Zone-DR: Discovery Radiomics via Zone-level Deep Radiomic Sequencer Discovery for Zone-based Prostate Cancer Grading using Diffusion Weighted Imaging

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Linda Wang*[1,2], Chris Dulhanty*[1,2], Audrey Chung[1,2], Farzad Khalvati[3], Masoom Haider[3], Alexander Wong[1,2]
equal contribution*, University of Waterloo[1], Waterloo AI Institute[2], Lunenfeld-Tanenbaum Research Institute[3]

VIP lab vip.uwaterloo.ca
UNIVERSITY OF WATERLOO

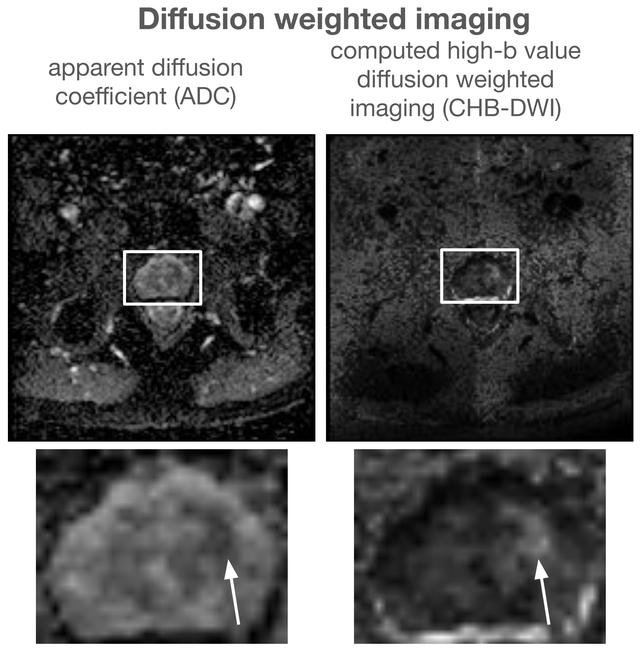
Introduction

1 in 9 men will be diagnosed with prostate cancer during his lifetime

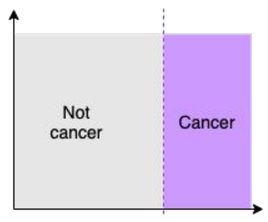
Prognosis is good given early detection

Fast and reliable screening methods, i.e.: MRI

Diffusion weighted imaging



Current methods use threshold approaches
Does not account for variations in imaging equipment, signal characteristics between healthy and cancerous tissue



Contributions:

- Investigate efficacy of ADC and CHB-DWI when applied to prostate zone gradings
- Propose **Zone-DR**, zone level deep radiomic sequencer discovery

Methods

Dataset

101 patients

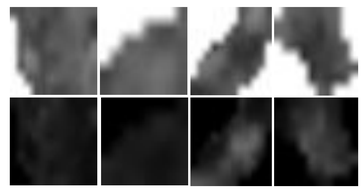
12,466 pathology verified prostate zones from DWI data

12,361 negative (non-cancerous)

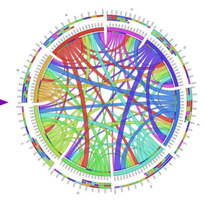
135 positive (cancerous)

To account for imbalance, weights of 1 and 95 are used for negative and positive zones, respectively.

Discovery Radiomics



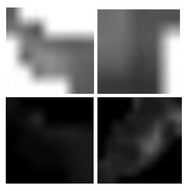
Medical imaging archive

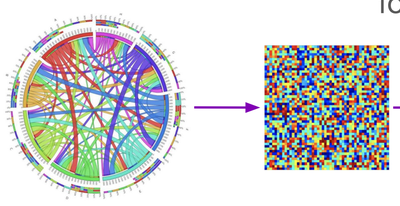


Radiomics sequencer discovery

Performed Bayesian optimization (Sigopt conditional experiments) over sequencer design space: number of convolutional layers, number of filters per layer and number of channels for fully connected layers.

Current patient data





0. Non-cancerous
1. Cancerous

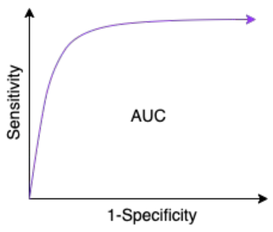
Discovered radiomic sequencer

Zone-DR

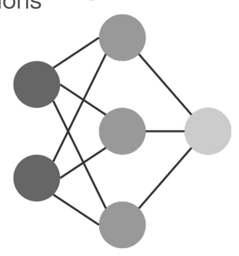
SIGOPT

Send score of current architecture

Network architecture suggestions



Training results



ADC	CHB-DWI
input	
conv3-15	conv3-10
	conv3-29
conv3-15	conv3-23
	conv3-46
conv3-18	conv3-106
flatten-288	flatten-1696
FC-341	FC-295

Results

Optimal threshold for Zone-DR depends on clinical setting. For this study, equal weight was given to specificity and sensitivity.

$$\hat{\theta} = \underset{\theta}{\operatorname{argmax}}((1 - fpr(\theta)) + tpr(\theta))$$

ADC Threshold

$$1 - \frac{\min \text{ ADC value of zone}}{M_{ADC}}$$

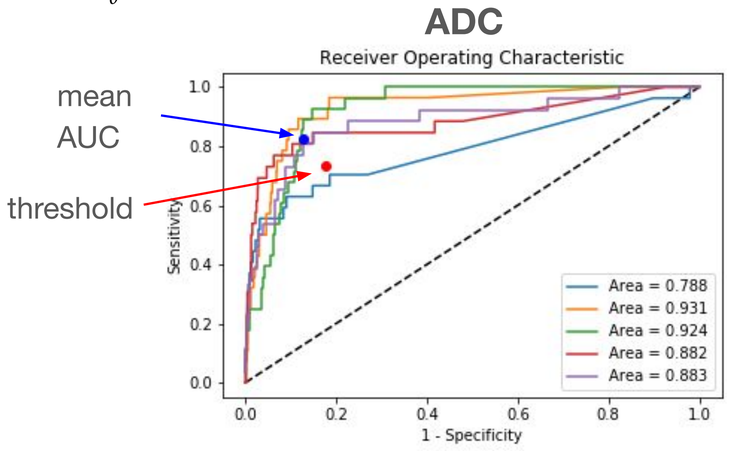
< 1000s/mm^2	Cancerous
>= 1000s/mm^2	non-Cancerous

CHB-DWI Threshold

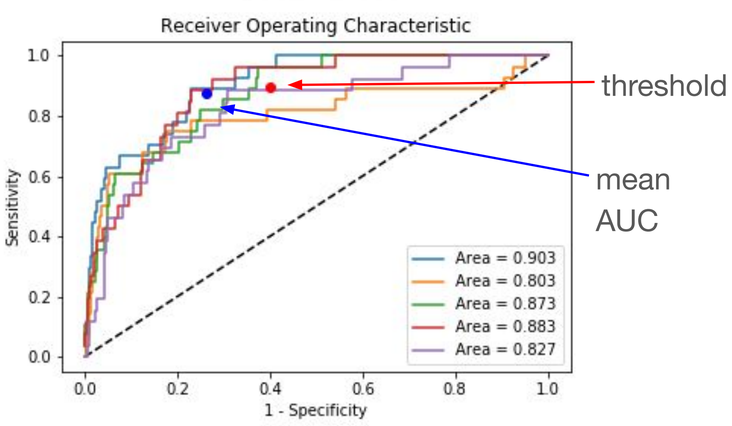
$$\frac{\max \text{ CHB-DWI value of zone}}{M_{CHB}}$$

> 1000s/mm^2	Cancerous
<= 1000s/mm^2	non-Cancerous

ADC



CHB-DWI



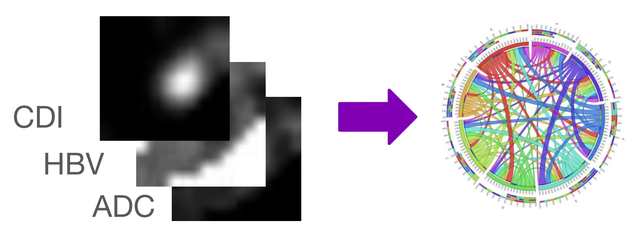
Modality	Technique	AUC	Sensitivity	Specificity	Accuracy
ADC	Threshold		0.895	0.601	0.604
	Zone-DR	0.858	0.874	0.737	0.738
CHB-DWI	Threshold		0.733	0.824	0.823
	Zone-DR	0.882	0.828	0.873	0.873

Conclusion

- For different clinical scenarios, weighting for sensitivity and specificity can be adjusted
  - Maximizing specificity is important for surgery for removal of prostate → minimize false positive rate to avoid unnecessary surgeries
  - Maximizing sensitivity for cancer screening may be useful to avoid missing cancerous patients

Future work

- Explore different methods to overcome the imbalanced dataset
- Use current work to build up to slice-level detection
- Experiment with a combination of modalities (i.e.: one modality per channel)
- Explore different deep radiomic sequencer designs



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