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Gleason grading of biopsies using an attention-based multi-resolution model ensembled with LGBM and XGBoost

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Computational Diagnostics
Medical Image Informatics
Radiology
Pathology & Laboratory Medicine

Group Photo of Medical Image Informatics

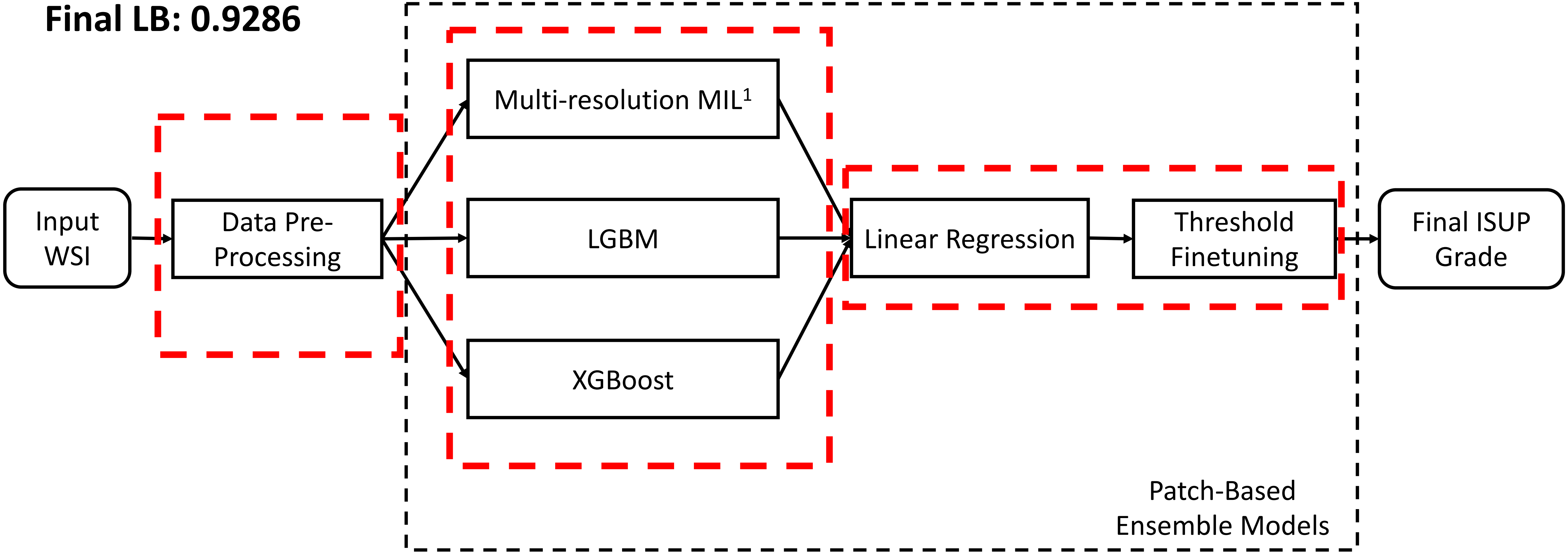
Computational Diagnostics (CDx)
Medical Imaging Informatics (MII)
University of California, Los Angeles, USA

Computational Diagnostics

UCLA medical imaging INFORMATICS

Overall Solution

Final LB: 0.9286



[1] MIL: multi-instance learning.

Data Cleaning

- Removal of Pen Marks by ***akensert***

- Suspicious Slides by ***Zac Dannelly***

No cancerous tissue but ISUP Grade > 0	85
Blank Slides	5

- Duplicate Slides by ***Appian***

Original

Pen Marks Removed

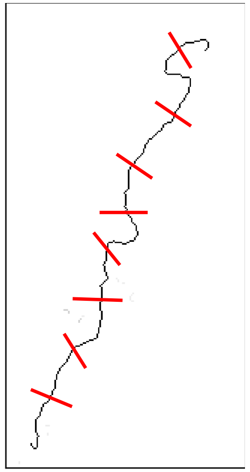
*65be0

*af93e

Data Pre-Processing

Original Image

Tissue Mask

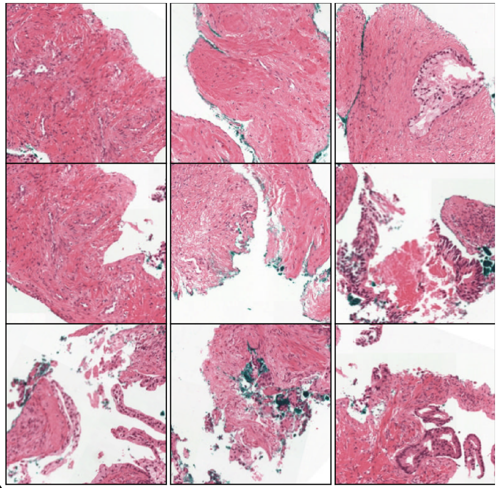


Midline

Spread Patches on "Spine"

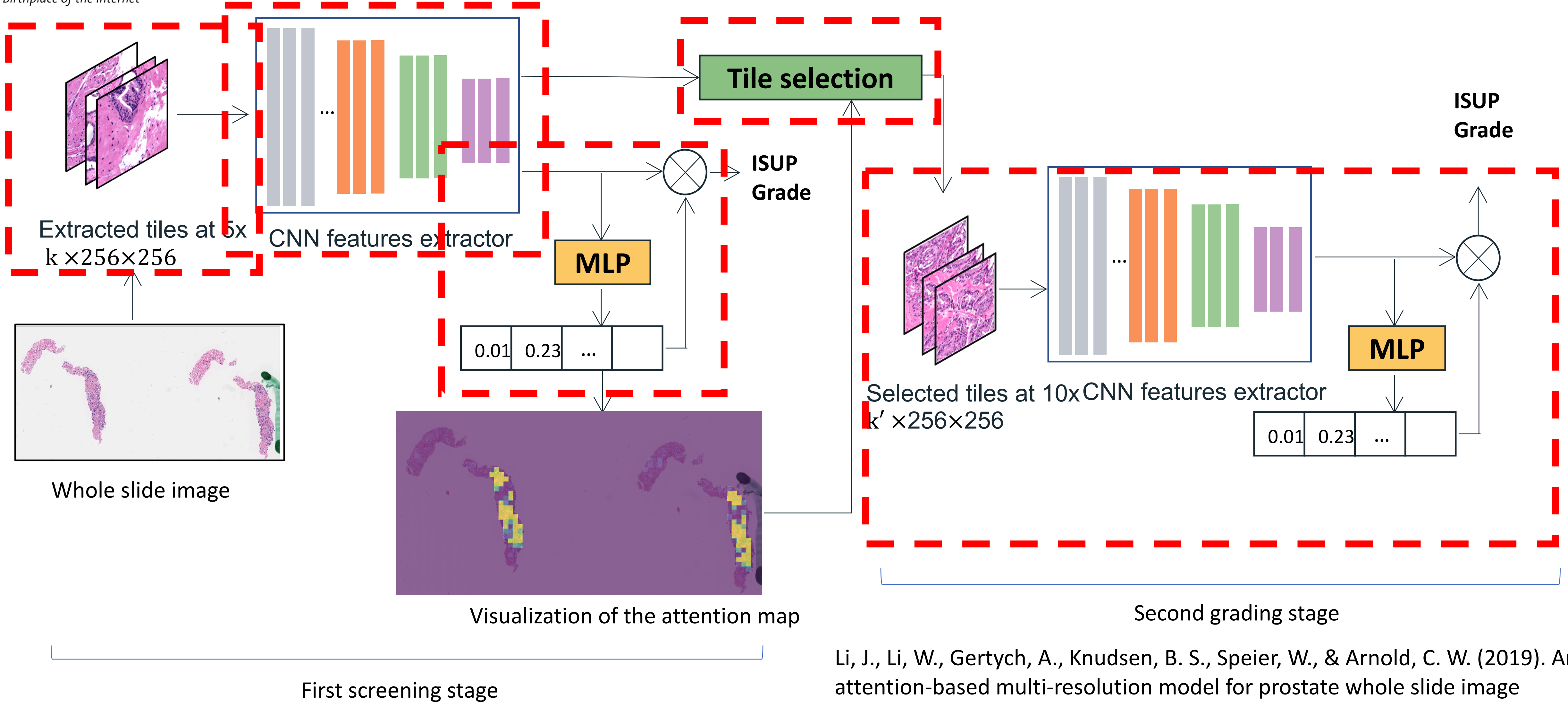
Blue Ratio Selection

$$BR = \frac{100 \times B}{1 + R + G} \times \frac{256}{1 + R + G + B}$$



Top *k* Patches based on BR

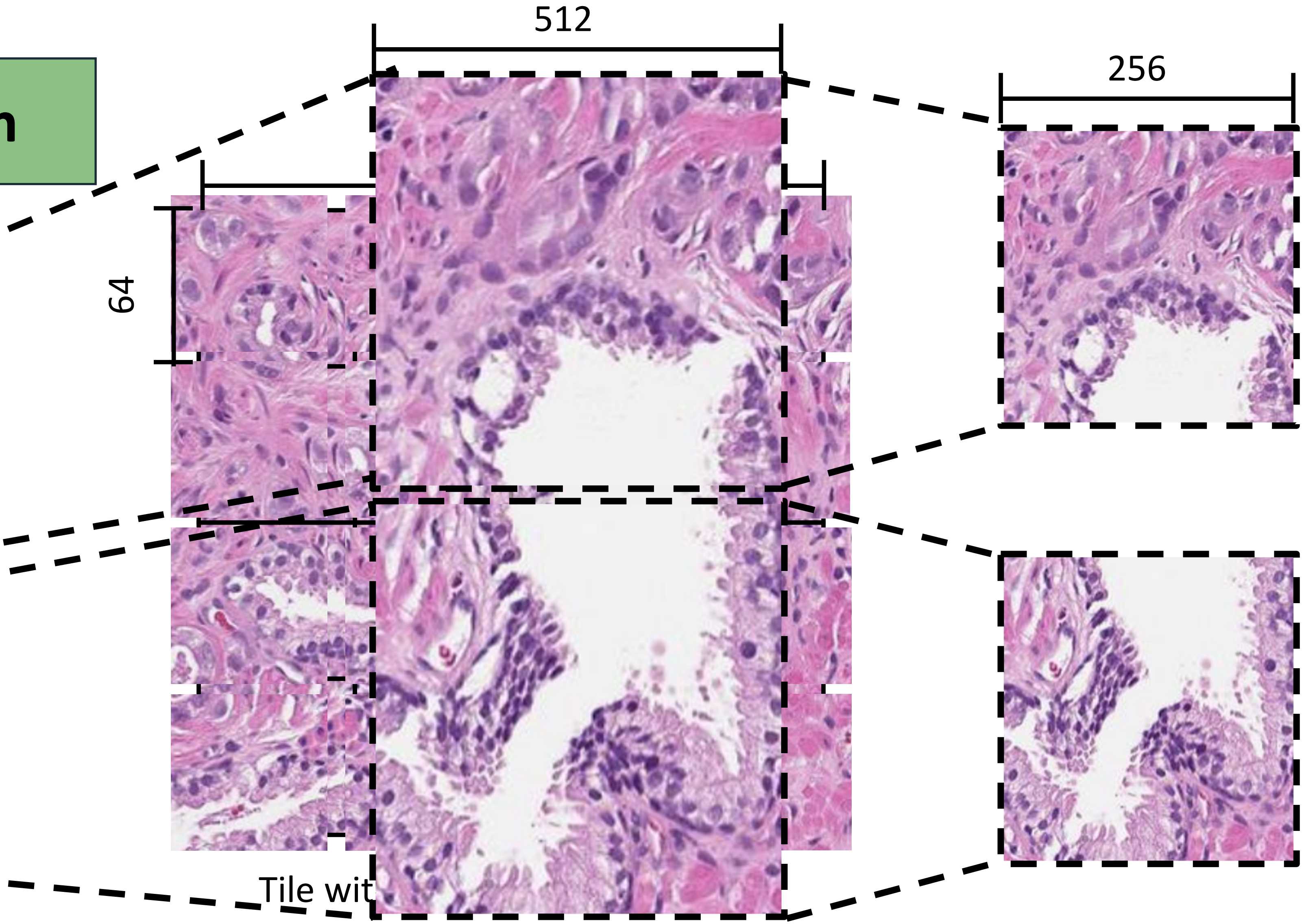
Multi-resolution MIL



Li, J., Li, W., Gertych, A., Knudsen, B. S., Speier, W., & Arnold, C. W. (2019). An attention-based multi-resolution model for prostate whole slide image classification and localization. *CVPR Workshops* (2019).

Tile Selection of Multi-reso MIL

Tile selection



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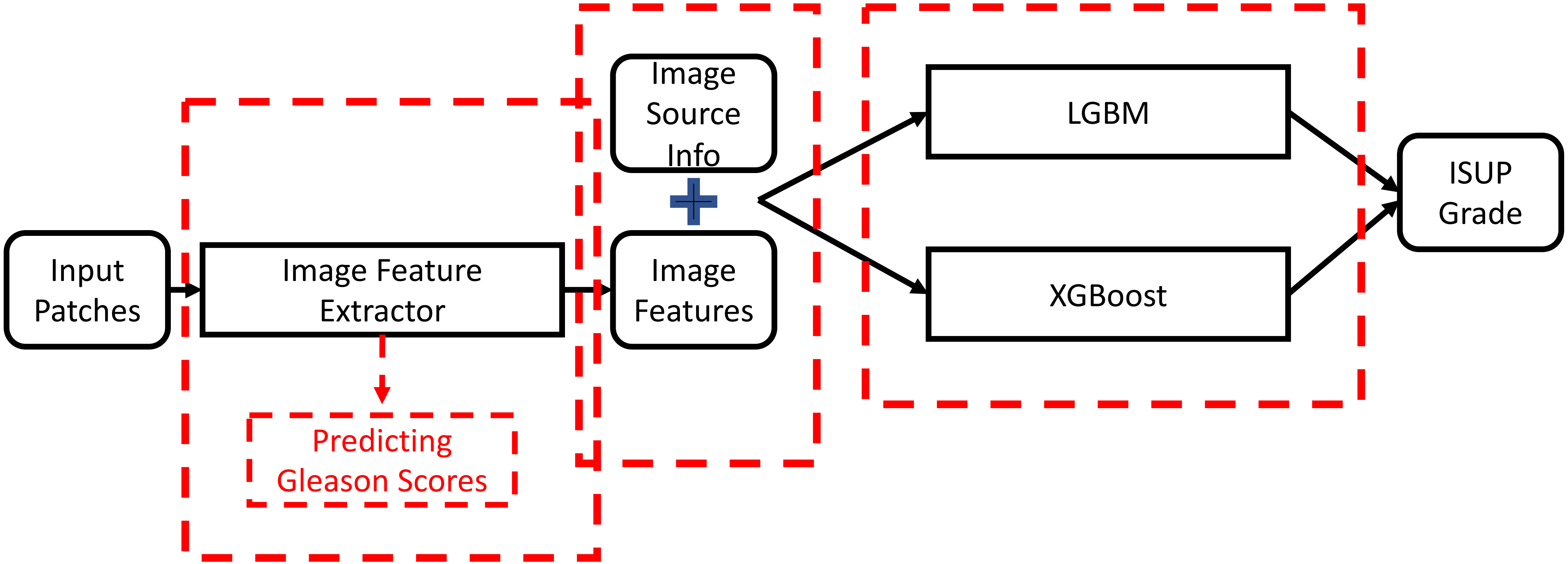
LGBM & XGBoost



Threshold Finetuning

- Optimizer of threshold for QWK: Brute force search
- Optimizer of threshold for QWK: Partial differentiation

Pseudo Code of Partial Differentiation Method

```
def fit(X, y):
        ## construct partial differential equation
        loss_partial = partial(kappa_loss, X=X, y=y)
        ## initialize the threshold
        initial_coef = [0.5, 1.5, 2.5, 3.5]
        ## optimize the coefficient by specified method
        coef_  = optimize.minimize(loss_partial, initial_coef, method='nelder-mead’)
```

Training Details

- 4-fold Cross Validation:
  - Result 4 * 3 (# of models, i.e. MIL, LGBM, XGBoost) = 12 models at inference time
- Network Architecture:
  - **ResNext 50**, EfficientNetB0
- Optimizer:
  - Adam Optimizer with Cosine Annealing Learning Rate Scheduler
- Loss Function: adopt ordinal regression (binning strategy)
  - Label = [0,0,0,0,0] means target 0, label = [1,1,0,0,0] means target 2, and label = [1,1,1,1,1] means target 5.

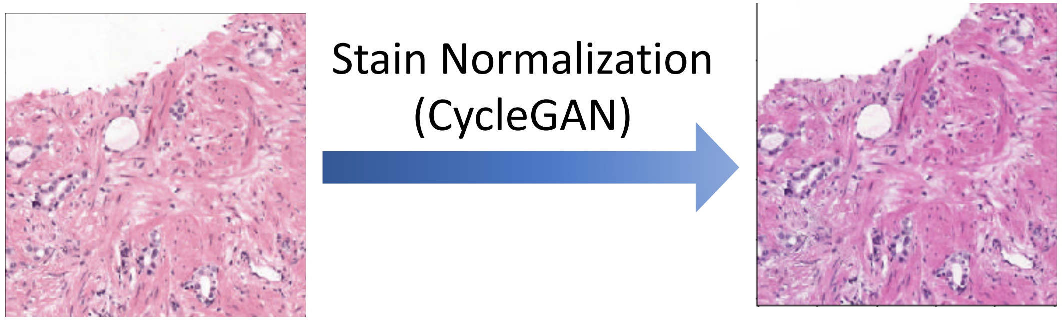
Performances Comparison

Method	Public LB Score	Private LB Score
LGBM	0.9135	0.9239
LGBM + XGBoost	0.9121	0.9248
MIL (w/o threshold optimization)	**0.9161**	0.8968
MIL	0.9018	0.9185
MIL + LGBM + XGBoost (w data source)[1]	0.9132	0.9262
MIL + LGBM + XGBoost	0.9061	**0.9286**

[1] "w data source" means we used data source information as input feature.

Discussions

- Things we have tried:
  - Stitching v.s Stacking
  - Stain Normalization: Reinhard v.s CycleGAN
  - Segmentation
  - Multi-task learning with Gleason score
  - Multi-resolution input
- Things we think can be improved:
  - Noisy samples detection
  - Self-supervised pre-training for feature extractor
  - Reinforcement learning or RNN for dynamic tile selection



Acknowledgement

- Thanks to organizers for this fantastic Kaggle challenge.
- Thanks all the competitors for helpful discussions and kernels:
  - Data cleaning & pre-processing:
    - Removal of Pen Marks by ***akensert***
    - Suspicious Slides by ***Zac Dannelly***
    - Duplicate Slides by ***Appian***
    - Imaging Tiling by ***rftexas***
  - Network architectures & Training Details
    - Concatenate tile pooling by ***lafoss***
    - Binning loss strategy by ***haiqishen***
    - Optimizer for QWK by ***abhishek***

Q & A

Thank you for your attention!

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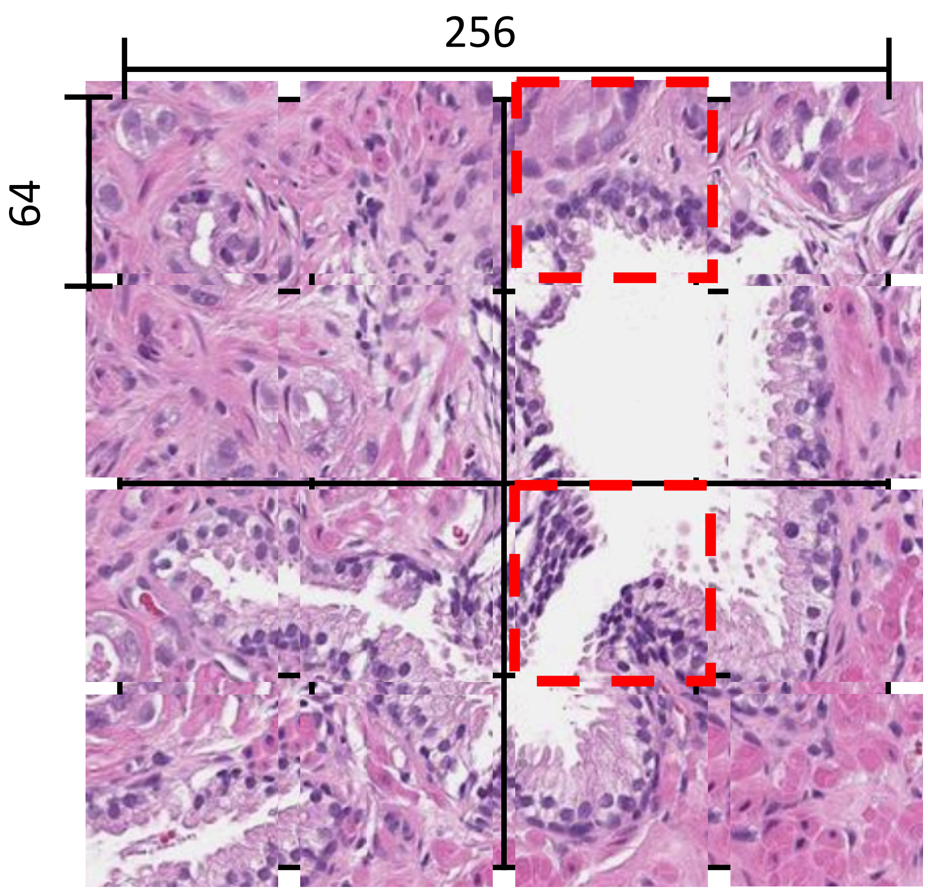
Tile Selection of Multi-reso MIL

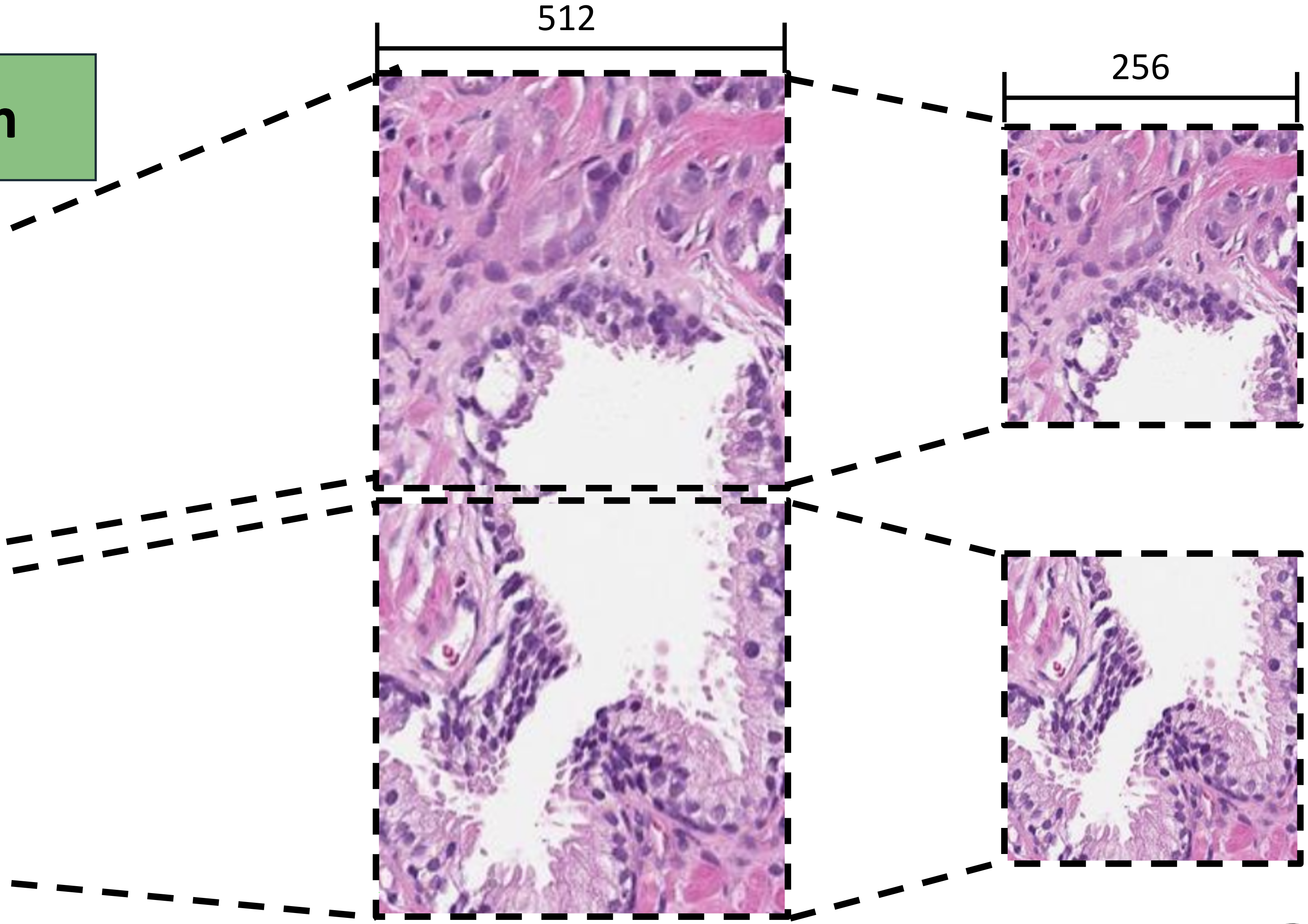
Tile selection



Tile with high attention weights

Tile Selection of Multi-reso MIL

Tile selection



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Tile Selection of Multi-reso MIL

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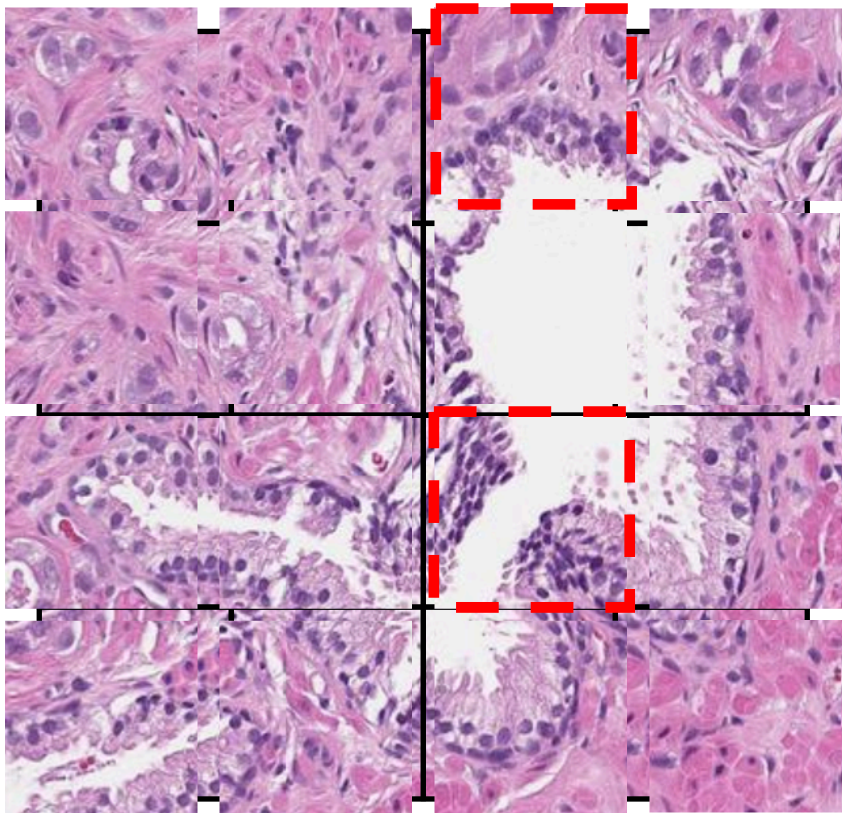
Tile selection



Tile with high attention weights

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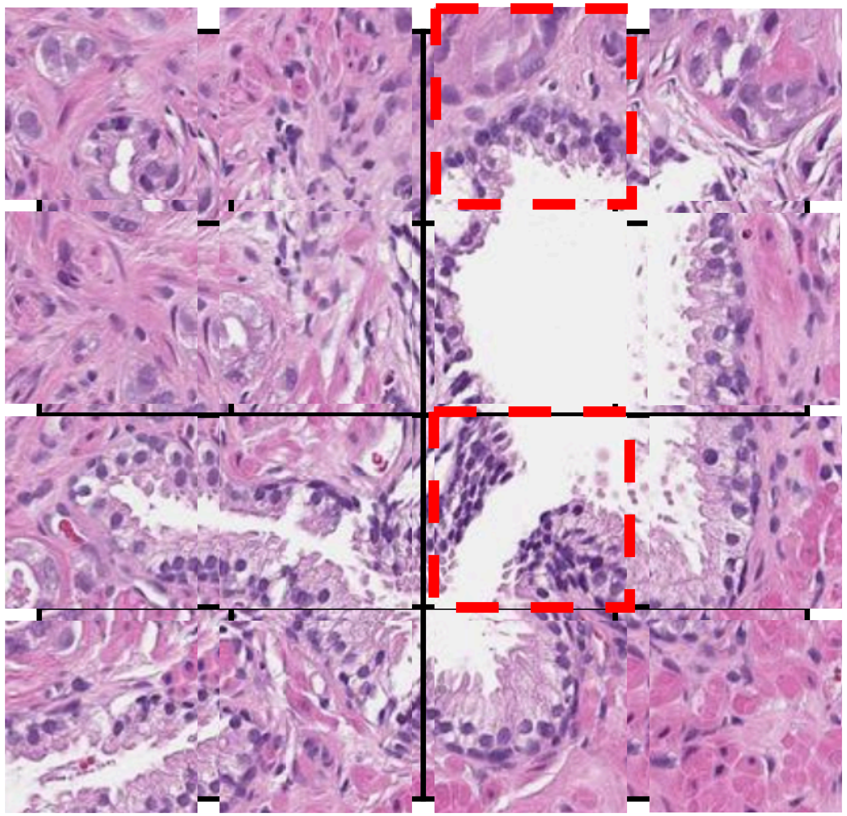
Tile Selection of Multi-reso MIL

Tile selection



Tile with high attention weights