Medical Image Translation using 3D ShuffleUNet

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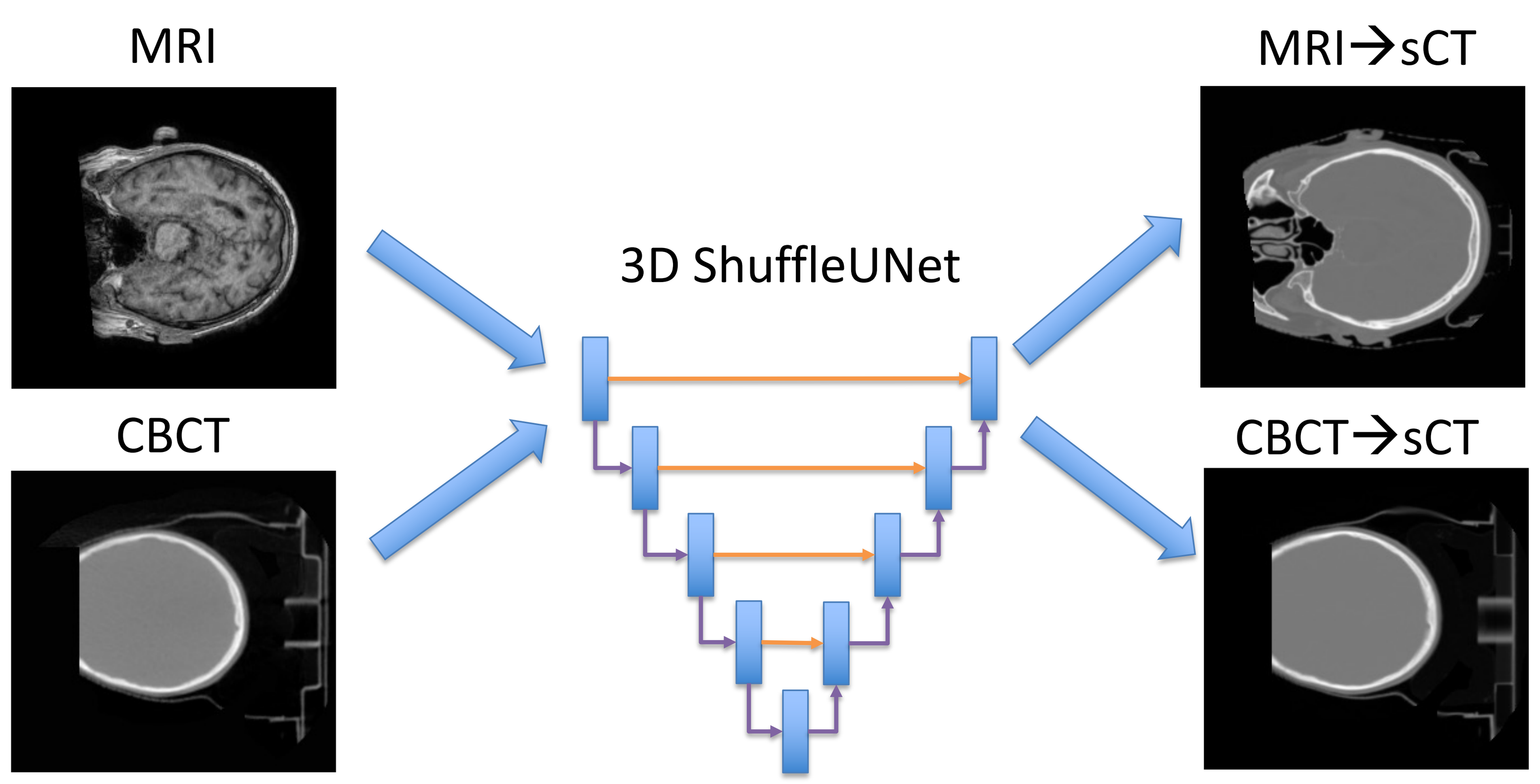
1. Background/ Introduction

- **Problem Statement**
  Medical image-to-image translation between different radiology modalities
  - Track 1: MRI-to-sCT translation
  - Track 2: CBCT-to-sCT translation
  ***sCT: synthetic CT

- **Image-to-image Translation**
  Learn a mapping between an input image and output image. In our study, we used 3D ShuffleUNet that maps between MRI/CBCT to sCT.



2. Challenges

- **Difference between image modalities**
  - MRI & CT: different protocols for obtaining image, so the contrast, texture, and highlights are very different
  - CBCT & CT: similar protocol, but CBCT has limited information in texture and quality
- **Image artifacts**
  Artifacts such as checkboard artifacts, outliers, and blurriness are very common in image translation

3. Methods

- **Processing**
  - MRI: Z-score normalization

$$\frac{(x-\mu)}{\sigma}$$

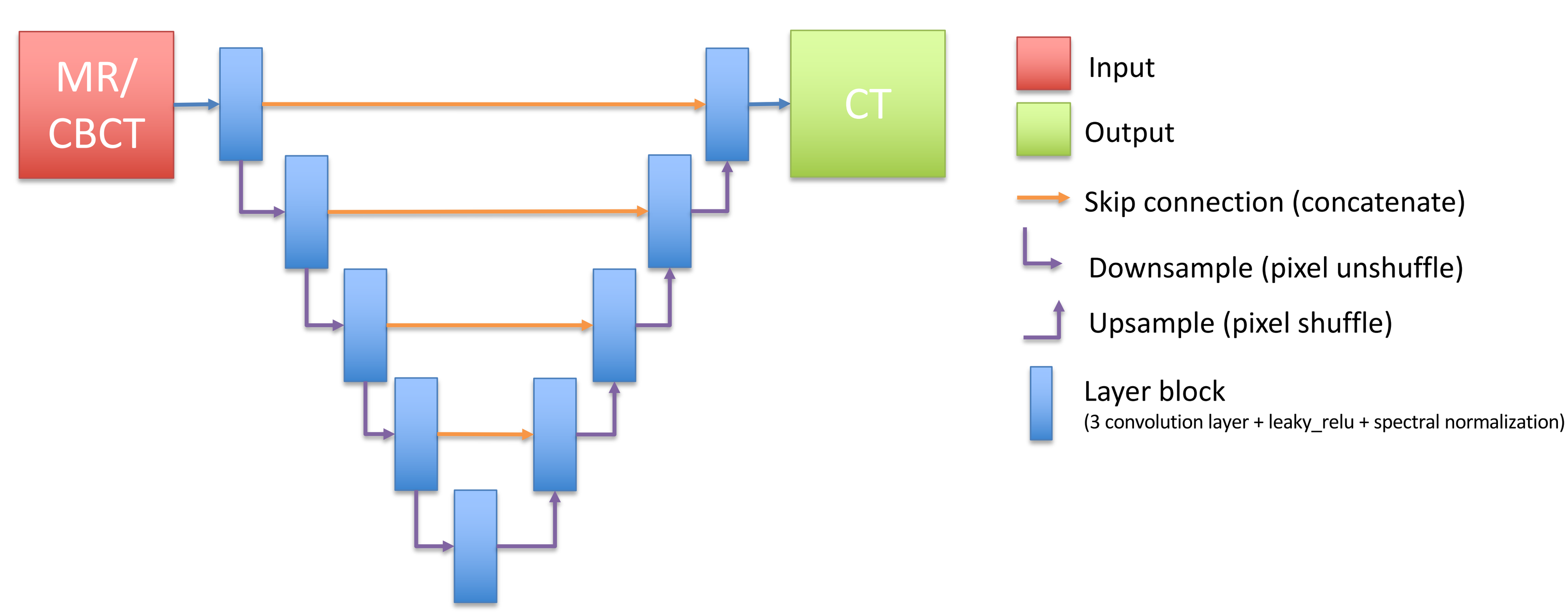
  - CBCT/ CT: fixed-range intensity scale

$$\frac{x - voxel_{min}}{voxel_{max} - voxel_{min}} = \frac{x + 1024}{3000 + 1024}$$

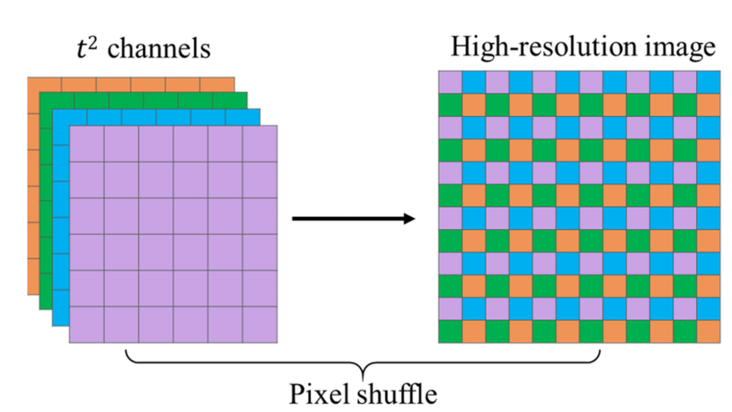
- **Model**
  We used 3D ShuffleUNet, a U-Net with
  1. 3D convolution layers
  2. Pixel-unshuffle for downsample module
  3. Pixel-shuffle for upsample module

- **3D Pixel Shuffling/ Unshuffling**
  To address the issues of well-known artifacts such as blur and checkboard effects, we utilized pixel shuffling/ unshuffling to minimize the artifacts.

3D ShuffleUNet



Pixel shuffling/unshuffling



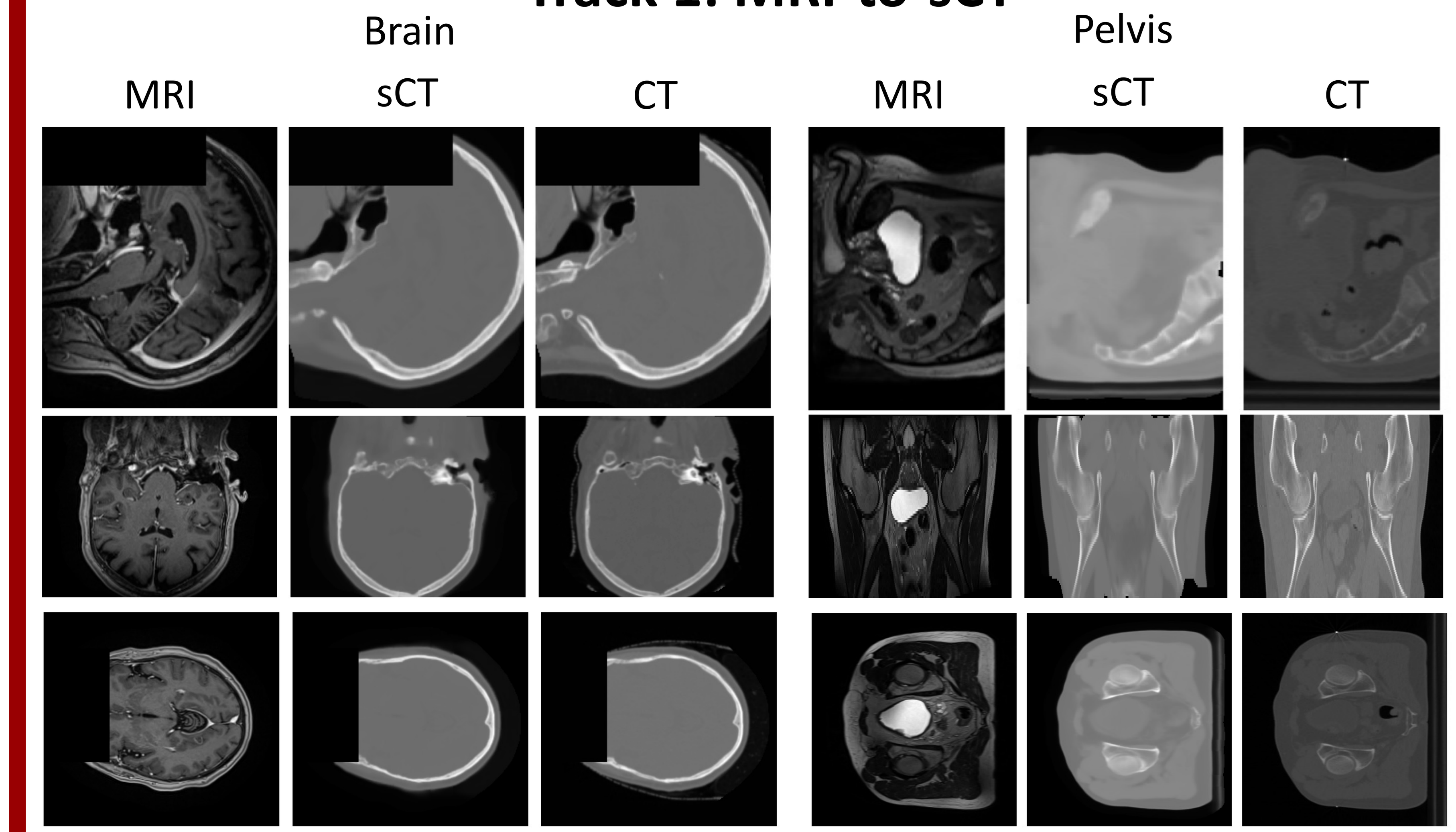
Ref: Wenzhe Shi, 2018 (ref)

4. Results

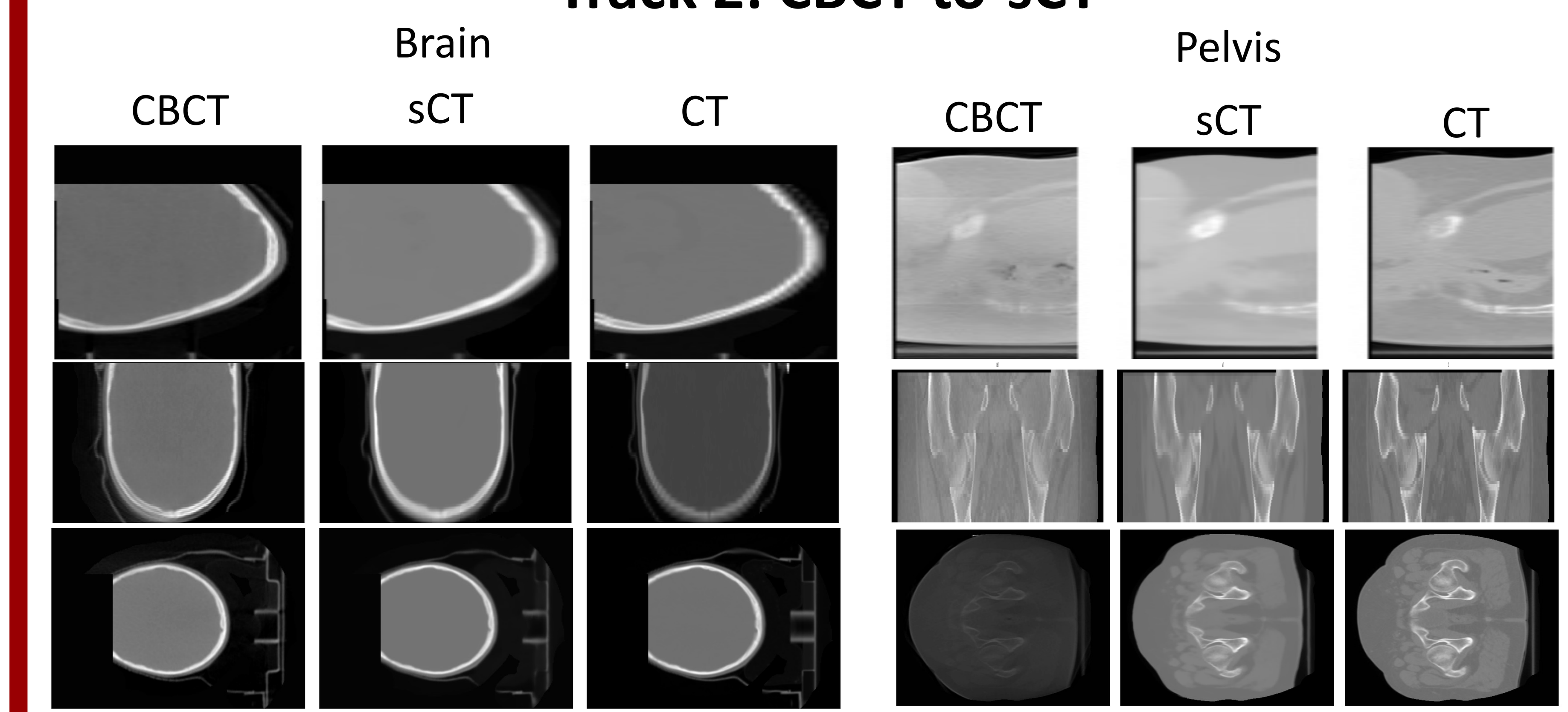
Performance table

Track	PSNE	SSIM	Dose MAE	DVH metric
Track 1 (top 5)	28.70 ± 1.59	0.87 ± 0.03	0.004 ± 0.003	0.028 ± 0.053
Track 2 (top 3)	30.58 ± 1.95	0.91 ± 0.03	0.004 ± 0.008	0.033 ± 0.154

Track 1: MRI-to-sCT



Track 2: CBCT-to-sCT



5. Limitations and Future Work

- For our future works,
  - We will incorporate more modules such as attention to improve the translation performance.
  - We will further explore in model hyperparameter for better tuning.