Synthesis of Pediatric Abdominal Computed Tomography with Deep Convolutional Generative Adversarial Networks

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***Abstract*— This paper presents a method to synthesize abdominal computed tomography (CT) scans using a modified deep convolutional generative adversarial network (DCGAN). The proposed network generated 424 2D pediatric abdominal CT images, and can be further trained to generate other medical images.**

I. Introduction

Deep learning is a powerful tool in medical image processing and analysis. Recent advances in deep generative adversarial networks have been applied in the field of medical imaging for tasks such as denoising and cross modality transfer [1]. One major challenge in medical image processing is the lack of training data from pediatric patients. Diagnostic imaging tests such as Computed Tomography (CT) scans require radiation, and it has been found that the use of CT scans in children to deliver cumulative doses of about 50 mGy might almost triple the risk of leukemia [2]. The fact that children are much more radiosensitive than adults make them vulnerable to radiation exposure in CT scans. Since most deep learning models used in the medical field requires large amounts of training data, there is a need to synthesize more high-definition, realistic CT scans from pediatric patients.

II. Methods

We first preprocessed pediatric abdominal CT scans (n=20) in Nifti (*.nii*) format into 2D slices of *png* format using lossless compression. 424 slices containing the liver region were further selected as training data. We selected slices containing the liver region because it is the easiest region to be identified by segmentation algorithms.

We also modified the DCGAN's network architecture to stabilize the training. An additional layer was added to accommodate the 512x512 image size, and we chose batch normalization plus SELU (scaled exponential linear units) instead of RELU (rectified linear units) to be our network's activation layer (1). BS layers' discriminatory property allows networks to form unbiased estimators. Previous research has shown that using batch normalization along with SELU will help stabilize training while increasing convergence speed [3].

$$selu(x) = \lambda \begin{cases} x & if\ x > 0 \\ \alpha e^{x} - \alpha & if\ x \leq 0 \end{cases} \quad (1)$$

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III. Results

We measured the multi-scale structural similarity index (MS-SSIM) and peak signal to noise ratio (PSNR) of 222 unique pairs of generated images (Tab. I). A pair of original and generated CT images is included [Fig. 1] to demonstrate the effectiveness of the trained DCGAN.

TABLE I. Quantitative Analyses of Generated Images

Average MS-SSIM	***Average PSNR***
0.6856	19.68

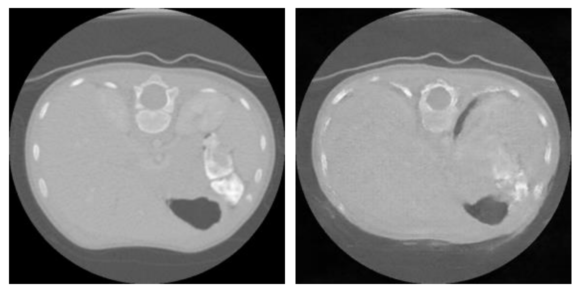

Figure 1. Example of original (left) and generated (right) images

IV. Discussion & Conclusion

In this study, we unconditionally synthesized abdominal CT scans with a modified DCGAN with batch normalization-SELU (BS) activation layers. The proposed network architecture generated 512x512 abdominal CT images with average MS-SSIM 0.6856 and average PSNR 19.68. MS-SSIM can be further improved by increasing variety in training images, and perhaps adding an additional layer to capture finer details. This method of image synthesis can be extended to synthesize other pediatric CT images, since obtaining pediatric medical images is often harder than obtaining adult images. Possible extensions include conditional generation of CT images based on age and other patient information, as well as directly generating scans in Nifti (*.nii*) instead of converting scans to *png*s.

References

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