Multi-Contrast MRI synthesis using Generative Adversarial Networks

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MEDICAL PHYSICS COMMUNITY INSPIRATION INNOVATION IMPACT
2026 JULY 19–22 VANCOUVER, BC
JOINT AAPM | COMP MEETING

RÉSEAU DE SANTÉ Horizon HEALTH NETWORK

TAKE-HOME MESSAGE: One scan → Three synthetic MRI contrasts with improved image quality

BACKGROUND

- Multi-contrast MRI (T1-contrast enhanced (T1-CE), T2, T2-FLAIR) is essential for brain radiotherapy planning.
- Acquiring multiple MRI sequences increases scan time, patient discomfort, and gadolinium contrast exposure.
- Synthetic MRI from a single T1 scan could simplify imaging while preserving diagnostic information.

AIM & WHAT WE DID

- **Aim:** Developed a novel dual-scale 2.5D GAN that synthesizes (T1-CE, T2, T2-FLAIR) each slice using the corresponding T1 slice and its adjacent slices and compared it with a 2D GAN that uses only the corresponding T1 slice as input to evaluate the benefit of neighboring-slice information.
- Evaluated synthetic image quality using SSIM and PSNR and assessed clinical utility by comparing automatic tumour segmentation performance (Dice and Hausdorff Distance) on synthetic versus real MRI using the BraTS 2021 dataset.
- Demonstrated the feasibility of reducing the motion artifacts.

IMPACT

- ✓ Higher-quality synthetic MRI than conventional 2D synthesis.
- ✓ Reduced motion artifacts by generating all contrasts from a single artifact-free T1 scan.
- ✓ Potential to reduce MRI scan time, minimize GBCA use, and streamline brain radiotherapy workflows.

CONTACT

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METHODS: OVERVIEW

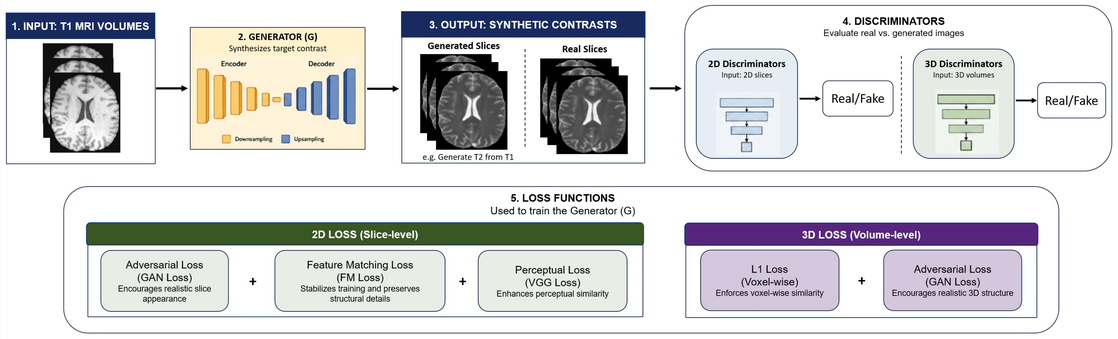

Figure 1: 2.5D model training workflow

QUALITATIVE RESULTS

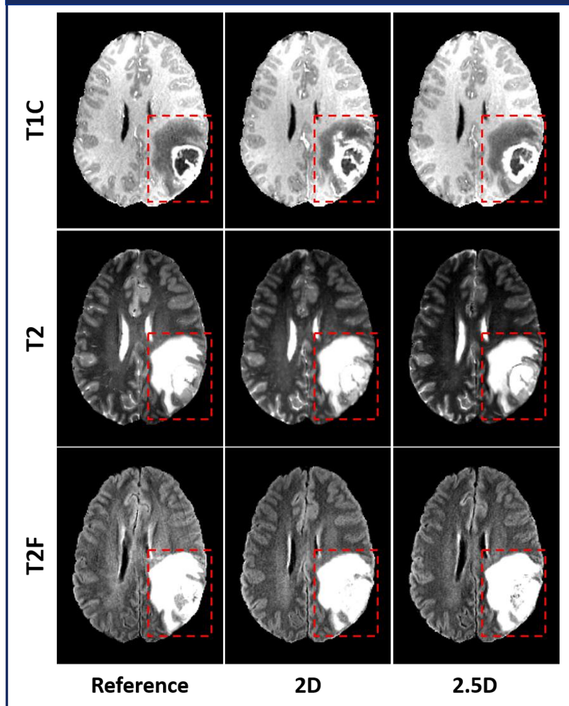

Figure 2: Examples of synthetic MRI images

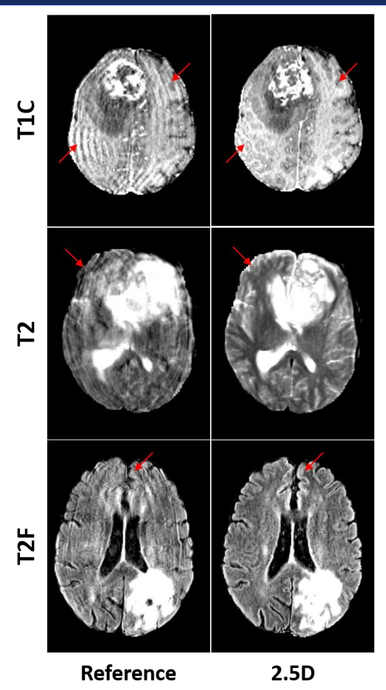

Figure 2: Synthetic image examples showing motion artifact mitigation. Reference images have artifacts, and synthetic images are artifact-free.

QUANTITATIVE RESULTS

Table 1: Quantitative evaluation of segmentation performance.

Input Configuration	Dice TC ↑	Dice WT ↑	Hausdorff TC ↓ (mm)	Hausdorff WT ↓ (mm)
All original MRI (T1, T1-CE, T2, T2-FLAIR)	0.86 ± 0.16	0.91 ± 0.05	4.5 ± 2.8	4.1 ± 2.0
T1 + fully synthetic 2D inputs (T1-CE, T2, T2-FLAIR)	0.49 ± 0.22	0.76 ± 0.10	8.2 ± 3.3	7.7 ± 2.4
T1 + fully synthetic 2.5D inputs (T1-CE, T2, T2-FLAIR)	0.53 ± 0.23	0.81 ± 0.09	8.3 ± 3.7	7.4 ± 2.5

Key results

- ✓ 2.5D improved tumor segmentation (Dice TC: 0.49→0.53, WT: 0.76→0.81).
- ✓ Better spatial accuracy with lower HD for whole tumor (7.7→7.4 mm).

RESULTS

- ✓2.5D GAN outperformed the 2D baseline across all MRI contrasts.
- ✓Achieved significantly higher SSIM and PSNR for T1-CE, T2, and T2-FLAIR ($p < 0.006$ for all comparisons).
- ✓Generated synthetic images with improved anatomical fidelity and closer agreement with reference MRI.
- ✓Tumor segmentation improved, with Dice scores increasing from 0.49 → 0.53 (tumour core) and 0.76 → 0.81 (whole tumour).

DISCUSSION & CONCLUSIONS

- ✓2.5D context improved anatomical consistency compared with conventional 2D synthesis.
- ✓Synthetic images preserved clinically relevant features and supported improved tumor segmentation, indicating potential for downstream radiotherapy applications.
- ✓Generating all MRI contrasts from a single, fast-acquired T1-weighted scan may reduce motion-related artifacts, shorten overall scan time, and eliminate the need for contrast-enhanced acquisitions.

LIMITATIONS

- Evaluated using the BraTS 2021 open dataset only.
- Performance was assessed on retrospective data without prospective clinical validation.
- Image quality and tumor segmentation were evaluated; impact on radiotherapy delineation and planning remains to be assessed.

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