessary. On axial 2D images acquired with a recently proposed MR sequence, called AMIRA, we experiment with various automatic segmentation algorithms.
We first use variational model-based segmentation approaches combined with appearance models (2, 3) and later directly apply supervised deep learning to train segmentation networks (4). Evaluation of the proposed methods shows accurate and precise results, which are on par with manual segmentations.
We test the developed deep learning approach on images of conventional MR sequences in the context of a GM segmentation challenge, resulting in superior performance compared to the other competing methods (4). To further assess the quality of the AMIRA sequence, we apply an already published GM segmentation algorithm to our data, yielding higher accuracy than the same algorithm achieves on images of conventional MR sequences (3).

From the methodical point of view, this work provides an introduction to computer vision, a mathematically focused perspective on variational segmentation approaches and supervised deep learning, as well as a brief overview of the underlying project's anatomical and medical background.

Department of
Biomedical Engineering
Gewerbestrasse 14
CH – 4123 Allschwil
+41 61 207 54 02
news-dbe@unibas.ch
www.dbe.unibas.ch

Funding:

FNSNF
Swiss National Science Foundation

Group Leaders:

Prof. Dr. Philippe Cattin
philippe.cattin@unibas.ch

Dr. Simon Pezold
simon.pezold@unibas.ch

PD Dr. Katrin Parmar
katrin.parmar@usb.ch

References:

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(2) Horváth et al. *Variational Segmentation of GM-WM in the SC using a shape prior.* MICCAI CSI, 2016.

(3) Tsagkas et al. *Automatic SC GM Quantification: A Novel Approach.* AJNS, 2019.

(4) Horváth et al. *SC GM-WM segmentation on AMIRA images with MDGRU.* MICCAI CSI, 2018.