Comparison of Deep Learning and Shape Modeling for Automatic CT-based Liver Segmentation

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Introduction

Many liver interventions require an organ segmentation for volumetry and procedure planning [1]. The liver's varying appearance in CT images makes this organ very time consuming for manual delineation and challenging for automatic segmentation approaches. Automatic methods are desired, since they allow for a speed-up and reproducibility of the planning process. We investigated two automatic segmentation algorithms based on fully convolutional neural networks (FCN) and statistical shape models (SSM).

Materials & Methods

Data We used 219 abdominal contrast-enhanced CT datasets from Yokohama City University Medical Center. Each liver was manually delineated in a semi-automatic fashion by a qualified medical staff using an established algorithm [2]. The data was divided into non-overlapping groups for training (147), method optimization (32), and testing (40).

FCNN-Based Method We trained a FCN based on the U-net architecture [3] with four resolution levels using axial slices resampled to a 2 mm isotropic voxel size [4].

SSM-Based Method The SSM was built using the MDL algorithm [5] for point correspondence establishment. The SSM-based segmentation process consists of several steps with varying scale and the search modes [6]. For the appearance model, we trained a random forest classifier using profiles extracted from liver boundaries.

Evaluation We compared both methods on 40 CT volumes using the relative volume error and the elapsed time for evaluation.

Results

The relative volume error was 3,8% ± 1,7% and 5,9% ± 6,8 % and the elapsed time was 3 ± 1s and 39 ± 8s for the FCNN- and SSM-based method, respectively. We had to exclude three cases from the evaluation, where the SSM-based approach failed to segment the liver completely due to the organ' abnormal appearance (polycystic and resected cases). For significance tests we used the Wilcoxon signed-rank test ($p=0.001$).

Conclusion

Both investigated methods compute liver volumes with acceptable accuracy [7]. The FCN-based method is more robust and runs significantly faster than the SSM-based algorithm.

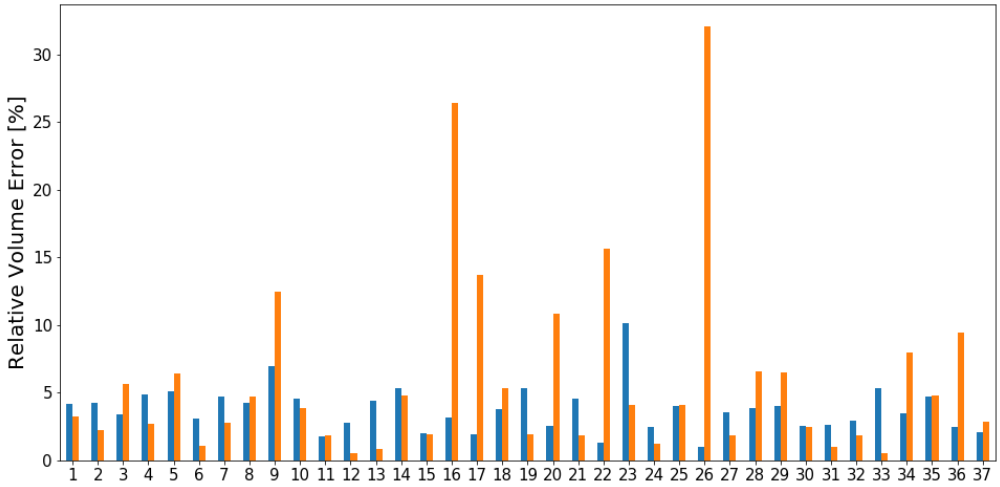

Figure 1 Relative volume difference for the FCN- (blue) and SSM-based (orange) methods.

References

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