AI Powered Contrast Enhanced CT Generation and Segmentation for Heart Substructures in Breast RT Patients

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Introduction

- Recently, there has been a growing interest in breast cancer among cancer species that may develop cardiac toxicity after radiation treatment.
- The increase in the long-term survivor of breast cancer has shown that the cause of non-cancer death is heart disease caused by dose to the heart during breast cancer radiation treatment.
- Thus, we should consider the effect of radiation on the heart. This will be minimized if the substructures of the heart can be contoured when receiving breast cancer treatment.
- So currently the contrast enhanced CT are used to contour the heart's substructures in radiation therapy planning.
- However, there are some patients who are unable to take contrast enhanced CT due to clinical or other reasons.
- Therefore, we want to solve this problem by creating a contrast CT image only with non-contrast CT images with the use of deep learning.

Methods

- Our framework includes three main parts:
  - a preprocessing, a training, and a prediction
- The preprocessing was performed by adjusting the contrast for better training of the heart's substructures and the position of each patient was registered by affine transform.
- The training and prediction parts were implemented by Generative Adversarial Networks (GANs) which includes two image types.
- A non-contrast CT image for input and a contrast CT image for output. Of 19 patients,
  - Training : 13 patients (8,646 2D paired images)
  - Validating : 3 patients (2,554 2D paired images)
  - Testing : 3 patients (2,554 2D paired images)

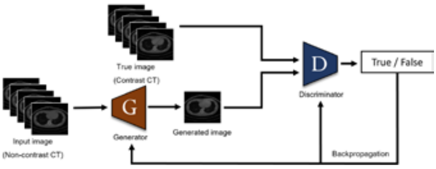

Figure 1. The Generative Adversarial Networks (GANs) architecture used in this study.

Results

- It is necessary to compare the image quality between the result CT images and the contrast enhanced CT images which are used as a reference data.
- The image quality assessment was implemented by Peak Signal-to-Noise Ratio (PSNR) and Structural Similarity Index Map (SSIM) for 3 patients.
- The results of PSNR are 21.65, 21.87, and 22.73. The results of SSIM are 0.68, 0.67, and 0.67.

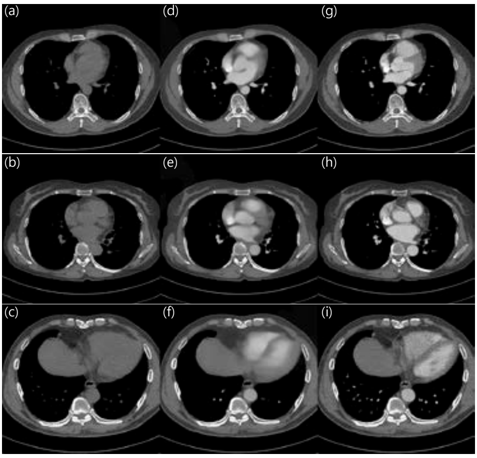

Figure 2. Image comparisons for a representative axial slice. (a), (b), and (c) are Input non-contrast CT images. (d), (e), and (f) are predicted images. (g), (h), and (i) are ground truth contrast CT images.

	Patient 1	Patient 2	Patient 3
PSNR	21.65	21.87	22.73
SSIM	0.68	0.67	0.67

Table 1. Comparison of PSNR and SSIM for each test patients.

Conclusion

- The results represent a potential of generating the contrast enhanced CT image from the non-contrast CT image.
- We will conduct a further study with different methods of preprocessing or post processing to get better results and with larger data set.
- Furthermore, not only the proposed methods, we plan to segment automatically the substructures of heart from the generated CT using deep learning methods.

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