Deep Learning Evaluation for Cholangiocarcinoma Diagnosis in Bile Duct Whole Slide Images

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ABSTRACT

- Deep learning algorithm to accurately predict the malignancy of bile duct cell clusters
- Multi-class classification model leveraging cellular architecture was used to differentiate clusters as atypical or benign
- Utilized pre-trained AlexNet Model
- Reduces the need for manual diagnosis and extensive labor with aims to improve early diagnosis and patient outcomes

INTRODUCTION

- Bile duct cancer (**Cholangiocarcinoma**) is an extremely rare cancer affecting only approximately 8,000 people annually in the U.S.
- Particularly challenging to identify due to its internal location, often remaining asymptomatic until it reaches an advanced stage
- Techniques like ERCP and EUS are commonly used but are expensive, with costs ranging from $4,000 to $11,000 per test.
- Over 35% of cases are initially misdiagnosed as other types of cancer (ASCO Post Staff, 2021).

Goal

- Enhance identification and classification of cell types (atypical or benign) within bile duct tissue.
- Train a CNN to identify clusters of atypical and benign clusters

METHODS

Dataset

- 300 whole slide images provided by Dartmouth Hitchcock Medical Center
  - Visual images of individual cells and cell clusters

Connected Component Analysis (CCA)

- Using Jupyter notebook, all WSI's had white background filtered and clusters extracted

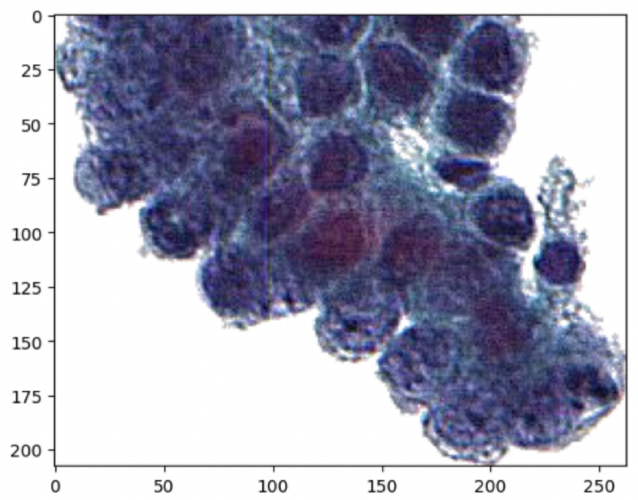


Figure 1. A WSI after being processed through Connected Component Analysis

Methods

SAM Annotations

- Tool for semantic segmentation of cells from cluster images
- ~30 WSI's of each cluster type were annotated: atypical cells, benign cells, SUSPos areas, and white blood cells

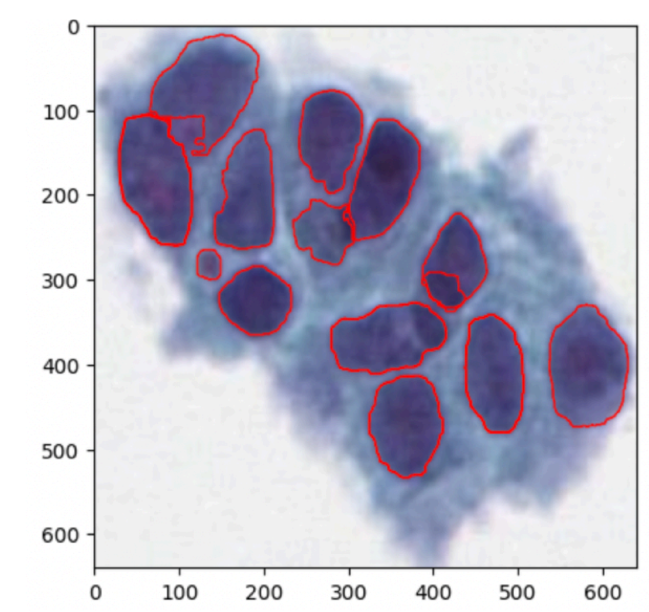


Figure 2. Cell cluster with masks around individual cells.

YOLO Object Detection

- Applied YOLO object detection framework to identify and classify various cell types within images
- Trained with 20 images
- Validated with 10 images
- Confidence threshold was lowered from 0.95 to 0.7 to avoid overlooking any overlaps

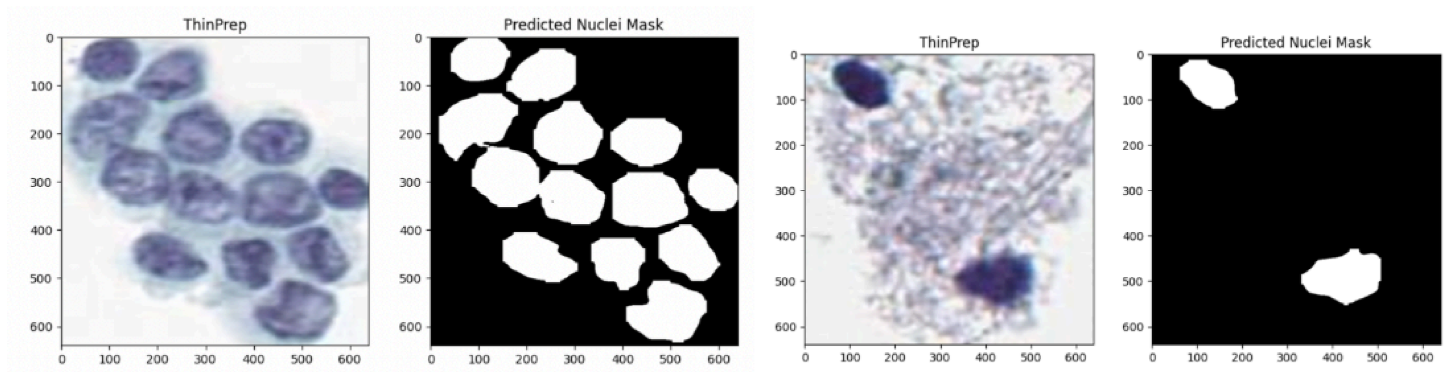


Figure 3. YOLO accurately masking the cells.

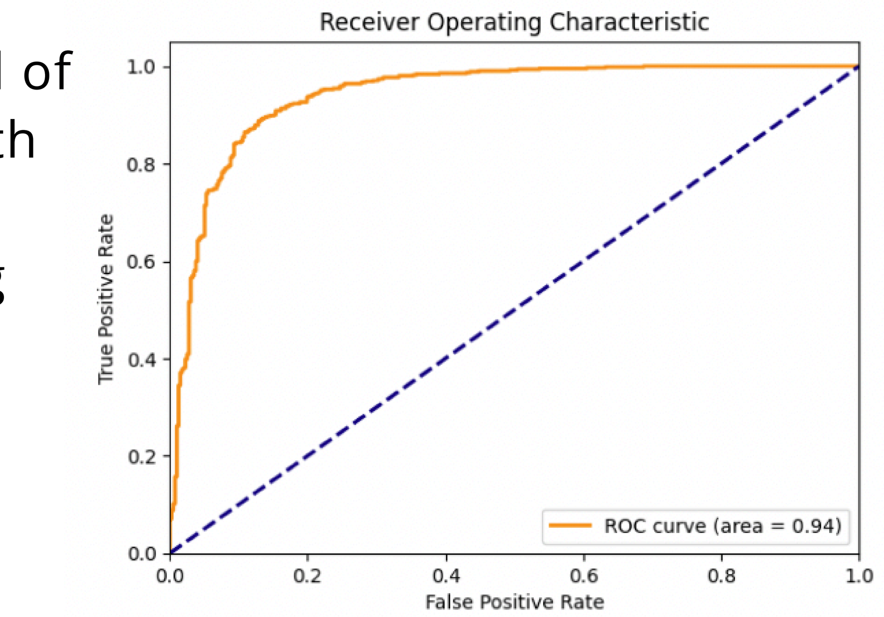
Convolutional Neural Network (CNN)

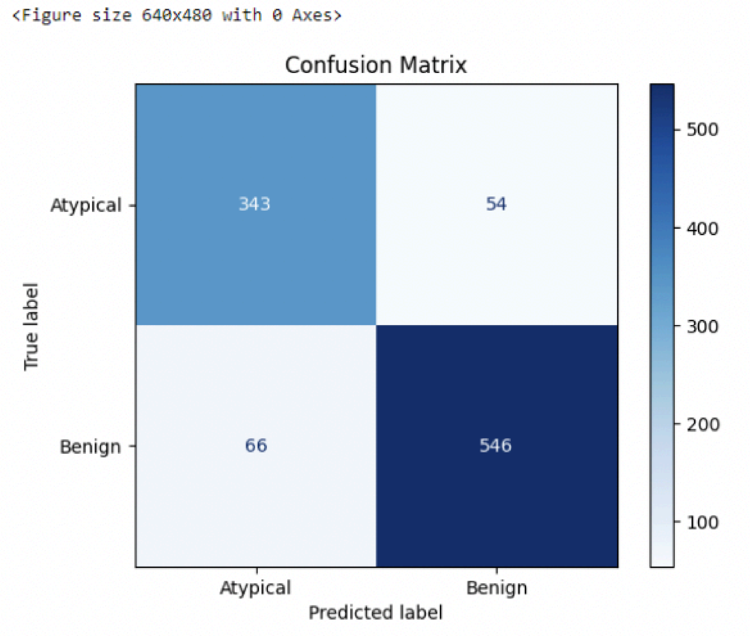
- Based on AlexNet and was employed for the binary classification of cell images into atypical and benign categories
- Images resized to 224x224 pixels and normalized using standard mean and standard deviation values to facilitate effective training
- CellDataset class created to handle data loading and preprocessing, while the dataset was split into training and testing subsets to evaluate the model's performance
- Includes a set of fully connected layers with dropout layers to mitigate overfitting
- Training performed using the Adam optimizer and binary cross-entropy with logits loss function

RESULTS

ROC Curve

- Demonstrates high level of discriminative ability with an area under the curve (AUC) of 0.94 suggesting the model effectively distinguishes between atypical and benign cell images





Confusion Matrix

- Reveals accuracy of 88% on the test dataset
- High accuracy indicates the model's effectiveness in correctly classifying the majority of cell images into their respective categories

High ROC AUC and substantial accuracy illustrate high performance rate of model supporting its potential application in automated diagnostic systems.

CONCLUSION

Potential for Clinical Impact

- Study demonstrates potential of integrating WSI's with deep learning techniques to enhance early detection and classification of bile duct cancer

Limitations

- Data was provided only from one center leading to underlying bias
- Presence of significant false positives and false negatives highlights potential risks in clinical settings

Future Directions

- Train a model to identify malignent cells
- Use additional testing sets to verify our model's accuracy rate

REFERENCES

References Link:
https://docs.google.com/document/d/1TYUzN0DfHAQ1mhjpJRLdbc3XAZfpoRC9utN7BOtBu0A/edit?usp=sharing

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