Automated Assessment of Tumor-Infiltrating Lymphocytes (TILs) Using Deep Learning

Case Study on the TIGER Grand Challenge

Abstract

Tumor-Infiltrating Lymphocytes (TILs) are a clinically significant biomarker in breast cancer, particularly in HER2-positive and triple-negative subtypes. Traditional TIL assessment relies on manual visual scoring by pathologists, which is time-consuming, subjective, and difficult to scale. The TIGER Grand Challenge aims to develop automated, reproducible, and clinically meaningful computer vision methods for TIL assessment from histopathology slides.

In this work, we address the task of automated detection of lymphocytes and plasma cells using a deep learning-based object detection pipeline. A YOLOv8-based model is trained on annotated histopathology image patches derived from whole-slide images. Experimental results demonstrate that the proposed approach reliably detects immune cells, forming a strong foundation for downstream automated TIL score computation.

1 Introduction

Breast cancer remains one of the leading causes of cancer-related mortality worldwide. Recent studies have established tumor-infiltrating lymphocytes (TILs) as an important prognostic and predictive biomarker, particularly in HER2-positive and triple-negative breast cancer. Higher TIL levels are associated with improved patient survival and better response to immunotherapy.

Currently, TIL assessment is performed manually by expert pathologists through visual inspection of hematoxylin and eosin (H&E) stained histopathology slides. This process is labor-intensive, subject to inter-observer variability, and challenging to scale in clinical settings with limited pathology expertise.

The TIGER Grand Challenge addresses this problem by promoting the development of automated methods for TIL assessment using computational pathology and deep learning. This challenge defines multiple tasks spanning immune cell detection, tissue segmentation, and automated TIL score computation.

2 Problem Statement

The primary objective of the TIGER Grand Challenge is to develop automated algorithms that can accurately assess TILs from digitized histopathology slides. The challenge is divided into three main tasks:

- Detection of lymphocytes and plasma cells
- Segmentation of invasive tumor and tumor-associated stroma
- Computation of an automated TIL score

In this work, we focus on the first task: **detection of lymphocytes and plasma cells**. Accurate immune cell detection is a critical prerequisite for reliable TIL scoring, as TIL density is computed relative to the tumor-associated stroma area.

3 Dataset Description

The experiments are conducted using the WSIROIS subset of the TIGER dataset. This dataset consists of cropped regions of interest (ROIs) extracted from whole-slide images, along with detailed cell-level annotations.

3.1 Dataset Characteristics

- High-resolution histopathology image patches
- Annotations provided in COCO format
- Classes include lymphocytes and plasma cells
- Strong class imbalance and dense cellular regions

The dataset used in this study contains 1503 training images and 376 validation images. Each image is paired with corresponding bounding box annotations for immune cells.

4 Methodology

4.1 Preprocessing

All images are resized to 512×512 pixels to ensure consistent input dimensions. Annotations are converted from COCO format to YOLO-compatible format. Basic quality checks are performed to remove corrupted or empty annotations.

4.2 Model Architecture

A YOLOv8 object detection model is employed for immune cell detection. YOLOv8 is a state-of-the-art single-stage detector known for its balance between detection accuracy and computational efficiency. Its ability to detect small objects makes it particularly suitable for lymphocyte and plasma cell detection in histopathology images.

4.3 Training Strategy

The model is initialized with pretrained weights and fine-tuned on the WSIROIS dataset. The training configuration includes:

- Image size: 512×512
- Optimizer: AdamW
- Learning rate: 10^{-3}
- Batch size: 16
- Number of epochs: 60

Early stopping is used to prevent overfitting and improve generalization.

5 Results

The trained model demonstrates reliable detection of lymphocytes and plasma cells across validation images. The detection performance improves steadily during training, with stable convergence observed in validation metrics.

Qualitative results indicate that the model successfully identifies immune cells even in densely packed tumor regions. Some errors are observed in areas with heavy stain variation and overlapping cellular structures.

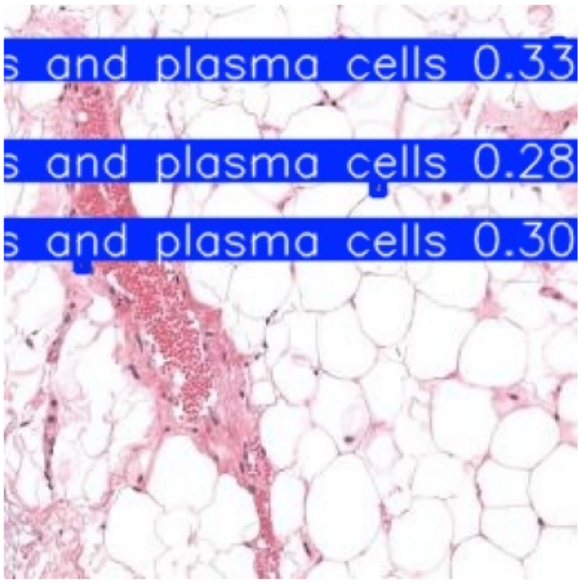

Figure 1: Enter Caption

6 Challenges and Observations

Several challenges were observed during experimentation:

- Variability in staining across slides affects model generalization
- Dense cell clusters lead to overlapping bounding boxes
- Annotation noise limits the achievable upper bound on accuracy

Despite these challenges, the model provides sufficiently accurate immune cell detection to support automated TIL scoring.

7 Conclusion and Future Work

This work presents a deep learning-based pipeline for automated detection of tumor-infiltrating lymphocytes as part of the TIGER Grand Challenge. The proposed YOLOv8-based approach demonstrates effective immune cell detection on histopathology images.

Future work includes integrating tumor-stroma segmentation, applying stain normalization techniques, and computing a complete automated TIL score with clinical relevance.

References

[1] TIGER Grand Challenge. `https://tiger.grand-challenge.org/`

[2] International TILs Working Group. `https://www.tilsinbreastcancer.org/`

[3] Jocher et al. YOLOv8: Ultralytics Object Detection Framework.