JULY 12–16 2020 VIRTUAL
JOINT AAPM | COMP MEETING
EASTERN TIME [GMT-4]

Fully probabilistic optimization framework integrating uncertainty in clinical target volume definition

G. BUTI [1], K. SOURIS [1], A.M. BARRAGAN MONTERO [1], J.A. LEE [1] and E. STERPIN [1,2]
1 UCLouvain, Molecular Imaging – Radiation – Oncology (MIRO), Brussels, Belgium
2 KULeuven, Laboratory of Experimental Radiotherapy, Leuven, Belgium

INTRODUCTION

Considering the uncertainty of **microscopical tumor extension** in the target volume is of crucial importance in radiation therapy clinical practice :

1. **Clinical target distribution** (CTD) has been introduced for this purpose as a probabilistic alternative to the CTV [1]
2. Today, robust optimization that involves such a probabilistic target is lacking

AIM

1. To propose a realistic procedure to construct a probabilistic target (= CTD) from known microscopic tumor extension models
2. To develop a **fully probabilistic** robust optimization framework that includes the CTD together with other important treatment errors

METHOD

CTD construction

1. Randomly sample **N microscopic tumor extensions** (MTE)
2. For each MTE :
   1. dilate the GTV isotropically
   2. correct for anatomical barriers (delineated as blocking structures (BS)) to generate the final target volume mask (TV)
3. Sum obtained TV masks and divide by *N*

Considered treatment uncertainties

	sigma	mu
Systematic setup (mm)	[2.4, 2.4, 2.4]	[0, 0, 0]
Random setup (mm)	[3, 3, 3]	[0, 0, 0]
Range (%)	1.6	0
MTE (mm)	2.8	3.4
Tumor motion	10 respiratory phases	

Optimization algorithms

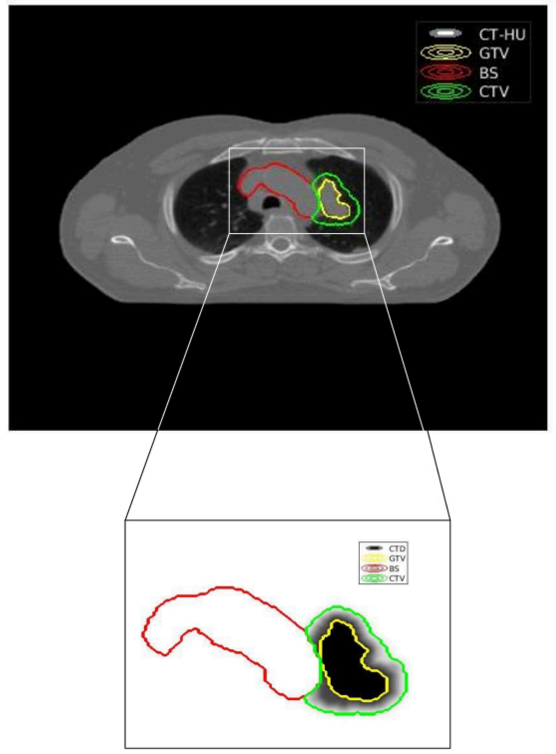
The **fully probabilistic** method uses the CTD to calculate the expected value of the objective function over 220 considered error scenarios

Proposed method is benchmarked against **worst-case** robust optimization that uses the CTV as target volume in 114 error scenarios (= 19 systematic setup x 2 random setup x 3 range scenarios scenarios)

Optimization software : all methods were implemented in the open TPS **MIROpt** (uses Monte Carlo dose engine **MCsquare**) [3],[4]

RESULTS

Representation of the target :



GTV *gross tumor volume*
CTV *clinical target volume*
BS *blocking structures*
CTD *clinical target distribution*

Test case :

- Lung tumor with motion
- Mid-position (MidP) CT as nominal CT
- IMPT treatment plan (co-planar beams at 90, 135, 180 gantry angles).
- 60 Gy dose prescription (30 fractions of 2 Gy)

Evaluation procedure :

Recompute the planned dose distribution on 250 evaluation scenarios using **MCsquare** dose engine [2]

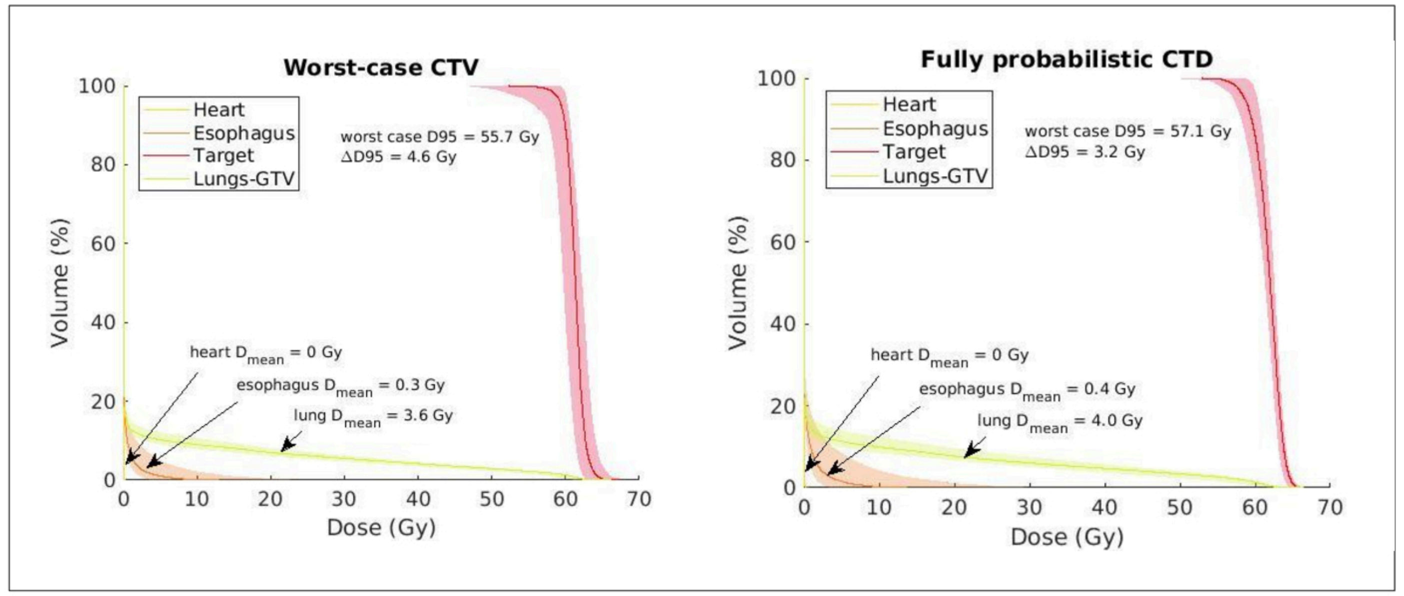
Each scenario is randomly sampled combination of :

1. Systematic setup error (rigid isocenter shift)
2. Random setup error for each fraction (rigid isocenter shift)
3. Range error (CT density scaling)
4. Microscopic tumor extension (dilation of GTV) → target realization

For each scenario : the dose is computed on all respiratory phases and accumulated on MidP-CT

The target realizations are used to evaluate target coverage

Dosimetric results :



Fully probabilistic optimization improves target coverage and robustness (indicated target bandwidth at the D95 dose level ΔD95) :

- worst case D95 increased by 1.4 Gy
- ΔD95 reduced by 2.4 Gy

Slightly increased OAR radiation with higher mean esophagus and mean lung dose (increase of 0.1 Gy and 0.4 Gy respectively)

CONCLUSIONS

A **fully probabilistic** robust optimization framework is implemented and achieves promising results for a lung tumor case by improving robustness of the treatment plan

A procedure was proposed to construct a probabilistic target from a microscopic tumor infiltration model

The framework can be extended by introducing additional uncertainty sources in the target volume definition without increasing the computational cost

REFERENCES

[1] N. Shusharina, D. Craft, Y.-L. Chen, H. Shih, and T. Bortfeld, “The clinical target distribution: a probabilistic alternative to the clinical target volume,”Physics in Medicine & Biology, vol. 63, p. 155001, July 2018.

[2] K. Souris, A. B. Montero, G. Janssens, D. D. Perri, E. Sterpin, and J. A. Lee, Technical Note: Monte Carlo methods to comprehensively evaluate the robustness of 4D treatments in proton therapy, Medical Physics (2019).

[3] A. M. Barragan Montero, Miropt - http://www.openmiropt.org/ Accessed November 2019.

[4] K. Souris, MCsquare - http://www.openmcsquare.org/ Accessed June 2019.

ACKNOWLEDGEMENTS

Gregory Buti is supported by the Télévie Grant from the Belgian 'Fonds National pour la Recherche Scientifique' F.R.S-FNRS.

CONTACT INFORMATION

Gregory Buti
gregory.buti@uclouvain.be

Social media

Follow MIRO lab on Twitter by scanning the QR code