Discover Hidden Information in Images for Enhanced Diagnostics

Oncology | Tissue Scoring | Explainable Artificial Intelligence | Preclinical

Introduction

Context

- Allow researchers to discover new diagnoses by analyzing huge medical images (100000 pixels)
- Give researchers insights on how the features in the images relate to the outcomes to make conclusions that would not have been obvious otherwise. This can lead to biomarker discovery.

Issue 1
Expert resources are scarce/limited in routine
→ **Solution 1**: Classify automatically with a precision >= to human
Issue 2
Analysing large images is tedious
→ **Solution 2**: Multiple Instance Learning splits images into tiles to analyse efficiently

Goal: Integrate deep learning in easy to use tool for diagnosis.

Abstract

We are using the **KEEN EYE AI** to evaluate the inflammation and tissue damage in mice colon. We specifically want to analyse histology images of mice models with Inflammatory Bowel Syndrome.

We are interested in scoring the histology images' cellular infiltration, by scoring images from **low infiltration (1)** to **severe infiltration (5)**. In order to create this algorithm, we use a **Multiple Instance Learning** model in which we input images and the scores associated.

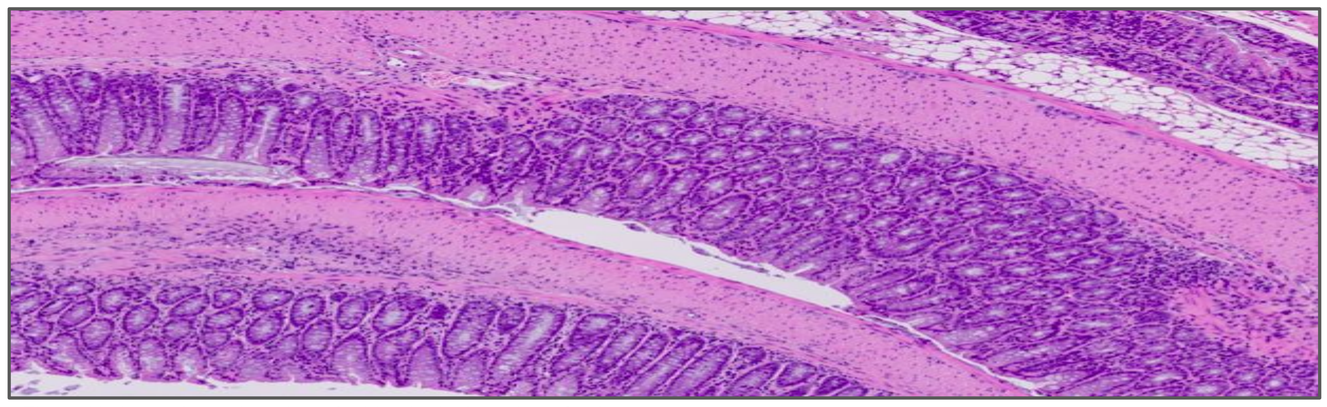
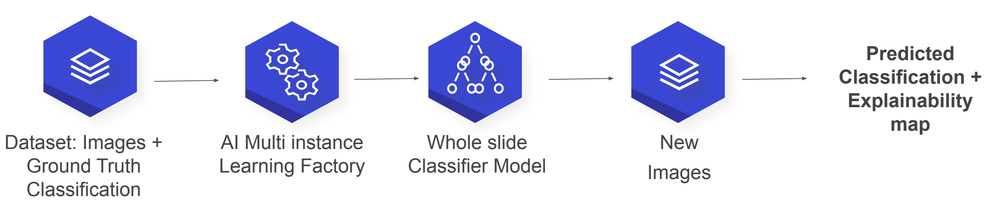


Fig a. High-resolution imaging of a histological section of colon

Methods

KEEN EYE AI Workflow



Images are tiled into smaller images of 224x224 pixels that's why it's called Multi Instance Learning.

KEEN EYE Platform

Web-based access

Access the service from anywhere, any screen 24/7

Secure

Work under the latest cybersecurity and data privacy standards

Community oriented

Grant secure access to your coworkers and clients and request collaborative or blind reviews.

KEEN EYE Platform gives researchers an easy to use tool to train and run complex, powerful machine learning algorithms for research and routine usage.

Experiments and Results

Tested the model on

- Mononuclear infiltration - white blood cells arrive to clear debris. Could be a autoimmune disease etc.
- Hyperplasia - cells are growing larger,
- Ulceration - creation of open sores in stomach

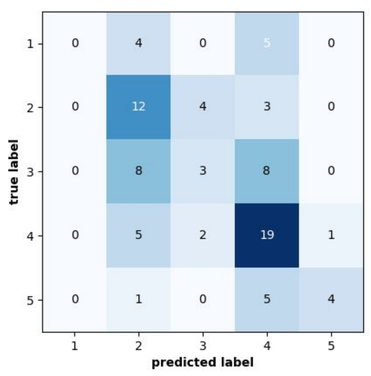


Fig d. Confusion Matrix

1,4

Mean Square Error on score, similar to pathologist's disagreement rate

45,78 %

Accuracy on 4 classes (providing only false positive)

84 regions kept for the Test Set:

Label	Count
1	9
2	19
3	19
4	27
5	10

Fig e. Test Set: Repartition among classes

Label counts for test set regions, from low infiltration (1) to high infiltration (5)

Explainability Map

After running the algorithm, the scoring of the images has been compared with the pathologist scoring. The results matches the pathologist scoring at a score similar to the pathologist' disagreement. The explainability map outputted by the pipeline shows the contribution of each tile to the global prediction. This allows us to objectify the scoring and identify the regions affecting the predicted score to enhance interpretability of Deep Learning algorithms and add transparency to the AI "black box" for Diagnosis. By analyzing the features in the resulting map, researchers can gain insights to discover biomarkers and/or enhanced their quantification.

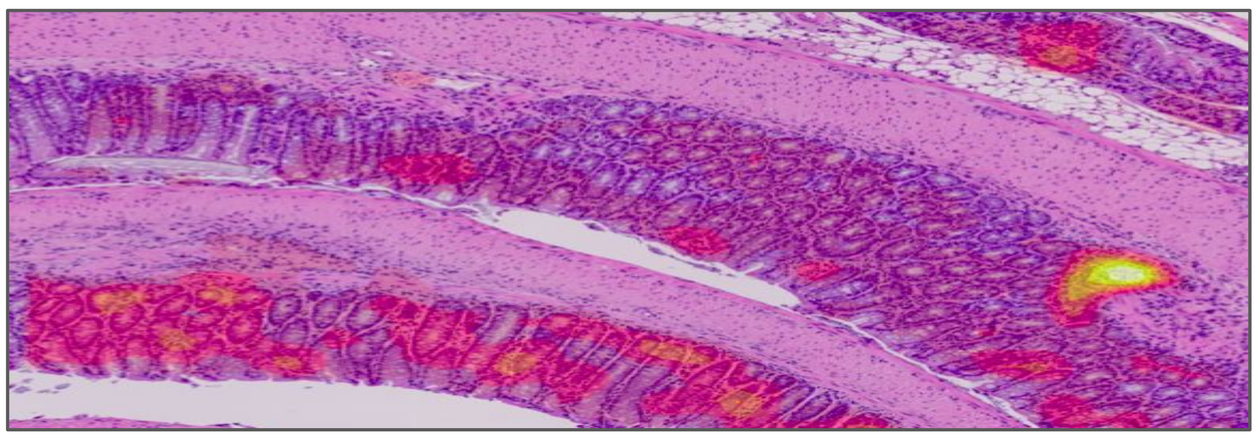


Fig b. High value predictive signals, yet extremely difficult to detect by eye

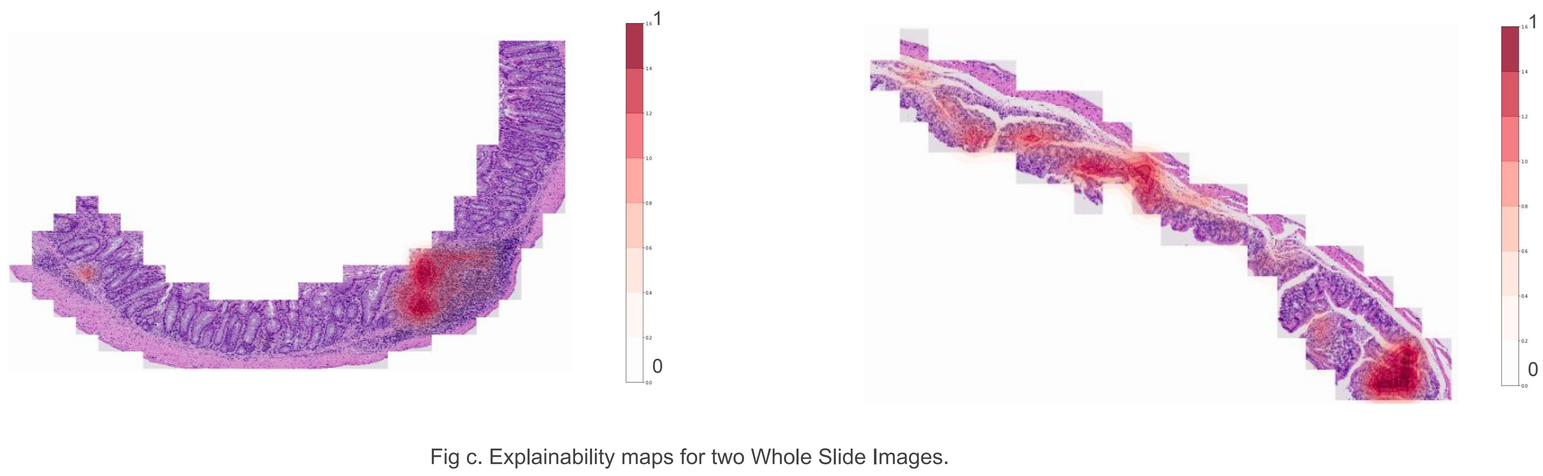


Fig c. Explainability maps for two Whole Slide Images.

The trained model is used to make predictions on new unseen Whole Slide Images. These images are first tiled into smaller ones and the background is removed. Then, the **KeenEye AI** pipeline predicts a level of cellular infiltration on the full image considering all the descriptors computed by the model for each tiles.
Therefore, the heatmaps show in red the area of that contributed the most the overall classification result.

Conclusion

- Our method has demonstrated promising results for Whole Slide classification in a context of Multiple Instance Learning by reaching significant accuracy.
- The explainability maps allow rich interpretations of Deep learning models. We believe that it will increase doctors' trust in Machine Learning-aided diagnosis. Additionally, this will lead to biomarker discovery.
- The Keen Eye AI pipeline has shown to be an easy to use tool to visualize, store, share, annotate and analyze Whole Slide Images. It is expendable to any format of images and medical applications.

Future Works:

- Enlarge and balance the dataset to improve accuracy and MSE
- Provide KPIs to properly compare expert's infiltration localization to the ones obtained with our method.