Automated error localisation and correction techniques for deep-learning based segmentation of musculoskeletal anatomy from MRI

Valentin Rösler

Supervisors: MSc Hanspeter Hess, MSc Adrian Ruckli, Dr. Niolas Gerber
Institution: University of Bern, School of Biomedical & Precision Engineering
Examiners: MSc Hanspeter Hess, PD Dr. Kate Gerber

Introduction

Segmentation of MR images enables quantitative measurements of target anatomy that can support the clinical decision-making process. For automated segementation deep learning networks are being more frequently employed. However, these networks occasionally produce inadequate segmentations, requiring time-consuming manual inspection and correction by clinicians. Recently developed algorithms exploit network generated uncertainties to automatically detect if the segmentation of a target structure has failed. However, the location of the error within the structure can not be determined. Therefore, segmentations flagged by these algorithms still require manual correction. The aim of this thesis was to investigate the use of network generated uncertainties for automatic error localization and correction.

Materials and Methods

Predictive uncertainties were calculated based on the variance of multiple predictions that were obtained by applying test time dropout. These uncertainties were aggregated over supervoxels to identify image regions that are likely to contain segmentation errors. Because of the feature-derived nature of the supervoxels, the identified regions possibly align with the borders of present segmentation errors. Two semi-automatic correction techniques were developed and evaluated that update the classification within high uncertainty supervoxels to improve the segmentation quality.

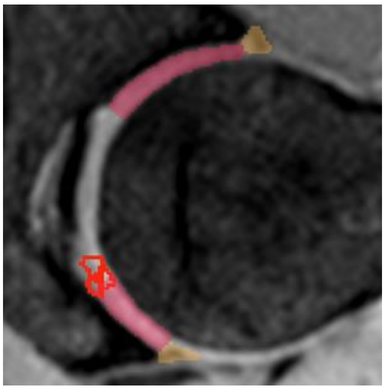

Fig. 1 Identified regions that contain a segmentation error. The outlines of the corresponding high-uncertainty supervoxels are highlighted.

Results

We found, that aggregating network uncertainties over feature-derived regions resulted in a more accurate identification of regions that are likely to contain a segmentation error. Applying the developed semi-automatic correction techniques to supervoxels with high associated uncertainties resulted in an improved overall segmentation quality.

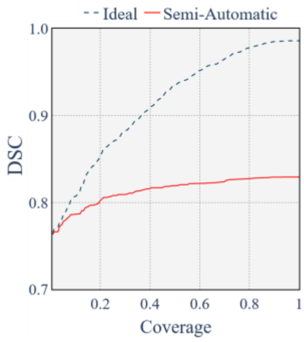

Fig. 2 Corrections applied to all supervoxels in decreasing order of uncertainty. The dice similarity coefficient (DSC) increased more significantly when high-uncertainty regions were treated.

Discussion

The developed technique to localize segmentation errors resulted in more accurate identification of segmentation regions that require correction by a clinician. Further evaluation is required to assess the clinical relevance of the increase in segmentation quality that was achieved by employing the developed semi-automatic correction technique. However, the correction of multiple voxels with a single user interaction and the observed increase in segmentation quality highlight the potential of assisting algorithms in the correction process.

References

Jörg Sander, Bob D de Vos, and Ivana Išgum. Automatic segmentation with detection of local segmentation failures in cardiac mri. Scientific Reports, 10(1):21769, 2020.