Cross Modality Medical Image Synthesis and Registration through Machine Learning

Computer Integrated Surgery II - Spring, 2021

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Introduction

- We have proposed a cycle generative adversarial network (cycleGAN) based pipeline to achieve MR-to-CT translation and registration. The pipeline includes pre-processing process of input volumes from different modalities, the training workflow, and our performance evaluation approach.
- This project provides robust MR-to-CT synthesis and evaluation method to assist surgeons during operations such as core-decompression surgeries.

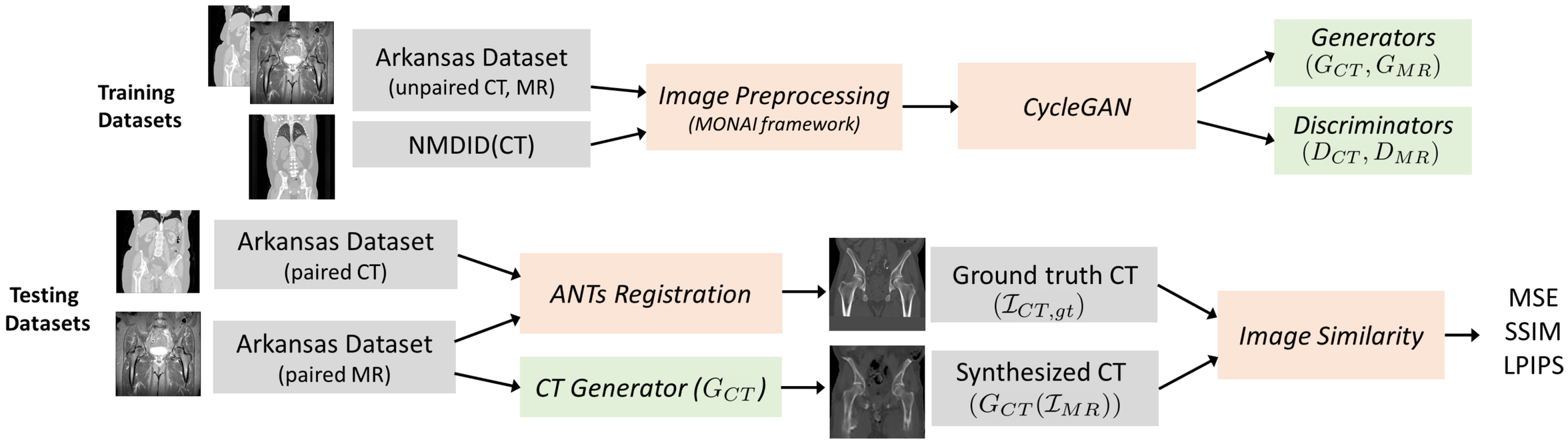

Figure 1. Project pipeline, including the training and evaluation workflow

The Problem

- Surgeons rely on preoperative MR scans for tool trajectory planning for core decompression surgeries. However, necrotic tissues and the drilling paths are not easily visible in intraoperative x-rays.
- Direct MR to x-ray registration has been challenging due to the lack of cross modality information between the two imaging modalities.

The Solution

CT to x-ray registration has been studied and implemented. Therefore, successful MR-to-CT translation algorithms would allow indirect registration between MR and x-rays.

- **Preprocessing module**
  1. Accepts datasets with different imaging modality, different FOV, or with either paired or unpaired data.
  2. Implementation of image normalization and data augmentation for network training.
- **CycleGAN Training**
  1. Modified loss formulation to take structural consistency loss (L_{SC}) into consideration.
- **Evaluation**
  1. Performs ANTs registration to obtain ground truth CT.
  2. Implementation of network performance evaluation module that calculates similarity metrices between ground truth and synthesized CT scans.

Outcomes and Results

- (Training) Input MR images and synthesized CT

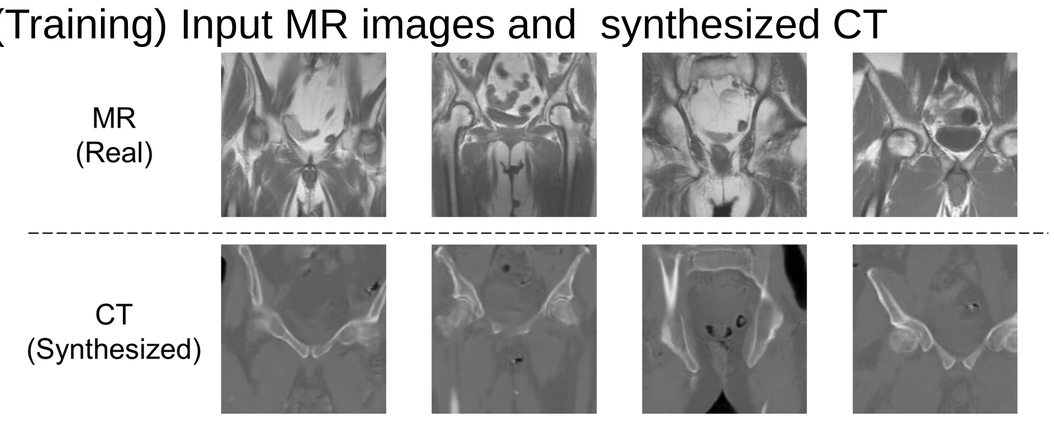

Figure 2. CycleGAN training results

- (Evaluation) Comparison between synthesized and ground truth CT (with different training size (ts) and structural consistency loss settings)

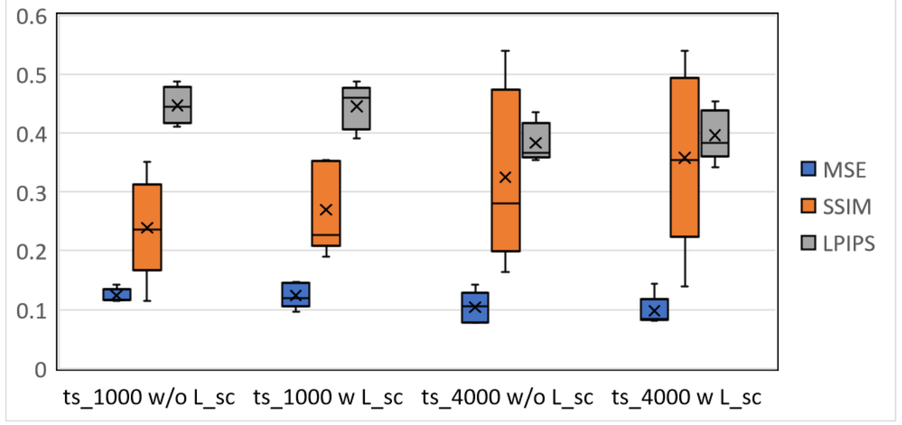

Figure 3. Evaluation results

Future Work

- Ping-Cheng Ku will continue work on similar research topics. Detailed documentations of this project have been provided for future researchers to work on cycleGAN-based image translation.

Lessons Learned

- Proper performance evaluation method and experiment setup is crucial. Existing algorithms should be implemented for performance benchmarking.

Credits

- Ping-Cheng Ku conducts all the implementation and the evaluation.

Publications

- With more training datasets available and with proper benchmarking algorithms developed, this work could be extended for publications.

Support by and Acknowledgements

- Thanks to Dr. Armand and Alejandro for their guidance throughout the project.
- Thanks to Robert for sharing his expertise and provide feedbacks on image registration and network training.