Automatic target propagation strategies for MRI-guided cervical brachytherapy

Rita Simões
Eva E. Schaake
Eva C. Rijkmans
Marlies E. Nowee
Tomas M. Janssen

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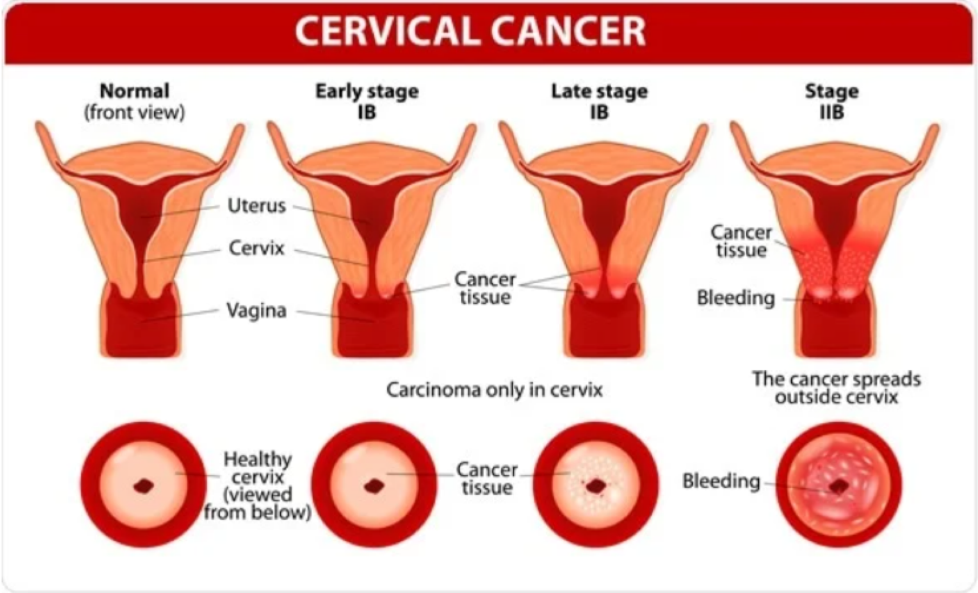
Cervical cancer

4th most common cancer in women

~ 350k deaths in 2022 (WHO)



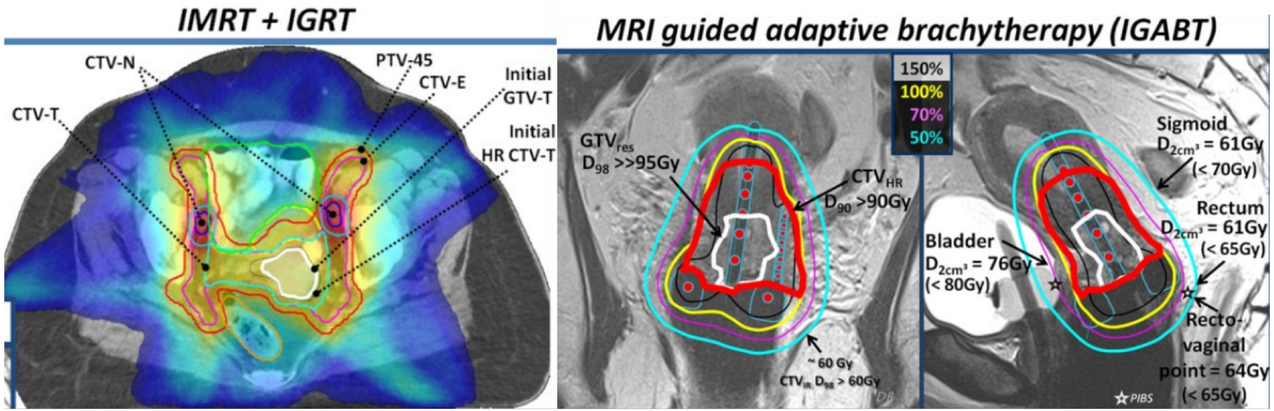
Cervical Cancer. Carcinoma of Cervix. Malignant neoplasm arising from cells in the cervix uteri.
Image Copyright: Designua / Shutterstock

@ Netherlands Cancer Institute: ~50 patients treated per year

Cervical cancer

Standard of care

- 25 x 1.8 Gy EBRT + chemo
- 3 x 7 Gy MR-guided adaptive brachytherapy



Pötter *et al* ctRO 2018

→ Time-consuming workflow!

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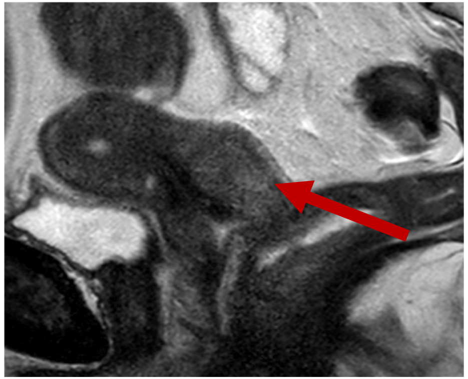
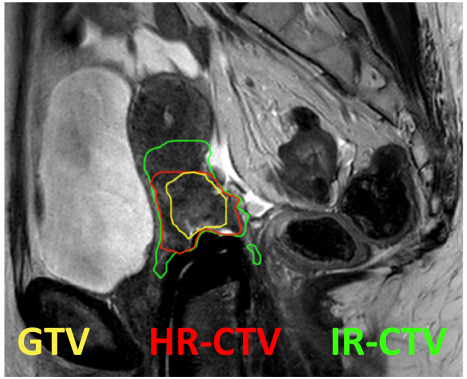
Cervix brachytherapy: target volumes



Pre-treatment



Fraction 1

GTV	visible tumor
HR-CTV	GTV + microscopic disease + cervix
IR-CTV	pre-treatment tumor extent (+ possible margin on the HR-CTV)

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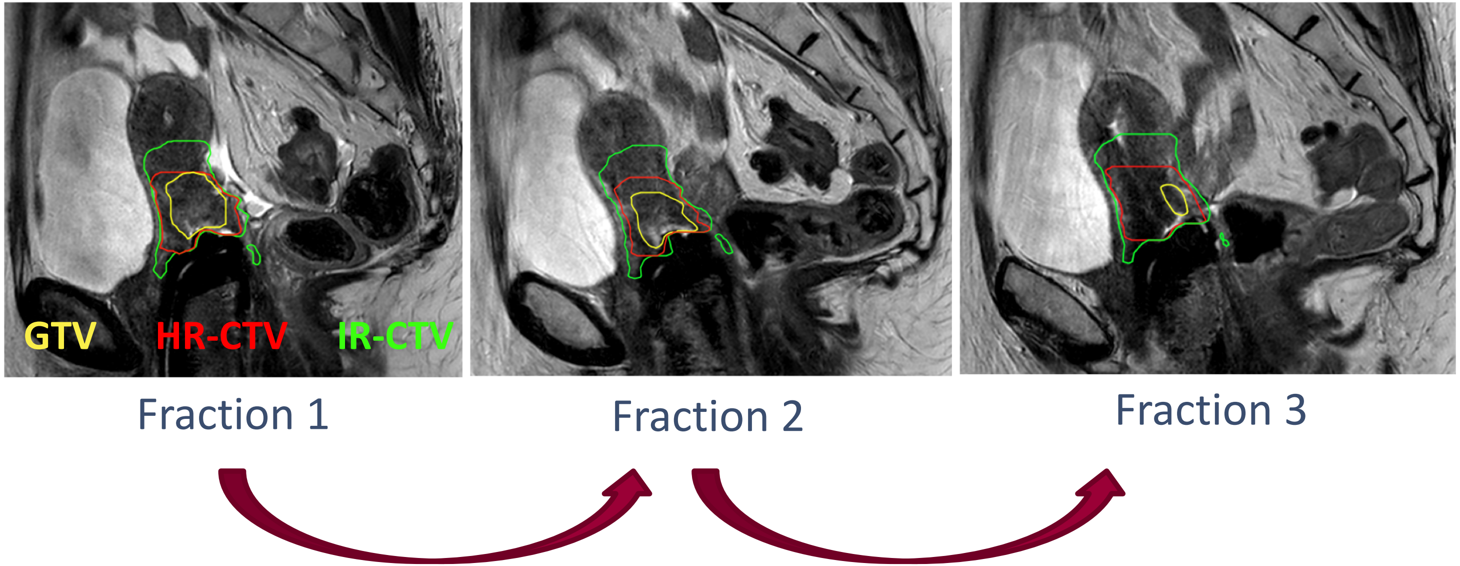
Cervix brachytherapy: target volumes



How can we best **propagate** structures from **fraction 1 to fractions 2 and 3**?

Data

1. Training set: **203 patients**, 2011-2021

   - tT2 scans

   - clinically used structures

	train	validation
patients	168	41
images	455	120

2. Test set: **29 patients** (79 images), February 2022-August 2023

   - for all fractions: tT2 scans + clinically used structures

   - for fractions 2 and 3: rigidly propagated structures before correction

Methods

1) **Rigid registration**: currently used clinically

2) **Deformable registration**

3) **Image-only auto-segmentation**: MRI as input to auto-segmentation

4) **Image+prior auto-segmentation**: MRI + previous segmentations as input

5) **Patient-specific fine-tuning**: image-only model is trained on the previous fraction images → one model per patient/fraction

Methods

Performance evaluation

- on the 2nd and 3rd fractions of the 29 patients
- clinical structures as ground truth
- surface Dice (3 mm), mean surface distance, added path length
- Wilcoxon signed-rank test

Training details

1) Training of the **auto-segmentation models** on the training set: 3D nnU-Net

2) Patient-specific **fine-tuning** on the test set
   - Continued training the image-only model on **fraction N-1**, **evaluated on fraction N**
   - Stopped after **5 iterations** (empirically observed that results didn't change much)

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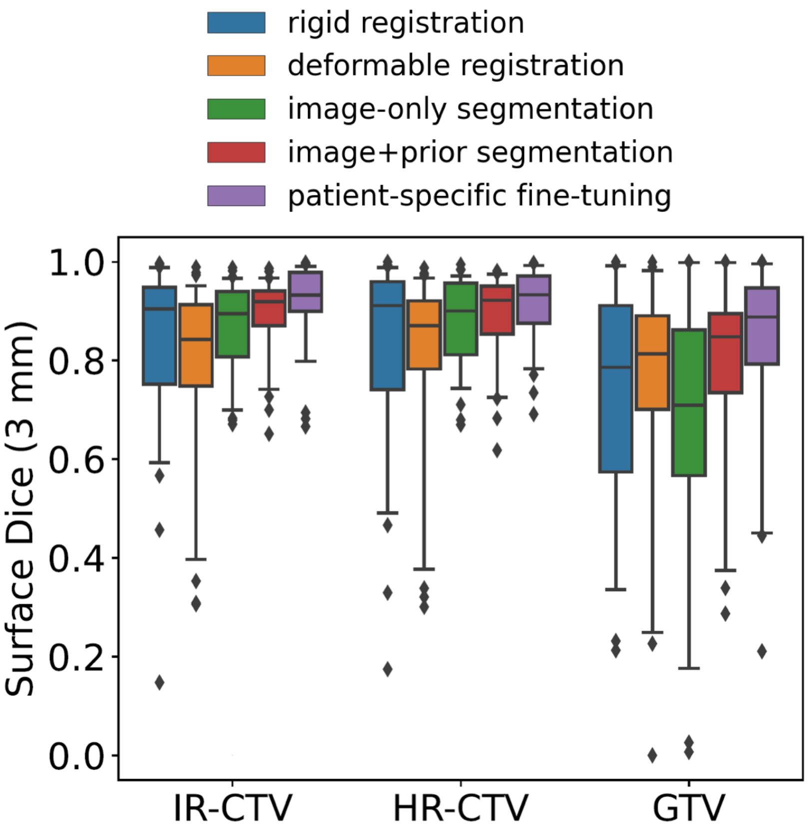
Results



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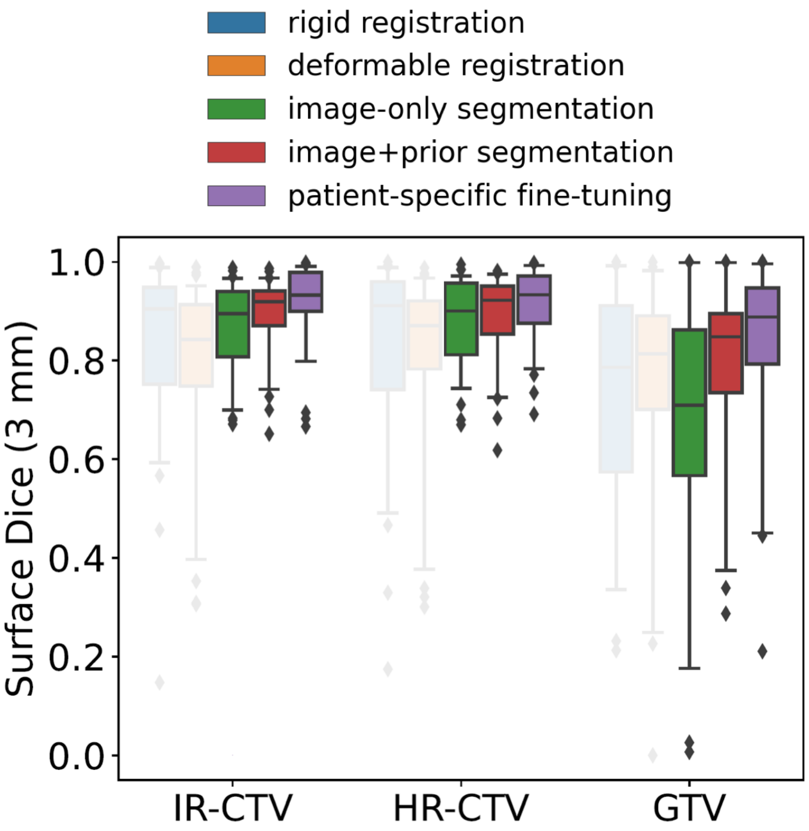
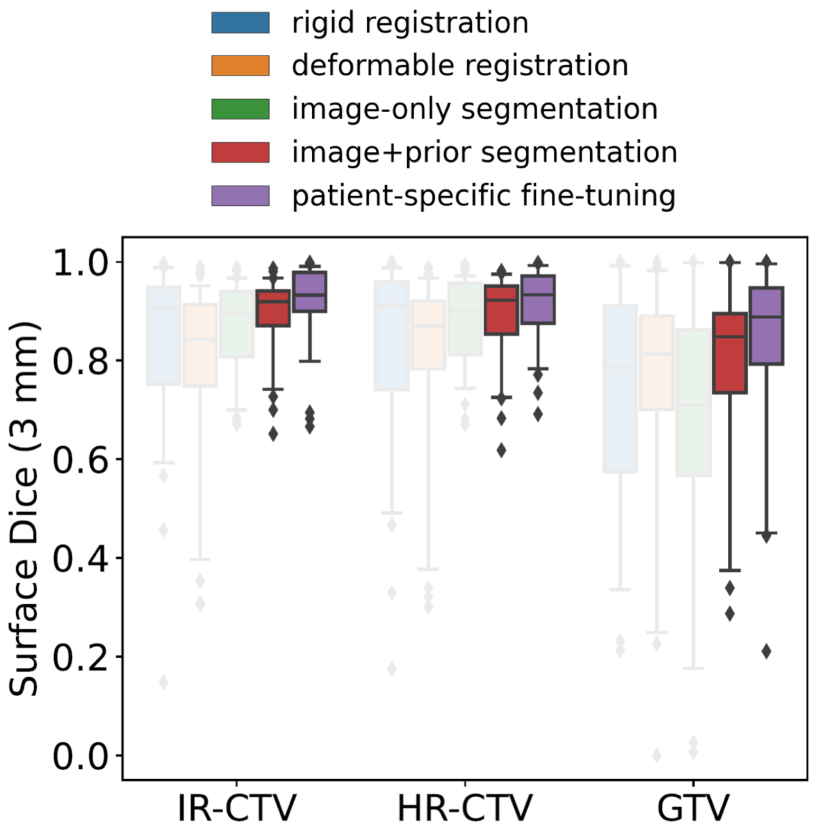
Results



Deep learning-based auto-segmentation outperformed the registration methods

Results



Deep learning-based auto-segmentation outperformed the registration methods

Adding patient-specific information improved upon the image-only model

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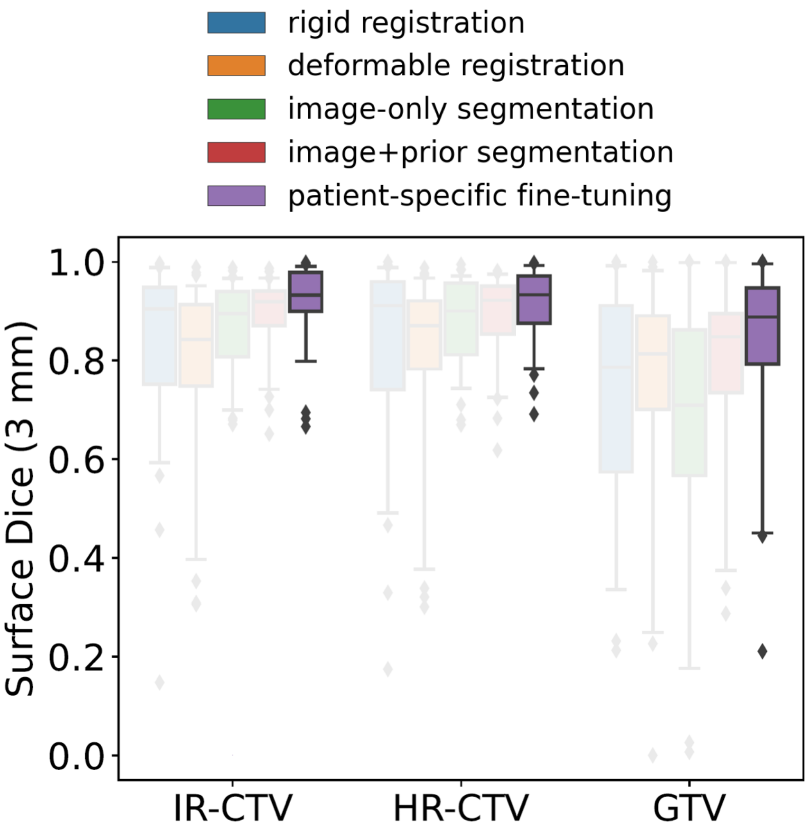

Deep learning-based auto-segmentation outperformed the registration methods

Adding patient-specific information improved upon the image-only model

Patient-specific fine-tuning outperformed the image + prior model

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Current steps

Evaluation of the potential clinical impact of using the **image-only** and the **patient-specific** models

- Automation bias
- Dosimetric impact
- Inter-observer variability
- Time gains

Clinical implementation!

Thank you!

r.simoes@nki.nl

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