A deep learning network along with PIRADS can distinguish clinically significant and insignificant prostate cancer on bi-parametric MRI: A multi-center study

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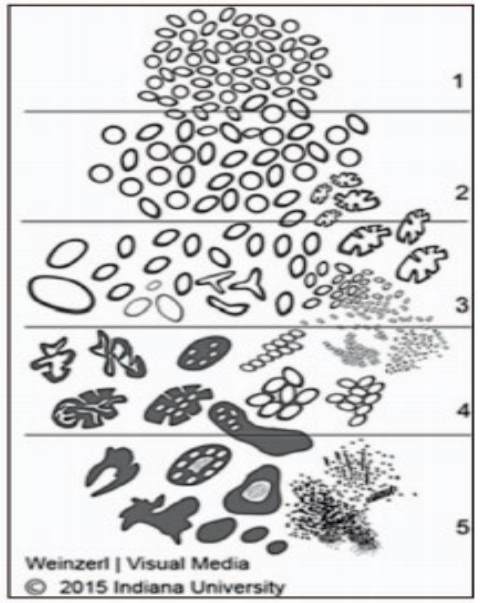
The Center for Computational Imaging & Personalized Diagnostics

Identification of clinically significant prostate cancer



Gleason Grade Group[1] (GGG)

GGG = 1

Clinically insignificant prostate cancer (csPCa)

Active Surveillance

GGG > 1

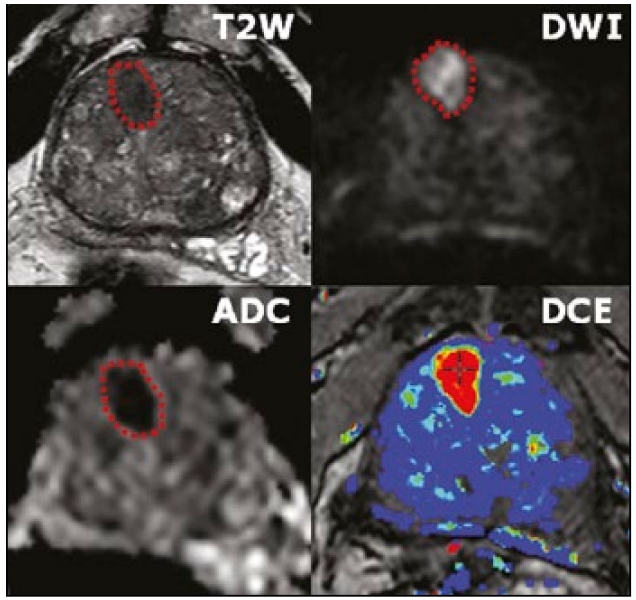
Clinically significant prostate cancer (ciPCa)

Radiation Therapy, Surgery

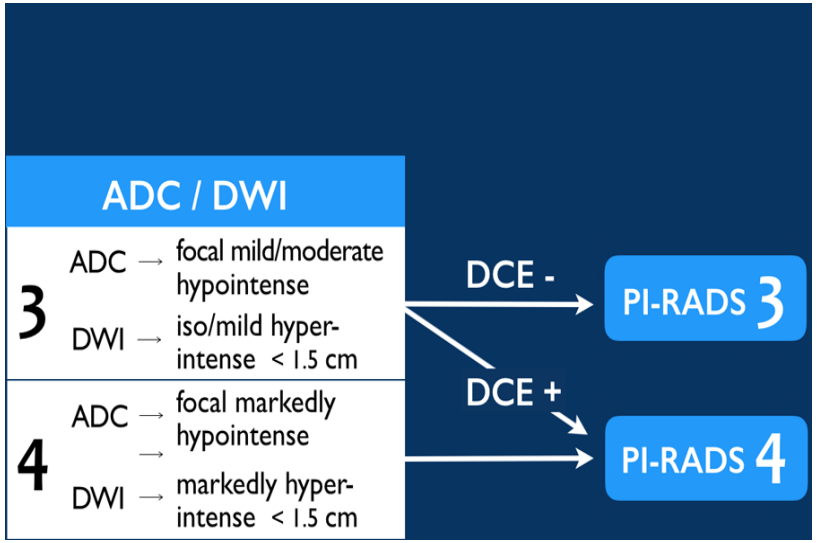
- Decide treatment strategies (Surgery, radiation therapy or active surveillance)
- Current standard of assessment: Invasive biopsies!

[1]Epstein, J. I. et al. The 2014 International Society of Urological Pathology (ISUP) Consensus Conference on Gleason Grading of Prostatic Carcinoma: Definition of Grading Patterns and Proposal for a New Grading System. Am. J. Surg. Pathol. 40, 244–252 (2016).

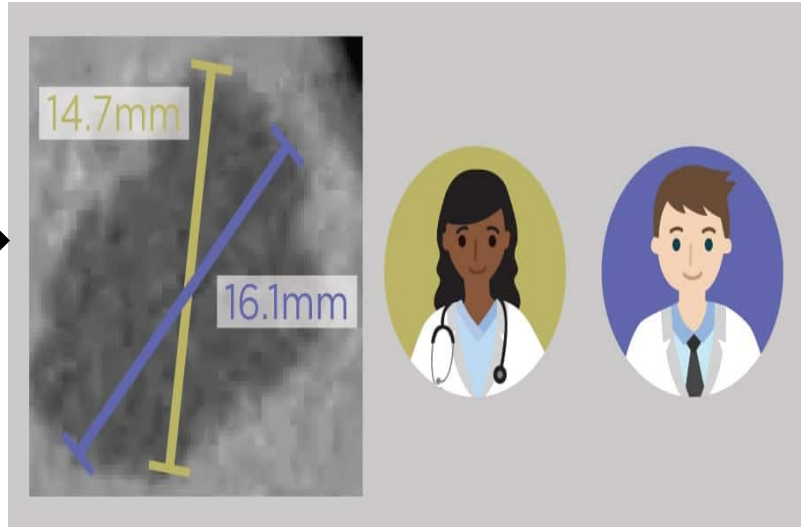
MRI for identification of clinically significant prostate cancer



Multi-parametric MRI



PI-RADS
(Prostate Imaging-Reporting Data System)



MODERATE inter- and intra- reader variability

- Prostate Imaging-Reporting Data System (PI-RADS) scoring.
- Vulnerable to inter- and intra- reader variability

Source : https://www.ncbi.nlm.nih.gov/pubmed/29226826

Previous Work in Prostate Cancer CAD and AI

Prostate Cancer Detection[1]	Single Instance Learning: Noisy patch labels
Clinically significant PCa detection: ResNet based transfer learning[2]	Single site study
Prostate Cancer Diagnosis using 3D multi-parametric MRI[3]	Patch based: No contextual and spatial information
Classification of clinically significant prostate cancer using UNet[4]	Combination of deep learning predictions and PI-RADS unexplored.

1.Epstein, J. I. et al. The 2014 International Society of Urological Pathology (ISUP) Consensus Conference on Gleason Grading of Prostatic Carcinoma: Definition of Grading Patterns and Proposal for a New Grading System. Am. J. Surg. Pathol. 40, 244–252 (2016).

2. Zhong, X. *et al.* Deep transfer learning-based prostate cancer classification using 3 Tesla multi-parametric MRI. *Abdom Radiol (NY)* **44**, 2030–2039 (2019).

3. Liu, S., Zheng, H., Feng, Y. & Li, W. Prostate cancer diagnosis using deep learning with 3D multiparametric MRI. in (eds. Armato, S. G. & Petrick, N. A.) 1013428 (2017). doi:10.1117/12.2277121.

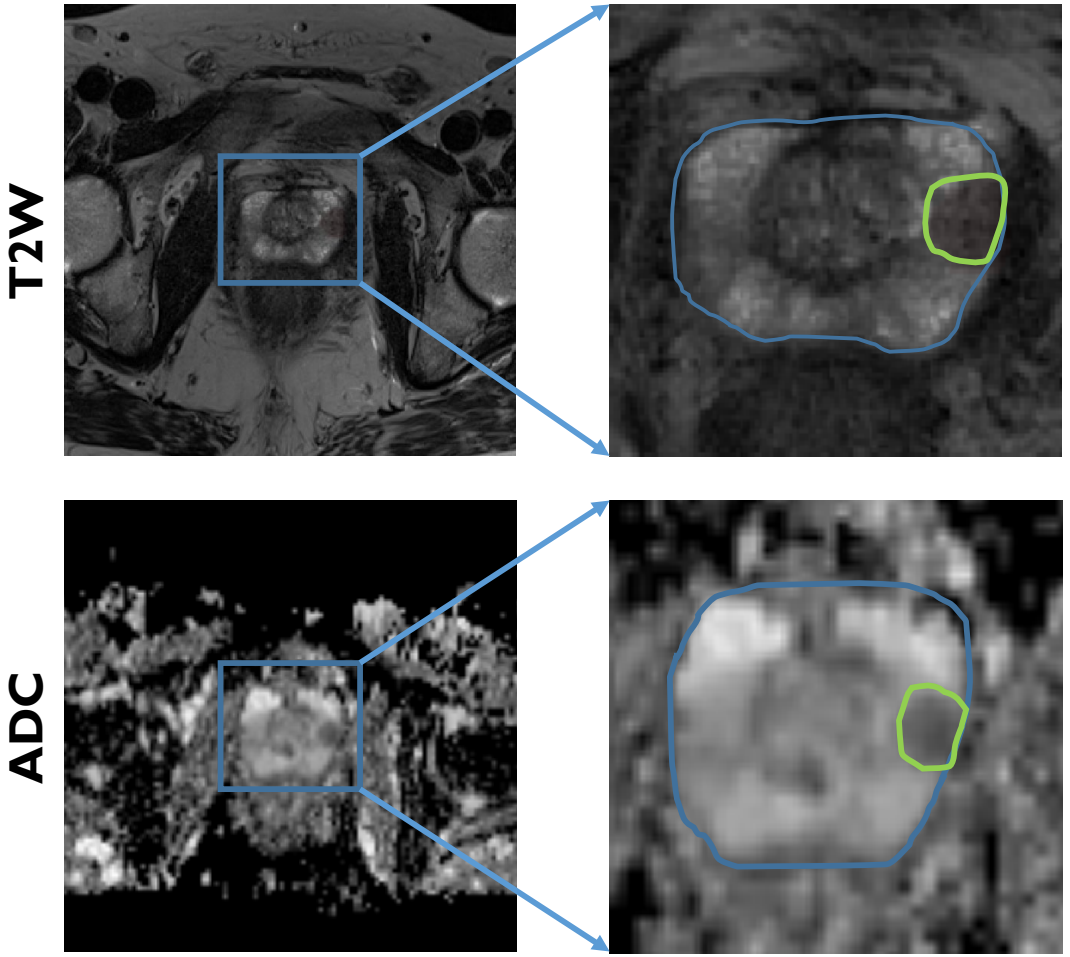
4. Schelb, P. *et al.* Classification of Cancer at Prostate MRI: Deep Learning versus Clinical PI-RADS Assessment. *Radiology* **293**, 607–617 (2019).

Objective

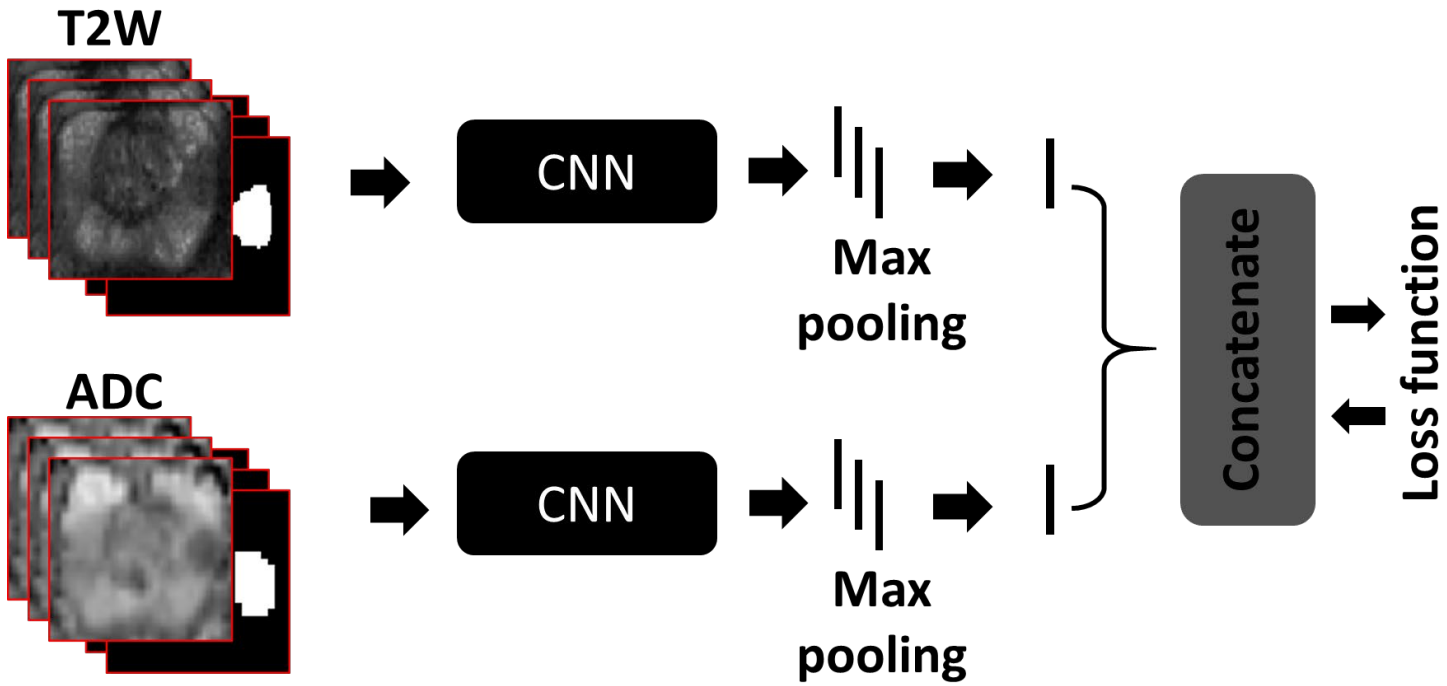
Distinguish clinically significant (csPCa) and insignificant prostate cancer (ciPCa) on bi-parametric MRI by combining deep learning predictions with PI-RADS score

Dataset

- Three institutions (D_1, D_2, D_3)
  - N = 359 patients, N = 492 lesions
  - Training set : D_1 (N=155 lesions)
  - Testing set : D_2,D_3 (N=337 lesions)
- Bi-parametric 3T MRI
  - T2W MRI and ADC maps (b-values: 0-2000s/mm^2)
- Endorectal / Surface coil
- Ground truth: radiologists > 9 years experience (whole mount prostatectomy sections or biopsies).

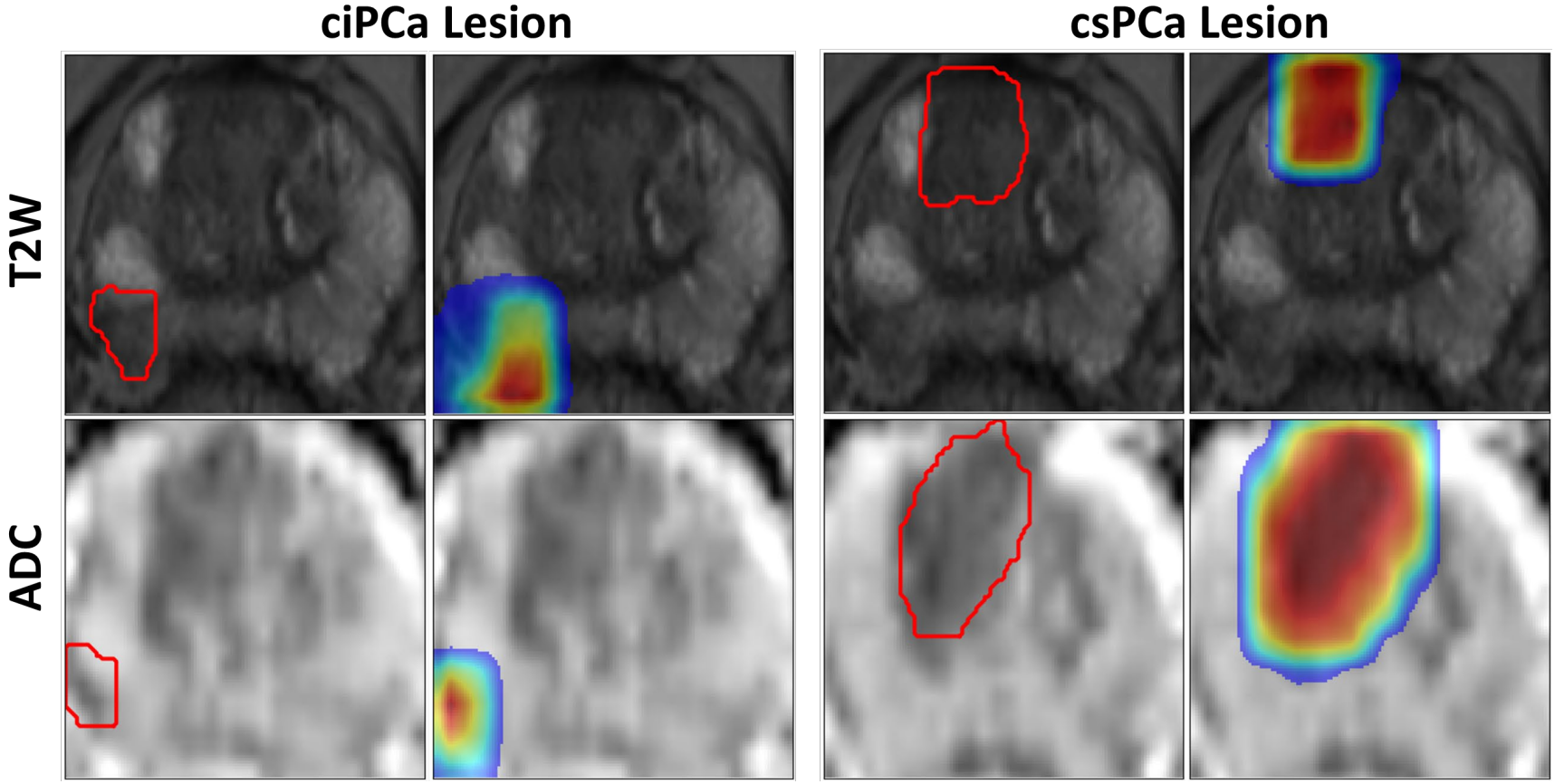


Experiment 1: Distinguishing clinically significant, insignificant prostate cancer using attention based deep learning model



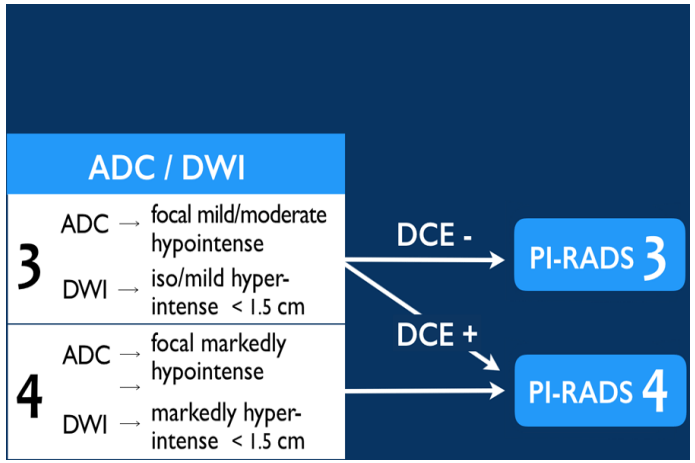
- Patches cropped around the prostate
- Attention based model : Binary segmentation as input channel.
- Parallel branches for T2W and ADC maps.
- Multiple instance learning : summarize decisions of multiple image slices.

Experiment 1: Distinguishing clinically significant, insignificant prostate cancer using attention based deep learning model

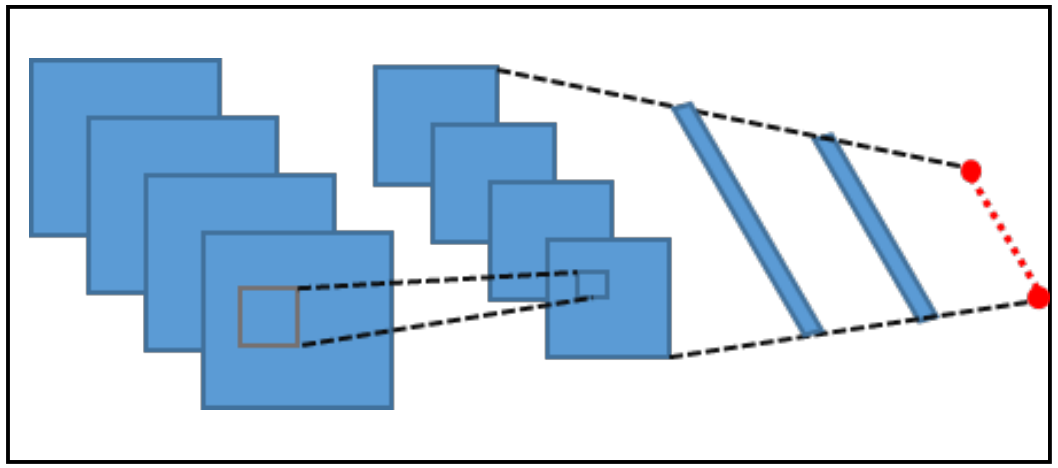


- AUC : 0.76, Sensitivity : 85%, Specificity: 38% on the testing cohort.
- Activation maps : Networks focusing at cancerous regions to make decisions.

Experiment 2: Combining deep learning predictions with PI-RADS score to distinguish clinically significant and insignificant prostate cancer



PI-RADS
(Prostate Imaging-Reporting Data System)

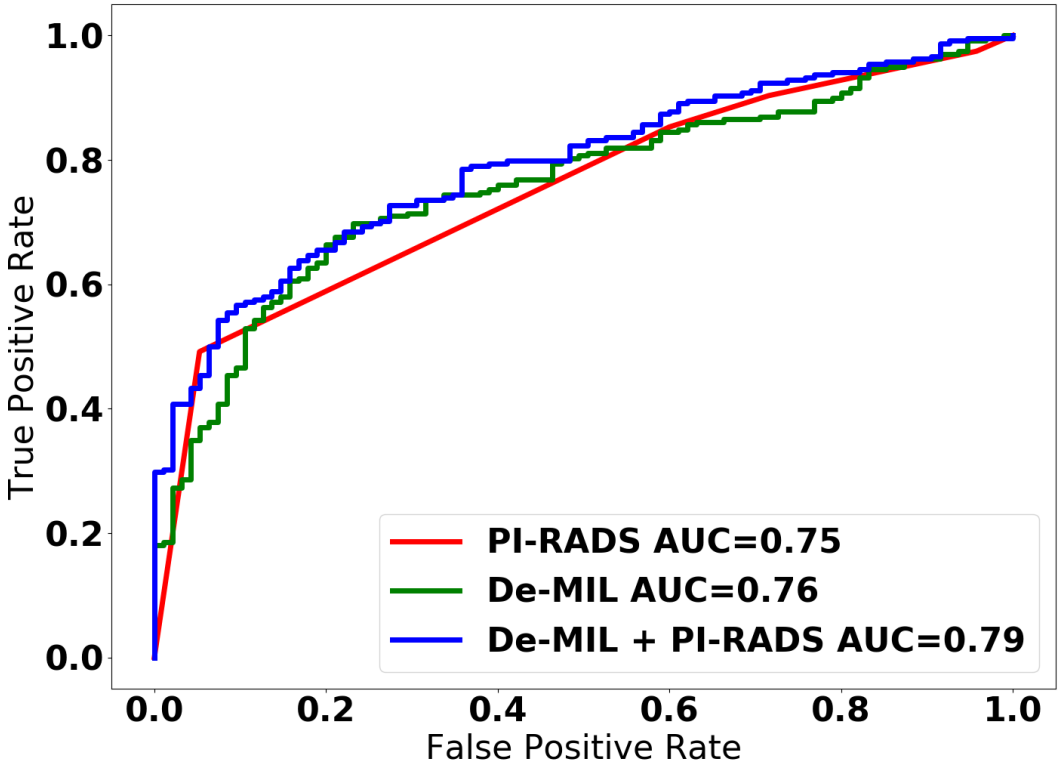


Deep Learning Predictions

- Combining deep learning predictions and PI-RADS score.
- Training logistic regression classifier on the combination.

Source : https://www.ncbi.nlm.nih.gov/pubmed/29226826

Experiment 2: Combining deep learning predictions with PI-RADS score to distinguish clinically significant and insignificant prostate cancer



	PI-RADS	De-MIL	De-MIL + PI-RADS
AUC	0.75	0.76	0.79
Sensitivity	85%	85%	85%
Specificity	40%	38%	43%
PPV	78%	78%	79%
NPV	52%	51%	55%

Conclusions

- An attention based multiple instance learning CNN (De-MIL) can distinguish clinically significant and insignificant prostate cancer.
- Performance similar to PI-RADS assessment
- Combination of deep learning predictions and PI-RADS can improve performance.
- Future work: Combine other clinical variables, predict upstaging in active surveillance patients.

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