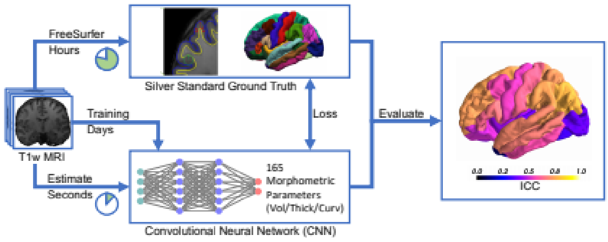


INSELSPITAL
UNIVERSITÄTSSPITAL BERN
HOPITAL UNIVERSITAIRE DE BERNE

SCAN
Support Center for Advanced Neuroimaging

University Institute of Diagnostic and
Interventional Neuroradiology

Master's Thesis Proposal: CNN regression of new variables of brain morphometry

Brain morphometry is a computational method that enables statistical assessment of brain structure based on T1-weighted magnetic resonance imaging (MRI) by extracting variables like local cortical thickness, surface area, gyrification indices and the contrast between grey and white matter along the cortical band. Originally developed for scientific group studies, variants are more and more utilized also to support clinical diagnostics in individual patients.

Recently, a bio-physically motivated **scaling law** of brain morphology has been introduced, that connects a number of morphometric variables of the cortex (Mota & Herculano-Houzel, 2015). Interestingly, it was shown that the scaling law holds across different mammalian species and human subjects (Wang et al., 2016) as well as across different spatial scales of the human brain after correction for the Gaussian curvature (Wang et al., 2019; Leiberg et al., 2021). When accounting for covariance, **new variables of cortical morphology** can be derived that are more sensitive to pathologies (Wang et al., 2021) and reveal locally differential aging that is obscured when using the traditional morphometric variables (Leiberg et al., 2021; see Figure).

In a previous master's thesis (Rebsamen et al., 2020) **CNN regression** was used to estimate regional cortical thickness and curvature directly from the input images, i.e. without prior image segmentation or surface tesselation. We propose to reuse the existing (well structured, documented and publicly available) training and evaluation code to estimate the variables for axonal tension, brain isometry and shape. Meanwhile, a significantly larger dataset is available for training and testing. In addition, we have hardware (Nvidia RTX A6000 with 48GB memory) available that allows to explore deeper and more modern network architectures.

This master's thesis will be performed at the Inselspital Bern in close collaboration with our research partner Dr. Yujiang Wang at the University of Newcastle, UK.

The student's tasks are:

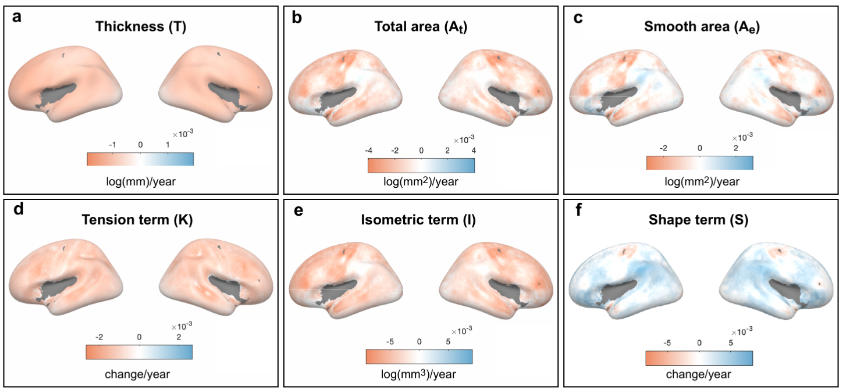
- review the literature on brain morphometry and CNNs
- extend existing software to enable regression of new morphometric variables
- explore the benefit of larger training sets
- explore the benefit of deeper and more modern network architectures

Specific requirements:

- programming skills in Python
- basics in Deep Learning
- basics in differential geometry
- basic statistics

Nature of the master thesis:

- literature study: 10%
- implementation: 30%
- data exploration: 40%
- documentation: 20%



Local effects of healthy ageing (see e.g. the bilateral precentral gyrus) are better revealed by the new variables tension, isometry and shape than by cortical thickness and surface areas. Taken from Leiberg et al. (2021).

References:

- Leiberg K, Papasavvas C, Wang Y (2021). Preprint available at http://arxiv.org/abs/2103.14061
- Mota B, Herculano-Houzel S (2015). Science 349, 74-77.
- Rebsamen M, Suter Y, Wiest R, Reyes M, Rummel C (2020). Frontiers Neurology 11, 244.
- Wang Y, Leiberg K, Ludwig T, Little B, Necus JH, Winston G et al. (2021). NeuroImage 226, 117546.
- Wang Y, Necus J, Kaiser M, Mota B (2016). Proc. Natl. Acad. Sci. USA 113, 12820-12825.
- Wang Y, Necus J, Peraza Rodriguez L, Taylor PN, Mota B (2019). Comm. Biology 2, 191.

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