Mid-PhD Defense

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21st June 2023

Outline

Cancer treatments

Surgery

+: Safe (little damage to healthy tissues)
-: Tumor needs to be localized & accessible

Chemotherapy

-: Heavy medicine on all the body
+: Tumor does **not** need to be localized

Cancer treatments

Surgery

Radiotherapy

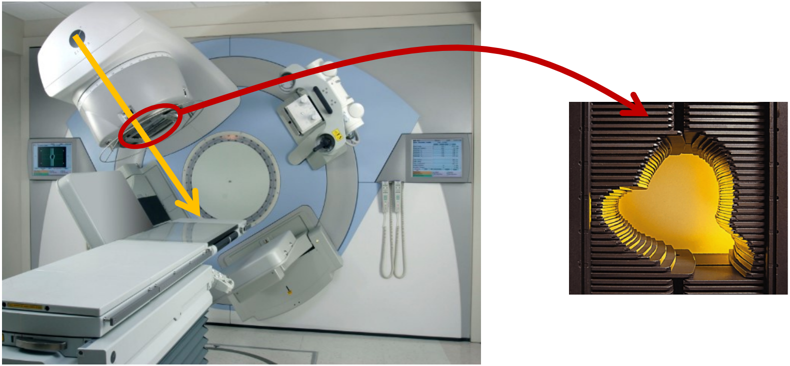
Chemotherapy

+: Safe
-: Tumor needs to be loca

+: Relatively safe (most tissues are spared)
-: Tumor needs to be (relatively) localized

cine on all the body
s **not** need to be localized

Multi-Leaf Collimator



V-MAT Irradiation Technique

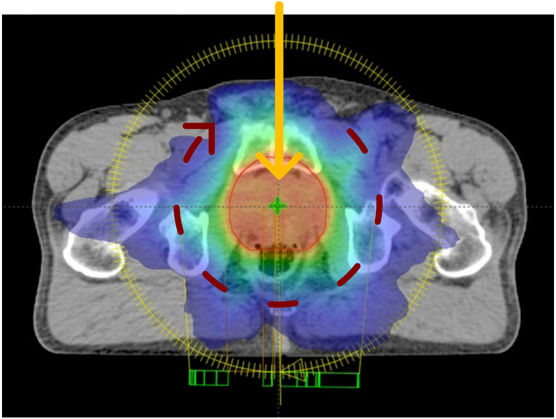


Figure: Typical V-Mat dose slice.

IMRT Irradiation Technique

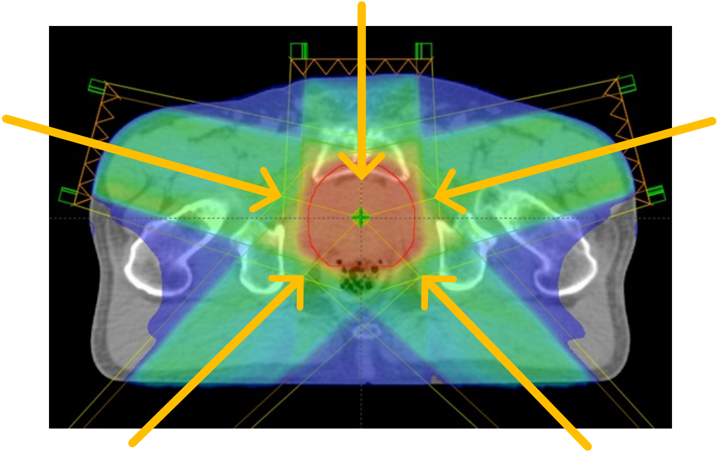


Figure: Typical 5 beams IMRT dose slice.

Step-and-Shoot (1/3)

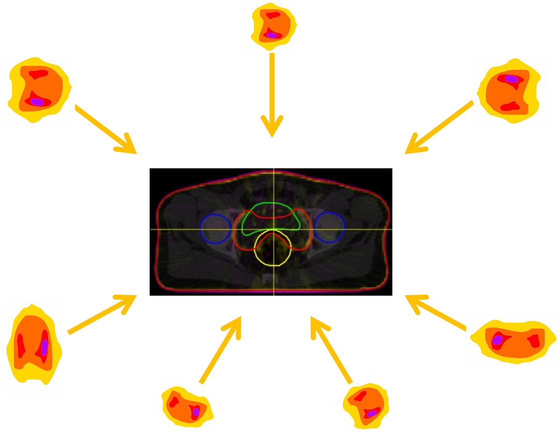


Figure: Optimal Continuous Fluence.

Step-and-Shoot (2/3)

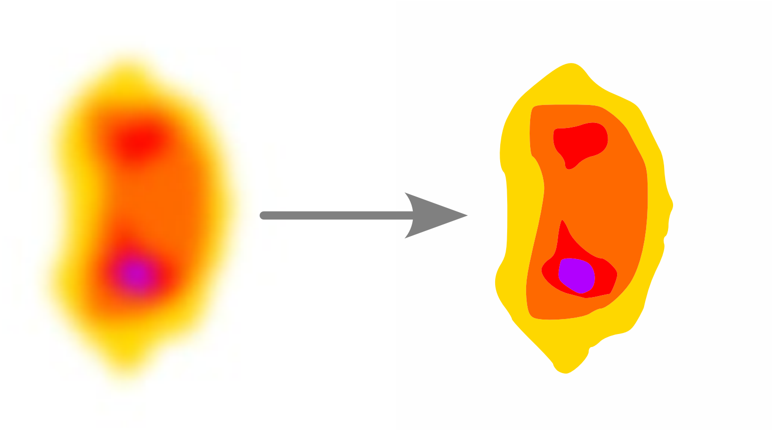


Figure: Discretizing the Fluence.

Step-and-Shoot (3/3)

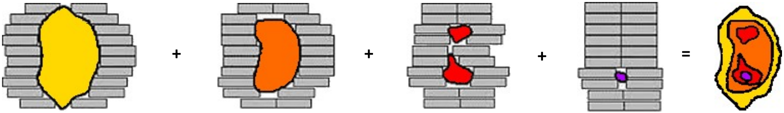
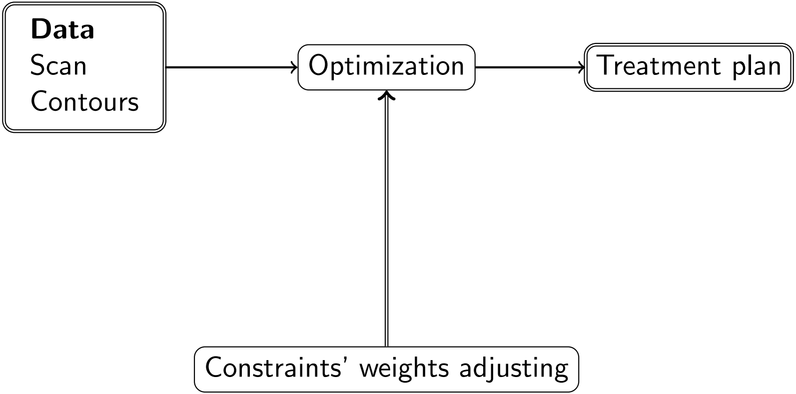


Figure: Delivering Discrete Fluence.

Automatic Dose Optimization for Radiotherapy



Problem Formulation
IMRT

Bixel values:

$$x_{i,j}^{\theta} \geq 0, \text{ for } \theta \in \Theta \text{ and } 1 \leq i, j \leq 20^{1}$$

usually concatenated to a single bixels-value vector x.

Dose calculation:

$$\mathbf{y} = L\mathbf{x} \text{ with } L \text{ (pre-calculated) dose-influence (DI) matrix}$$

[1] 20x20 is a typical bixel discretization

Problem Formulation

IMRT (bis)

Objective for *maximum* constraint c on structure s, dose d:

$$f_c(\mathbf{y}) = \frac{1}{|\mathcal{V}|} \sum_{v \in \mathcal{V}} (\mathbf{y}_v - d)_+^2$$

(reverse sign for minimal constraint).

Final objective:

$$f(\mathbf{y}) = \sum_{c \in \mathcal{C}} w_c f_c(\mathbf{y})$$

with w_c the weight of constraint c.

Problem Optimization

Optimizer review

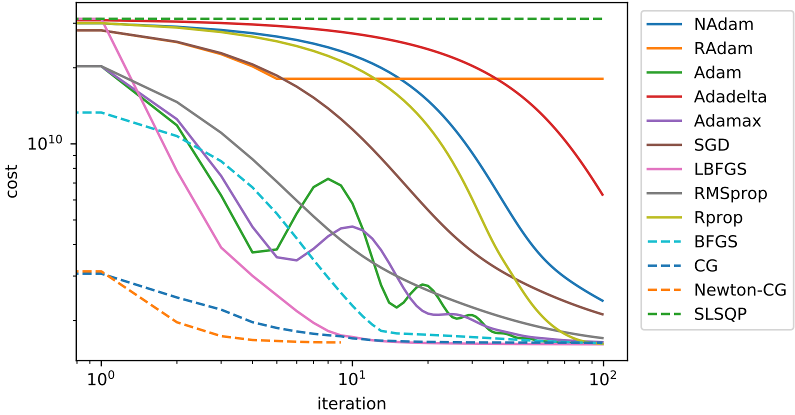


Figure: Typical prostate case.

https://arxiv.org/abs/2305.18014

Problem Optimization

Optimizer review (bis)

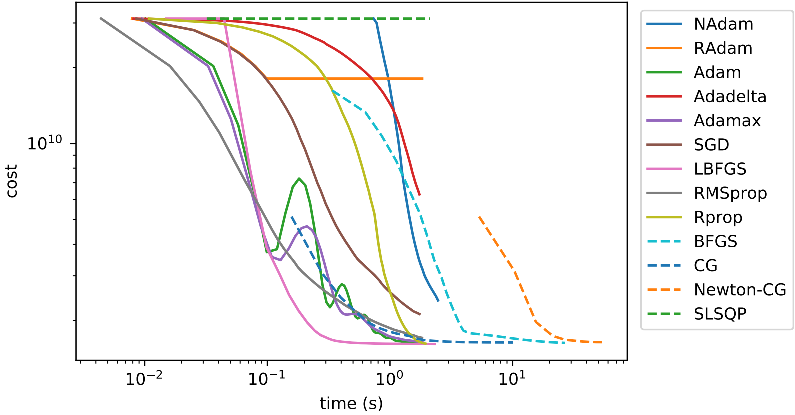


Figure: Typical prostate case.

https://arxiv.org/abs/2305.18014

Meta-Optimization

Usual optimization

$$\min_{\mathbf{x}} f(\mathbf{x}, w) \text{ s.t. } \mathbf{x} > 0$$

... and fine-tune w until the dose is clinically acceptable.

Meta optimization

$$\min_{w} \left\{ \min_{\mathbf{x}} f(\mathbf{x}, w) \text{ s.t. } \mathbf{x} > 0 \right\}$$

... still need to fine-tune the parameters (learning rate, momentum, etc...) of the meta-optimizer.

Dose Distances

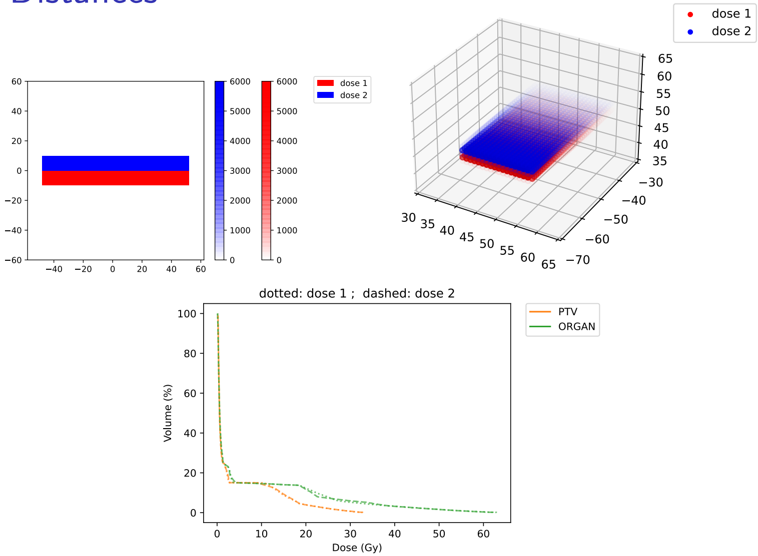


Figure: Example of two doses that have the same clinical effect (measured from the DVHs), but very different voxel-wise dose values.

References