Noise Reduction with Image Inpainting: An Application in Clinical Data Diagnosis

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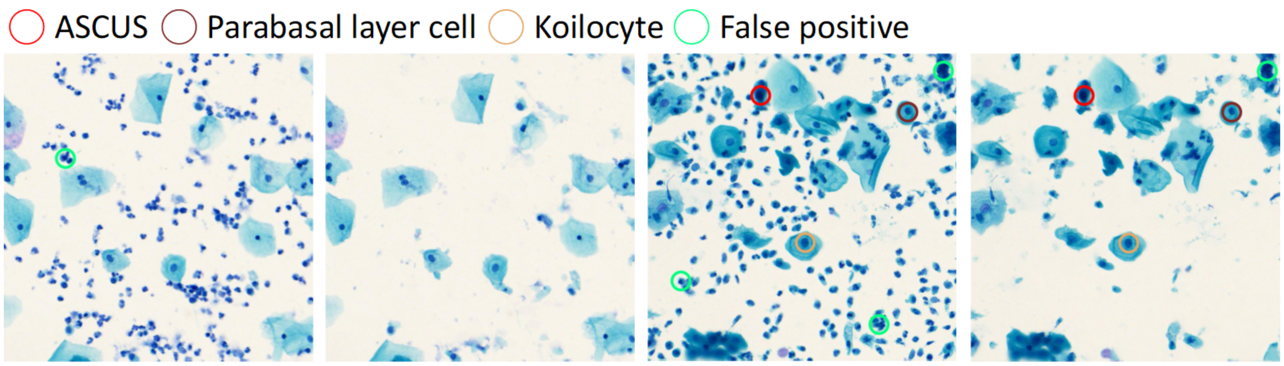

Figure 1: Cervical cancer detection of false positives and true positives, from left to right: general one-stage detection on a negative slide, detection after the proposed noise reduction model on the same negative slide, general one-stage detection on a positive slide, detection after the proposed noise reduction model on the same positive slide.

ABSTRACT

For cytology, pathology or histology image analysis, whether performed by computer-aided algorithms or human experts, a general issue is to exclude the disturbance caused by noisy objects, especially when appeared with high similarities in shape, color and texture with target cell or tissues. In this paper, we introduce a novel model to reduce such type of noisy objects with large quantity and distribution in the microscope images based on deep learning and hand-craft features. The model experimentally reduces the false positives without effect on objects of interest for cancer detection. Moreover, it also provides much distinct images for human experts for the final diagnosis.

CCS CONCEPTS

• **Computing methodologies → Neural networks**; • **Applied computing → Imaging**;

KEYWORDS

noise detection, PatchMatch algorithm, residual learning

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1 INTRODUCTION

Robust detection and removal of noisy objects has been a classical problem in computer-aided image analysis. As higher sensitivity is often achieved at the expense of lower specificity, especially for abnormality detection in clinical data, intensive final diagnosis is left to human experts. For general object detection, higher efficiency often comes from multi-stage approaches. In medical image analysis, based on the characteristics of the targets to detect, incorporating handcrafted features can obtain better result in task-specific detection. Moreover, as any disease or cancer diagnosis must be made by human, the presence of clear images alleviate the burdens in final identification, especially in large-scale microscope images [Litjens et al. 2017].

In this work, we propose a model incorporating hand-crafted features in CNN based architecture to detect and reduce the top-rank false positive types. We use the detection of cervical cancer as a case study, as its numerous inflammatory cells are widely spread over the whole slides and overwhelming disease of interests in quantity and distribution. In the proposed model, the inflammatory cells

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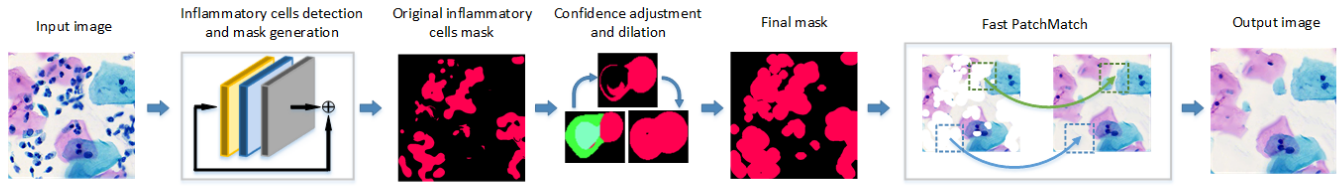

Figure 2: The framework of proposed model in the detection, enhancement and image inpainting of inflammotry cells.

are firstly detected and masked as cells of interest, then enhanced by adaptive confidence and morphological transformations, and finally fill the vacancies left by the removal of inflammatory cells and provide reasonable imagery, shown in Figure. 2.

2 METHODS

We propose a three-stage model for inflammatory cells reduction in this study: (1) A hybrid ResNet and U-Net architecture is proposed for joint detection and segmentation of nuclei and inflammatory cells. Figure. 3 shows the hybrid architecture for four-catalogue classification of inflammatory cells, nuclei, cytoplasm and background. The loss function is described as:

$$l(\theta) = LW^T \cdot (-LX^T + \log(\sum_{j=1}^{n} \exp(X_j))) \quad (1)$$

where $L = (l_1, l_2, ..., l_n)$ is the one-hot-encoded label for one pixel in the order of (background, inflammatory cell, cell nucleus, cytoplasm) $W = (w_1, w_2, ..., w_n)$ is the weight for each class. $X = (x_1, x_2, ..., x_n)$ is the output of the network before the softmax layer. In the detection and segmentation task, n is set to 4 and $W = (1, 2, 2, 1)$ for expected segmentation results.

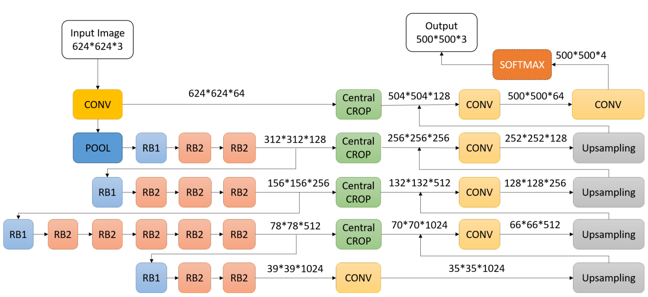

Figure 3: Residual U-net for inflammatory cell prediction.

(2) Enhancement of the mask of inflammatory cells. As aggregation is a most significant peculiarity, we adjust the confidence of inflammatory cells, then perform morphology operators of erosion and dilation, and the false positives are deducted during this processing. Figure. 4 shows the mask enhancement process. With The enhancement always preserves the true positive of abnormal cells by the threshold of confidence.

(3) Reduction of inflammatory cells from image. We design a quick algorithm based on the proposed PatchMatch [Barnes et al. 2009] algorithm in this case study for image inpainting after the removal of inflammatory cells after the detection and enhancement. Compared with the original PatchMatch, as the materials we prefer

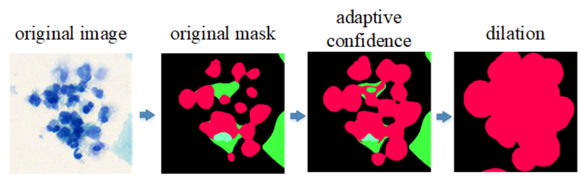

Figure 4: The expansion of aggregative and overlapped inflammatory cells.

to fill is either from background or cytoplasm, we set a color range of inflammatory cells and nuclei that the pixels in the restricted regions are not selected to fill the holes, also the search neighboring area is narrowed down to only several pixels instead of the whole image to remove inflammatory cells from the image, shown in Figure. 5. The image inpainting makes the image look more natural without causing obstacles.

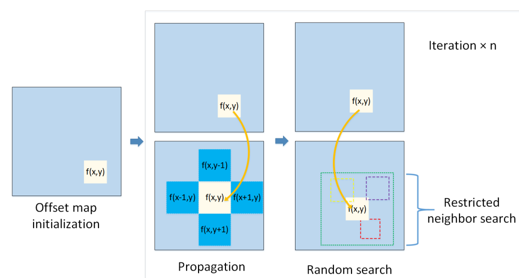

Figure 5: Fast patchmatch in our proposed flow

3 RESULTS

The noise removal image significantly reduces the number of false positives in cancer detection. The model experimentally shows a significant increase in precision without decline in sensitivity. Furthermore, this solution offers a distinct view to cytologists for the final diagnosis.

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