Graduate School of Science and Technology Master's Thesis Abstract

Laboratory name (Supervisor)	Imaging-based Computational Biomedicine (Yoshinobu Sato (Professor))		
Student ID	2011413	Submission date	2022 / 7 / 26
Name	LI GANPING		
Thesis title	Evaluation of Cross-modality Image Synthesis and Bayesian Active Learning in Segmentation of Lower Limb Muscles in MR Images		

Abstract

Image segmentation is a fundamental problem as it extracts the organ/tissue of interest for medical research, such as the analysis of the muscle volume reduction due to the aging of the musculoskeletal system. Current deep learning-based musculoskeletal segmentation methods require a large number of annotated data to cover large variations in different anatomy, different subjects, noise, and so on. On the other hand, the manual annotation of medical image needs considerable efforts and costs. Furthermore, it would be efficient to leverage the annotations made for images acquired by a modality, e.g., magnetic resonance imaging (MRI), into another, e.g., Computed Tomography (CT), and vice versa. This study investigated the feasibility of cross-modality image synthesis and Bayesian active learning (Bayesian AL) in segmenting lower limb muscles in MR images to build medical image dataset with low costs. The task was twofold: 1) to build a small number of annotated MR datasets using existing annotated CT datasets (20 cases) based on cross-modality image synthesis as an initial seed for the AL step, and 2) to generate high-quality annotations for the unlabeled MR images using Bayesian AL. In addition, an improvement of the Bayesian AL method with an "Equal-Number-of-Candidate" policy, which boosts the diversity of the selected samples in preliminary stages by choosing an equal number of candidates for every instance before the sample selection, was achieved. In the experiments, the results of a 4-structure MR dataset of 119 cases demonstrated reduction of the annotation cost by 87.1% using only 990 training slices (7264 slices in total) by utilizing prior information from other modalities (i.e., CT image) and acquiring samples of high variety and representativeness within a limited number of iterations. The efficiency of the improved Bayesian AL was proven with a comparative experiment. In this experiment, the proposed method surpassed both the random policy and the conventional Bayesian AL considerably by 2.3% and 1.1%, respectively, at the first acquisition of 90 slices while showing a similar performance to the conventional Bayesian AL (improved by -0.3% ~) on the subsequent iterations. The generalizability of the proposed approach was additionally tested on 50 annotated lower limb CT datasets. The proposed approach was used to build 24-structure large-scale lower limb MR image datasets of 136 cases for subsequent clinical studies. A potential application would be the construction of a longitudinal dataset for a longitudinal study of lower limb aging/disease.