Deep Learning-Based Identification of Lymph Node Metastasis in Prostate Cancer

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Overview

- Pelvic lymph node metastasis in prostate carcinoma is associated with poor prognosis among surgical candidates. These patients may benefit from adjuvant or salvage radiation and hormonal therapy.
- The mainstay for definitive diagnosis of lymph node metastasis is microscopic screening of all H&E slides containing dissected lymph nodes by surgical pathologists, often in cases containing only very minute foci of cancer cells that can be readily missed.
- To avoid false negatives, therefore, surgical pathologists tediously perform this lymph node screening task at medium to higher power in a time-consuming process.
- We present a deep-learning-based tool to assist pathologists in identifying micro-metastatic foci on hematoxylin and eosin (H&E) stained digitized images.

Methods

- Transformer-based segmentation model trained to identify and segment metastatic areas in these images.
- Based on the detection of malignant regions, the algorithm further categorised the WSI as "*metastasis detected*" or "*no metastasis detected*".
- **Segformer model**[1] , that consists of a hierarchical Transformer encoder and a lightweight all-MLP decode head was trained with combined loss of cross entropy and F1-score.

Dataset

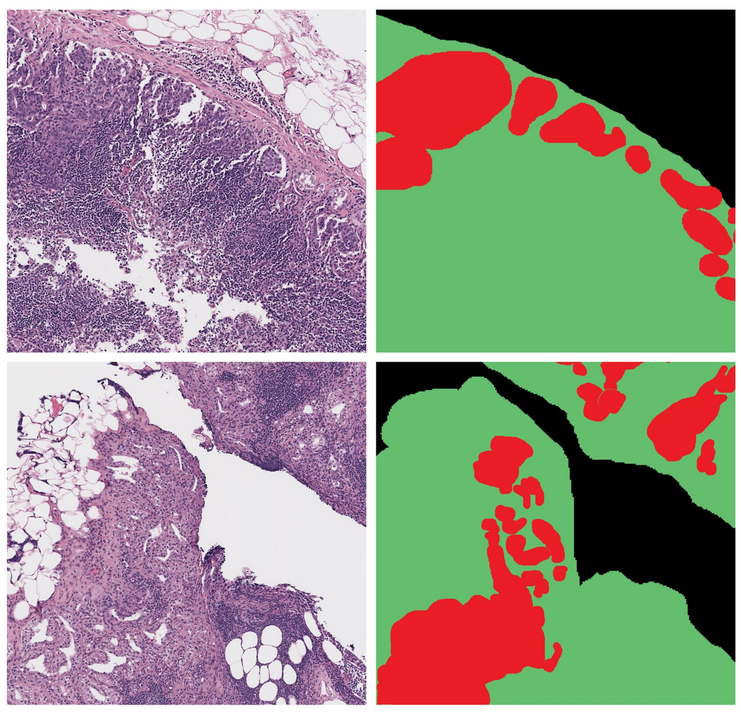


Fig 1. Sample images with labels (Green : Lymphoid tissue , Red : Metastasis)

- For 39 H&E WSI, lymph node and metastatic regions were annotated. For training, 10x magnification tiles were extracted from annotated images.
- Since the whole tissue area was used to generate data, the dataset (raw dataset) contained a significant number of tiles with a similar appearance. Using the cosine similarity score on tile embeddings generated by MobileNet that was pre-trained on the ImageNet dataset, a set of unique-looking tiles was chosen as training data.

	WSI	Annotated Tiles
Training	25	1645
Validation	14	973

Table 1. Tile level distribution between Training and Validation sets

References

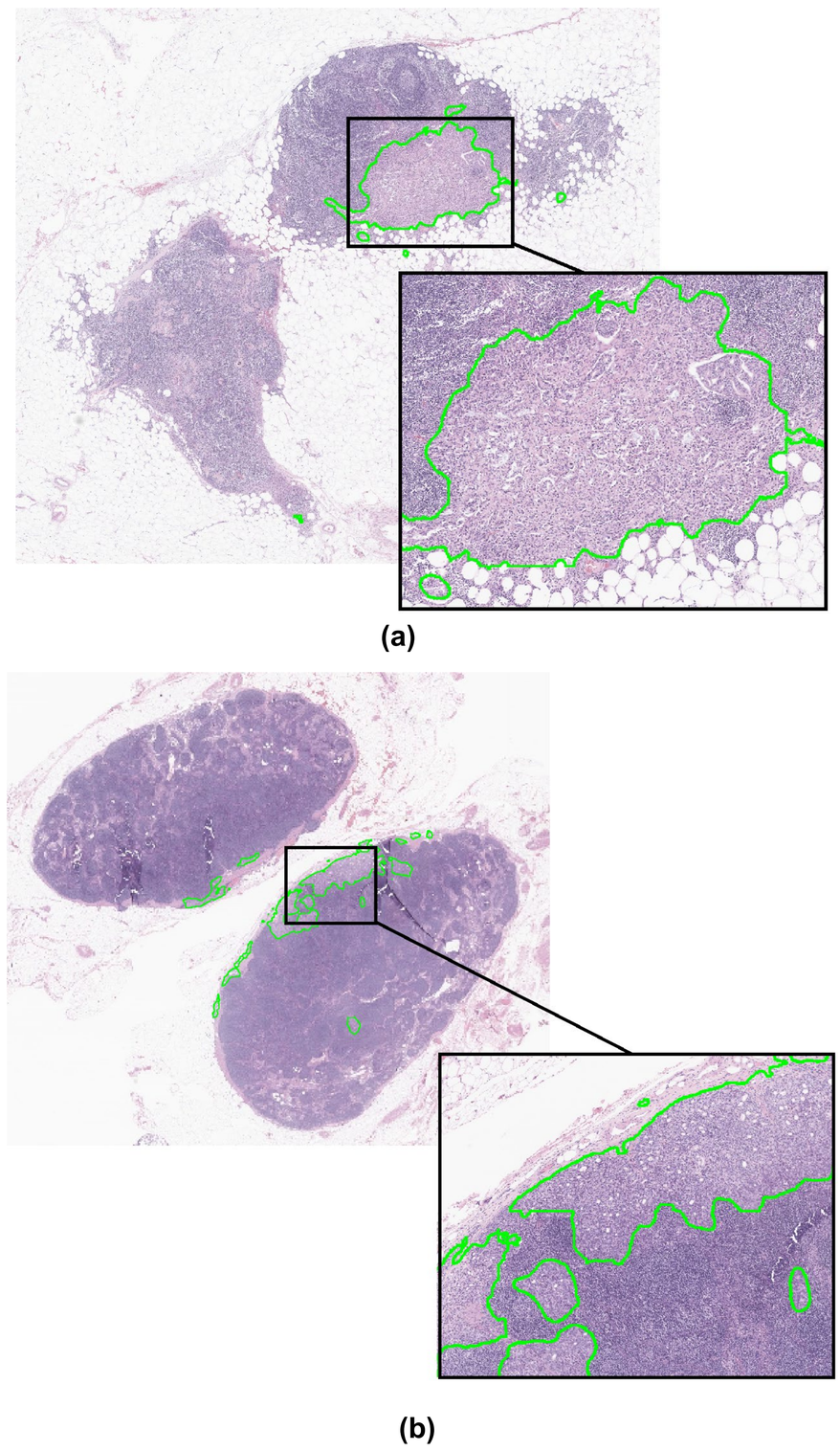
[1] Enze Xie, Wenhai Wang, Zhiding Yu, Anima Anandkumar, Jose M. Alvarez, Ping Luo - SegFormer: Simple and Efficient Design for Semantic Segmentation with Transformers

Results

	SegFormer[1]		
Classes	**Metastasis**	**Non-Metastasis**	**Tissue**
F1-Score	0.94	0.89	0.97

Table 2. Class wise F1-score

- On a test set of 81 WSI, the model achieved an accuracy of 89% in detecting metastatic regions in pelvic lymph node images, with a **sensitivity of 95%** and a **specificity of 80%** in classifying lymph nodes as "metastasis detected" and "metastasis not detected".



(a)

(b)

Fig 2. Illustrative Examples. (Green : Metastatic foci). Scanner- Hamamatsu Nanozoomer XR

Conclusion

- Patients with lymph node metastases have a poor prognosis with substantially decreased disease-specific and biochemical recurrence-free survival rates; therefore, the detection of lymph node metastasis has a significant prognostic impact.
- The proposed approach assists the pathologist in detecting lymph node metastasis in prostate cancer patients.
- Future development will incorporate external validation of the solution and will examine whether the process is rendered more efficient for pathologists.

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