Deep Learning Based Segmentation & Grading of Pancreatic Intraepithelial Neoplasia

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Objective

To develop a computer-assisted algorithm for automated detection and grading of Pancreatic Intraepithelial Neoplasia (PanIN) lesions into low and high grade, in histopathological sections of pancreas.

Introduction

Pancreatic Intraepithelial Neoplasia are possible microscopic epithelial precursor lesions of pancreatic ductal adenocarcinoma (PDAC). Existing imaging modalities cannot accurately identify PanIN lesions pre-operatively; they can be identified only on histopathological examination. We propose a deep learning-based method for the detection and grading of PanIN lesions in histopathological sections of pancreas.

Materials

37 Hematoxylin and Eosin (H&E) stained Whole Slide Images (WSIs) of human pancreatic tissue consisting of low and/or high grade PanIN regions.
All WSIs were acquired by digitizing sections of paraffin embedded pancreatic tissue using an Aperio AT2 slide scanner (Leica), at 40x magnification.

Methods

Model development

10 WSIs were considered to create a training dataset.
2600 tiles size of 1024×1024 comprising low and high grade PanIN regions were extracted under 20x magnification.
Target regions from all extracted tiles were manually labeled to create ground truth dataset (Fig. 2).
1820 tiles were used to train the model and the rest 780 tiles were used for validation.
A deep neural network model (DeepLabv3) was developed on 1024×1024 size tiles from the WSIs and trained to classify lesions into high or low grade PanIN.

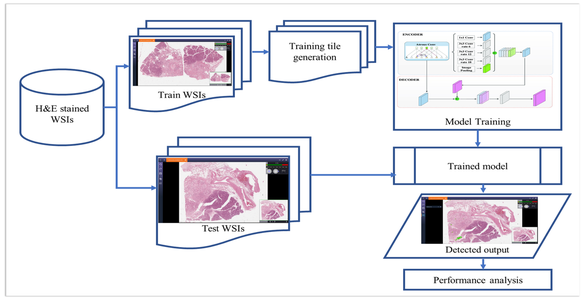

Fig. 1: Process flow for detection and classification of low and high grade PanIN from pancreatic tissue images.

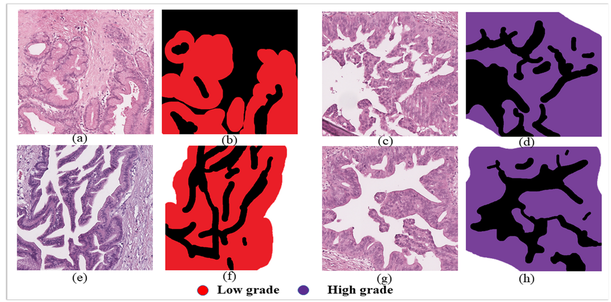

Fig. 2: Ground truth generation to train detection and classification model. (a), (b), (e), (f): Low grade PanIN: Input and Output, (c), (d), (g), (h): High grade PanIN: Input and Output

Validation

Algorithm was tested on 27 WSIs of pancreatic tissue.
The results were compared with annotations and grades provided by the pathologist as the gold standard.

Results

The software generated low and high grade PanIN regions as shown in Fig. 3.
Comparison of algorithm outputs with pathologist annotations to detect high/low grade PanIN showed a sensitivity of 91.56% and specificity of 85.68% (Fig. 4).
In some cases, invasive carcinoma was misclassified as high grade PanIN by the algorithm.

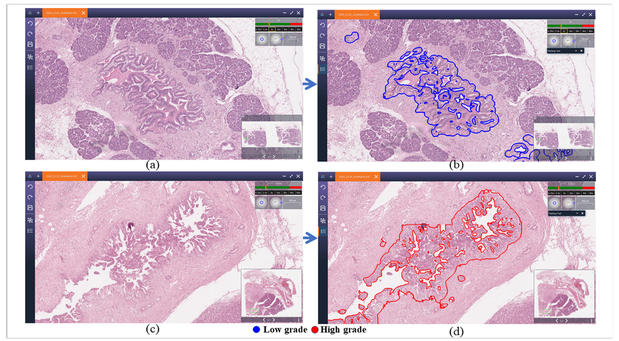

Fig. 3: Classification results: (a), (b): Low grade PanIN: Input and Output, (c), (d): High grade PanIN: Input and Output.

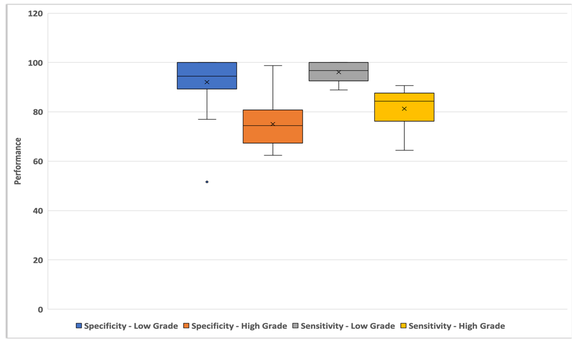

Fig.4: Graphical representation of low/high grade PanIN detection performances from histopathological sections of pancreas

Discussion and Conclusions

We developed a computer-assisted automated algorithm for the detection and grading of PanIN lesions into low and high grade classes using H&E stained histopathological sections of pancreas.
This algorithm provides quantification-based segmentation and classification of PanIN, facilitating early detection of precursors to PDAC, potentially accelerating pathological workup.
Further improvement of the performance for PanIN detection as well as for identification of invasive carcinoma is under process.
The application can be further extended for differential diagnosis of precursor neoplastic lesions like intra ductal papillary neoplasm and mucinous cystic neoplasm to develop a comprehensive early detection solution for PDAC precursors.

References

1. Eser, Stefan, et al. "In vivo diagnosis of murine pancreatic intraepithelial neoplasia and early-stage pancreatic cancer by molecular imaging." Proceedings of the National Academy of Sciences 108.24 (2011): 9945-9950.
2. Kelly, Kimberly A., et al. "Targeted nanoparticles for imaging incipient pancreatic ductal adenocarcinoma." PLoS Med 5.4 (2008): e85.

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