(MP58-06) Automated Staging of T1 Bladder Cancer Using Digital Pathologic H&E Images: A Deep Learning Approach
Muhammad Khalid Khan Niazi1, Thomas E. Tavolara1, Vidya Arole2, Cheryl Lee3, Anil Parwani4, Metin N. Gurcan1
1Center for Biomedical Informatics, Wake Forest School of Medicine
2Dept. of Biomedical Informatics, 3Dept. of Urology, 4Dept. of Pathology, The Ohio State University

Introduction
Normal bladder mucosa is comprised of urothelium (U), resting at the basement of the membrane, lamina propria (LP), and muscularis propria (MP), adjacent of LP.

T1 bladder cancer is defined as the invasion of tumor cells into LP. Studies have shown that depth of tumor invasion into LP is correlated with worse prognosis (more recurrence and higher rates of progression) [1]. Yet, prevailing literature suggests that pathologists struggle to recognize LP invasion accurately from H&E bladder biopsies [2]. To enhance pathologic interpretation, we are developing a deep learning method to identify bladder layers (U, LP, MP) from H&E tissue biopsies and to measure the extent of LP invasion.

Materials and Methods
Our database consists of 86 whole slide H&E images of bladder biopsies scanned at 40x magnification using a high resolution scanner and was annotated for U, LP, MP, cauterized tissue, red blood cells (RBCs), and inflammation by an expert pathologist.

Each annotation was automatically sampled for 64x64-pixel tiles at 10x magnification using an overlaid regular grid. Finally, 86 distinct datasets were created from the pre-processing results, each withholding tiles from 1 of 86 whole slide images. We explored two deep learning paradigms for the identification of bladder layers – convolutional networks (CNNs), trained via transfer learning, and autoencoders, trained from scratch. Two different CNN architectures were used – AlexNet [3], which was fine-tuned, and Inception v3 [4], which was used as a feature extractor.

Results
When validated on LP and MP tiles, Inception has 96% accuracy, AlexNet 97%, and autoencoders 88%. When tested, Inception performs at 97% accuracy, AlexNet at 88%, and autoencoders at 80%. When formed into a two-class problem (U vs. LP/MP), Inception has 96% testing accuracy. When segmentation of bladder layers on 37 test images was evaluated by an expert pathologist (0.5 rating, step size 0.5), the proposed method resulted in an average score of 4.6 (+/- 0.6).

Conclusions
The results suggest that it is possible to transfer knowledge between recognition tasks, i.e., use discernable features learned from non-pathology images to recognize bladder layers using deep learning. Each model achieved high accuracy on both validation and testing sets. When given a set of tumor nuclei, the system is capable of determining the depth of invasion. A relationship between this measurement and patient prognosis has yet to be determined.

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References