Multi-level colonoscopy malignant tissue detection with adversarial CAC-UNet

Chuang Zhu, Ke Mei, Ting Peng, Yihao Luo, Jun Liu, Ying Wang, Mulan Jin

School of Information and Communication Engineering, Beijing University of Posts and Telecommunications, Beijing, China

Abstract

The automatic and objective medical diagnostic model can be valuable to achieve early cancer detection, and thus reducing the mortality rate. In this paper, we propose a highly efficient multi-level malignant tissue detection through the designed adversarial CAC-UNet. The proposed scheme achieves the best results in MICCAI DigestPath2019 challenge1 on colonoscopy tissue segmentation and classification task.

Methods

In this paper, we proposed a multi-level colonoscopy malignant tissue detection incorporated with domain adaptive segmentation scheme. The multi- level architecture is adopted to realize the malignant tissue detection in a coarse to fine manner, achieving lowering the risk of false positive detection while alleviating the high computing complexity at the same time. The domain adaptive segmentation is built to address the problem of appearance variations and thus boost the segmentation performance. The main contributions of this paper are summarized as follows:

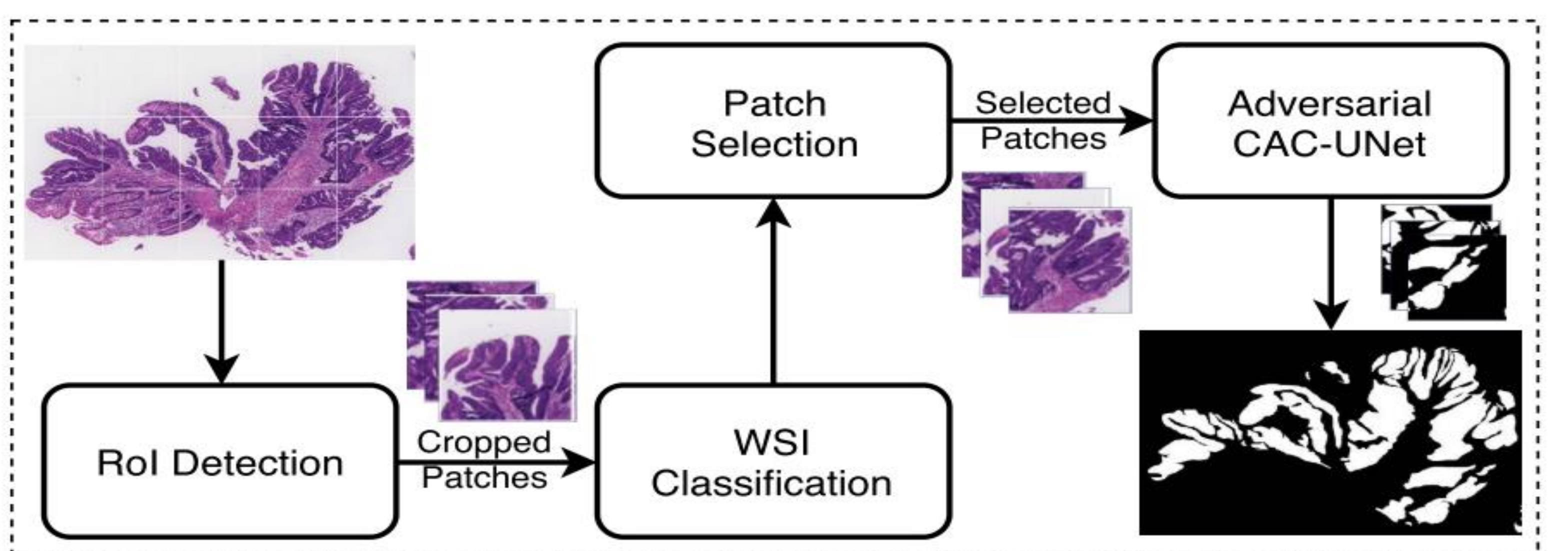

Fig 1. An overview of the proposed WSI automatic multi-level detection architecture

- We proposed a highly efficient multi-level malignant tissue detection architecture. In our architecture, the WSI-level classification is performed based on a patch-level classifier with a pre-prediction scheme. The WSIs without any malignant areas are dropped and thus the computing time is saved. For the selected positive WSIs, multiple patch-level models are trained with skillfully selected samples and then integrated together to choose the key patches. Besides, a malignant area ratio guided label smoothing scheme is applied to further increase the model accuracy.

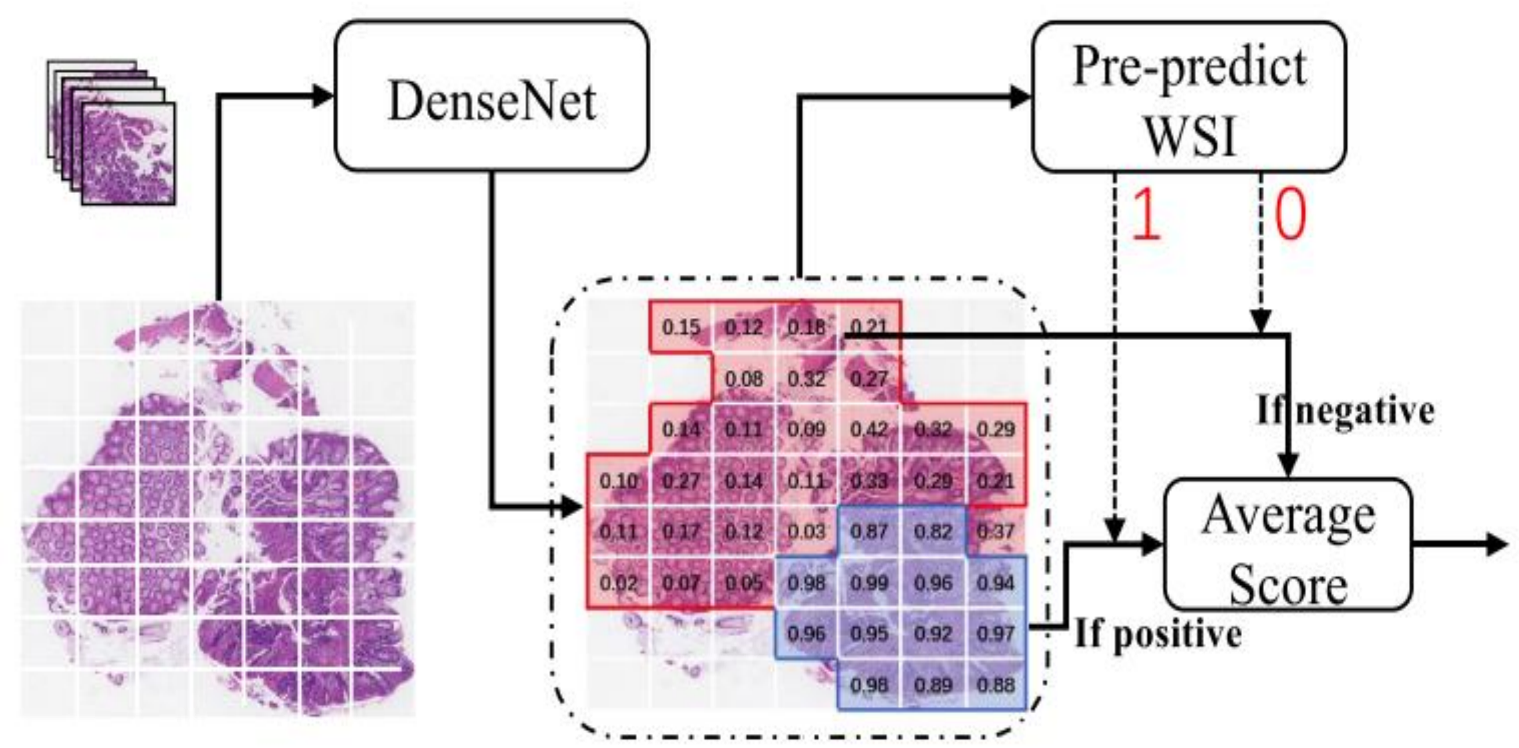

Fig 2. WSI-level classification flow

- We proposed an adversarial context-aware and appearance consistency (CAC-UNet) model to achieve robust appearance-invariant segmentation. Mirror designed discriminators are able to seamlessly fuse the whole feature maps of the generator without any information loss. The mask prior is further added to guide the accurate segmentation mask prediction through an extra mask-domain discriminator. Besides, several powerful strategies are integrated into the backbone of CAC-UNet to further improve the appearance-invariant ability.
- The proposed scheme achieved the highest dice similarity coefficient (DSC) and area under the curve (AUC) score on the dataset of MICCAI 2019 challenge on colonoscopy tissue segmentation and classification task.

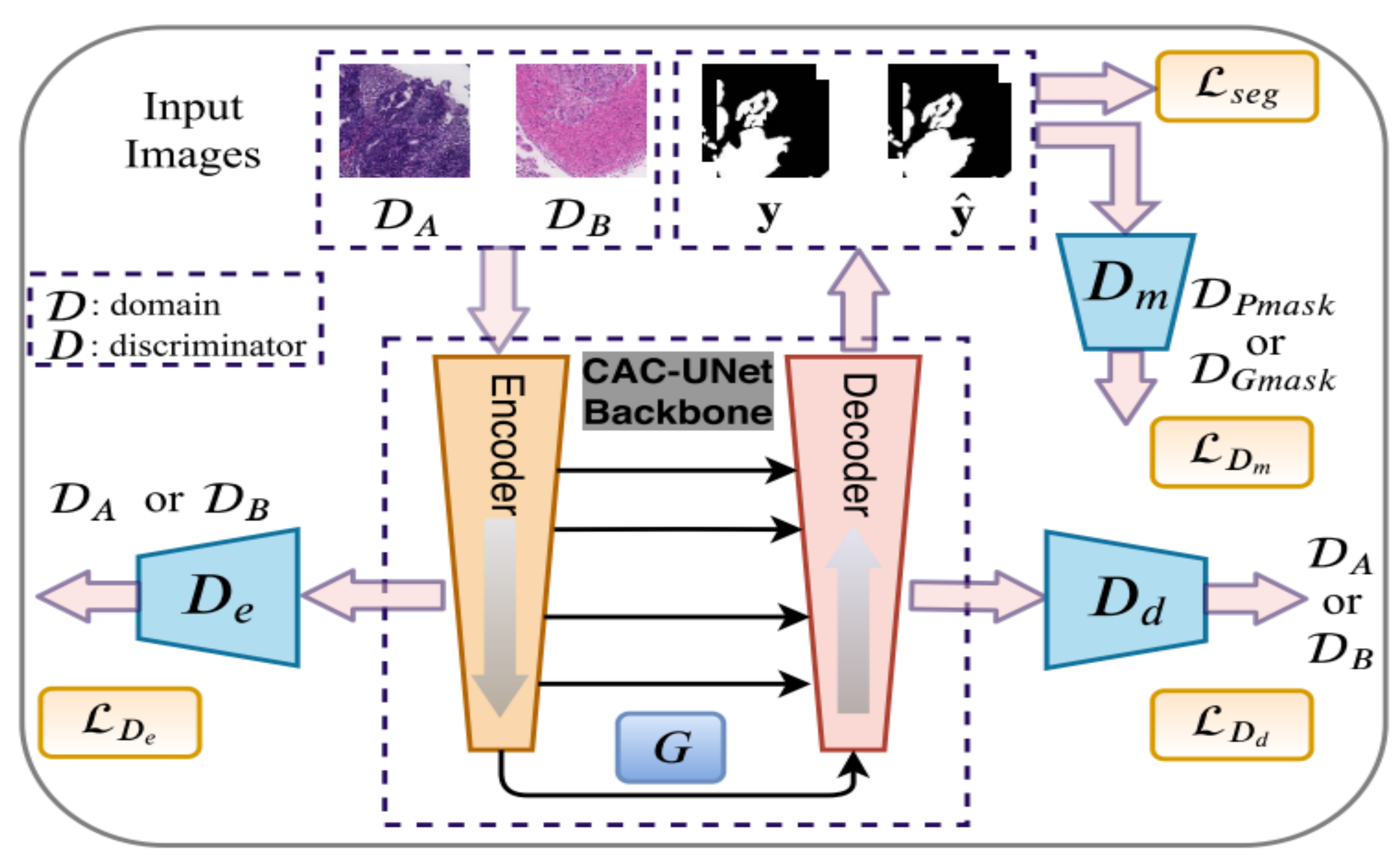

Fig 3. Overview of our proposed adversarial CAC-UNet framework

Results

On the unreleased test data of DigestPath2019, the final tissue segmentation and classification results are reported as Table 1. Our method achieves the best DSC and AUC (AUC is the same as the zju_realdoctor team) at the same time, and we achieve the best Final Rank among all methods. This demonstrates that our model has strong generalization ability on the unknown test data.

Table 1. DSC and AUC of the MICCAI 2019 Challenge on Digestive-System Pathological Detection and Segmentation

Team	DSC	DSC Rank	AUC	AUC Rank	Final Rank
kuanguang	**0.8075**	**1**	**1.0000**	**1**	**1**
zju_realdoctor	0.7789	5	1.0000	1	2
TTA_Lab	0.7878	3	0.9948	4	3
SJTU_MedicalCV	0.7928	2	0.9773	6	4
ustc_czw	0.7862	4	0.9784	5	5
chenpingjun	0.7197	8	0.9974	3	6
MCPRL_218	0.7397	7	0.9745	8	7
path_fitting	0.6794	10	0.9754	7	8
mirl_task2	0.7590	6	0.5164	13	9
Roselia	0.6920	9	0.8886	11	10

We compare our proposed method with another two WSI segmentation solutions: 1) directly performing segmentation on cropped patches based on UNet [15]; 2) performing patch classification first and then segmenting the selected positive patches [16]. Testing is presented on two validation datasets: 1) the sampled lesion patches from WSI; 2) the entire 68 validation WSIs. The lesion segmentation results are tabulated in Table 2. As presented in Table 2, our work achieves the best patch level and WSI level segmentation accuracy among all the listed methods.

Table 2. Segmentation performance comparisons among work [15], work [16] and our proposed method

Method	Patch	WSI
Work [15]	0.8568	0.8120
Work [16]	0.8505	0.7591
Ours	**0.8749**	**0.8292**

Software and hardware environment: The proposed method for WSI classification is implemented with Python3.6 and Pytorch0.4 using an NVIDIA GeForce GTX 1080Ti GPU.