INTERPRETABLE CLASSIFICATION OF RENAL AND COLONIC NEOPLASIA ON HISTOPATHOLOGICAL SLIDE IMAGES USING PROTOTYPICAL EXPLAINABILITY

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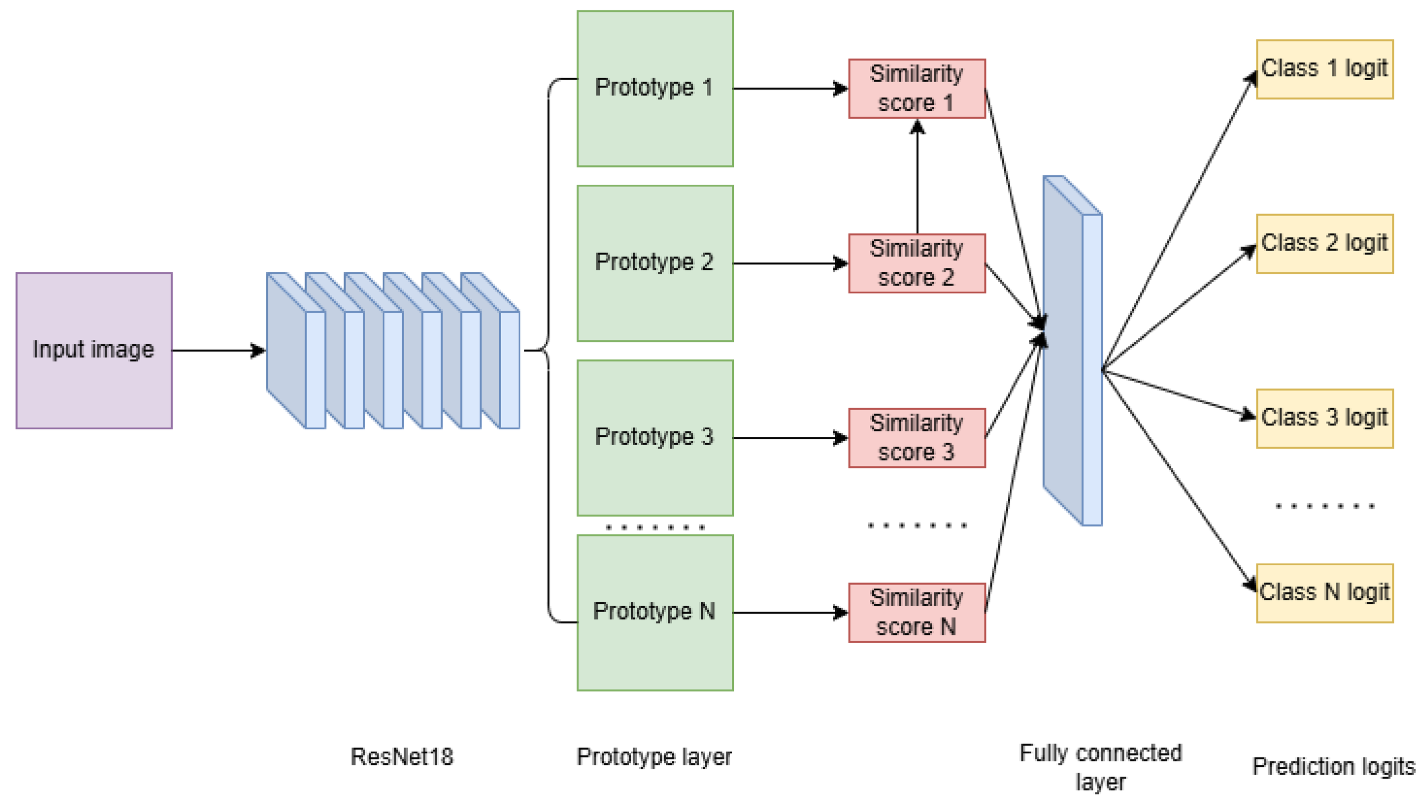
INTRODUCTION

Clinical Significance:
Histopathology is the gold standard for identification of malignancies, and digital slide images can be applied to computer vision tasks for image analysis
Epidemiology:
Renal cell carcinoma: 400,000 cases and 200,000 deaths annually [1]
Colorectal carcinoma: 14 million cases and 8 million deaths annually [2]
Clinical Need:
Accurate and interpretable AI methods can be implemented to classify histopathology images and support decision making of pathologists

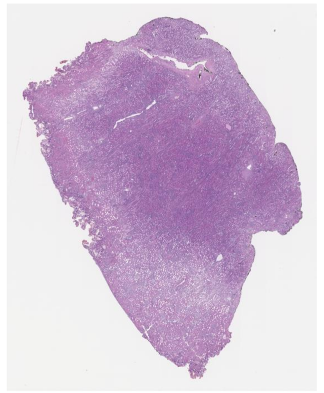
Prototypical Part Network:
Deep neural network that classifies images by comparing regions of input **to class-specific prototypes**, providing **built-in**, **human-interpretable** "this-looks-like-that" reasoning and transparency [3]



Datasets:

RCC Dataset

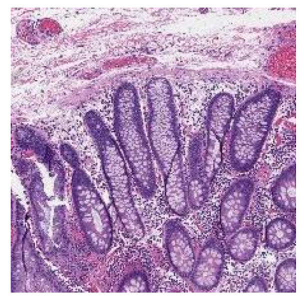
484 whole-slide images of renal resections from DHMC [4]



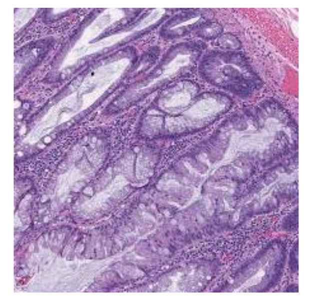
5 classes:
Benign
Chromophobe
Clear cell
Oncocytoma
Papillary

MHIST Dataset

3,152 patches from whole-slide images of colonic biopsies from DHMC [5]

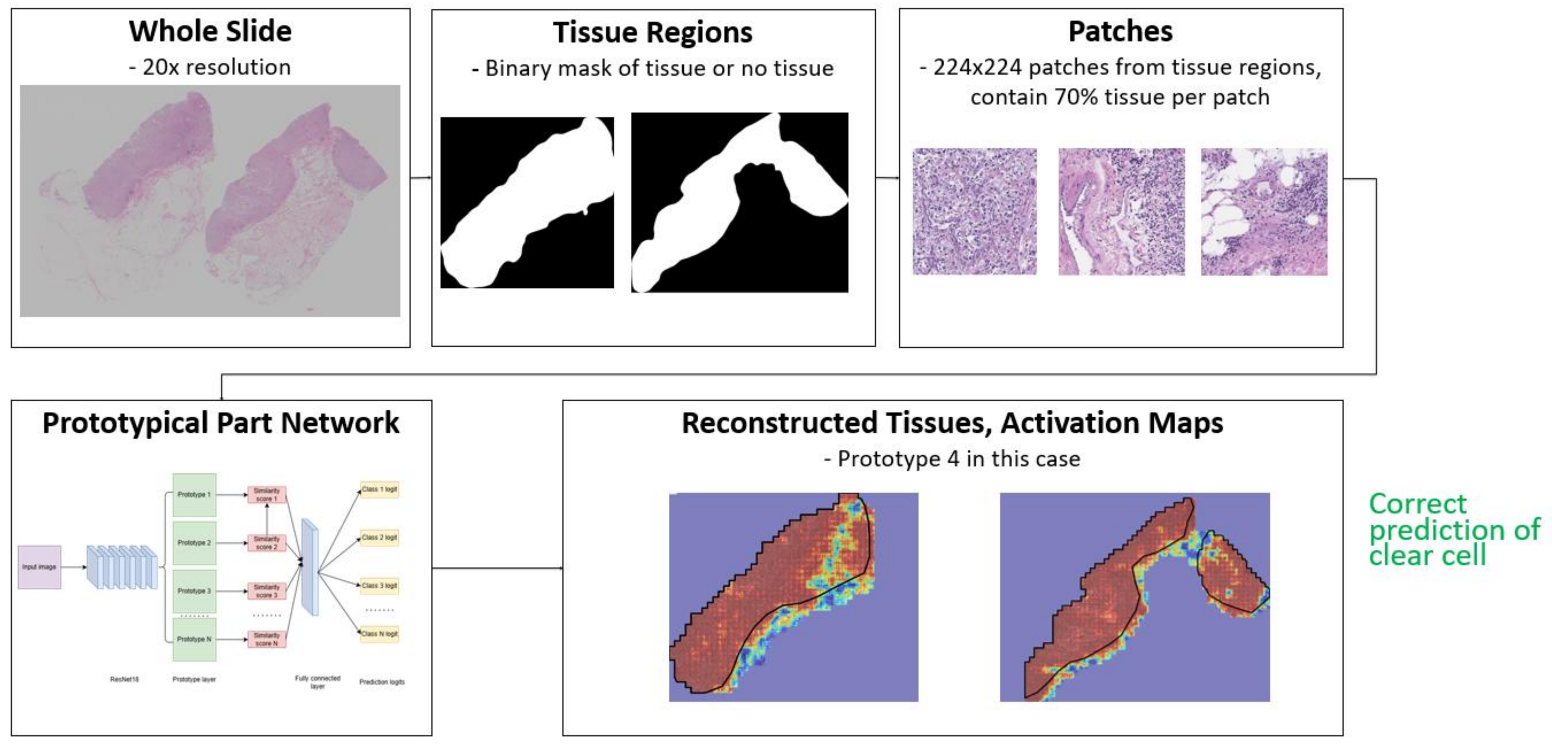


Hyperplasia (HP)



Sessile serrated adenoma (SSA)

METHODS

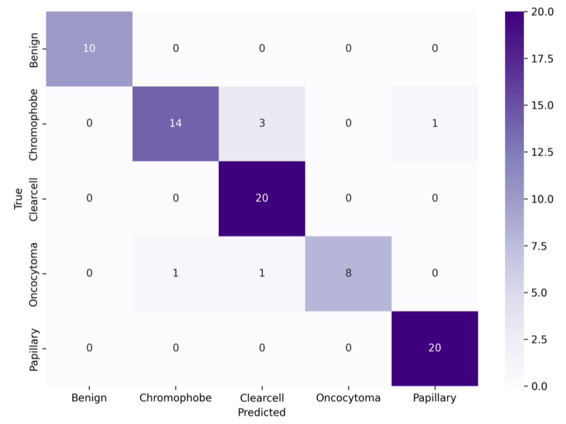


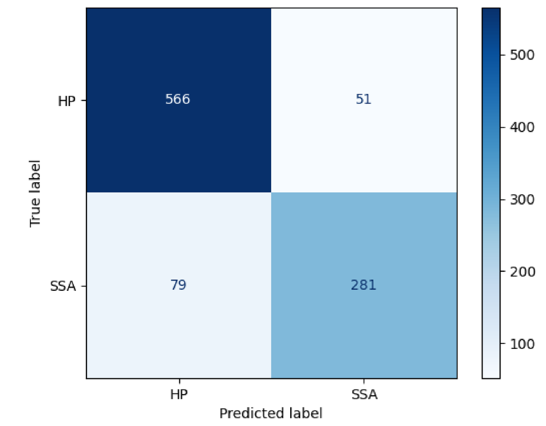
Whole slides are disassembled into patches, which are passed through the model. Individual patches are classified, and whole slides are reconstructed. Regions of malignancy are marked as "hot spots."

RESULTS

1 MODEL ACCURACY

RCC Dataset: accuracy reaches 92.3% **MHIST Dataset: accuracy reaches 85.5%**

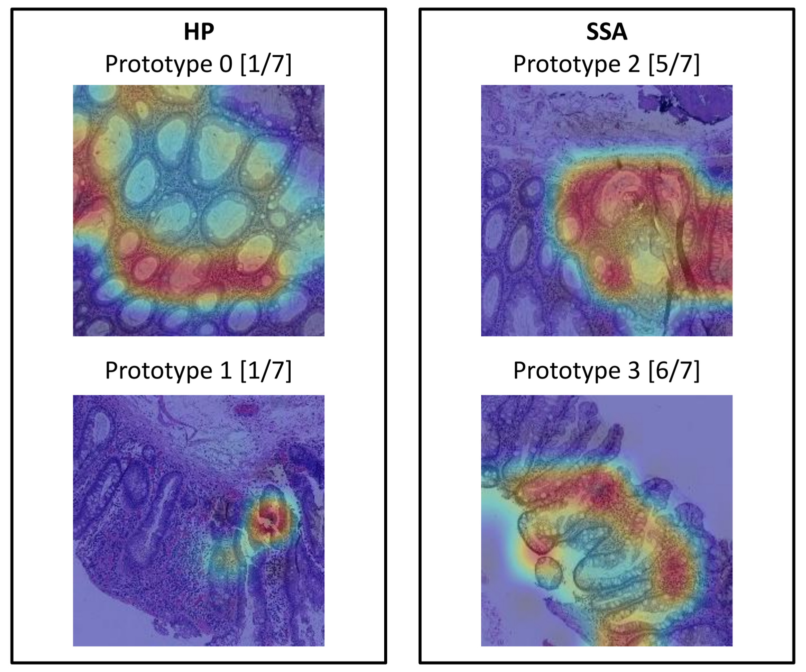




2 MODEL PATCH-LEVEL PERFORMANCE

Model learns "prototype" images to compare to test images, providing a human-interpretable reasoning behind predictions

MHIST Dataset Prototypes



Blue = weak activation **Red** = strong activation

"Tough" Example (5/7 pathologists labeled as SSA)

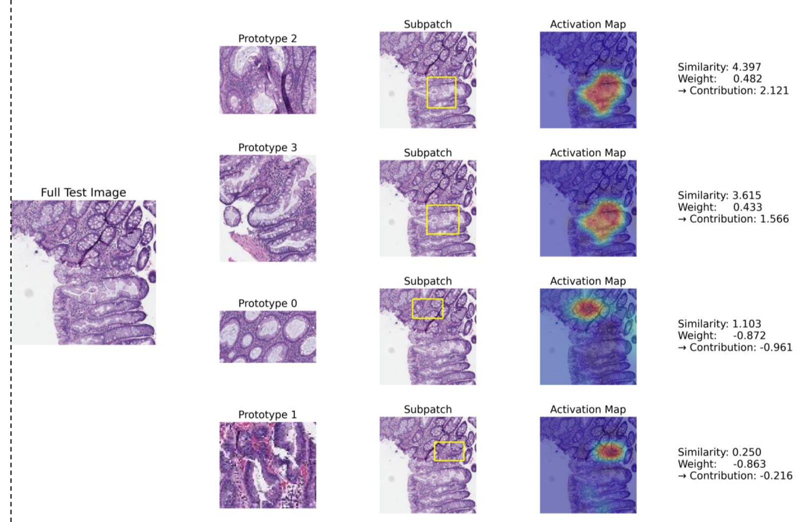
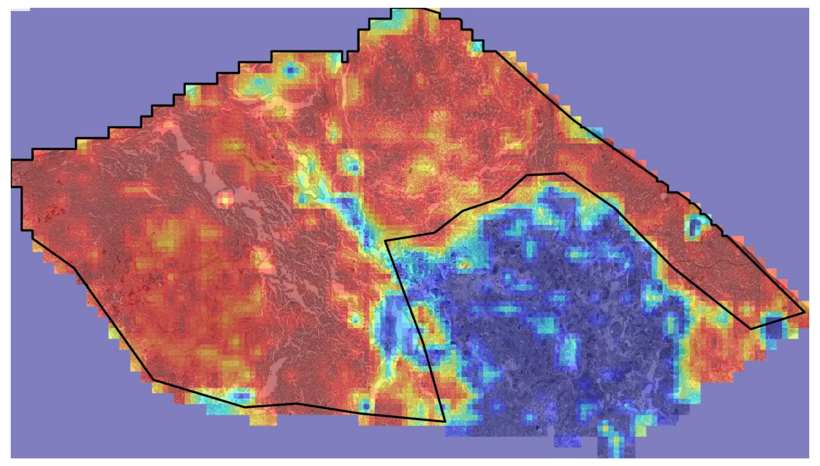


Image has higher similarity scores for SSA prototypes (2 and 3)

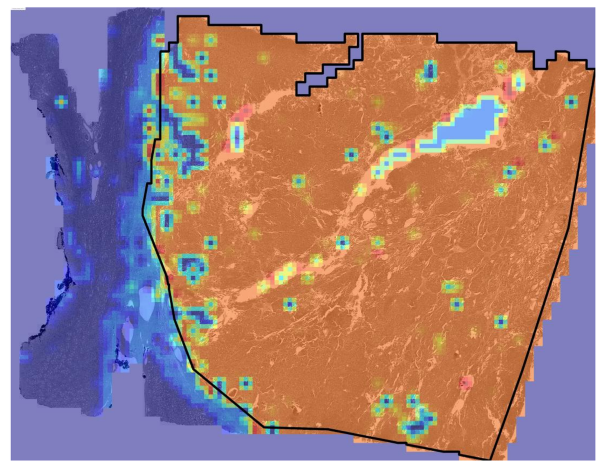
3 MODEL SLIDE-LEVEL PERFORMANCE

Model capable of analyzing whole-slide at the subpatch-level to identify regions of suspected malignancy on a biopsy slide

Chromophobe tumor biopsy

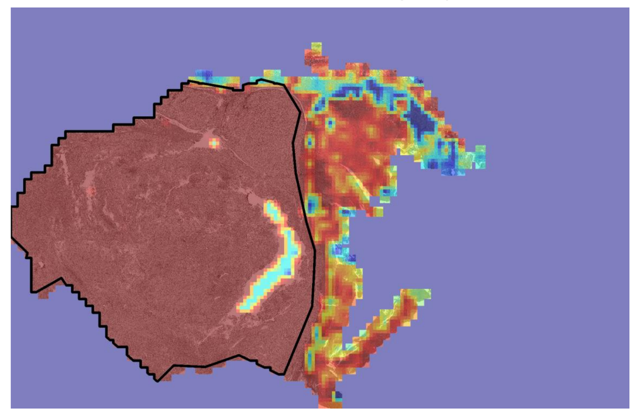


Oncocytoma tumor biopsy



Papillary tumor biopsy

Clear cell tumor biopsy



Blue = weak activation **Red** = strong activation **Black border** = pathologist border of malignancy

DISCUSSION & CONCLUSIONS

Performance:
Model obtains high accuracy on MHIST and RCC Datasets
Interpretability:
1. Prototype activations reveal model logic for both correct and incorrect predictions, aiding in error analysis
2. Subpatch-level activations provide fine-grained context for whole slide images, which can align with histologic structures

Clinical impact:
1. The prototypical part network can enable pathologists to audit AI decisions and builds trust
2. The model's interpretability reduces black-box opacity, which is a large barrier to clinical adoption

ACKNOWLEDGEMENTS

Professor Saeed Hassanpour and the **Hassanpour Lab**
The **Department of Pathology and Laboratory Medicine at DHMC**

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