Artificial Intelligence based segmentation and planning of a male pelvis

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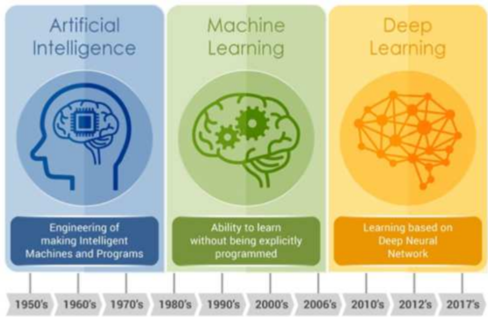
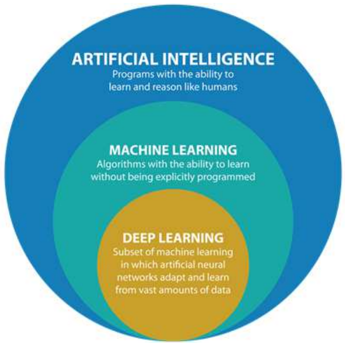
Iridium Kankernetwerk is involved in an on-going scientific collaboration with RaySearch Laboratories.

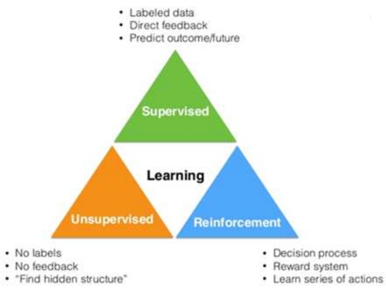
Evolution of AI technology

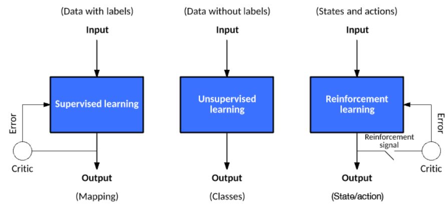




Big Data

Machine Learning: Principle





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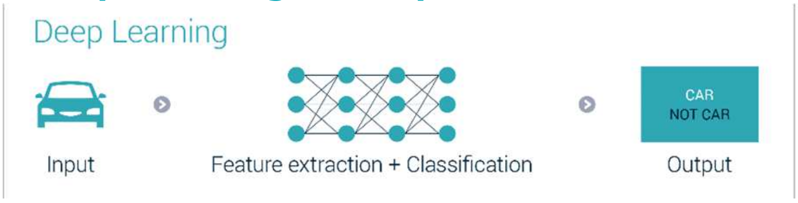
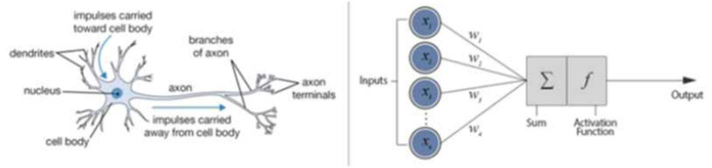
Deep Learning: Principle



Biological Neuron versus Artificial Neural Network



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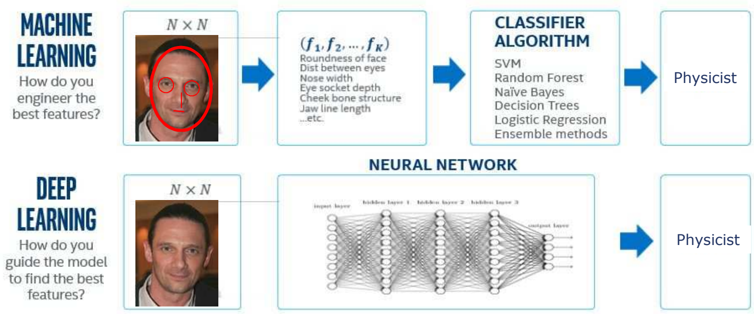
Example: how to recognize a physicist

Machine Learning and Deep Learning



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AI Hype vs Reality

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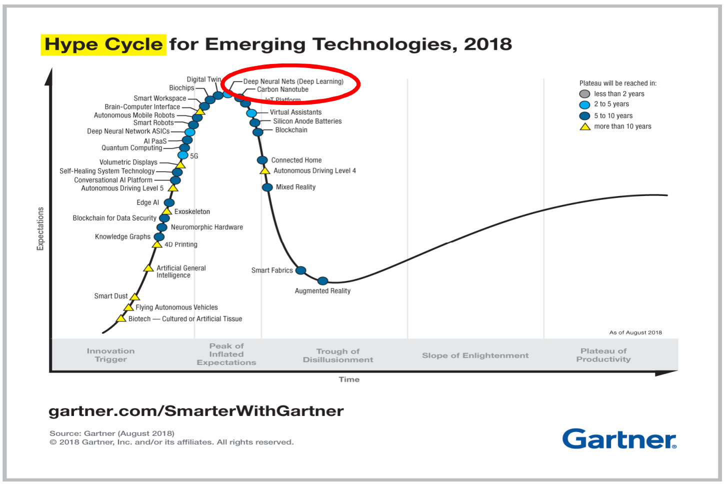
Hype



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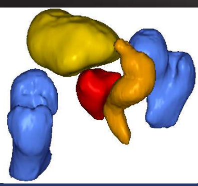
AI in radiation oncology



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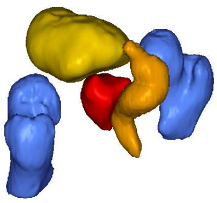
Deep Learning Segmentation

for prostate cancer



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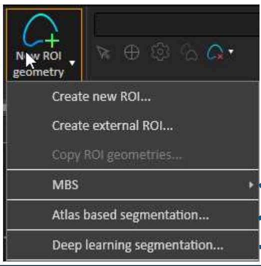
Why Deep Learning organ segmentation?

CT simulation → Image Registration RS → Contouring RS → Dose Planning RS → Plan Review RS

→ Export plan → Review staff → Time-out @linac → Plan Review → Start RT



Some structures

Some pathologies

???

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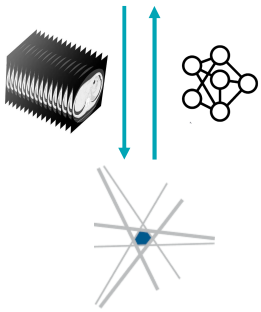
Training

- U-NET Convolutional Neural Network
- Model trained @RaySearch
- CT-based only
- 350 prostate cases documented
  - Primary/post-op
  - Pelvic node y/n
  - ACROP guidelines for anorectum
  - Fiducials
  - Hip prosthesis



282 Femoral heads | 286 Bladder | 222 Anorectum | 170 Prostate (primary)

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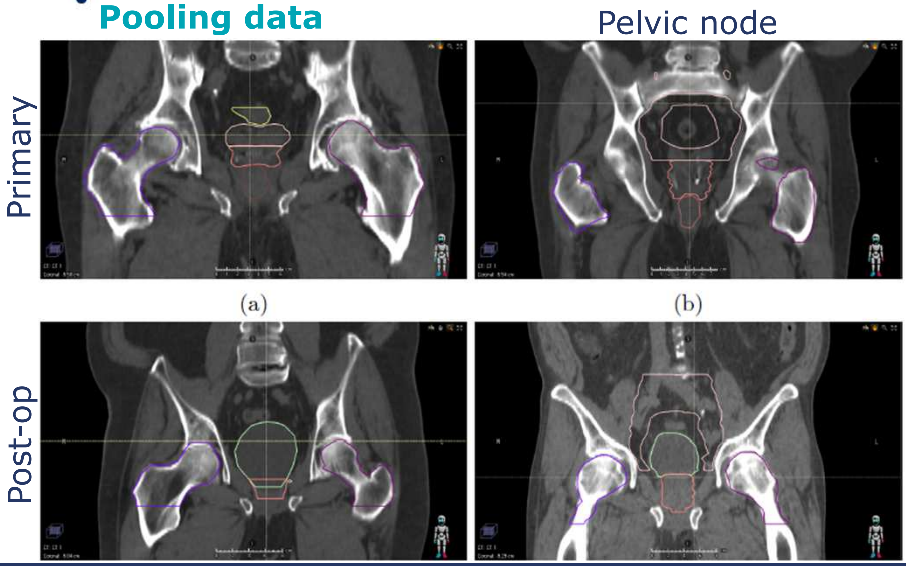
Pooling data



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Validation set

38

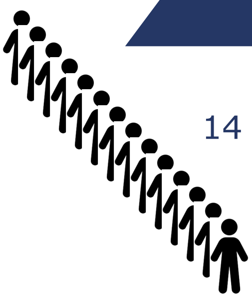
>= Jan 2019

Primary

No hip prosthesis

ACROP guidelines

With and without lymph nodes



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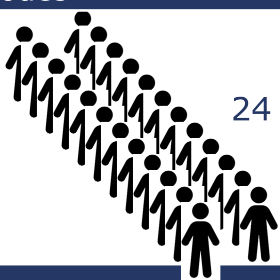

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The results

- Evaluation
  - Mathematical Metric
    - Dice (DSC) — Inter-physician variability
    - Hausdorf
    - …
  - Clinical Metric
    - DVH
    - Adaptations

$$DSC(A, B) = \frac{2|A \cap B|}{|A| + |B|}$$

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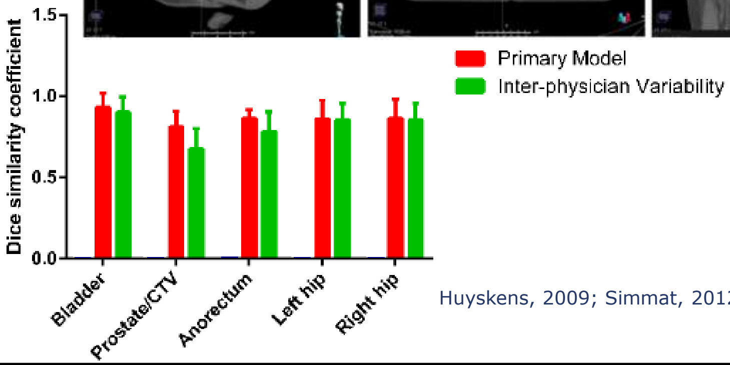
Results of Primary Model



Huyskens, 2009; Simmat, 2012; Xia, 2013; Xia, 2014

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Data selection needed?

Primary model

- 350 prostate cases documented
  - Primary/post-op
  - Pelvic node y/n
  - ACROP guidelines for anorectum
  - Fiducials
  - Hip prosthesis

282 Femoral heads | 286 Bladder | 222 Anorectum | 170 Prostate (primary)

Mixed model

- 185 mixed prostate cases

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GIGO

https://xkcd.com/1838/

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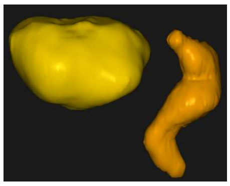
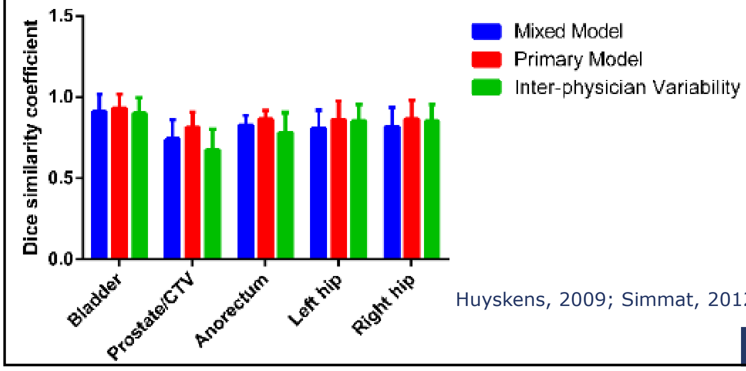
GIGO





Huyskens, 2009; Simmat, 2012; Xia, 2013; Xia, 2014

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Some more details

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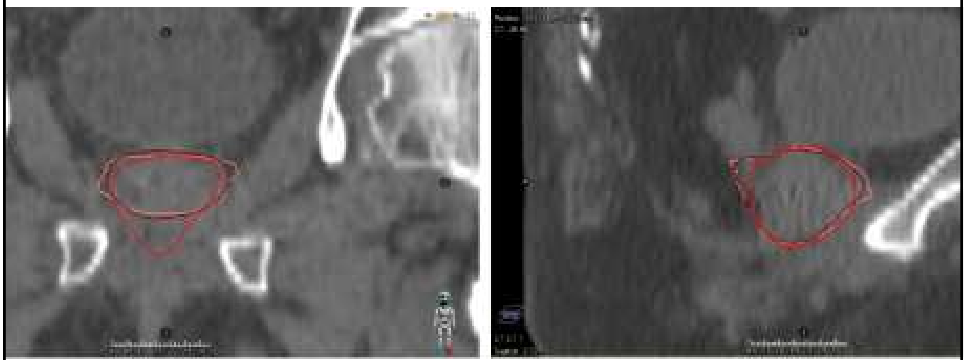
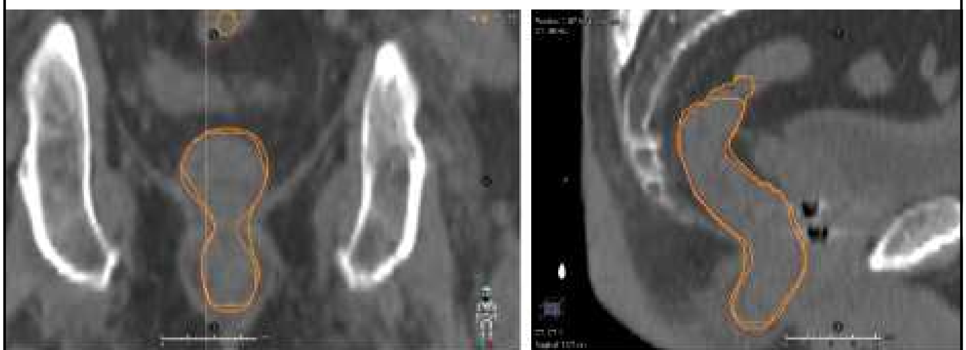
Pollution - Prostate

- Primary and post-op

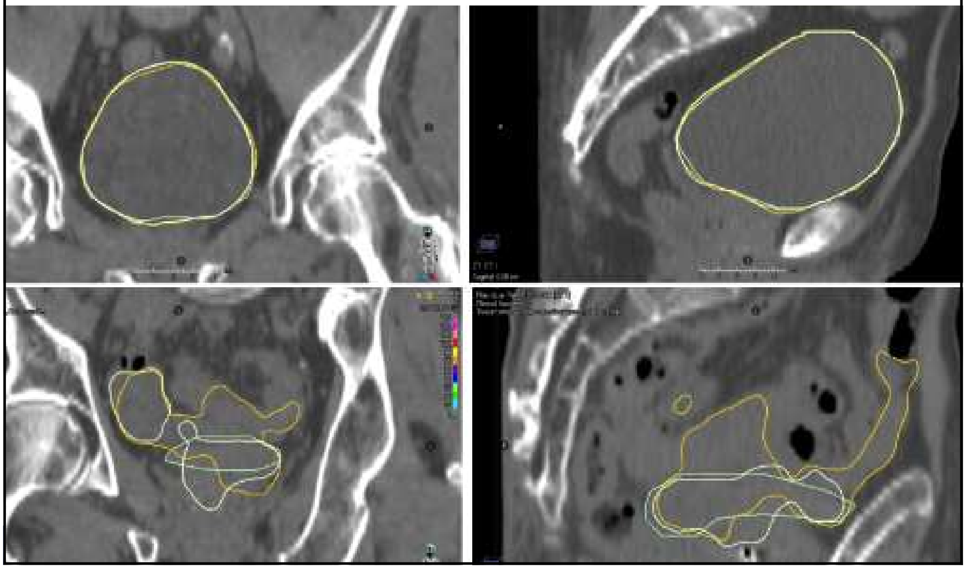


Pollution - Rectum

- ACROP guidelines

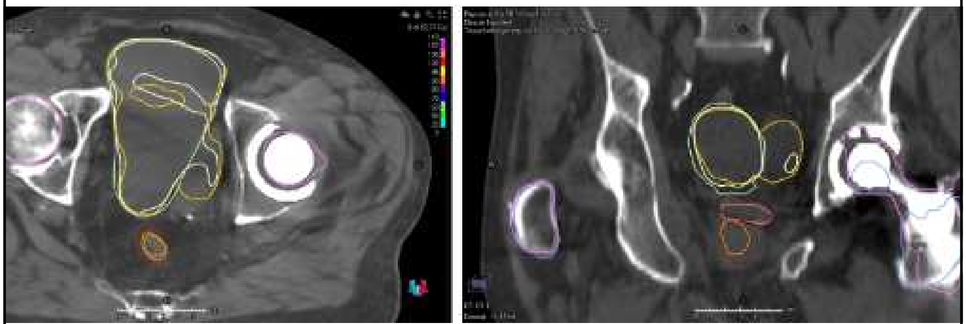


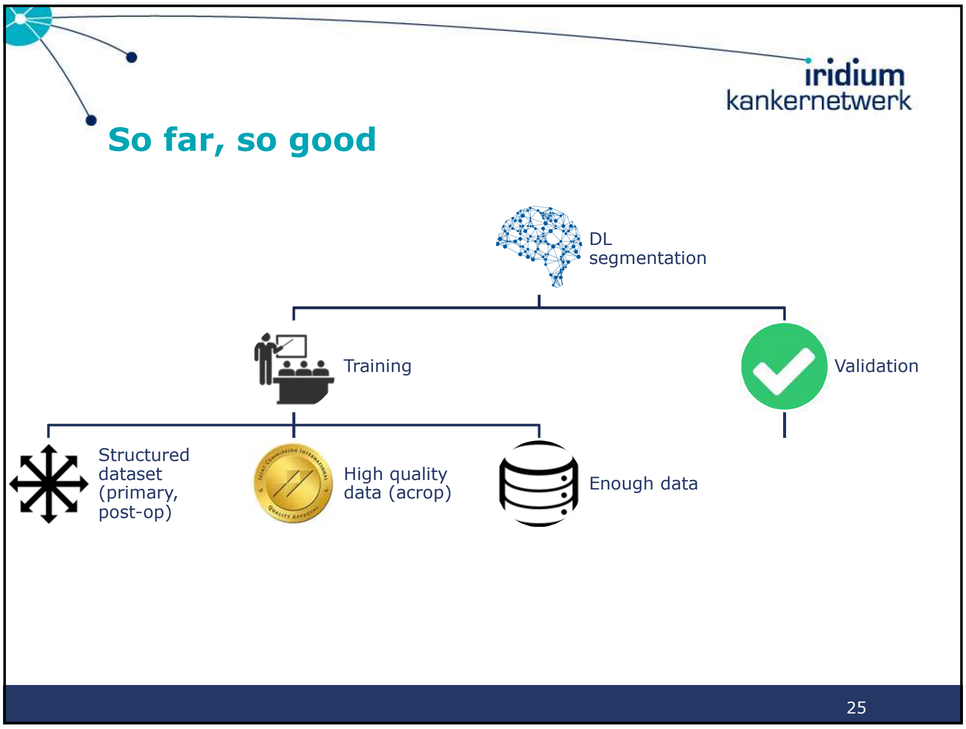
The perfect bladder



Hip prostheses

- Model trained with or without prostheses

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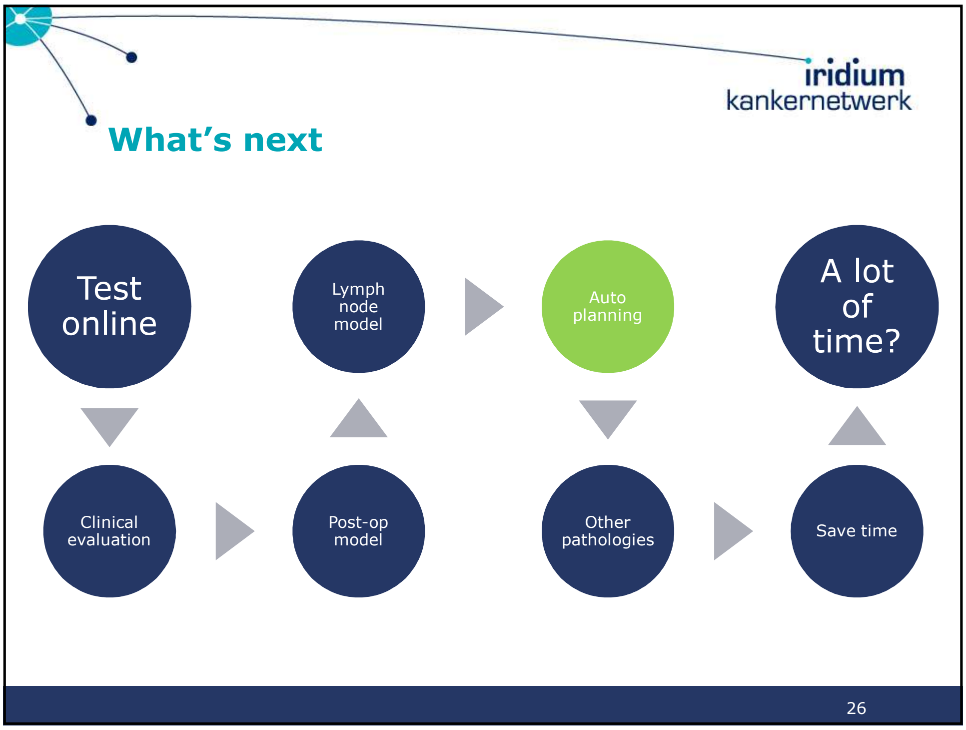
So far, so good
DL
segmentation
Training
Validation
Structured
dataset
(primary,
post-op)
High quality
data (acrop)
Enough data
25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What's next
Test
online
Lymph
node
model
Auto
planning
A lot
of
time?
Clinical
evaluation
Post-op
model
Other
pathologies
Save time
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Machine Learning treatment plan generation

'Automation is the future of planning'

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Planning

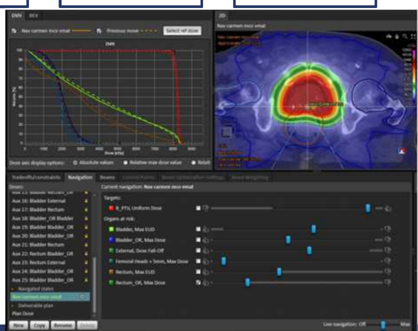
CT simulation → Image Registration RS → Contouring RS → **Dose Planning RS** → Plan Review RS

Export plan → Review staff → Time-out @linac → Plan Review → Start RT

Purpose:

- Machine parameters:
  - Gantry and collimator angle
  - Leaf position, beam weights

- Algorithm-based 3D dose distribution
- High PTV coverage ⇔ low OARs radiation



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Why automation?

- Goal is to create high quality plans to meet clinical objectives
- Efficient Process
  - Automate standard procedures
- Clinic time constraints
  - Spend more vabuale time on complex cases
  - Evaluate different treatment techniques
- Help department workflow

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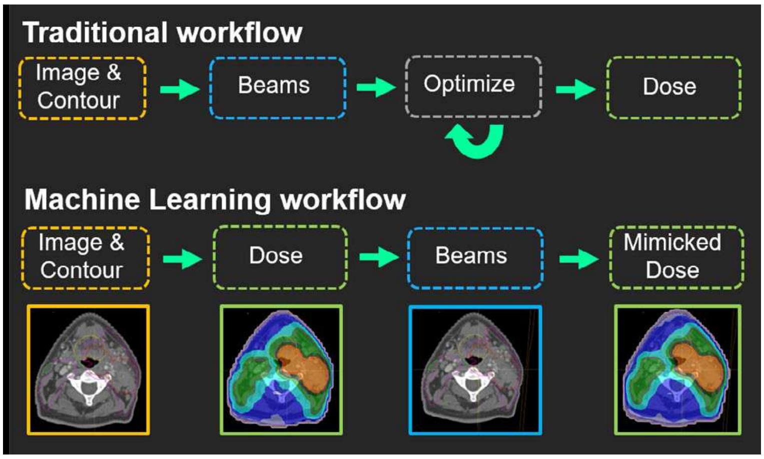
ML workflow



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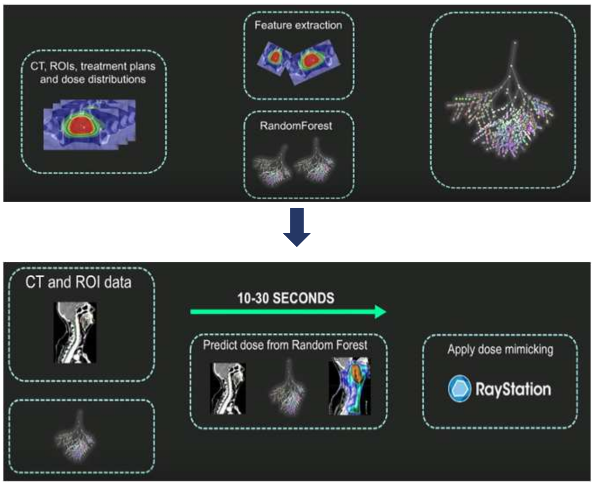
Atlas-based regression forest



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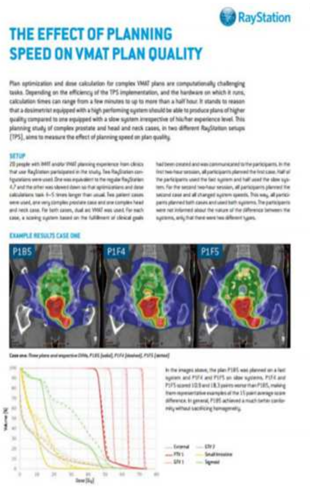
Impact of speed on planning quality

- Automated tools affect the planner’s speed
- Given a high performing system, a dosimetrist will produce higher quality plan compared to one equipped with a slow system
- Relationship between speed and plan quality
- Planning on the faster computer had significant increase in fulfilment of clinical goals


RayStation

THE EFFECT OF PLANNING SPEED ON VMAT PLAN QUALITY

SETUP

EXAMPLE RESULTS CASE ONE

P1B5 P1F4 P1F5

Future of planning

- Future is knowledge-based planning
  - Use previous experience to drive the solution
- Plan optimization driven by big data
- Computer speed
  - Need advanced hardware, algorithms, and techniques
- More patients needing adaptive therapy will increase workload
  - Day to day dose tracking
  - Implementing multiple changes over the course of treamtment
- Automation will help bring efficiency to the workflow and higher quality care to the clinic

THANK YOU!