Master's Thesis - User Guidance for Interactive Segmentation Systems

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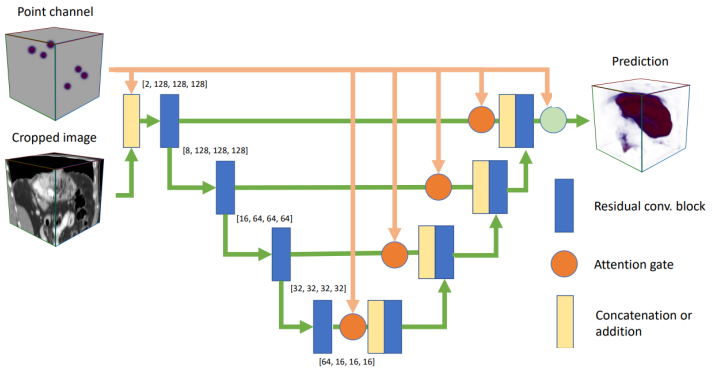

Figure 1: Interactive segmentation in medical images, e.g., MRI.

Motivation

Interactive segmentation is a method which combines an automatic segmentation model and corrections from a human annotator (human-in-the-loop). The annotator needs to provide guidance for the segmentation model, e.g., in the form of clicks, which in turn, iteratively refine the segmentation result. The goals of interactive segmentation are to iteratively improve the automatic segmentation model by adding more user guidance (e.g. clicks) and to reduce the amount of necessary human annotations. This alleviates the burden of manual data annotation and can be used to refine already existing automatic segmentation models. Interactive segmentation models are proliferated in many fields, such as medical image analysis, and natural images as seen in Figure 1. Demo example [1] of interactive segmentation: `https://www.youtube.com/watch?v=szJ85HOuyLI`.

Problem Definition

There are various ways to represent the user guidance clicks - Gaussian Heatmaps [6], Euclidean Distance transforms [2], Geodesic Distances [5] and many others as seen in Figure 2. Currently, there is no comprehensive comparison between the different representations of user guidance and any such comparisons are limited to small ablation studies. The goal of this thesis is to explore various interactive segmentation models in the field of medical imaging, e.g. DeepIGeoS [1], UGIR [4], DeepGrow [3] and investigate which user guidance leads to the best performance improvements. Additionally, based on the results from the comparisons, a new user guidance can be designed to improve the models' performance even further.

Figure 2: Various types of user guidance.

Requirements:

- Solid programming skills in Python and PyTorch.
- Motivation to do independent research and acquire knowledge in the field of interactive segmentation.
- Theoretical and practical experience with deep learning and computer vision.
- (Optional) Experience with segmentation models and medical image analysis.

Goal of the master's thesis:

- Literature research on different ways to integrate human interactions as guidance maps for segmentation.
- Implementation of these user guidance strategies and their integration with existing interactive segmentation models in the field of medical imaging. The final implementation can be integrated into MONAI-Label[1] - an open-source project for interactive segmentation.
- Evaluation and comparison of the performance of the models with different user guidance maps on a medical dataset.
- (Optional) Implementation of a novel guidance map. This could either an entirely new way of computing guidance maps or an improvement of an existing one.

Contact and Application: If you are interested in the topic and would like to discuss the timeline and goals more concretely, please contact Zdravko Marinov (zdravko.marinov@kit.edu) with your application (CV and transcript of records).

References

[1] Guotai Wang et al. "DeepIGeoS: a deep interactive geodesic framework for medical image segmentation". In: *IEEE transactions on pattern analysis and machine intelligence* 41.7 (2018), pp. 1559–1572.

[2] Yang Hu et al. "A fully convolutional two-stream fusion network for interactive image segmentation". In: *Neural Networks* 109 (2019), pp. 31–42.

[3] Tomas Sakinis et al. "Interactive segmentation of medical images through fully convolutional neural networks". In: *arXiv preprint arXiv:1903.08205* (2019).

[4] Guotai Wang et al. "Uncertainty-guided efficient interactive refinement of fetal brain segmentation from stacks of MRI slices". In: *International Conference on Medical Image Computing and Computer-Assisted Intervention*. Springer. 2020, pp. 279–288.

[5] Xiangde Luo et al. "MIDeepSeg: Minimally interactive segmentation of unseen objects from medical images using deep learning". In: *Medical Image Analysis* 72 (2021), p. 102102.

[6] Holger R Roth et al. "Going to extremes: weakly supervised medical image segmentation". In: *Machine Learning and Knowledge Extraction* 3.2 (2021), pp. 507–524.

[1] `https://github.com/Project-MONAI/MONAILabel`