# Mid-PhD Defense

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# Outline

# Automatic Dose Optimization for Radiotherapy
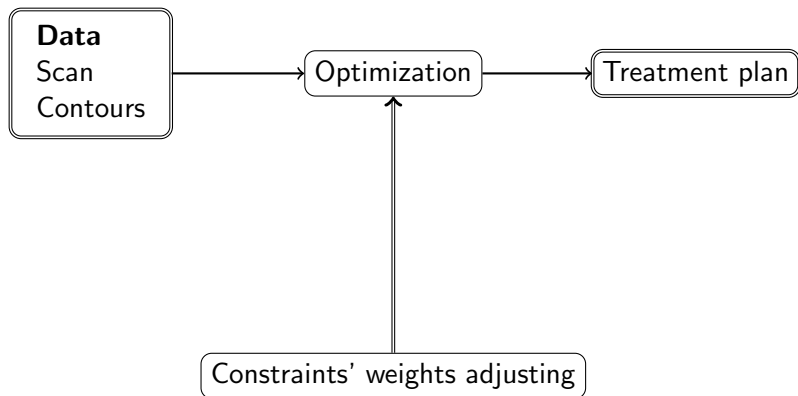
## Problem Formulation
IMRT

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:

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

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[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 $c$.
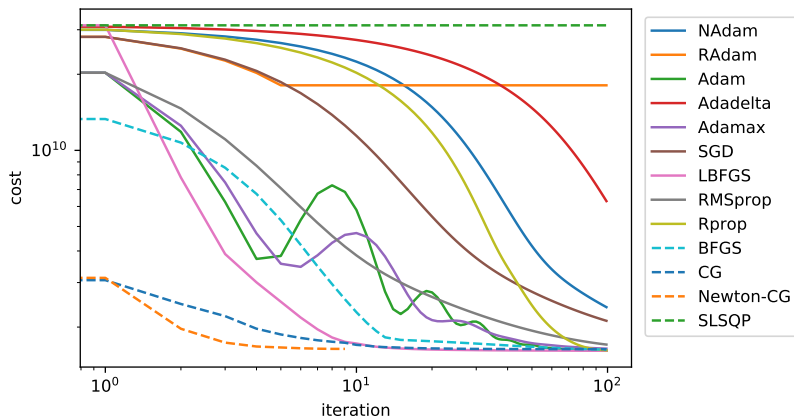
# Problem Optimization

Optimizer review



Figure: Typical prostate case.

https://arxiv.org/abs/2305.18014

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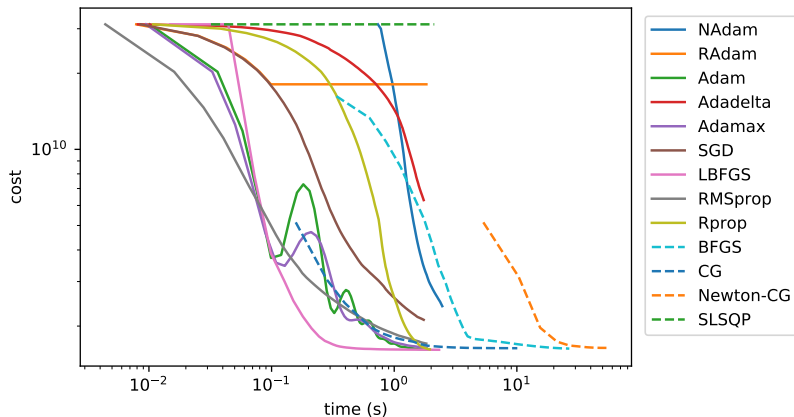
# Meta-Optimization

**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.
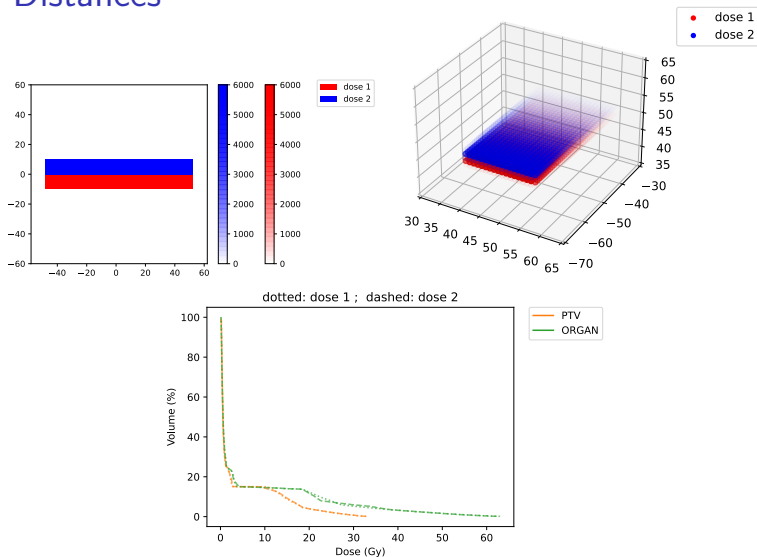
# Dose Distances



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

# References