Development & Evaluation of 3D PET synthetic tumors using TGAN and radiomics: Towards a digital patient population

BIOEMTECH

V. Paneta, V. Eleftheriadis, G. Savvidis, P. Papadimitroulas

BIOEMTECH Athens, Greece

Introduction

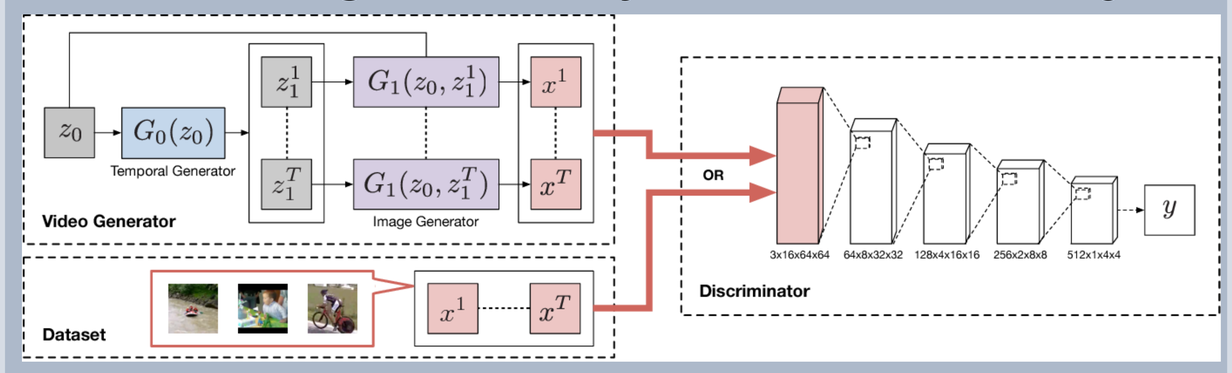
The development and application of high performing AI models in the field of medical imaging and oncology is hindered due to various reasons, ranging from data access and privacy concerns to the lack of appropriate data (e.g., data harmonization or variance among data) and model trust.

- This study aims **to develop a methodology towards the creation of realistic medical imaging data**.
- Combining AI techniques and Monte Carlo (MC) simulations (ground truth), we demonstrate the production of a **digital patient population**.

Method

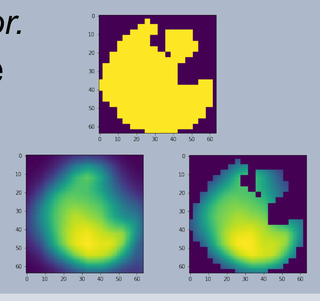
AI techniques

Temporal GAN architecture [1,2] adopting Wasserstein GAN model, was implemented on HECKTOR [3] head and neck tumor data **to generate 3D synthetic PET tumor** images



TGAN illustration (analogous study on video generation [2]): The video generator consists of two generators, the 1D temporal generator G_0 that captures how the frames evolve over time (t=1,..T) and the 2D image generator G_1 that transforms its output to a video data of T frames. The discriminator consists of 3D convolutional layers and evaluates whether these frames are from the dataset or the video generator.

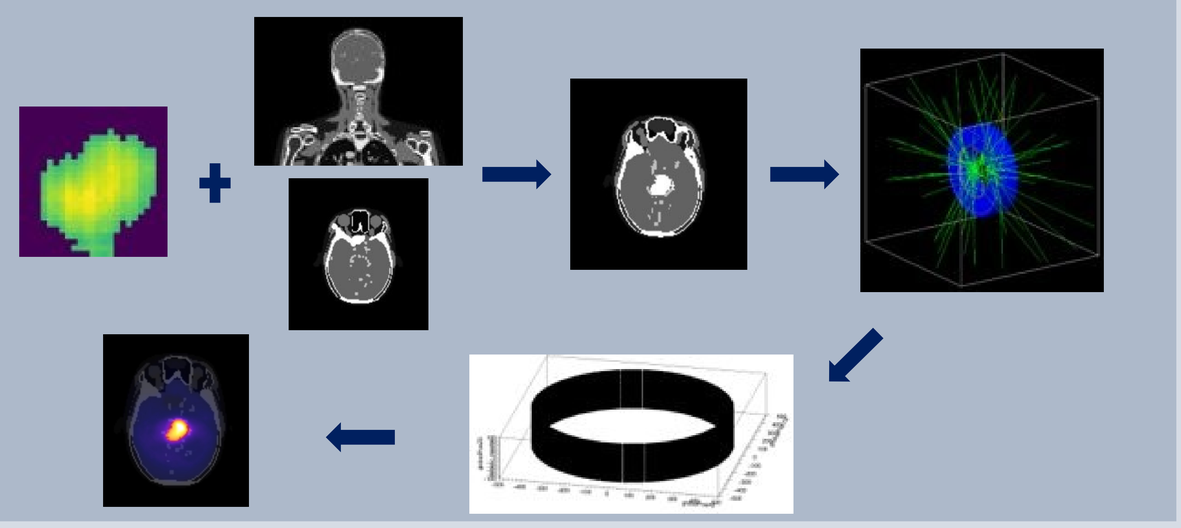
- Temporal variable t → Tumor slice sequence
- Crop of tumor PET images using the annotated bounding box
- Mask cropped tumors using the annotated masks



MC simulations

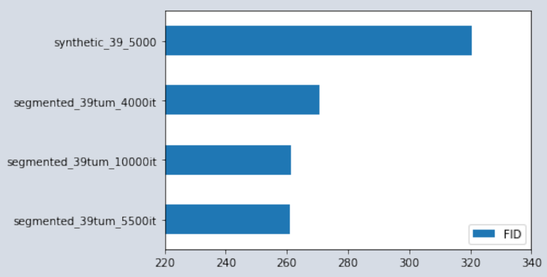
The generated synthetic tumors are imported to MC simulations in different anthropomorphic phantoms (XCAT) [4] **to simulate head and neck PET images of various patients** using the GATE MC toolkit.

- ✓ Activity map: **synthetic 3D PET tumors** (biodistribution from literature)
- ✓ Attenuation map: **XCAT phantom**
- ✓ Reconstruction: **CASToR**
- ✓ Outcome: PET data → **digital patient population**

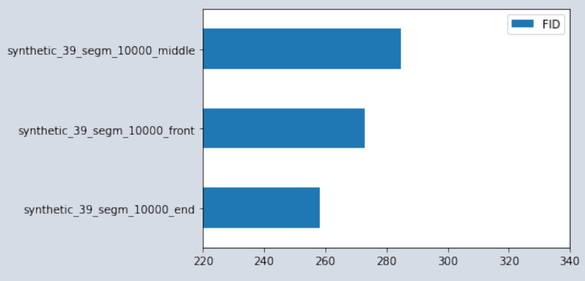


Synthetic Data Evaluation / Preliminary Results

- **Radiomic** features extracted from the generated tumor images to compare their distributions & correlations against those of real tumors → ***tumors are evaluated as volumes (3D)***
- **FID score** as "global" similarity score to the real 2D images, calculated over different TGAN generated image sets:

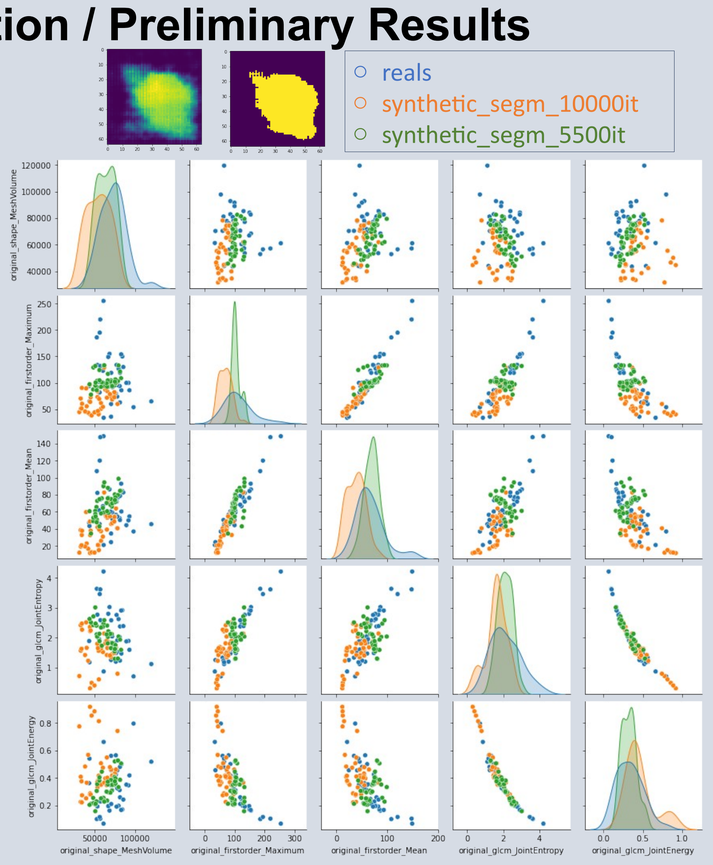


a) 1 set: all tumor slices



b) 3 tumor sets (front, middle, back)

→ ***tumors are evaluated as 2D images***



Selected radiomic feature distributions and correlation coefficients calculated on synthetic tumors are comparable to the real data.

Similar FID score but with big difference on max intensity

→ Radiomics comparisons and FID scores: comlpementary measures of similarity

Conclusions

The proposed methodology provides a reliable way for the development of synthetic PET tumor data, to enrich such datasets with harmonized, digital patients' population. Such methodology can be applied to other imaging modalities and contribute to the development of digital twins.

Next steps

→ Generate population of PET tumors to evaluate with FID
→ Use of a wider radiomics list for evaluation, with feedback from clinicians.
→ Standardize the methodology for tumor localization. Use of clinical PET data to keep reference points on location during TGAN training.

References

[1] Bergen R. et al., JNM, 2022.
[2] Saito M. et al., ICCV 2017.
[3] https://hecktor.grand-challenge.org
[4] Segars WP. et al., Med Phys 2010.

Acknowledgements

This work was supported by the CHIST-ERA grant [CHIST-ERA-19-XAI-007] with project acronym INFORM, by GSRI of Greece [T12EPA5-00053], NCN of Poland [2020/02/Y/ST6/00071] and ANR of France [ANR-21-CHR4-0006].