Efficient Multi-phase CT Image Segmentation Using Unsupervised Domain Adaptation

Swathi ANANDA†, Yinhao LI†, Rahul KUMAR JAIN†, Yutaro IWAMOTO††, Xianhua HAN†††, Lanfen LIN††††, Hongjie HU†††††, and Yen-Wei CHEN†

†Graduate School of Information Science and Engineering Ritsumeikan University, Japan

††Faculty of Information and Communication engineering, Osaka Electro-Communication University, Japan.

†††Artificial Intelligence Research Center, Yamaguchi University, Yamaguchi-shi, Japan.

††††College of Computer Science and Technology, Zhejiang University, Hangzhou, 310000 China.

†††††Department of Radiology Sir Run Run Shaw Zhejiang University, Hangzhou, 310016 China.

E-mail: gr0502if@ed.ritsumei.ac.jp

Multi-phase computed tomography (CT) images are widely used for diagnosing liver illness. However, applying deep learning approaches on multi-phase CT images is not a feasible solution, since each phase has a different contrast enhancement (i.e., different domain), the multi-phase CT images must be manually annotated for all phases to perform liver or tumor segmentation, which is labor-intensive and time-consuming. Moreover, due to the domain-shift problem results are low when the trained model is tested on unseen target domain. To address these issues, we have proposed three frameworks. Initially, we proposed a dual discriminator-based unsupervised domain adaptation (DD-UDA framework) for liver segmentation on multi-phase CT images without annotations using adversarial learning. We have performed domain adaptation at two levels: one is at the feature level, and the other is at the output level, to improve accuracy by reducing the difference in distributions between the source and target domains. To further minimize the domain shift problem, we proposed to use Fourier-based unsupervised domain adaptation (F-UDA) framework for multi-phase CT images where we generate augmented source images and train our framework using source domain and the augmented source domain. Then we performed segmentation using source images and augmented source images. Finally, we propose an efficient Multi-phase CT Image segmentation framework combining DD-UDA and F-UDA approaches. Experiments were performed using our public LiTS dataset and our private Multi-Phase CT dataset of Focal Liver Lesions (MPCT-FLL) dataset, and the results show a consistent and comparable improvement in the performance of our multi-phase liver segmentation using our proposed frameworks over the previously reported state-of-the-art methods.