EPID-based in vivo transit dosimetry in external beam radiotherapy: prediction of portal dose images using artificial neural networks

Côme Mével Dutertre[ab], Alexandre Hakimi[a], Eric Fadel[a], François Smekens[a], Xavier Franceries[b], François Husson[a]
[a]DOSIsoft Physics R&D, Cachan, France
[b]INSERM Toulouse NeuroImaging Center, Toulouse, France

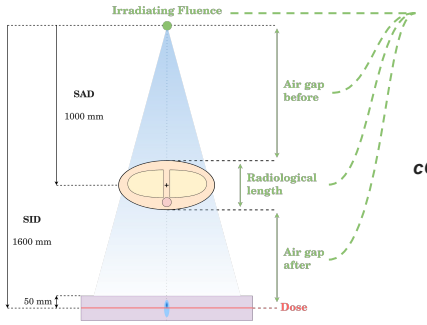
Introduction

EPID-based *in vivo* transit dosimetry using the forward technique requires the accurate calculation of the predicted (reference) image to be compared in terms of absolute dose with the acquired image.

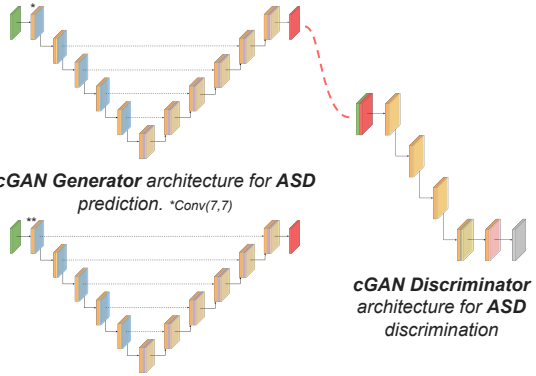
The **Collapsed Cone Convolution (CCC)** algorithm is a fast method for accurate dose predictions suitable to transit dosimetry, and allows a distinction between the dose generating phenomena. The **Detector Total Dose (DTD)** at the computation plane is the sum of the **Attenuator Transmitted Dose (ATD)** from direct photons beam transmission and the **Attenuator Scattered Dose (ASD)** from beam interaction in the attenuator.

This work introduces a **Machine Learning** workflow based on **CCC** ground-truths, using a **Convolutional Neural Network (CNN)** for **ATD** calculation and a **conditional Generative Adversarial Network (cGAN)** for **ASD** computation.

Machine Learning approach



Geometric parameters of interest in transit conditions used as the inputs for the predictive models



***cGAN Generator** architecture for **ASD** prediction.* *Conv(7,7)

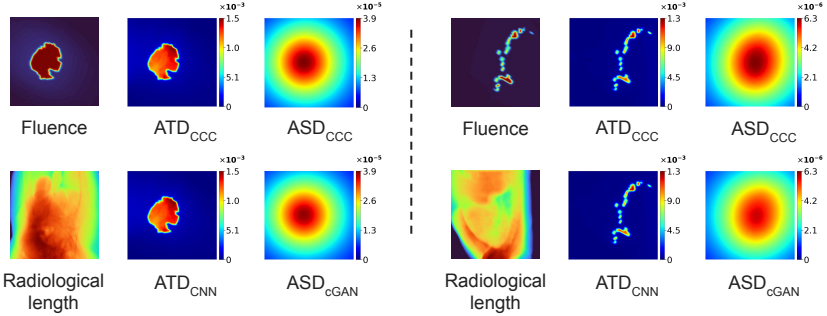
***cGAN Discriminator** architecture for **ASD** discrimination*

***CNN** architecture for **ATD** prediction*
**Conv(3,3)

- 17 unique CTs from various tumoral sites
  - 15 for training
  - 2 for testing
- 16 unique VMAT RTPlans
  - 14 for training
  - 2 for testing
- Irradiation segments
- Gantry angles variations
- Reference: CCC (ThinkQA DOSIsoft)
- Elekta Synergy 6 MV

➔ 9263 training cases
➔ 2573 testing cases

Results



	ATD_{CNN} vs ATD_{CCC}	ASD_{cGAN} vs ASD_{CCC}	ATD_{CNN} vs DTD_{CCC}	$DTD_{CNN + cGAN}$ vs DTD_{CCC}
Average GPR (%)	95.89	54.50	*91.98*	95.90
Median GPR (%)	98.95	58.68	*97.21*	98.96
GPR > 95% (%)	78.43	14.57	*61.17*	78.35
GPR > 90% (%)	87.01	21.26	*74.19*	87.21

GPR (2%, 2mm, 10% threshold) analysis is performed on the test dataset in terms of separate dose components and total dose

Conclusion

The full ML model allows:

- **CCC** equivalent predictions in terms of total dose at the EPID level
- Lower computation time for identical CPU/GPU **(~100x less)**
- **Generalization** across various tumoral sites
- Restitution of **physics phenomena** (transmission, scattering)