Cancer Metastasis Detection via Spatially Structured Deep Network

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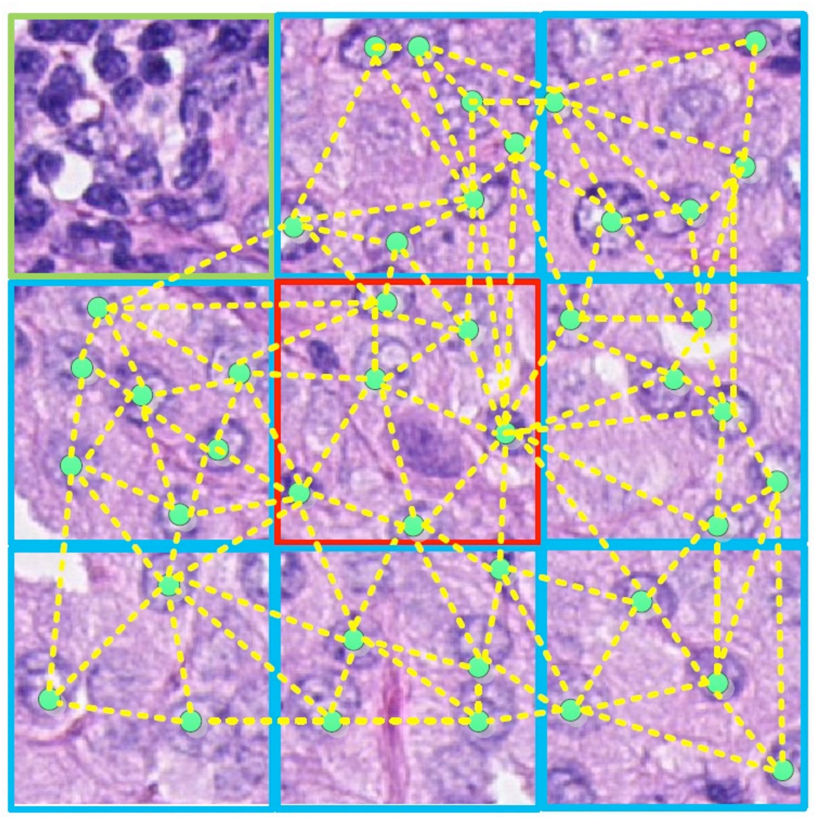
Background

- **Our goal:** Develop a Computer-aided diagnosis (CAD) platform for metastasis detection of lymph nodes in Whole-slide Images (WSIs).
- **Motivations:** Current state-of-the-art methods divide WSIs into small patches and tackle them individually. However, the spatially structured information, which is vital for the inference, is ignored.

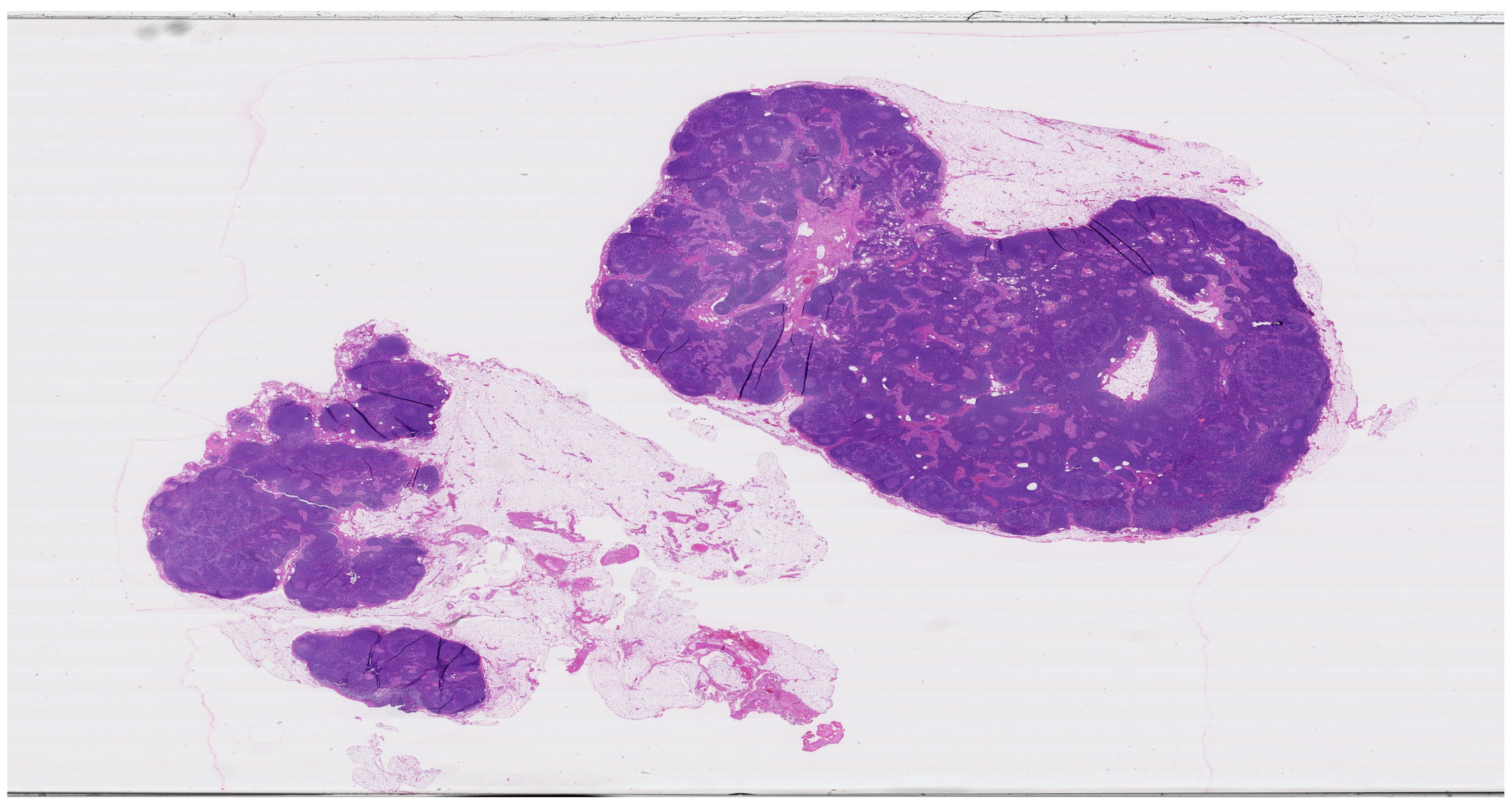


Observation 1: Nuclei follow certain patterns

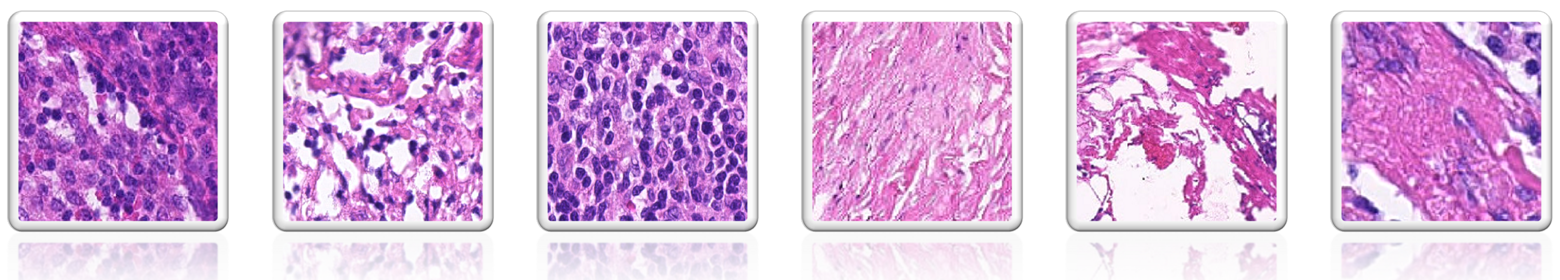
Observation 2: When a patch is in the tumor region, its neighbors also have a high prob. to be labeled a tumor, and vice versa.

Challenges

- **Gigantic Size:** WSIs are very large (e.g., 100k by 200k).

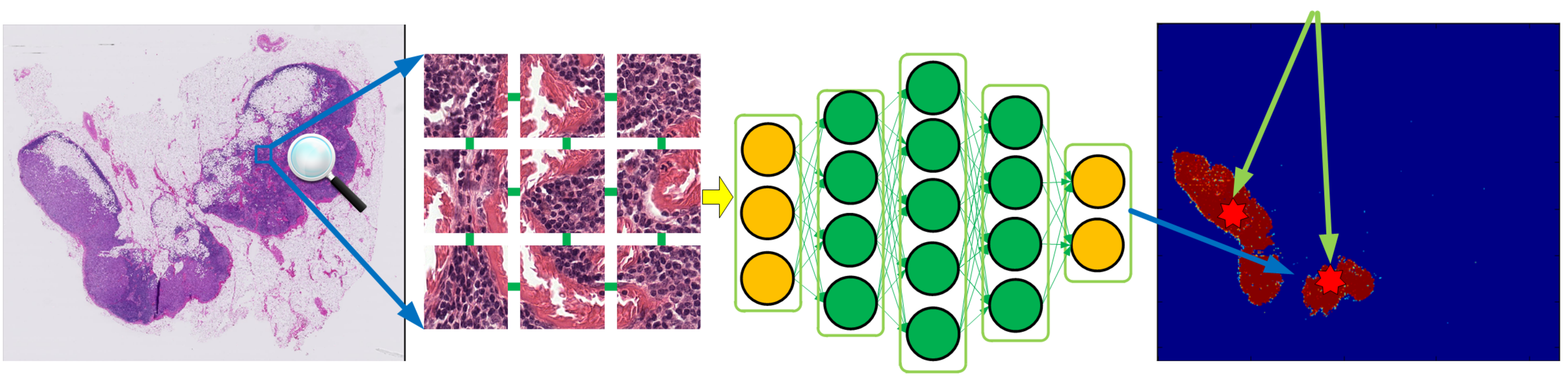


- **Large Variances:** Even regions from the same WSI seem visually dissimilar.



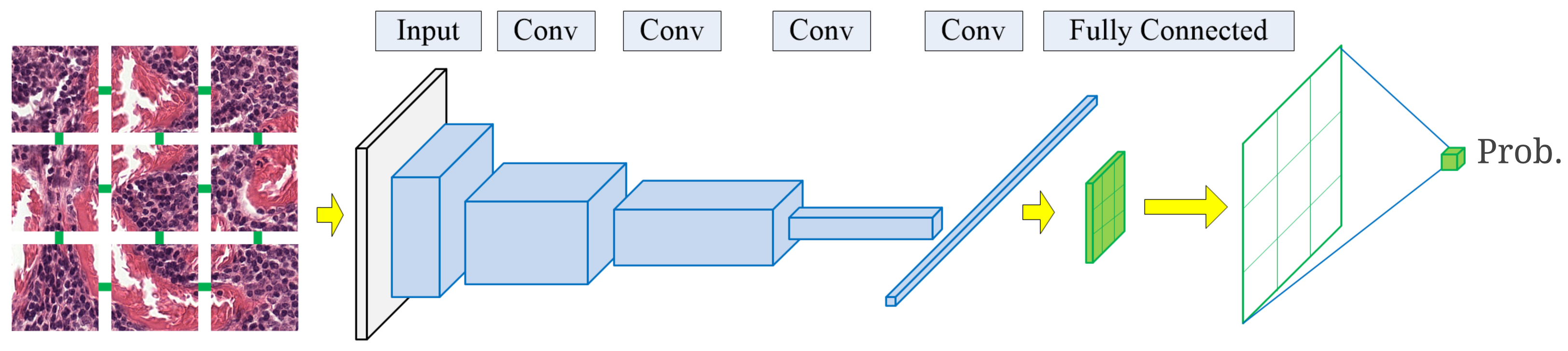
Our Method (1)

- **Overview of the framework**



Our Method (2)

- **Details of Spatio-Net**



- **We optimize the following loss function**

$$\lambda = \arg\min_{\lambda}\{L_{cls} + \alpha L_{reg}(\lambda) + \beta L_{spatio}\}$$

Cross entropy loss

Regularization term

$$L_{spatio} = \frac{1}{2}(L_{ind} - L_{dif})$$

Same Category

$$L_{ind} = \frac{1}{N}\sum_{x_* \in \mathbb{D}}\sum_{l}\{\mathbb{1}(y_* = y_l)\cdot[\eta(x_*) - \eta(x_l)]^2\}$$

$$L_{dif} = \frac{1}{N}\sum_{x_* \in \mathbb{D}}\sum_{l}\{\mathbb{1}(y_* \neq y_l)\cdot[\eta(x_*) - \eta(x_l)]^2\}$$

Different Categories

Experimental Results

- **CAMELYON16:** 160 normal and 110 tumor WSIs.
- Five-fold cross validation is performed on this dataset.

Methods	Baseline	Baseline+PostPro	Spatio-Net
Ave. FROC	0.7012	0.7104	**0.7539**
STD	0.012	0.015	**0.008**

- Different CNNs are used (with or without Spatially Structured (SS) constraint).
- Demonstrating that our method can benefit generic CNNs.

Methods	ZFNet	ZFNet (with SS)	GoogleNet	GoogleNet (with SS)	ResNet-101	ResNet-101 (with SS)
Ave. FROC	0.6832	0.7249	0.6932	0.7438	0.7012	0.7539
STD	0.018	0.013	0.011	0.014	0.012	0.008

Take Home Messages

- By integrating CNN and 2D LSTM, our framework not only learns representative features from each patch, but also considers the spatial dependencies.
- By enforcing the spatially structured constraint, the accuracy is greatly improved.
- The Ave. FROC of our system outperforms the baseline models by more than 5%.

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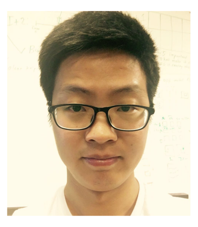

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