ESTRO

Abstract

Title

End-to-end Treatment Planning Optimization through Dose/Anatomy-based Metric-learning kNN Embeddings

Authors

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Purpose or Objective

Dose constraints satisfaction for non trivial treatment cases is among the most challenging parts of radiation planning. Despite progress thanks to Volumetric Modulated Arc Therapy (VMAT), ill-posedness often characterizes the plan inference process resulting on a time consuming, tedious, suboptimal and user biased treatment delivery through multi-objective optimization. The advent of machine learning and the increasing availability of radiation planning data open new perspectives for dose inference. The aim of our work is twofold (i) on the basis of the patient's anatomy and treatment planning prescription to predict the full scale dose satisfaction constraints that could be met, (ii) and integrate these constraints into the dose optimization step using compressed sensing.

Materials and Methods

Pelvis cases are among the most commonly treated anatomies in radiation therapy. In this study, on the basis of 374 multi-centric cohorts of pelvic patients using a VMAT plan, a full distance matrix was built between treatment plans across patients using a combination of anatomy-derived measurements (Spatial Target Signature and radiomics shape features) and dose-prescription / delivery constraints (Dose Volume Histogram Wasserstein distance). A deep learning model was used with anatomy / associated prescription of the patient as input to predict the closest k-matches within the full set of patients. This model learnt an embedding that preserves the distance matrix based on ranking losses. The dose constraints among these closest k-matches were used to determine the dose satisfaction constraints for the target patient: we set relevant volume fraction points on the target patient DVH and averaged the dose received over matches at these points. The result was then fed to a compressed sensing optimization algorithm on the basis of a VMAT planning using "Truebeam (X06/X18)" with two arcs.

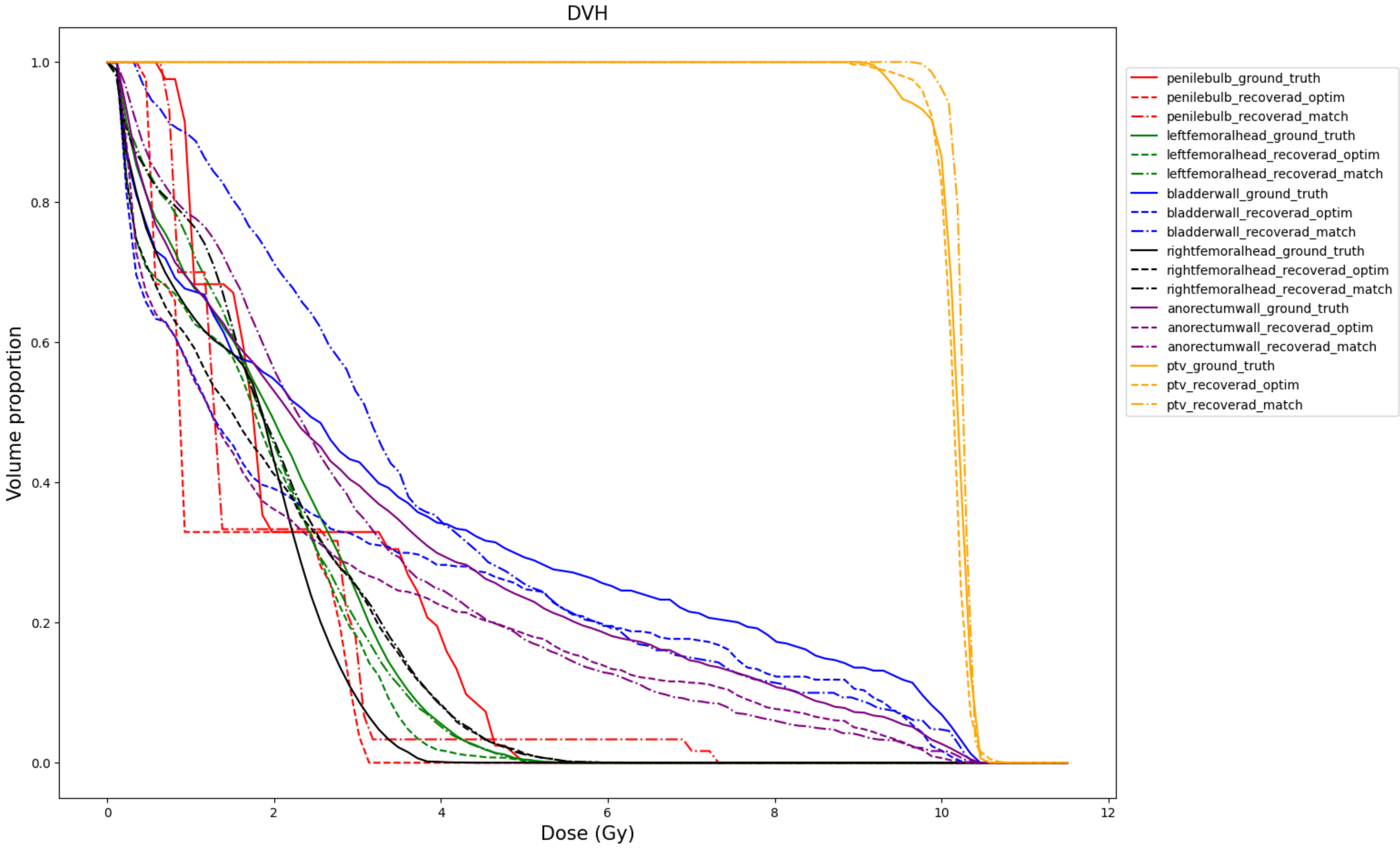
Results

A mean error (ME) was computed for the 10 test patients on the min, mean and max of the dose for each organ, target (table 1):

Table 1: Optimization ME in Gy per structure

	Penile bulb	Right femoral head	Anorectum wall	Left femoral head	Bladder wall	PTV
Minimum	-7.00±9.99	-0.25±0.67	-0.49±1.22	-0.20±0.45	-6.27±12.99	0.20±1.14
Maximum	-3.46±11.19	-1.87±5.88	-0.33±0.33	-2.27±5.87	-0.40±0.41	0.01±0.31
Mean	-6.59±7.53	-1.49±3.04	-3.41±6.19	-1.58±2.66	-4.26±7.79	-0.05±0.05

The PTV doses are extremely close while OARs are receiving on average less dose than the ground truth; which is highly promising. We also include the DVHs used in our methods (with k=5) for one test case.



Conclusion

Preliminary results demonstrate that dose constraints can be retrieved through a non-linear embedding of kNN treated patients with similar anatomy and prescription and their dose constraints. Harnessing these constraints could be used to provide end-to-end dose planning and deliver clinically acceptable plans. Large scale tests are ongoing involving cohorts with more patients and additional anatomies.