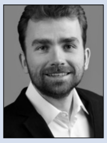

Martin Stypinski

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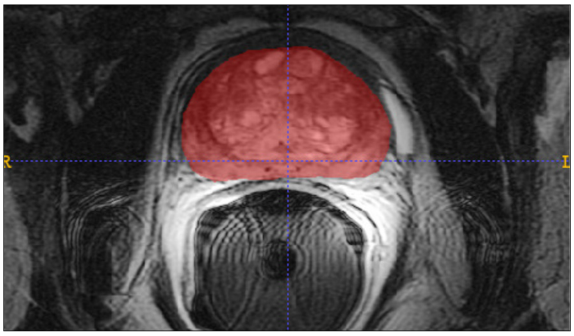
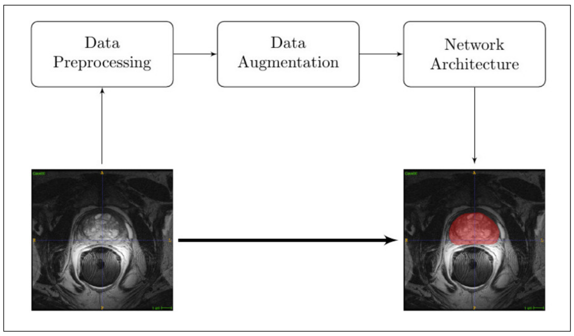
Subject Area	Software and Systems

ProSeg

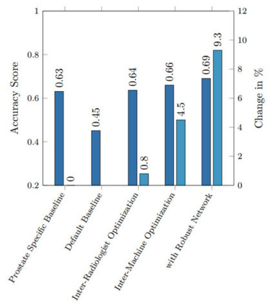
Increasing Robustness in Medical Image Segmentation with Deep Learning



A sample medical image MRI slice of segmented prostate. The area of interest marked in red.



An illustration of the pipeline used for medical image segmentation as demonstrated on the prostate.



Overview of the various improvements implemented to increase cross-cohort robustness on various prostate datasets

Introduction: Today, semantic image segmentation in the field of medical imaging is mainly done manually by professionally trained radiologists. These professionals spend hours to contour the area of interest within a collection of MRI or CT images. The segmentation is essential to outline organs, tumors or measure tissue volume for the diagnostical purpose. Recent development in deep learning shows promising accuracy in image-based tasks such as recognition or semantic segmentation. Progress in this field is driven by affordable computing hardware and openly available datasets, where researchers can compete on. The proposed solutions are often optimized for a particular problem and dataset and are only of limited applicability to the medical industry. In order to successfully transfer that knowledge to the industry, it is important to understand how these solutions will perform on different datasets. A method is considered to be robust if its ability to highlight an organ is independent of the scanning environment, the radiologist executing the scan or the machine used.

Objective: The main goals of this project were to understand and improve the robustness of prostate segmentation in medical imaging, by using deep learning for datasets with varying MRI T2 scanning procedure. The following specific subgoals were defined for this work:

- Investigate the robustness of a neural network configuration that is proven to work well on a specific prostate dataset challenge.
- Find means to improve inter-protocol, inter-machine and inter-radiologist robustness for this prostate segmentation task.
- Investigate better-generalizing network topologies, by reducing the parameter number compared to the baseline.

Result: The methods applied to improve the robustness of cross-cohort prostate segmentation included the optimization of all areas within the deep learning pipeline. An emphasis was put on domain-specific data augmentation and meta-parameter optimization within the network's topology. The proposed solution contains these three improvements:

- A novel approach to augment data to improve magnetic inhomogeneity invariance within the convolutional neural network.
- The use of the level-set method to introduce a novel context based segmentation variance to increase inter-radiologist invariance.
- A better fitting network architecture with fewer parameters than the one used in the already highly optimized baseline.

The results show improvements upon a highly-optimized baseline for each dataset and method applied within this work. Moreover, all the proposed enhancements are thoroughly benchmarked and discussed. The robustness-optimized method yields significant gains of 9.3% accuracy, averaged over all datasets, compared to the baseline.