Deep Learning Based Segmentation & Grading of Pancreatic Intraepithelial Neoplasia

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Objective

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

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 slides of human pancreatic tissue consisting of low and/or high grade PanIN regions.
- Aperio AT2 slide scanner (Leica) for digitizing slides at 40x magnification.

Methods

Model development

- Training Data Set: 10 WSIs
  - 2600 tiles size of 1024×1024 comprising low and high grade PanIN regions under 20x magnification.
  - Target regions manually labeled to create ground truth data set (Fig. 2).
  - 1820 tiles used to train the model and 780 tiles used for training validation.
- A deep neural network model (DeepLabv3) developed and trained to classify lesions into high or low grade PanIN.

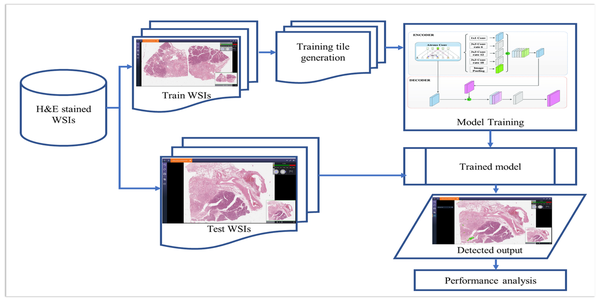

Fig. 1: Process flow for detection and classification of low and high grade PanIN from pancreatic tissue images.

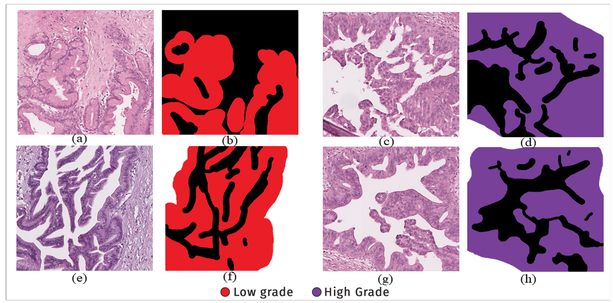

Fig. 2: Ground truth generation (20x magnification) to train detection and classification model - Input and Output: (a), (b), (e), (f): Low grade PanIN. (c), (d), (g), (h): High grade PanIN.

Algorithm Validation

- A separate set of 27 WSIs was used for algorithm validation.
- Results were compared with annotations and grades provided by the pathologist as the gold standard.

Results

- 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. 3).
- The software generated low and high grade PanIN regions as shown in Fig. 4.
- In some cases, invasive carcinoma was misclassified (~10%) as high grade PanIN by the algorithm.

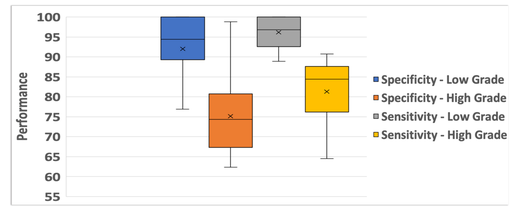

Fig. 3: Boxplot showing the performance specification for low/high grade PanIN detection.

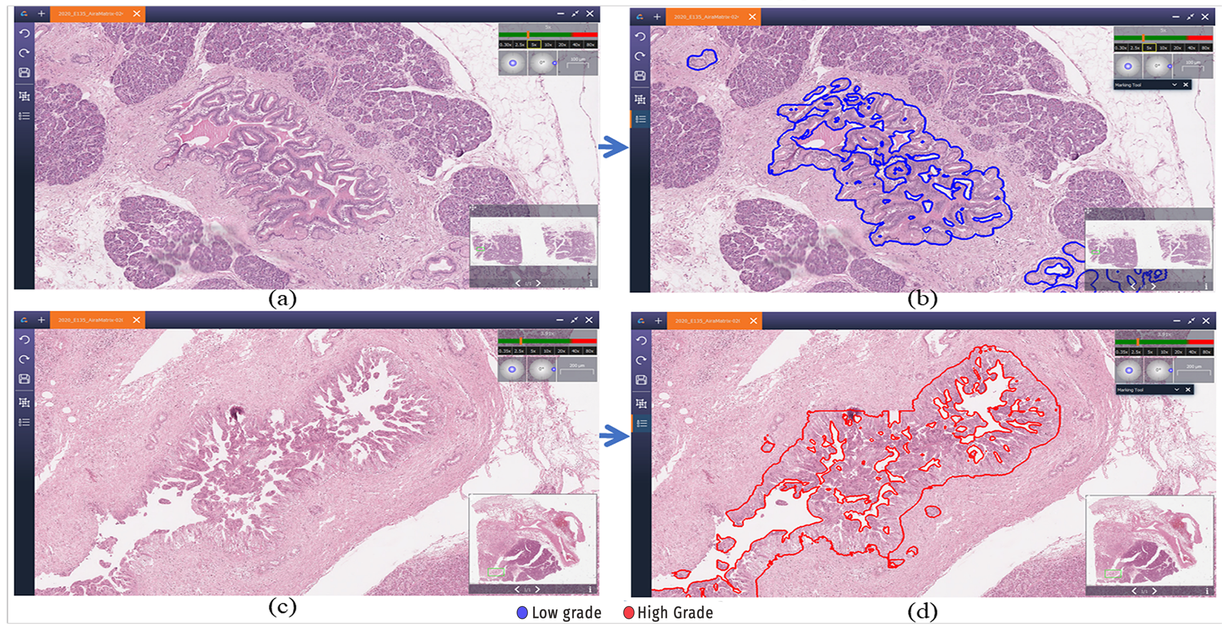

Fig. 4: Classification results: (a), (b): Low grade PanIN: Input and Output, (c), (d): High grade PanIN: Input and Output.

Discussion and Conclusions

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

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.