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Generation of High-Quality Synthetic CT Images from Cone Beam CT Images Using A.I. Based Generative Networks

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Abstract : Introduction: Cone Beam CT(CBCT) images play an integral part in proper patient positioning in cancer patients undergoing radiation therapy treatment. But these images are low in quality. The purpose of this study is to generate high-quality synthetic CT images from CBCT using generative models. Material and Methods: This study utilized two datasets from The Cancer Imaging Archive (TCIA) 1) Lung cancer dataset of 20 patients (with full view CBCT images) and 2) Pancreatic cancer dataset of 40 patients (only 27 patients having limited view images were included in the study). Cycle Generative Adversarial Networks (GAN) and its variant Attention Guided Generative Adversarial Networks (AGGAN) models were used to generate the synthetic CTs. Models were evaluated by visual evaluation and on four metrics, Structural Similarity Index Measure (SSIM), Peak Signal Noise Ratio (PSNR) Mean Absolute Error (MAE) and Root Mean Square Error (RMSE), to compare the synthetic CT and original CT images. Results: For pancreatic dataset with limited view CBCT images, our study showed that in Cycle GAN model, MAE, RMSE, PSNR improved from 12.57to 8.49, 20.94 to 15.29 and 21.85 to 24.63, respectively but structural similarity only marginally increased from 0.78 to 0.79. Similar, results were achieved with AGGAN with no improvement over Cycle GAN. However, for lung dataset with full view CBCT images Cycle GAN was able to reduce MAE significantly from 89.44 to 15.11 and AGGAN was able to reduce it to 19.77. Similarly, RMSE was also decreased from 92.68 to 23.50 in Cycle GAN and to 29.02 in AGGAN. SSIM and PSNR also improved significantly from 0.17 to 0.59 and from 8.81 to 21.06 in Cycle GAN respectively while in AGGAN SSIM increased to 0.52 and PSNR increased to 19.31. In both datasets, GAN models were able to reduce artifacts, reduce noise, have better resolution, and better contrast enhancement. Conclusion and Recommendation: Both Cycle GAN and AGGAN were significantly able to reduce MAE, RMSE and PSNR in both datasets. However, full view lung dataset showed more improvement in SSIM and image quality than limited view pancreatic dataset.

Keywords : CT images, CBCT images, cycle GAN, AGGAN
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