Marwadi University Marwadi Chandarana Group NAAC A+	**Marwadi University** **Faculty of Technology** **Department of Information and Communication Technology**	
Subject :- Generative AI – (01CT0711)	**Aim :- CT to MRI Image Translation Using CycleGAN**	
Assignment	**Date:- 14-09-2025**	**Enrollment No:-** 92200133030

Overview and Inspiration

- **The significance of medical imaging**: CT and MRI are both commonly used and have distinct advantages.
  - **MRI**: Time-consuming and costly, but excellent for soft tissue contrast.
  - **CT**: Quick and reasonably priced, but it uses dangerous ionizing radiation.
- **Problem**: MRI is expensive and scarce compared to CT, which is widely available.
- **Objective**: Convert CT scans into MRI-like images by combining the diagnostic depth of MRI with CT accessibility.
- **Gap**: There was not much previous research on translating CT to MRI; however, GANs (Pix2Pix, UNIT, and CycleGAN) worked well for translating other medical texts.
- Because CycleGAN can handle unpaired datasets (i.e., no exact CT–MRI pairs), it was chosen as the model.

Dataset

- **Source**: Brain cross-sections, open-source Kaggle repository.
- **Domains**:
  - **Domain A**: CT scans.
  - **Domain B**: MRI scans.
- **Preparation**:
  - scaled to [-1, 1] (for tanh) and resized to 256 x 256 pixels.
  - 500 CT and 500 MRI pictures (out of about 1700 total) were chosen for training.
  - Because of the small dataset, augmentation is used to lessen overfitting.

Methodology

1. **Why Are GANs Used?**

- GANs are useful for translating contrast, textures, and anatomy in medical imaging because they can model complex transformations.
- **Challenge**: Unpaired CT and MRI scans → resolved with Cycle GAN.

2. **Architecture of Cycle GAN**

- **Generators**
  - Transformer (6 residual blocks) → Decoder → Encoder.
  - CT (256 x 256 x 3) input, synthetic MRI output.
- **Discriminators**:
  - PatchGAN is used to classify local patches as real or fake rather than the entire image.
  - Consistency of Cycles:Synthetic MRI → CT → reconstructed CT (should match original).maintains anatomical precision.

3. **Functions of Loss**

- **Adversarial Loss**: Promotes outputs that resemble real MRIs.
- **Cycle Consistency Loss**: Guarantees the ability to reconstruct translated images.
- Adversarial + Cycle Consistency = Total Loss.

Experiments

- **Framework**: Keras, TensorFlow 2.6.5, and Python 3.8.
- **Hardware**: RTX A6000 GPU from Nvidia (CUDA 11.3).
- **Instruction**:
  - 500 periods.
  - 500 is the batch size.
  - Fifty thousand times.
- **Metrics for Evaluation**:
  - MAE (Mean Absolute Error) → similarity in pixel values.
  - MSE (Mean Squared Error) → error magnitude.
  - PSNR (Peak Signal-to-Noise Ratio) → image quality & fidelity.

Results

- **Produced Pictures**:
- Realistic anatomical features and MRI-like images were generated by CycleGAN.
- For instance, the gray matter, white matter, CSF, and vessels were all clearly visible in the T1-weighted brain MRI obtained from the CT scan.
- **Quantitative Comparison (CNN vs. CycleGAN):**

Metric	CNN	CycleGAN
MAE	70.44	0.5309
MSE	60.867	0.3790
PSNR	9.457	52.344

- **CycleGAN** performs significantly better than the CNN baseline.
- **Training Loss Trends**: Consistent decline across cycle and adversarial losses → model convergence verified.

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Conclusion

- Success of CycleGAN:
- CT → MRI accurately translated without paired data.
- produced MRI-like, high-fidelity images with a high PSNR and minimal error.

- **Clinical Significance**:
  - lessens reliance on expensive MRI equipment.
  - prevents further radiation exposure.
  - decreases patient wait times and improves diagnostic capabilities.
  - When compared to CNN, CycleGAN performs noticeably better on unpaired medical datasets.

Future Work

- **Improvements**:
  - Sharper, higher-resolution MRI images can be obtained by integrating Super-Resolution GAN (SRGAN).
  - For more realism and detail, investigate hybrid CycleGAN + SRGAN.
  - For robustness, compare with Pix2Pix, UNIT, and UNet.
- **Objective**: Create MRI-like scans that are clinically dependable for wider diagnostic use.