Multi-parametric MR Image Analysis for Prostate Cancer Assessment with Convolutional Neural Network

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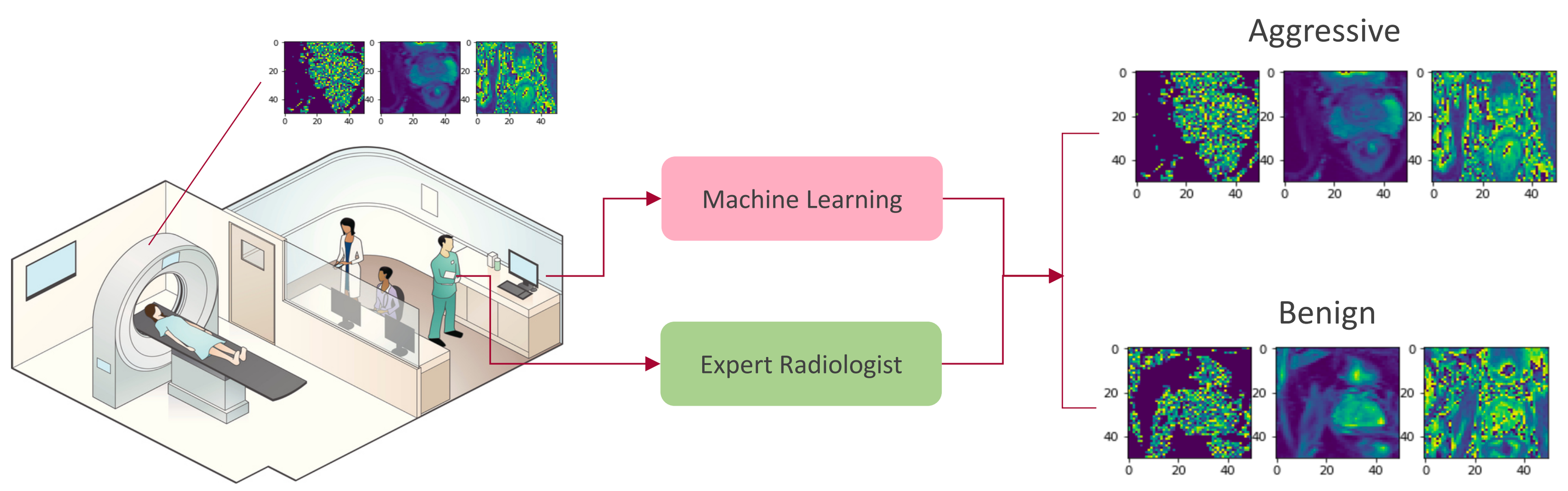
Background

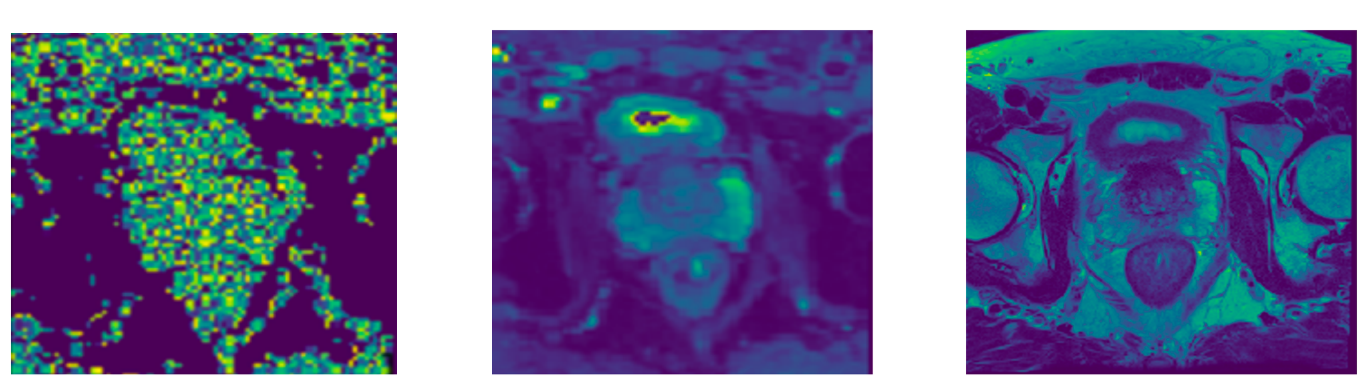
- **Prostate cancer** is the second leading cause of cancer death among American men. Early detection of prostate cancer usually comes with a 17 - 50% overdiagnosis of the cancer leading to discouragement in using treatment.
- **Multi-parametric MR** is a powerful imaging technique used in detecting the prostate cancer. However, analysis is plagued by inter-radiologist variability. To improve the analysis of MR imaging, conventional machine learning techniques are used to reduce the overdiagnosis.
- We propose a convolutional neural networks (CNNs) model to improve the performance of of automated multi-parametric MR image analysis of prostate cancer to classify an **aggressive type** and **benign type**.



Dataset

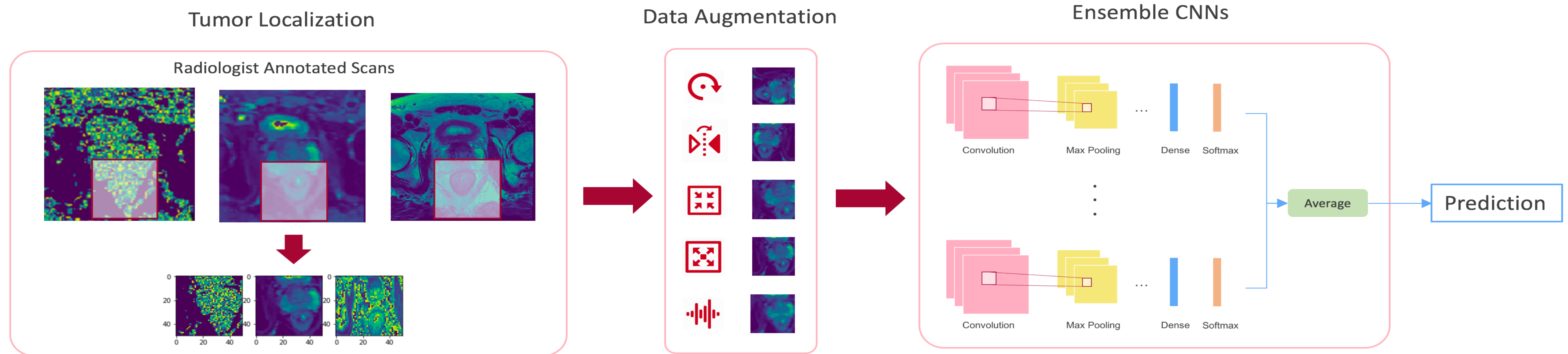
- The data set consists of **197 patients multi-parametric MR images** obtained from the Radiology Department, Stanford Medical School.
- 138 patients are diagnosed with aggressive prostate cancer and 59 patients are diagnosed with benign prostate cancer.
- All the images were acquired in the axial plane, and an expert radiologist identified and circumscribed the suspicious lesion.
- Each MRI includes 3 image modularities:
    1. Apparent Diffusion Coefficient (ADC)
    2. Diffusion Weight Imaging (DWI)
    3. T2 Weighted Image (T2)

Sample MR images



ADC DWI T2

Approach



- The full scans are cropped to 50 x 50 pixels at the radiologist annotated point.
- Due to the small sample size, the images are augmented using rotation, reflection, scaling, Gaussian noise, and Salt and Pepper noise.

Ensemble CNNs

- The main idea is to have many CNNs jointly make the decision by averaging the result from individual models.
- 20 different CNNs are sampled with dropout probability in (0.5, 0.9) and the output size of the last affine-ReLU in [128, 256, 512].

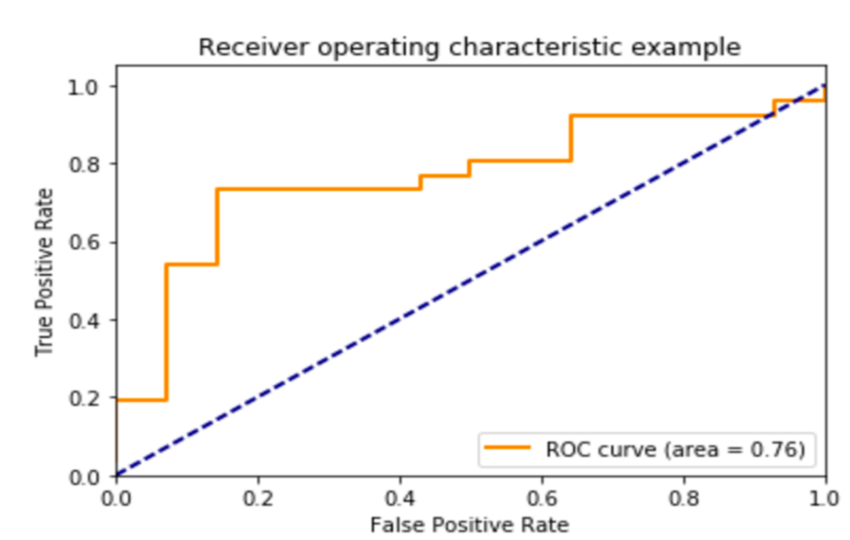
Ensemble Q-Learning CNNs

- We search for the best CNN architecture for the problem with Q-Learning agent that learns to select the layers to achieve high validation accuracy.
- The models in the ensemble are replaced with the top CNN architecture from the Q-learning agent.

Experiment Result

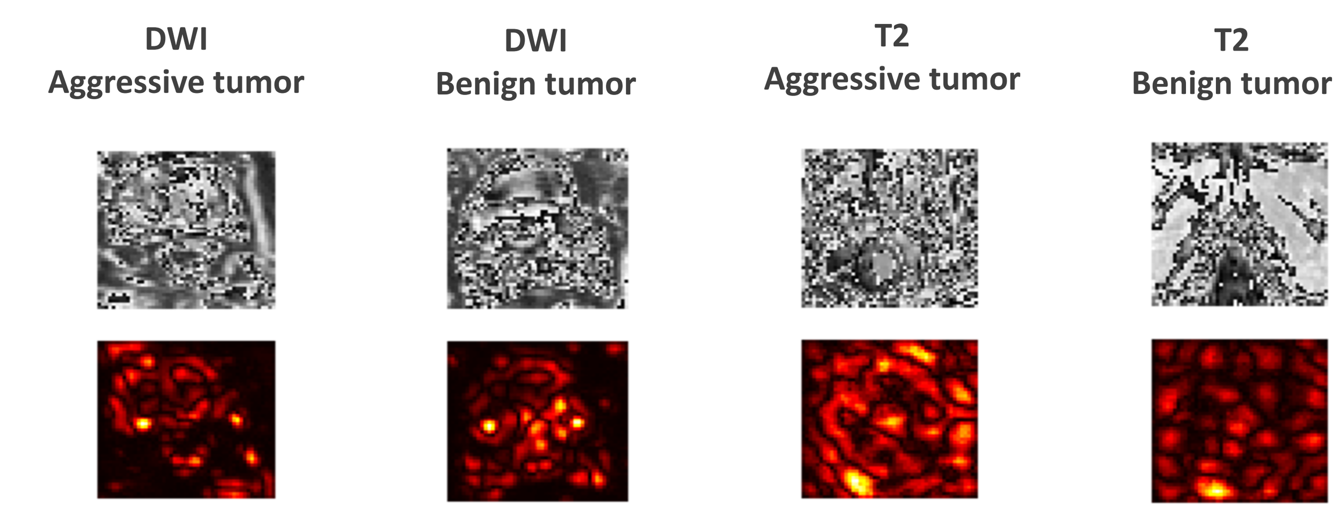
Type	Model	Accuracy	AUC
Individual Model	Linear SVM	48 %	0.54
	LASSO	52 %	0.53
	Elastic Net	55 %	0.56
	Simple CNN	58 %	0.61
	CIFAR-10 CNN	65 %	0.54
	Q-Learning CNN	67 %	0.52
Ensemble Model	Simple CNNs	72 %	0.76
	Q-Learning CNNs	73 %	0.73
State of the art	Elastic Net with Custom Feature	73 %	0.73

ROC curve for Ensemble CNNs



Network Visualization

Saliency Map



PCA t-SNE

Conclusion & Future Works

- End-to-end ensemble CNNs achieves similar performance with the state-of-the-art without feature extraction.
- Extract visual features via CNN, then use features to run on other algorithms such as boosting trees.

Acknowledgement

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