R3年度博士論文

題目：Study on Statistical Method for Segmentation of Multi-object on Abdominal CT Images
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Computer aided diagnosis (CAD) is the use of a computer-generated output as an auxiliary tool for the assistance of efficient interpretation and accurate diagnosis. Medical image segmentation has an essential role in CAD in clinical applications. Generally, the task of medical image segmentation involves multiple objects, such as organs or diffused tumor regions. Moreover, it is very unfavorable to segment these regions from abdominal Computed Tomography (CT) images because of the overlap in intensity and variability in position and shape of soft tissues. In this thesis, a progressive segmentation framework is proposed to extract liver and tumor regions from CT images more efficiently, which includes the steps of multiple organs coarse segmentation, fine segmentation, and liver tumors segmentation.

Benefit from the previous knowledge of the shape and its deformation, the Statistical shape model (SSM) method is firstly utilized to segment multiple organs regions robustly. In the process of building an SSM, the correspondence of landmarks is crucial to the quality of the model. To generate a more representative prototype of organ surface, a k-mean clustering method is proposed. The quality of the SSMs, which is measured by generalization ability, specificity, and compactness, was improved. We furtherly extend the shapes correspondence to multiple objects. A non-rigid iterative closest point surface registration process is proposed to seek more properly corresponded landmarks across the multi-organ surfaces. The accuracy of surface registration was improved as well as the model quality. Moreover, to localize the abdominal organs simultaneously, we proposed a random forest regressor cooperating intensity features to predict the position of multiple organs in the CT image. The regions of the organs are substantially restrained using the trained shape models. The accuracy of coarse segmentation using SSMs was increased by the initial information of organ positions.

Consequently, a pixel-wise segmentation using the classification of supervoxels is applied for the fine segmentation of multiple organs. The intensity and spatial features are extracted from each supervoxels and classified by a trained random forest. The boundary of the supervoxels is closer to the real organs than the previous coarse segmentation.

Finally, we developed a hybrid framework for liver tumor segmentation in multiphase images. To deal with these issues of distinguishing and delineating tumor regions and peripheral tissues, this task is accomplished in two steps: a cascade region-based convolutional neural network (R-CNN) with a refined head is trained to locate the bounding boxes that contain tumors, and a phase-sensitive noise filtering is introduced to refine the following segmentation of tumor regions conducted by a level-set-based framework. The results of tumor detection show the adjacent tumors are successfully separated by the improved cascaded R-CNN. The accuracy of tumor segmentation is also improved by our proposed method.

26 cases of multi-phase CT images were used to validate our proposed method for the segmentation of liver tumors. The average precision and recall rates for tumor detection are 76.8% and 84.4%, respectively. The intersection over union, true positive rate, and false positive rate for tumor segmentation are 72.7%, 76.2%, and 4.75%, respectively.