Chest CT synthesis from Whole-Body MRI for Oncologic Workup using Adversarial Domain Adaptation

Changi Kim[1], Dongheon Lee[2] and Chang Min Park[1,3,4*]

[1]Interdisciplinary Program in Bioengineering, Graduate School, Seoul National University, Seoul, Korea
[2]Biomedical Research Institute, Seoul National University Hospital, Seoul, Korea
[3]Department of Radiology, Seoul National University College of Medicine, Seoul, Korea
[4]Institute of Radiation Medicine, Seoul National University Medical Research Center, Seoul, Korea
* Correspondence: cmpark.morphius@gmail.com

Background

Magnetic resonance image (MRI) is characterized by superior soft-tissue contrast, and has no risk of radiation exposure to patients [1]. However, MRI is susceptible to field inhomogeneity and produces air-borne artifacts in the lung. Hence, MRI has not been the modality of choice for the lungs, but CT has been chosen for diagnosis of lung pathologies [2]. Consequently, patients who undergo whole-body MR, particularly for oncology work-ups are required to take additional chest CT scans for lung evaluation, which would lead to additional radiation exposure and financial cost. In this study, we aimed to develop a style transfer learning algorithm for chest CT images from the whole-body MRI by using a deep learning-based adversarial domain adaptation.

Materials and Methods

The pair of whole-body MRI and chest CT images were collected from 14 oncologic patients (9 men and 5 women; mean age of 55). Among them, 96, 103 slices from the MR and CT of 12 patients were used as training data, and the data augmentation was applied. In addition, lung region segmentation, CT image windowing, and contrast limited adaptive histogram equalization(CLAHE)[3] for MR images were included as pre-training steps. The CycleGAN was adopted for this study, and the performance was evaluated by an ablation study coherent to pre-processing methods.

Results

Compared to the model in which the entire chest image was trained, it was shown that the model learned by applying lung segmented images with CT image windowing and CLAHE were qualitatively better-representing lesions (Figure 1).

Discussion and Conclusion

The study proposed is to generate synthetic CT images from whole-body MR images with deep learning-based models. Our results suggest that the model with applying various pre-processing methods generates lung lesions better than the model without. However, there is a limitation that synthetic chest CT images do not fully reflect the characteristics of the original CT images, and we try to solve this problem by obtaining learning data from more diverse patients. The proposed study has shown the possibility that lung cancer diagnosis of patients can be performed only through whole-body MR imaging without additional CT imaging, and further models will be enhanced to confirm clinical implication through quantitative validation.

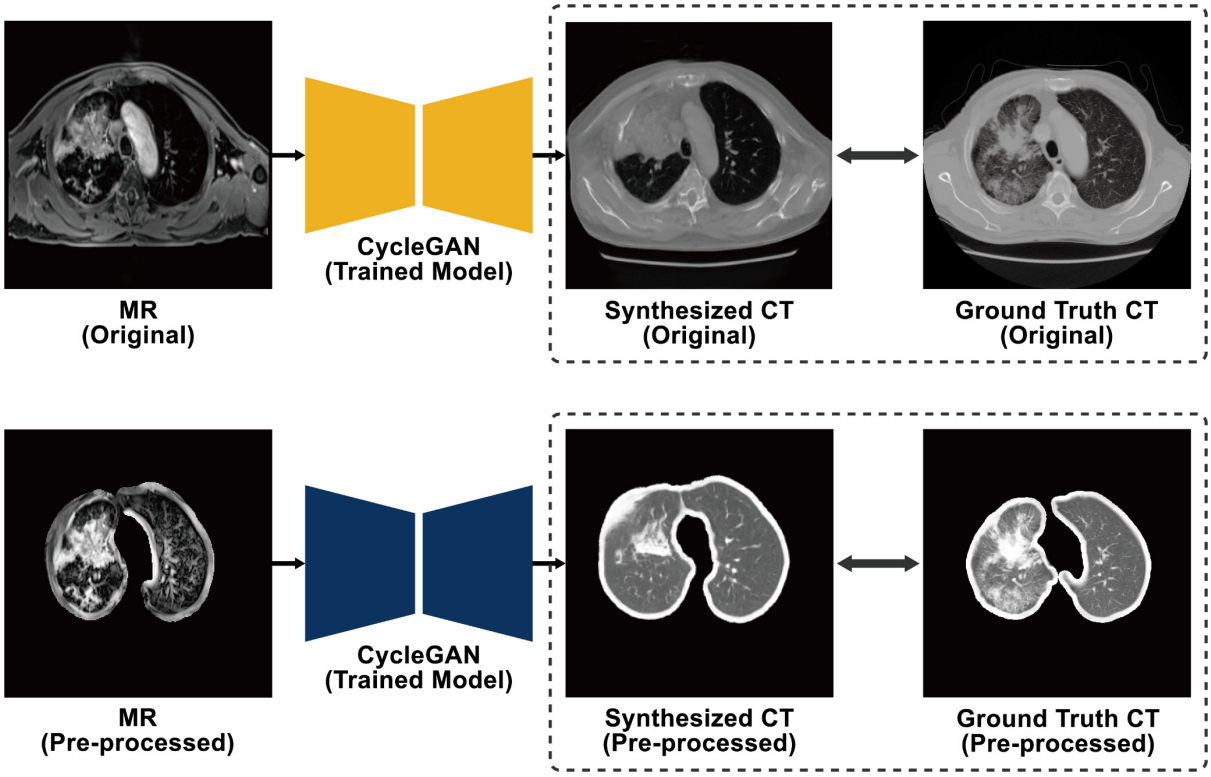

Figure 1. Pseudo CT image synthesized from the original MR and pre-processed MR.

References

1. Jue Jiang et al. 2019. Cross-modality (CT-MRI) prior augmented deep learning for robust lung tumor segmentation from small MR datasets.Medical Physics, 46(10), 4329-4404.
2. Richard Wender et al. 2013. American Cancer Society lung cancer screening guidelines. CA: A Cancer Journal for Clinicians, 63(2), 106-117.
3. S.M. Pizer et al. 1987. Adaptive histogram equalization and its variations. Computer Vision, Graphics and Image Processing, 39, 355-368.
4. Jun-Yan Zhu, Taesung Park, Phillip Isola, and Alexei A. Efros. 2017. Unpaired image-to-image translation using cycle-consistent adversarial networks. IEEE ICCV, 2223-2232.