Improving Prostate Cancer Detection from MRI with Ensembled Deep Learning Models

Sara Saunders, Urology Department

Mentors:
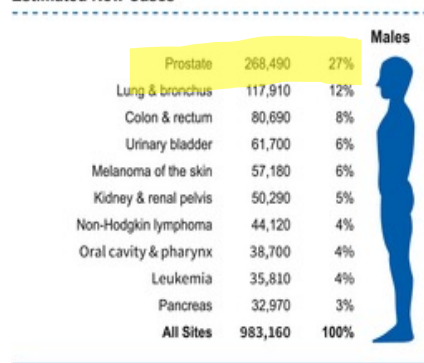
Mirabela Rusu, Geoff Sonn, Andrei Iagaru
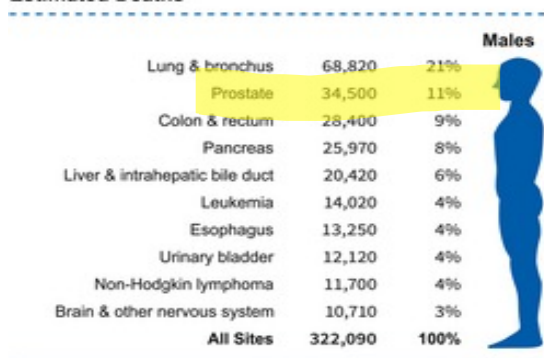
April 12, 2023

Prostate Cancer

- Among men in US - 2022
  – Most diagnosed Cancer
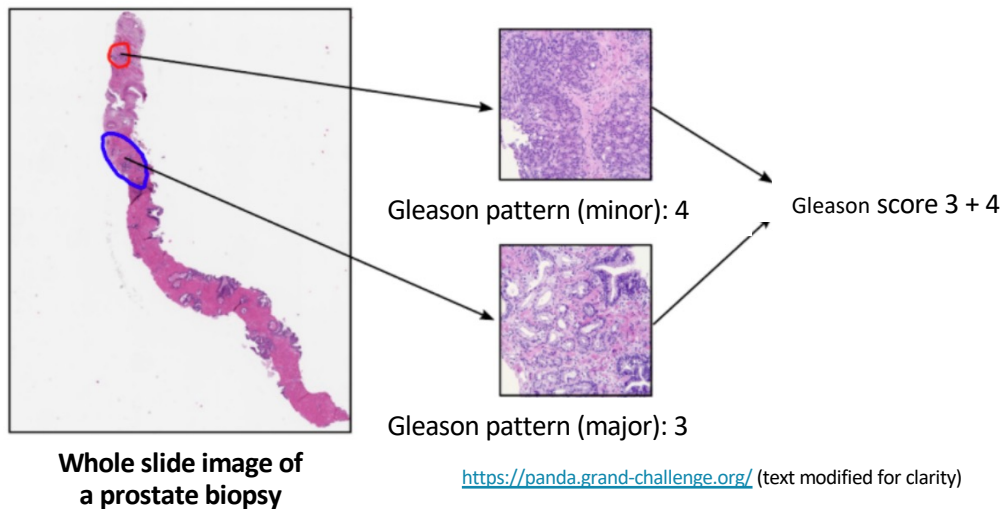 – 2nd cause of cancer death

Estimated New Cases — Males

Prostate	268,490	27%
Lung & bronchus	117,910	12%
Colon & rectum	80,690	8%
Urinary bladder	61,700	6%
Melanoma of the skin	57,180	6%
Kidney & renal pelvis	50,290	5%
Non-Hodgkin lymphoma	44,120	4%
Oral cavity & pharynx	38,700	4%
Leukemia	35,810	4%
Pancreas	32,970	3%
All Sites	983,160	100%

Estimated Deaths — Males

Lung & bronchus	68,820	21%
Prostate	34,500	11%
Colon & rectum	28,400	9%
Pancreas	25,970	8%
Liver & intrahepatic bile duct	20,420	6%
Leukemia	14,020	4%
Esophagus	13,250	4%
Urinary bladder	12,120	4%
Non-Hodgkin lymphoma	11,700	4%
Brain & other nervous system	10,710	3%
All Sites	322,090	100%

- Prostate-Specific Antigen (PSA) levels

Siegel, R.L. Cancer Statistics, 2022 (cropped, added highlight)

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Detection & Diagnosis

- Elevated PSA levels -> Biopsy
- Grading: Gleason Score
    - Pathology: 2 most prevalent patterns (major & minor)
    - Gleason Score 3+3: Indolent
    - Gleason Score ≥ 3+4: Clinically Significant

Gleason pattern (minor): 4

Gleason score 3 + 4

Gleason pattern (major): 3

**Whole slide image of
a prostate biopsy**

https://panda.grand-challenge.org/ (text modified for clarity)
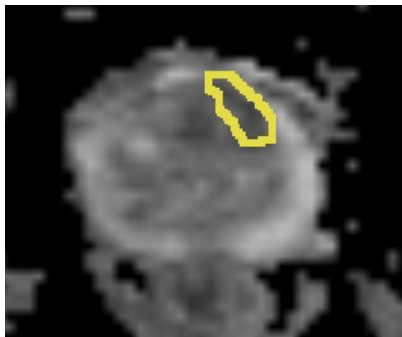
Prostate Cancer Detection on MRI

- MRI is increasingly used to guide treatment
  - Interpretation is difficult: image quality, subtle differences in tissue
- Radiologists:
  - Detect 66-88% of clinically significant cancer
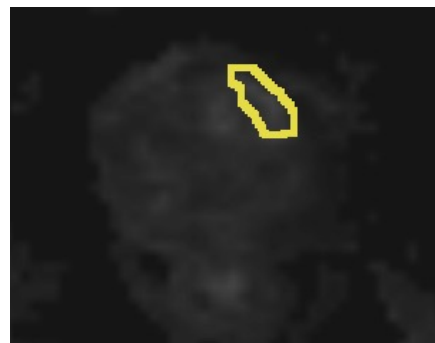 - High false positive rates
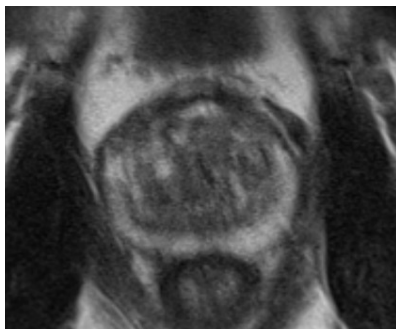
T2-weighted

Apparent Diffusion Coefficient

Diffusion Weighted Imaging

Ahmed, H.U. The Lancet, 2017.
Johnson, D.C. European Urology, 2019.
Saha, A. 10.5281/zenodo.6522364, 2022.
Barentsz, J.O. European Radiology, 2016.
Wallstroem, European Radiology, 2021.

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Prostate Cancer Detection on MRI

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T2-weighted   Apparent Diffusion Coefficient   Diffusion Weighted Imaging

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AI Could Assist Radiologists

T2 weighted

Apparent Diffusion Coefficient

Diffusion Weighted Imaging

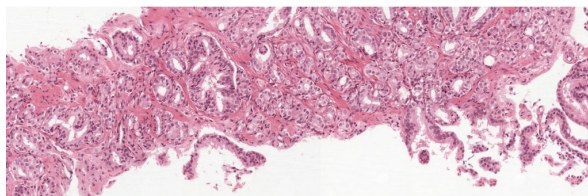Cancer Detection

Prediction

Human Annotation Pathology Confirmed
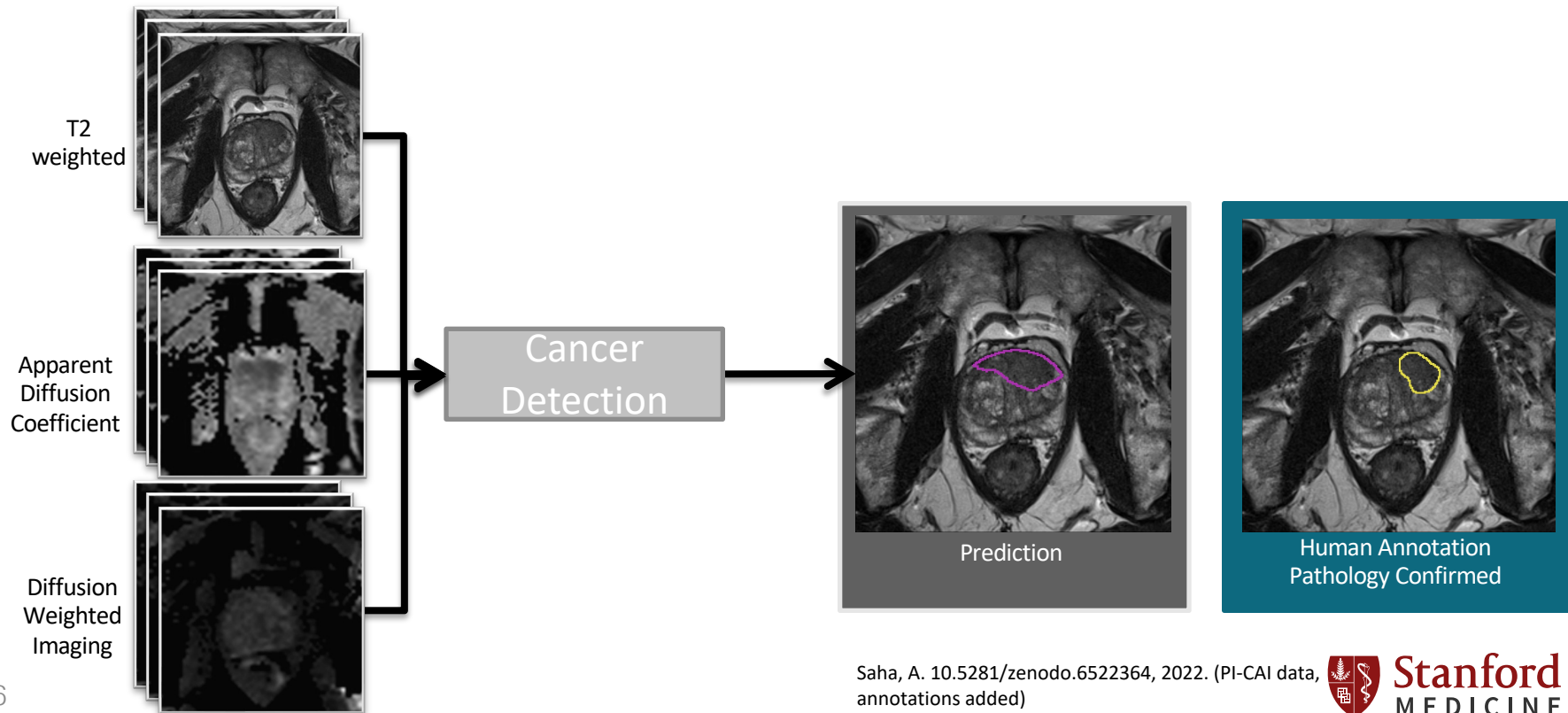
Saha, A. 10.5281/zenodo.6522364, 2022. (PI-CAI data, annotations added)

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Ensembles of AI Models

- Leading AI prostate cancer detection algorithms ensemble multiple models.

- Public Challenges

Prostate cANcer graDe Assessment (PANDA) Challenge

- Trained four AI prostate cancer detection models

- Experimented to determine the best techniques to ensemble these

https://panda.grand-challenge.org/,
https://www.aapm.org/GrandChallenge/PROSTATEx-2/,
https://pi-cai.grand-challenge.org/

Optimizing Ensembles of Prostate Cancer Detection Models

- What prostate cancer detection models to include in the ensemble?
- What ensemble techniques are most accurate?
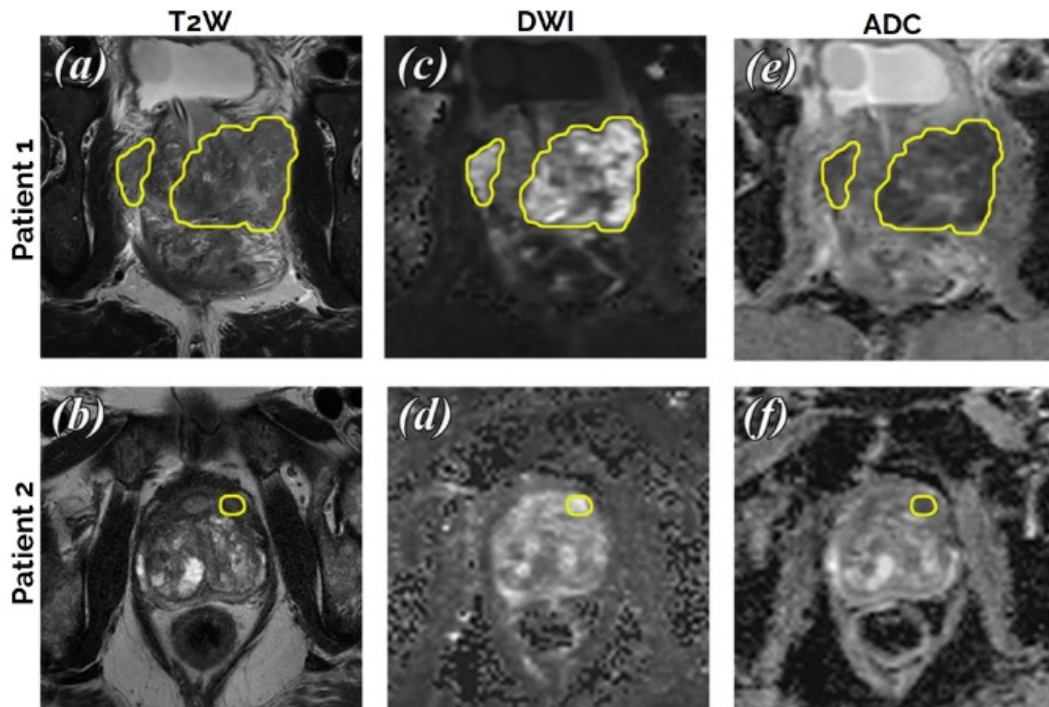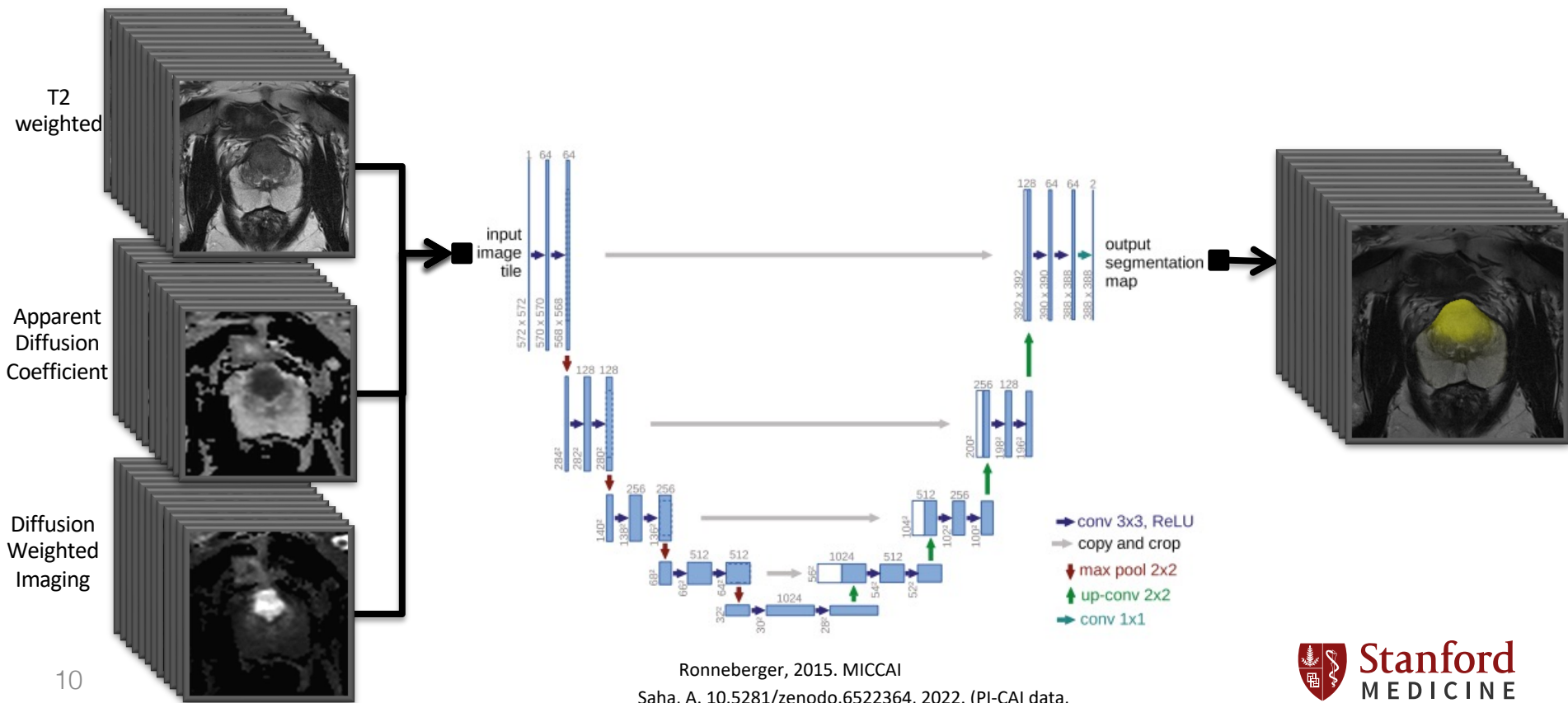
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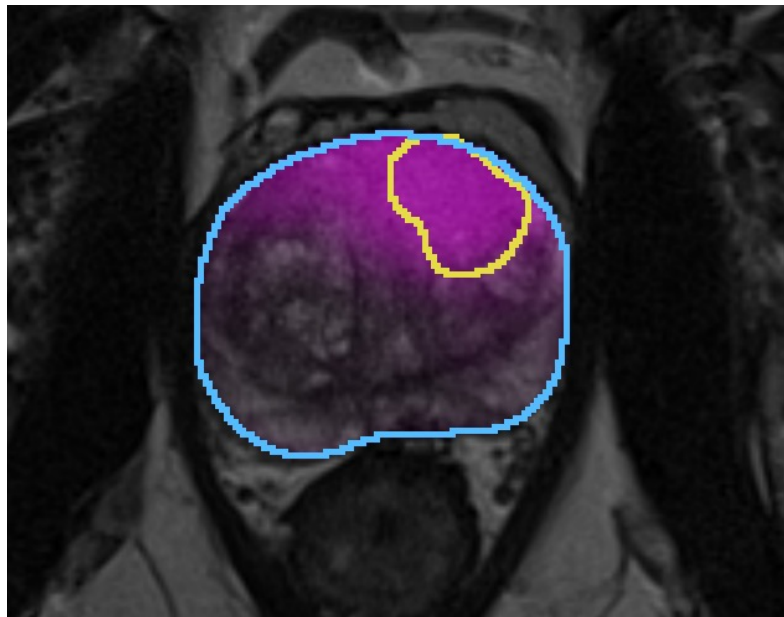
PI-CAI Dataset

- 1500 cases
  - 4 institutions
  - Siemens & Philips
  - 425 cases: prostate cancer
    - Annotated lesions
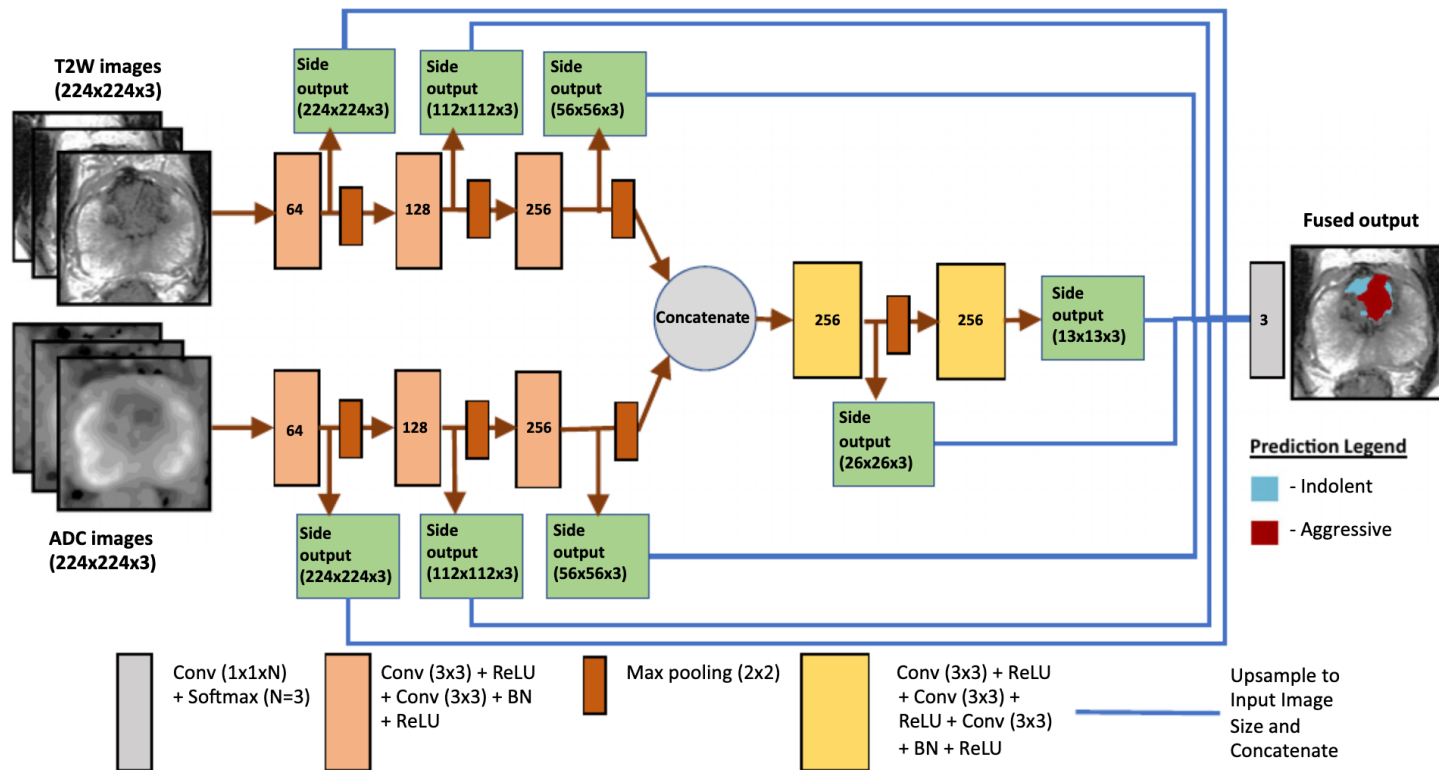   - Segmentations
  - Clinical variables
    - Gleason Score

https://pi-cai.grand-challenge.org/

U-Net

T2 weighted

Apparent Diffusion Coefficient

Diffusion Weighted Imaging

10

Ronneberger, 2015. MICCAI

Saha, A. 10.5281/zenodo.6522364, 2022. (PI-CAI data, annotations added)

SPCNet - Original

Seetharaman, 2021. Med. Physics

Discussion

- Ensembled all possible combinations of 4 prostate cancer detection models w/ traditional methods.
  - Average ensembles performed best
  - Improved true positive detection
  - Best quartet performed similarly to the best duet.
- Initial work with deep learning ensemble methods:
  - SPCNet-decision & SPCNet-clinical
- Future work
  - Include more varied models
  - More complex deep learning ensembles
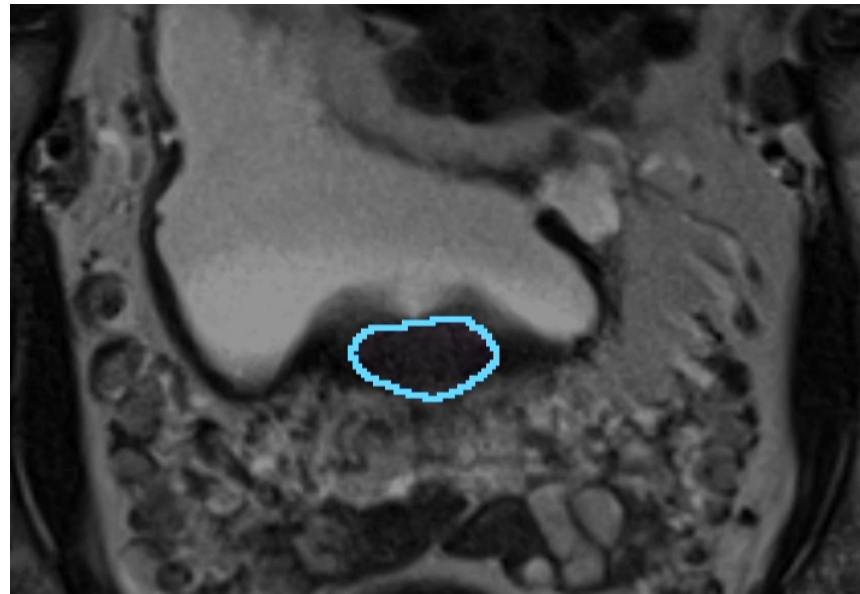
Prostate Gland
Ground Truth lesion
Ensemble Prediction

Saha, A. 10.5281/zenodo.6522364, 2022. (PI-CAI data, annotations added)

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Acknowledgements

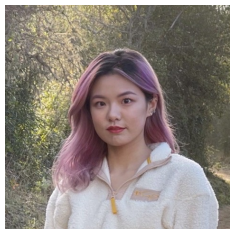
- Mentors

Mirabela Rusu   Geoff Sonn   Andrei Iagaru

- Personalized Integrative Medicine & Urologic Cancer Innovation Labs

Cynthia Li   Sulaiman Vesal   Indrani Bhattacharya

Developed models used in Ensembles

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