Radiotherapy induced cardiovascular toxicity: delineating hearts in 8000 patient CT scans

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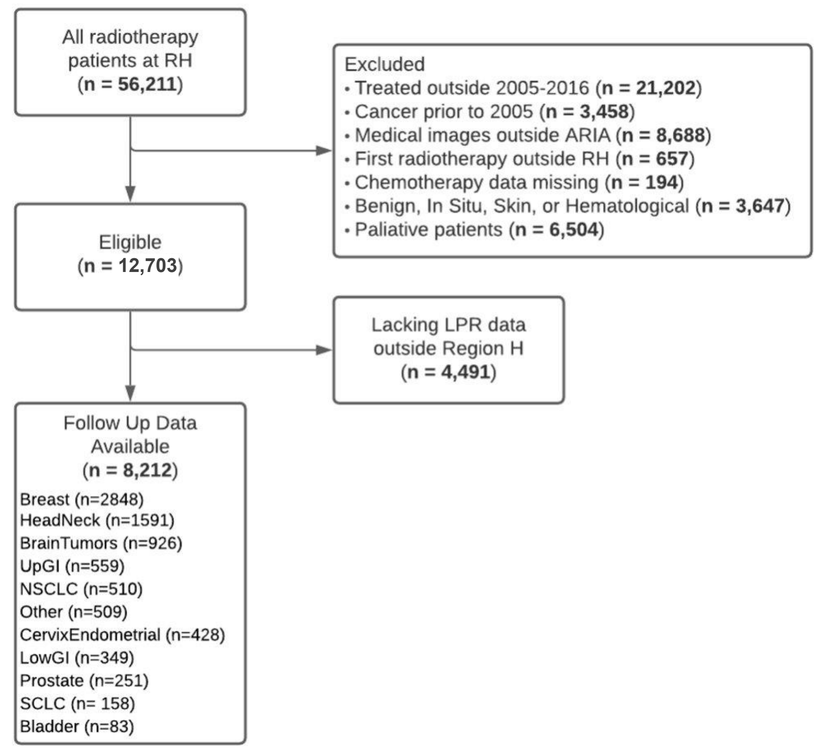
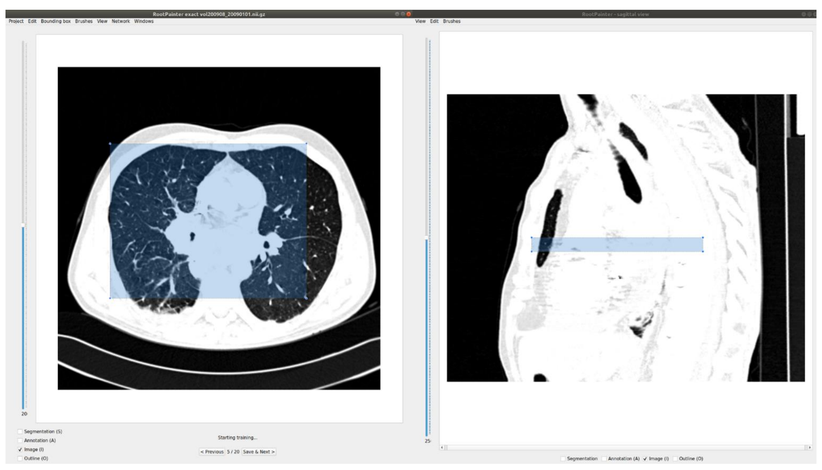
Purpose

- **Background:**
  - Cancer survivors experience ~10% increased risk of cardiovascular disease per gray of mean heart dose [1]
  - Mean heart dose is a proxy for substructure exposure [2]

- **Research goal:** Further describe the relationship between radiation and cardiovascular diseases to better inform treatment and ongoing care
  - Large retrospective cohort
  - Across multiple diagnoses
  - Detailed anatomic and dose data

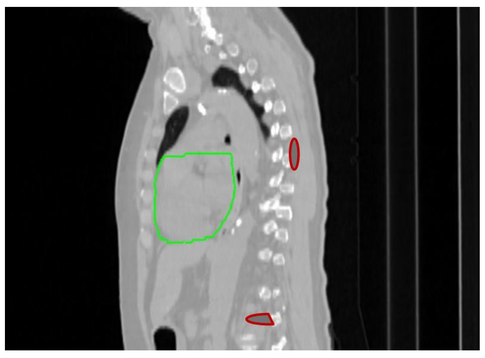
- **Challenges:**
  - Approval, access, and curation of patient registry and electronic health records
  - Segmentation of hearts in 8000 patients receiving radiation at Rigshospitalet



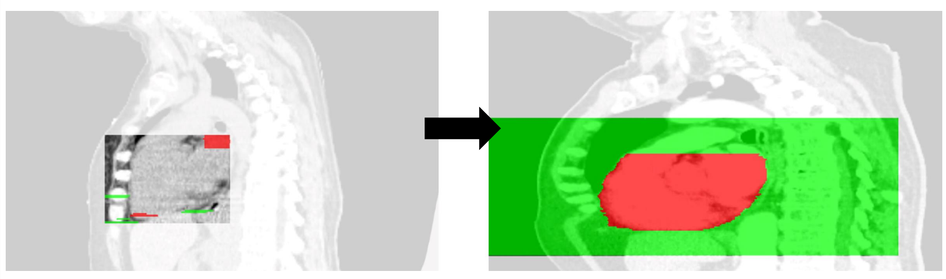


Execution

- **Method:** RootPainter model for **h**eart segmentation [3]
  - Impressive results in study of 900 hearts
- **Issue 1:** Islands predicted outside the heart
  - Save only largest contiguous regions

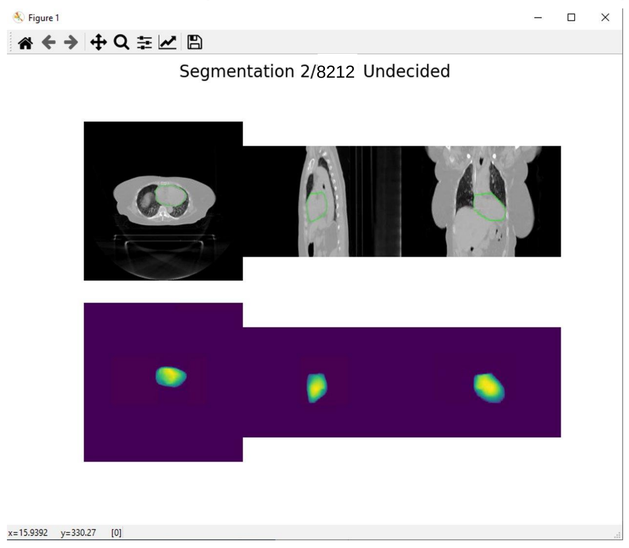


- **Issue 2:** Manual bounding box required
  - Not feasible for 8000 images (30 sec each)
  - Small bounding box and sparse labels/corrections converted to a large randomly positioned bounding box and dense labels
    - Goal: learn to find the heart in the image and not in a small bounding box
- **Conclusion:** Appears to work well
  - Identical dice coefficients (0.961)



Validation

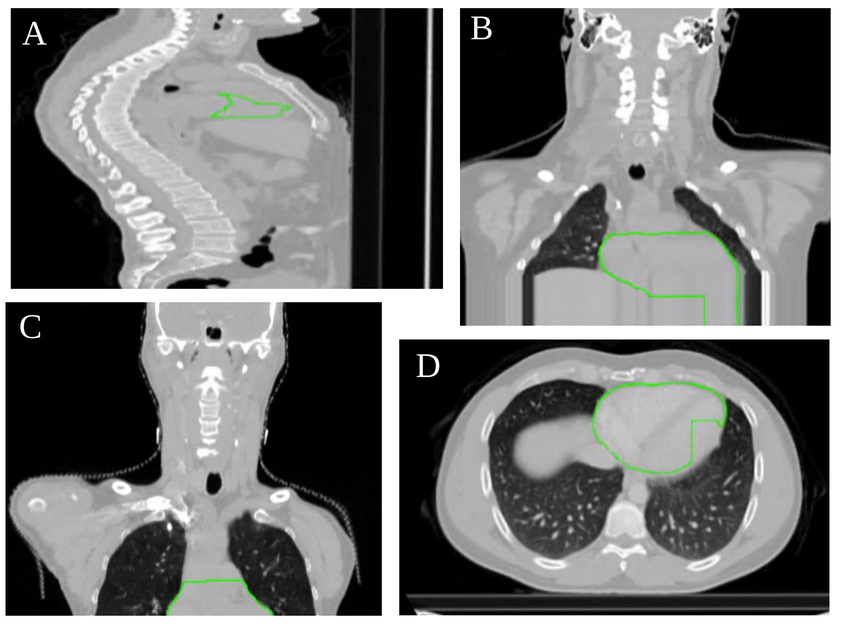
- **Question**: Is RootPainter good enough for fully automated large-scale analysis
- **Method**: Use a manual tool to review all 8000 segmentations
  - Viewing slices of CT overlaid with contour plus thickness projections
  - Delineation issues can be quickly identified (1-2 secs each = 2-4 hrs)



- **Issue 3:** Field of view extrapolation
  - RootPainter has never seen images without hearts
  - Patients included beyond chest irradiated diagnoses from training data

	Heart in view	Heart not in view	Total
Segmentation	5742	1715	7457
No segmentation	0	755	755
Total	5742	2470	8212

- Images without hearts were mostly head or abdominal scans
- We can assume zero radiation dose if heart is out of the field of view



Conclusions

- With minimal time spent on manual assistance and review, we segmented 8000 images
  - 95% of segmentations in images containing heart were acceptable
    - 98% in trained diagnoses
  - Frequent causes of unacceptable segmentation: rare anatomy[A] or pathology, artifacts[B], partial hearts[C]
  - Most errors are minor[D] and will have a small impact on dose calculation

Future Steps

- Expand patient cohort
- Improve model to enable fully automated segmentation
  - Train classification network on validation results to determine if heart is in view
  - Ensemble model
- Merging image data with patient health data
- Exploring distributional characteristics of dose exposure
- Time to event analysis for cardiovascular diseases and overall survival

Acknowledgements

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REGION H Rigshospitalet

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