OA-GAN: Organ-Aware Generative Adversarial Network for Synthesizing Contrast-enhanced Medical Images

Yulin Yang[1], Jing Jiu[2], Gan Zhan[1], Fang Wang[3], Qingqing Chen[3], Yinhao Li[1], Rahul Kumar Jain[1], Hongjie Hu[3], Lanfen Lin[4], and Yen-Wei Chen[1]

[1]Graduate School of Engineering, Ritsumeikan University, Japan
[2]Research Center for Healthcare Data Science, Zhejiang Lab, Hangzhou, China
[3]Department of Radiology, Sir Run Run Shaw Hospital, Zhejiang University School of Medicine, Hangzhou, China
[4]College of Computer Science and Technology, Zhejiang University, Hangzhou, China
E-mail: gr0528hs@ed.ritsumei.ac.jp

Contrast-enhanced computed tomography (CE-CT) images play a crucial role in the clinical diagnosis of focal liver lesions (FLLs). However, the use of CE-CT images imposes a significant burden on patients because of the injection of contrast agents and extended shooting. Deep learning-based image synthesis models offer a promising solution that synthesizes CE-CT images from non-contrasted CT (NC-CT) images. Unlike natural images, medical image synthesis requires a specific focus on certain organs or localized regions to ensure accurate diagnosis. Determining how to effectively emphasize target organs poses a challenging issue in medical image synthesis. To solve this challenge, we present a novel CE-CT image synthesis model called, Organ-Aware Generative Adversarial Network (OA-GAN). The OA-GAN comprises an organ-aware (OA) network and a dual decoder-based generator. First, the OA network learns the most discriminative spatial features about the target organ (i.e., liver) by utilizing the ground truth organ mask as localization cues. Subsequently, NC-CT image and captured feature are fed into the dual decoder-based generator, which employs a local and global decoder network to simultaneously synthesize the organ and entire CECT image. Moreover, the semantic information extracted from the local decoder is transferred to the global decoder to facilitate better reconstruction of the organ in entire CE-CT image. The qualitative and quantitative evaluation on a CE-CT dataset demonstrates that the OA-GAN outperforms state-of-the-art approaches for synthesizing two types of CE-CT images such as arterial phase and portal venous phase. Additionally, subjective evaluations by expert radiologists and a deep learning-based FLLs classification also affirm that CE-CT images synthesized from the OA-GAN exhibit a remarkable resemblance to real CE-CT images.