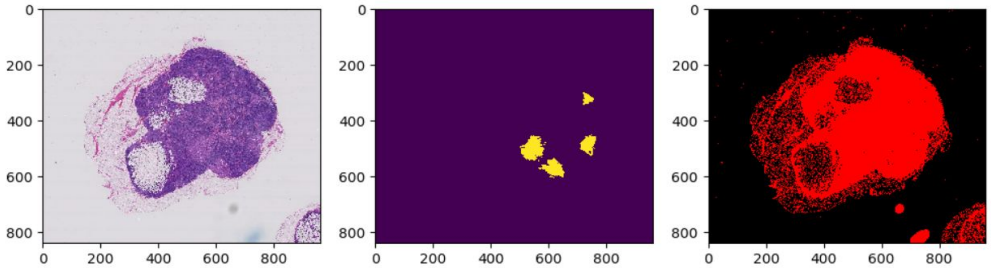
Tumor Detection with Transfer Learning from Gigapixel Pathology Images



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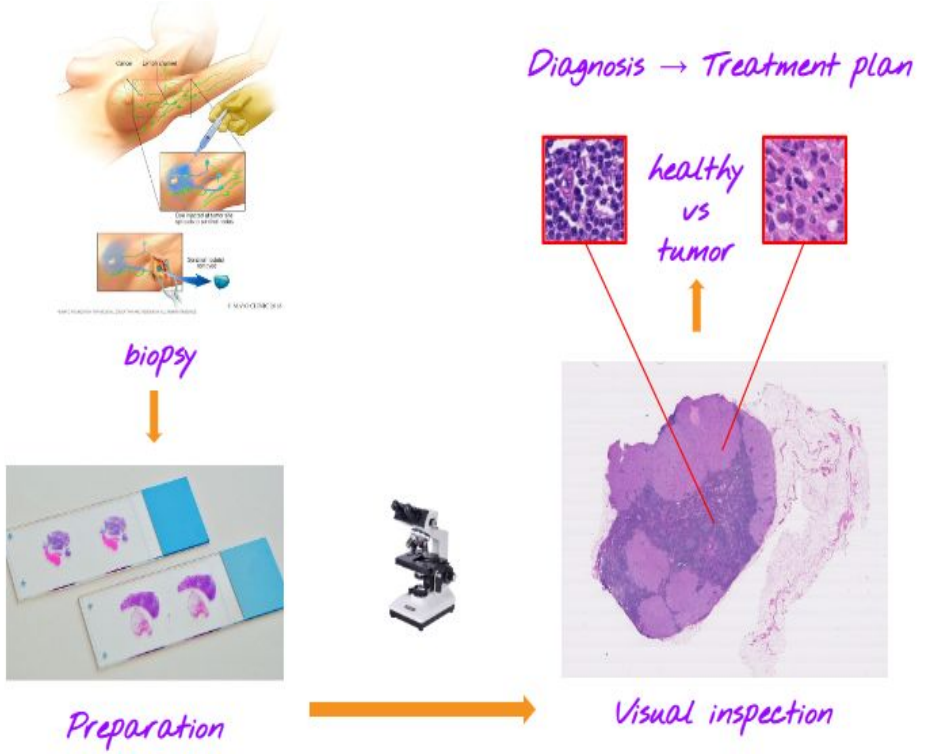
Motivation

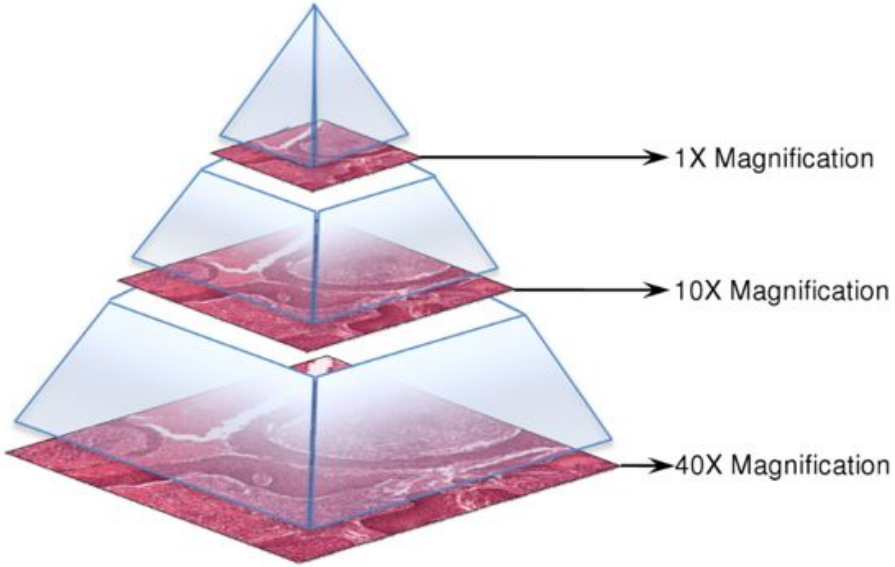
- Time Consuming & Error-Prone Procedure

- Computer-Assisted Diagnosis
  - Reduction to Misdiagnosis
  - Increase in Sensitivity, Speed, Consistency
  - Minimal cost with enough data



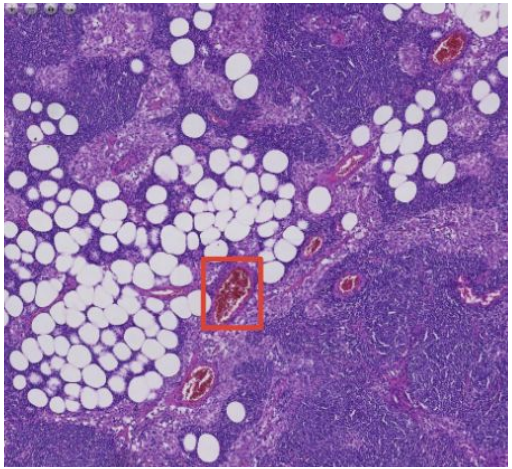
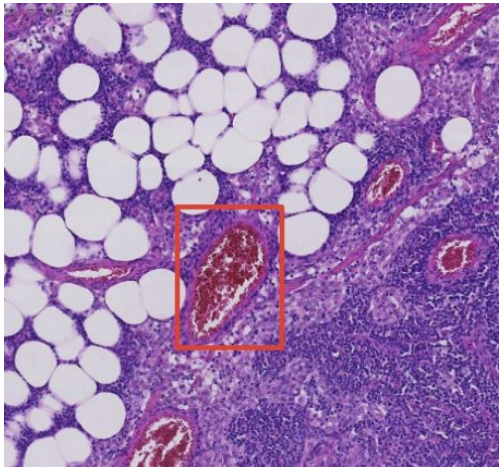
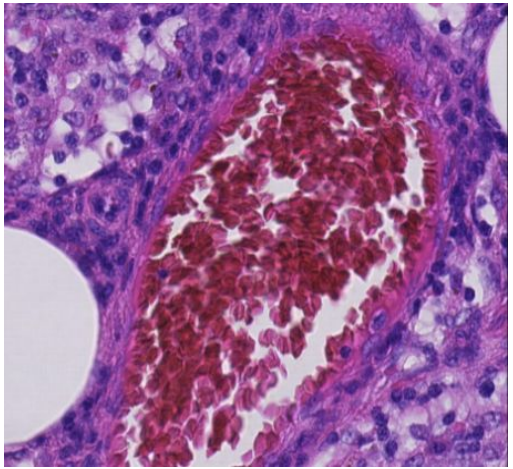
Data

- CAMELYON 16 challenge
- WSI (Whole Slide Image)
- 8 levels of magnification
- Different Zoom Level provides both context and detail
- Slide level annotation



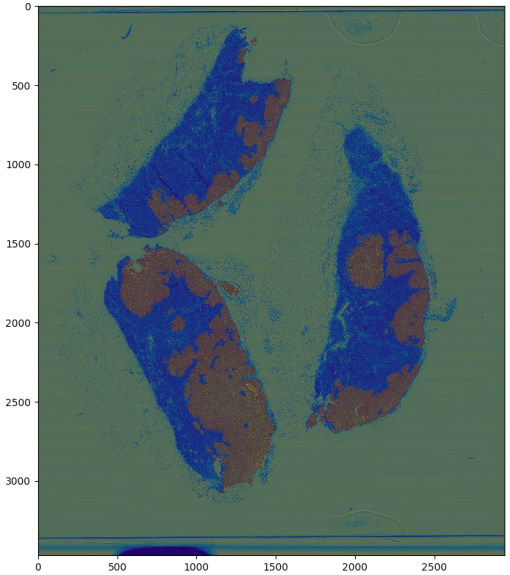
Approach

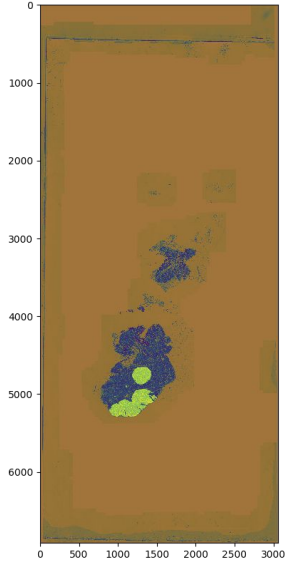
- Theoretical Foundation
  - Yun Liu et al., *Detecting Cancer Metastases on Gigapixel Pathology Images*
- Data Preprocessing using OpenSlide
- Color Normalization & Feature Extraction

Training Slides

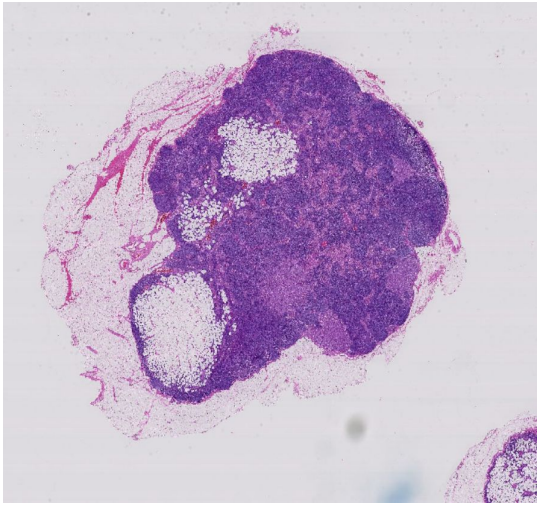
- Training Slides #: [016, 101, 084, 094, 096]
  - Extraction Level: 5 & 6
  - Extraction of 120 Positive Patches + 170 Negative Patches

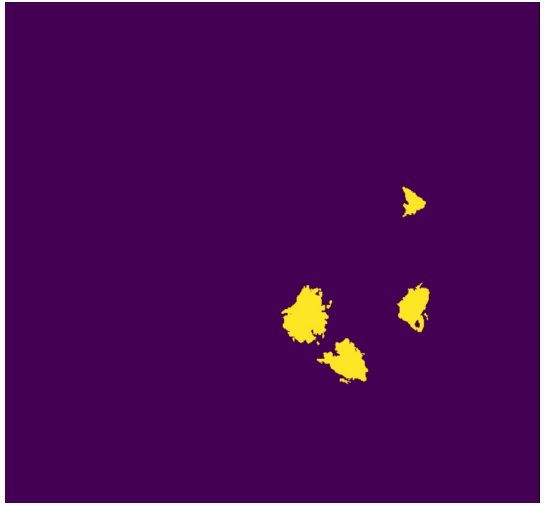


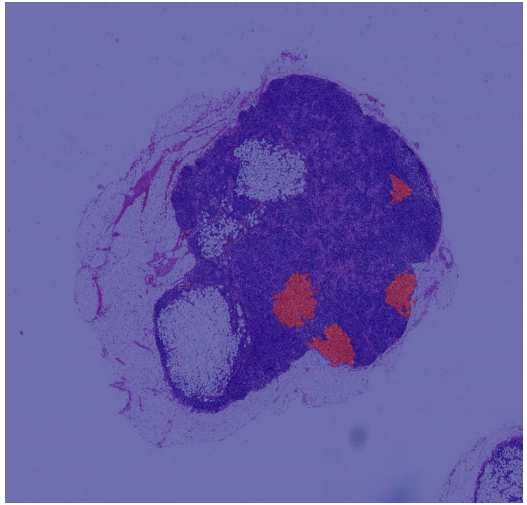


Annotation

- train_slides = tumor_[016, 101, 084, 094, 096].tif
- train_masks = tumor_[016, 101, 084, 094, 096]_mask.tif
- image + mask = overlay





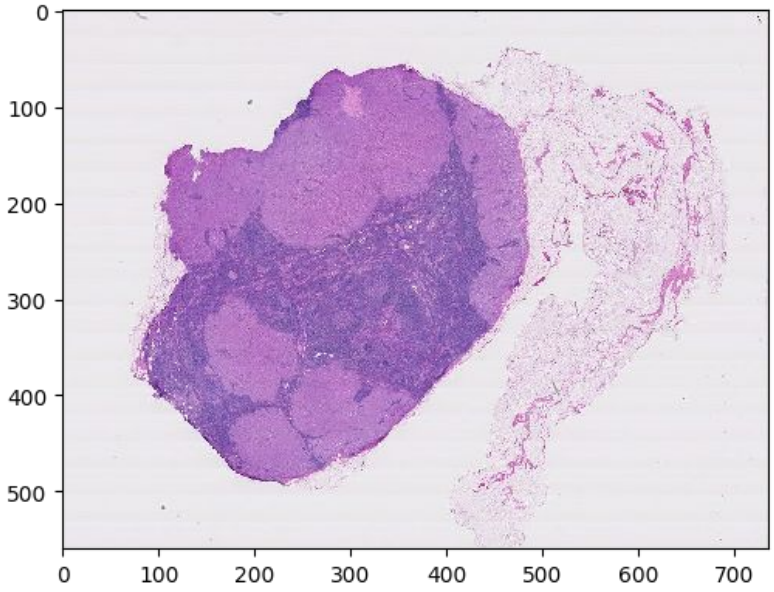


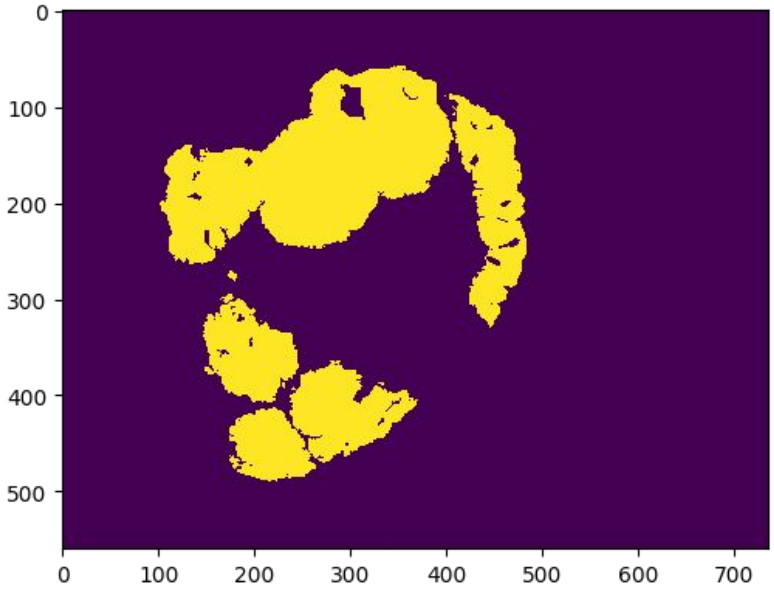
Extraction of Training Patches

- ~ 10^6 * 10^6 pixels per image
- Patch Size: 299 * 299
- > 50 % of pixels are tissue
- Positive (1) vs. Negative (0)
  - 128 * 128 Center Region
  - Positive Sample: sampled from mask due to small proportion of tumorous tissues
- Multiple Levels
  - Currently 5 & 6

Test Slide

- Test Slide #: 110

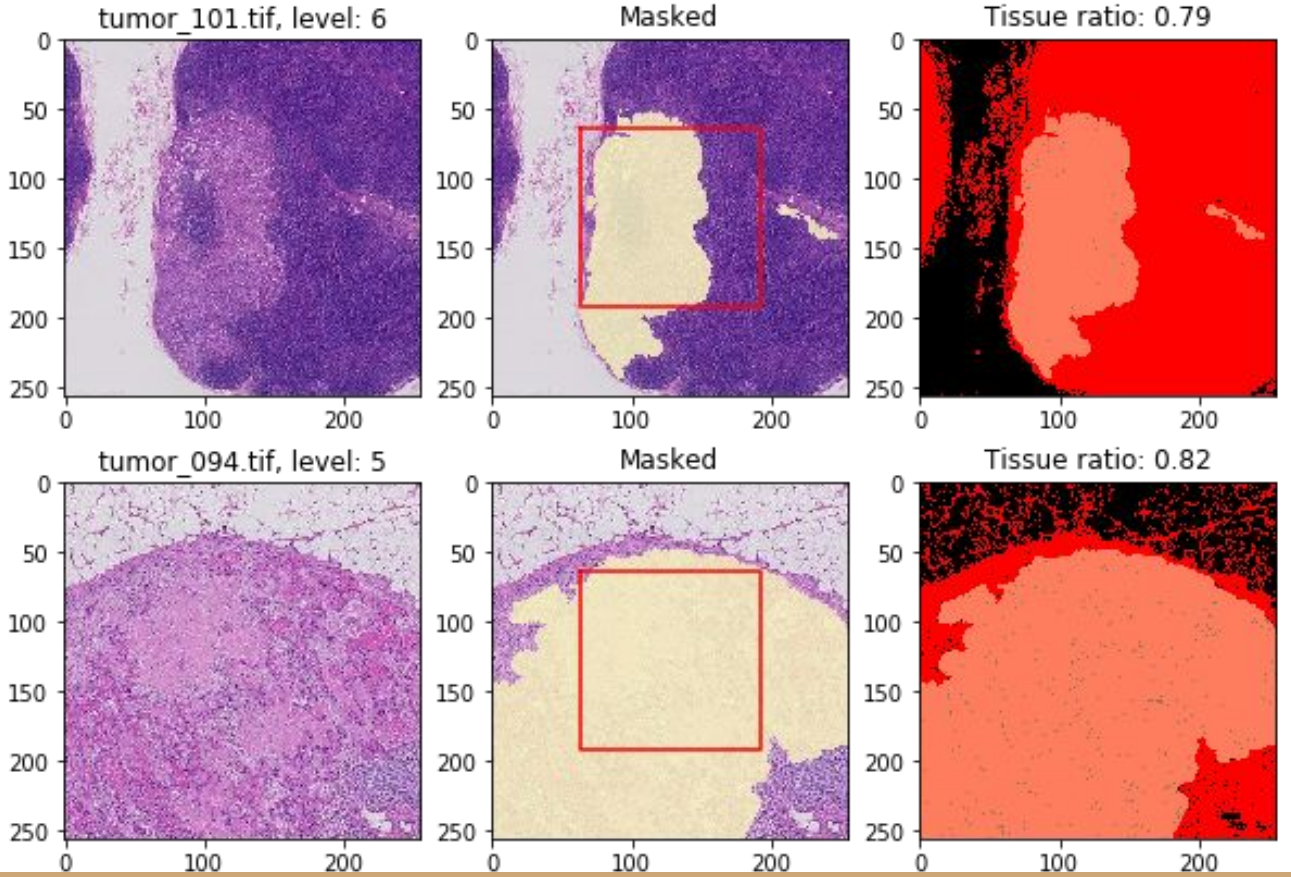




Examples of Patches

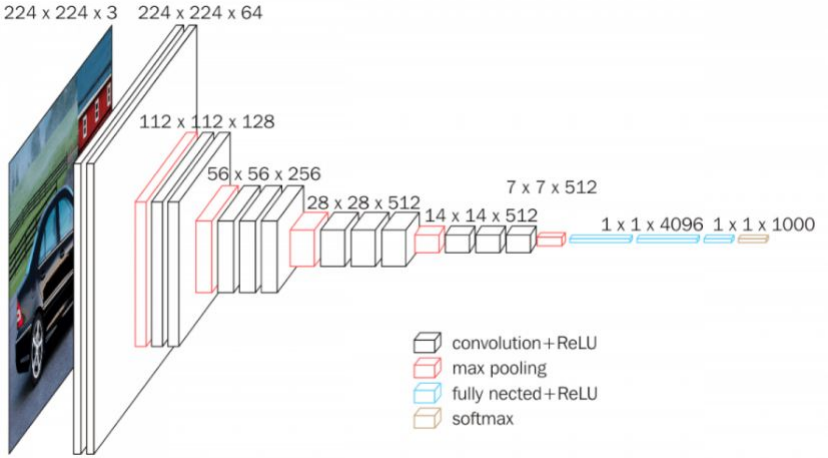
- Level 6

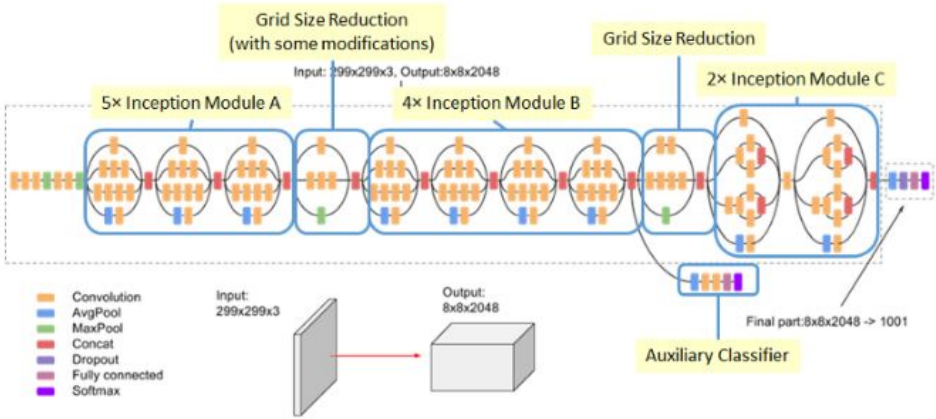
- Level 5



Transfer Learning

- Models:
  - Convolutional Base:
    i. VGG16
    ii. Inception V3
  - Top:
    i. Dense(128, activation='relu')
    ii. Dense(2, activation='sigmoid')
  - Both models trained on Colab





Visualization of Prediction as HeatMap

- Sliding Window
  - Prediction on patches of size (299, 299) from test slide
  - Reference Level Default to 7
  - Prediction on Zoom Level
- Confusion Matrix Based Evaluation Metrics
  - Accuracy
  - F1
  - Recall
  - Precision

Evaluation Metrics

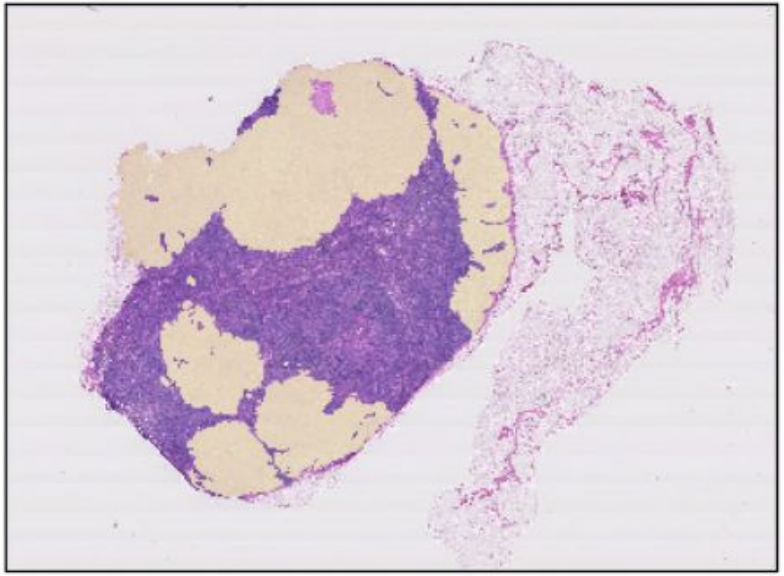
- Confusion Matrix Based
  - Accuracy
  - $\text{Recall} = \frac{tp}{tp + fn}$
  - $\text{Precision} = \frac{tp}{tp + fp}$
  - F1 = $2 \cdot \frac{\text{precision} \cdot \text{recall}}{\text{precision} + \text{recall}}$

- Tumor detection:
  - Class imbalance
  - Accuracy not useful

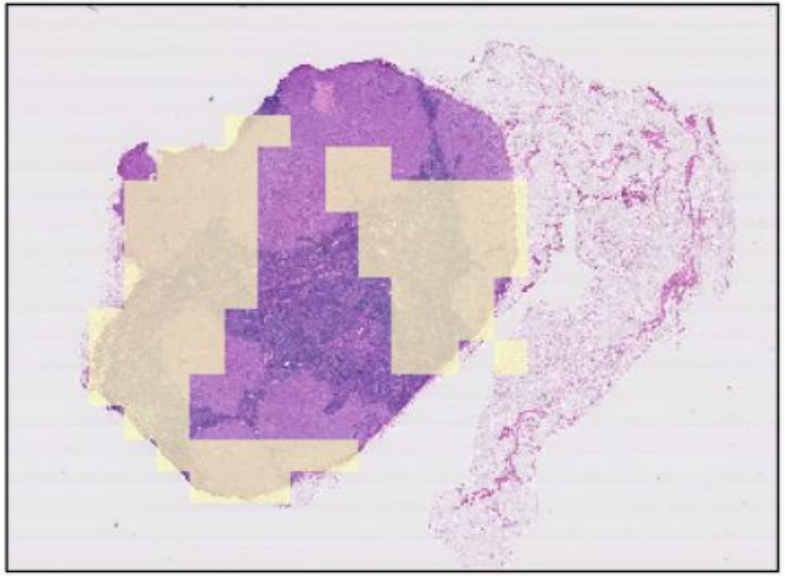
		Prediction	
		Positive	Negative
Actual	Positive	TP	FN
	Negative	FP	TN

InceptionV3-Based @ Level 5

Reference



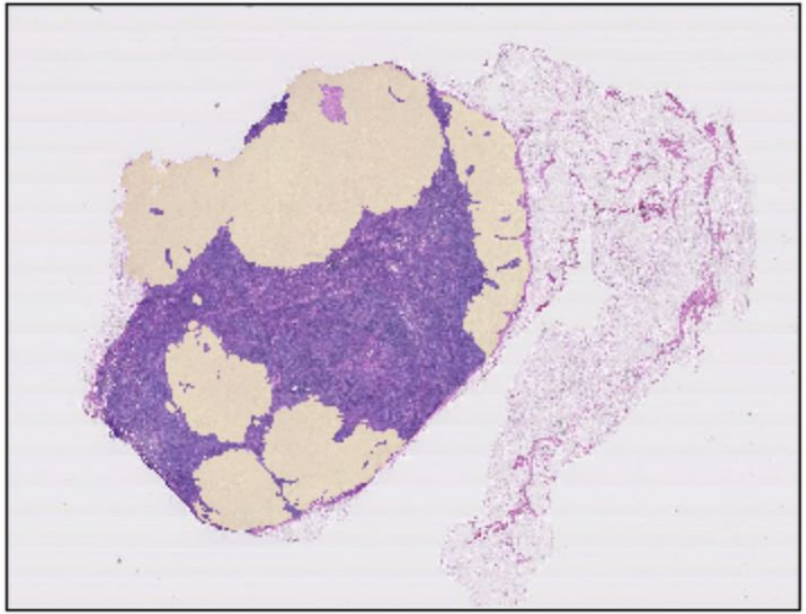
PRED



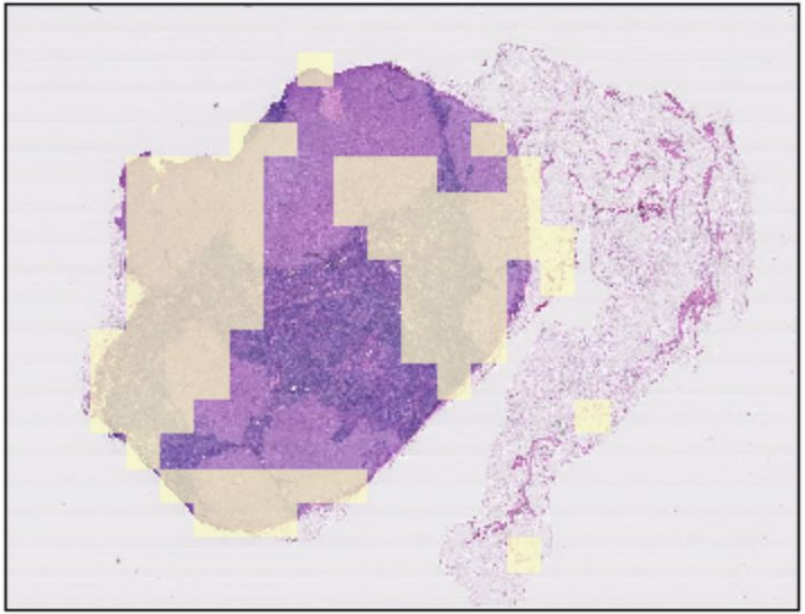
Accuracy: 0.86
Recall: 0.78
Precision: 0.99
F1 Score: 0.87

VGG16-Based @ Level 5

Reference



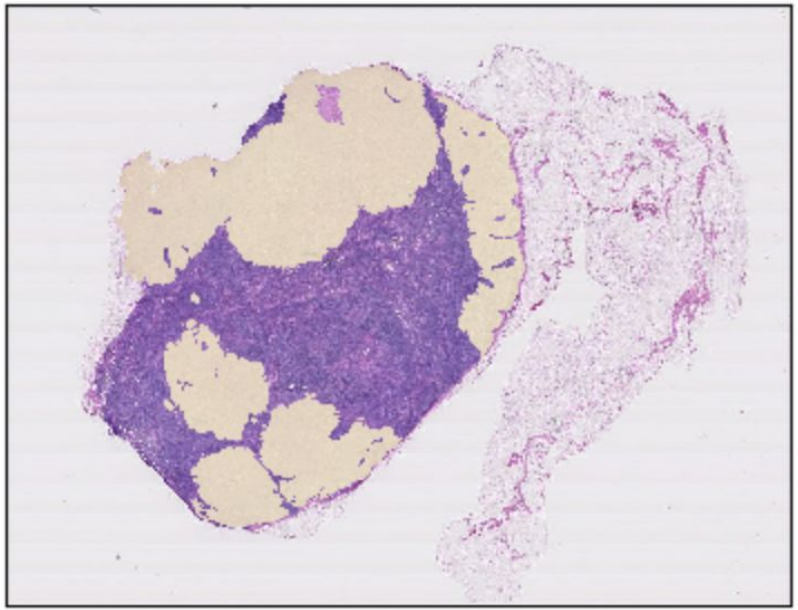
PRED



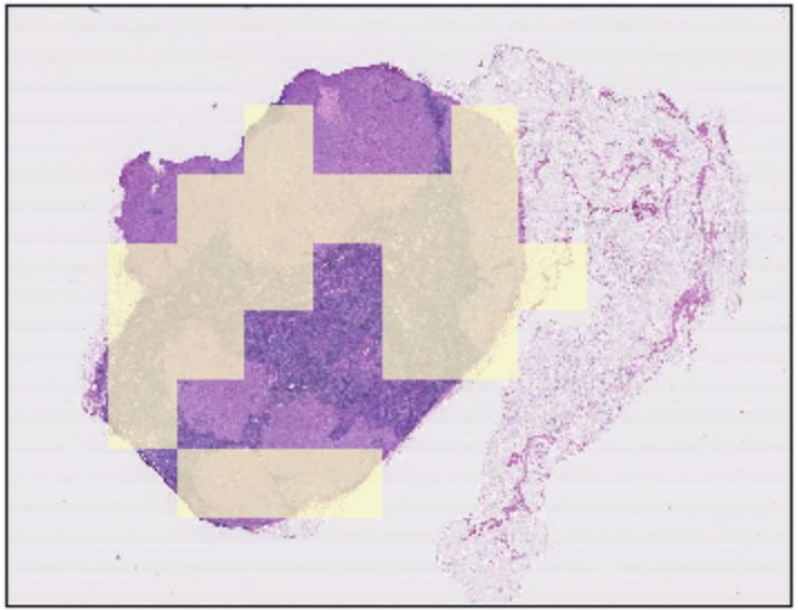
Accuracy: 0.88
Recall: 0.88
Precision: 0.88
F1 Score: 0.88

VGG16-Based @ Level 6

Reference

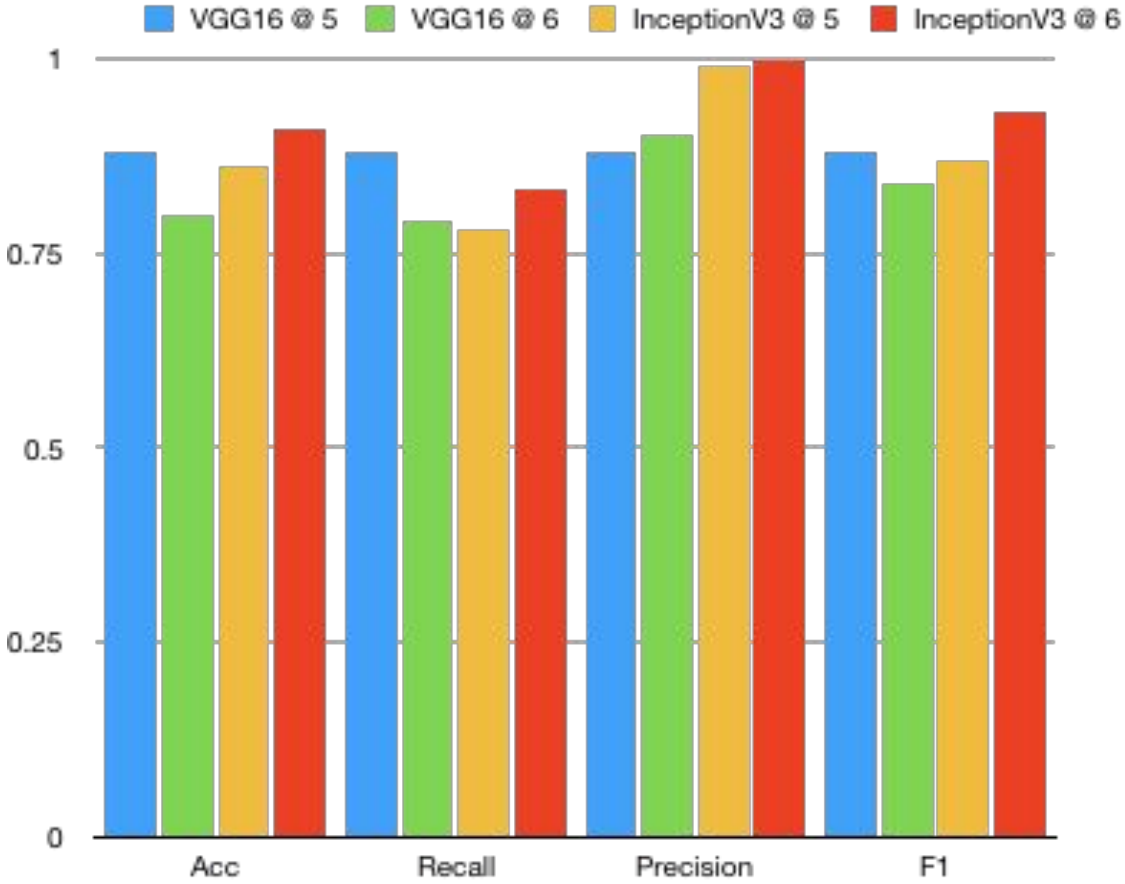


PRED



Accuracy: 0.80
Recall: 0.79
Precision: 0.90
F1 Score: 0.84

Performance Metrics in Test Slide



Conclusion

- Model Comparison:
  - VGG
    - `Precision: 0.9867549668874173, Recall : 0.9933333333333333, AUC : 0.9997166666666667`
  - Inception V3:
    - `Precision: 0.9933554817275747, Recall : 0.9966666666666667, AUC : 0.9998777777777778`
- Potential Improvements:
  - More Training Data
  - More Levels
  - Image Augmentation

Thank you!

Visit https://git.io/tumor_cancer for more information and source code