T1 – T2 WEIGHTED SYNTHETIC IMAGE GENERATION USING CYCLE GAN

A PREPRINT

Wahid Alam
Department of Biomedical Engineering
The University of Iowa
iowa city, IA 52242
mohammadwahidul-alam@uiowa.edu

Subin Erattakulangara
Department of Biomedical Engineering Engineering
The University of Iowa
iowa city, IA 52242
subin-erattakulangara@uiowa.edu

May 16, 2021

1 Introduction

Magnetic resonance imaging or MRI is a non-invasive imaging technology that produces three dimensional detailed anatomical images. It is often used for disease detection, diagnosis, and treatment monitoring. It is based on sophisticated technology that excites and detects the change in the direction of the rotational axis of protons found in the water that makes up living tissues. The method is well suited for imaging non-bony part tissues or soft tissues. Compared to Computed tomography MRI relatively safe since It does not generate any ionizing radiation like x-rays. The brain, spinal cord, and nerves, as well as muscles, ligaments, and tendons are seen much more clearly with MRI than with regular x-rays and CT; for this reason, MRI is often used to image knee and shoulder injuries. In the brain, MRI can differentiate between white matter and grey matter and can also be used to diagnose aneurysms and tumors. Because MRI does not use x-rays or other radiation, it is the imaging modality of choice when frequent imaging is required for diagnosis or therapy, especially in the brain. However, MRI is more expensive than x-ray imaging or CT scanning.

The most common MRI sequences are T1-weighted and T2-weighted scans. T1-weighted images are produced by using short TE(echo time) and TR(Reputation time). The TE and TR can be considered as a variable to switch between T1 and T2 images. The contrast and brightness of the image are predominately determined by T1 properties of tissue. Conversely, T2-weighted images are produced by using longer TE and TR times. In these images, the contrast and brightness are predominately determined by the T2 properties of tissue. Using these T1 and T2 protocols we can highlight certain tissue properties which are specific for diagnosis.

Machine learning has been aggressively applied to the field of magnetic resonance imaging in multiple ways. People have found its application ranging from data acquisition to analysis of MRI data. Machine learning has been in the forefront of helping clinicians to diagnose multiple diseases using MRI data. From MRI we can acquire data in multiple forms like static images, Dynamic (2D +time), 3D data and 4D data (3D + time). The ability of MRI to generate such kinds of data is helpful for machine learning since it's a data driven modality. Even though there is huge possibility to generate varies types of data MRI have some limitations and trade-offs on acquiring these. These trade-offs related to T1 and T2 protocols introduce certain constraints for collecting data from the hardware. We are unable to go beyond these physical constraints and generate data. But If we can go beyond these constraints there is a huge benefit for machine learning algorithms. In this project we are trying to address this problem by generating synthetic data which we cannon practically generate using MRI machines due to hardware limitations.

2 Problem definition

As we know there are certain advantages for T2 and T1 weighted imaging protocols, But In some cases It's hard to generate those specific protocol data. For example, if we are trying to take a dynamic MRI scan; T1 is the default protocol used since it can capture data at a higher frame rate compared to T2. From the machine learning standpoint T2

data have higher advantage over T1 since the images acquired using T2 protocol have a greater number of features embedded in the soft tissues. Since T2 protocol is a slow process, in practical it is not possible to acquire data of a moving object.
Due to the abundance of features on T2 weighted data machine learning algorithms will have higher performance on T2 compared to T1 weighted images. Due to the problem mentioned above we have a practical limitation on generating sufficient data to train a network for classification/segmentation on T2 weighted images. Since there is a possibility to generate dynamic data / video from T1 weighted imaging in an easy and fast manner, in this project we are trying to solve that limitation by synthetically generating T2 weighted images from T1 weighted data [1]. We are also trying the possibility of generating a dynamic T2 weighted sequence which is practically impossible due to the hardware constraints[2].

3 Dataset

The problem statement requires T1 and T2 images from an MRI dataset. So, we have choses MICCAI BraTS dataset. The dataset consists of T2, T1 and Flair dataset. All the data is acquired using clinically acquired 3T multimodal MRI scans.

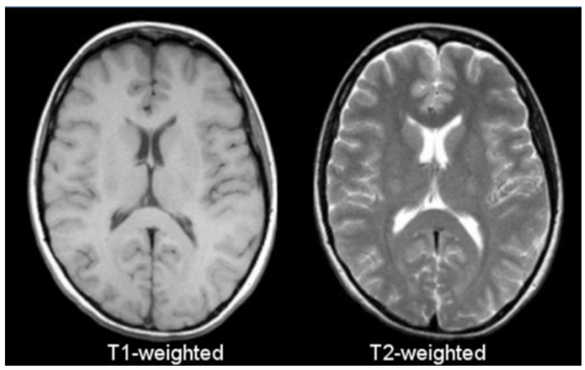

Figure 1: T1-T2 transformation pair .

The dataset is in a acquired as 3D data with multiple slices. For the current problem we won't be needing all the slices in the 3D data. So, the dataset processing pipeline will select few images in a range and will be saved separately to a folder.
Brats Dataset - `https://www.med.upenn.edu/sbia/brats2018/data.html`

References

[1] Bauer, D. F., Russ, T., Waldkirch, B. I., Segars, W. P., Schad, L. R., Zöllner, F. G., & Golla, A. K. (2020). Generation of Multimodal Ground Truth Datasets for Abdominal Medical Image Registration Using CycleGAN. arXiv preprint arXiv:2012.01582.

[2] Hiasa, Y., Otake, Y., Takao, M., Matsuoka, T., Takashima, K., Carass, A., ... & Sato, Y. (2018, September). Cross-modality image synthesis from unpaired data using CycleGAN. In International workshop on simulation and synthesis in medical imaging (pp. 31-41). Springer, Cham.