Self-adaptive Multi-receptive-field Segmentation Neural Network for Cytology Image: Proposal Report

Junwei Deng, Yirui Gao, Dongjian Chen, Yunzhe Jiang, Shuwan Feng

1 Abstract

We plan to present an efficient algorithm to do image semantic segmentation on microscope scanned cervical cancer cytology images based on the classification of each pixel. A powerful novel model updated from UNet++ which consider different receptive field size will be proposed. Moreover, we will design a auxiliary model to decide the cell size and automatically prune the segmentation model.

2 Introduction

Biomedical cytology image segmentation is a crucial technique in order to provide automatic and accurate characterization of cells in medical practices, like cancer research and drug discovery. Based on the classification of each pixel on a cellular image, cell image segmentation turns out to generate resulted images with clear cell boundaries and annotated cell types. For example, in Figure 1, we can see after the cell segmentation, the sub-cellular compartments are essentially structured and organized under the 2D microscopy.

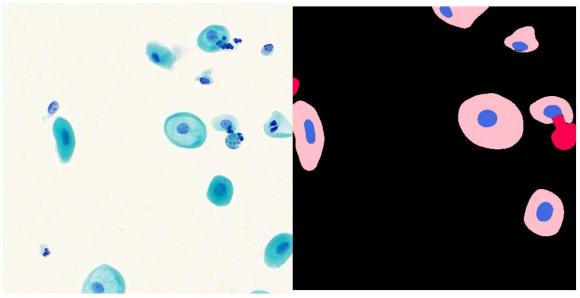

Figure 1: An example of cell segmentation. The left figure is the original one, and the right one is the resulted figure after cell segmentation. Here it shows the black as the background, pink the cytoplasm is colored. The nucleus is blue, and the inflammatory cells are red.

The traditional models for biomedical cell image segmentation are variants of the encoder-decoder architecture such as U-Net (Ronneberger et al., 2015) and fully convolutional network (FCN) (Long et al., 2014). UNet++ (Zhou et al., 2018) is a state-of-art powerful architecture as a deeply-supervised encoder-decoder network where the encoder and decoder sub-networks are connected through a series of nested, dense skip pathways.

Potential issues of the traditional methods turn out to be, first, models like U-Net doesn't have multiple adaptive receptive fields for different types of cells. For small cells like cancer cells, the segmentation effect is much worse than larger cells. For large network that provides multiple receptive fields, it heavily relies on artificial pruning to the model, which is not feasible in real scenarios. Thus in our project, we consider an improvement of this segmentation technology.

Our main contributions in this project are:

- Based on UNet++, we will propose a network with multiple receptive fields but easier to train.
- We will design a image style classifier to perform an automatic pruning mechanism for the deep network.

3 Problem Definition

Current diagnosis method based on manually counting by doctors is inefficient and time-consuming. So we purpose a new method to assist doctors to make decisions through identifying cell location and species based on image segmentation on microscope scanned cervical cancer cytology images.

The special properties of cellular images require our model to have multiple adaptive receptive fields for different types of cells. And our research is designed to face future practical applica-

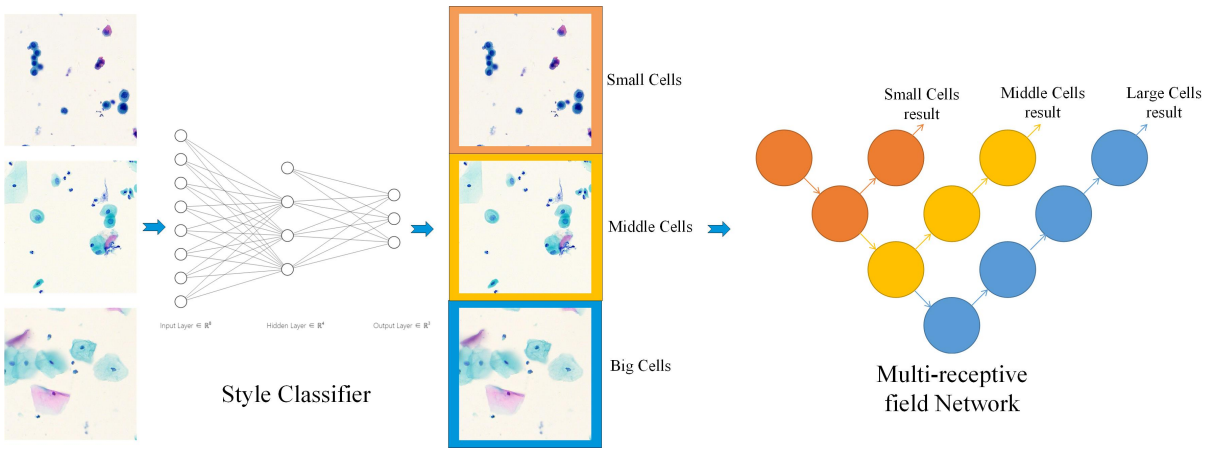

Figure 2: The overall diagram for our temp proposed model.

tion, so artificial adjustment to the model need to be prevented.

4 Data Set

Our data set contains both training set and testing set. In the training set, X_train is the data of original images and Y_train is the data of annotated masks. There are in total 2000 original images of size 776×776 in the training set, which are captured from four images of size 3000×4000. Though there are a lot of repetitive parts among the 2000 original images, the capturing did augment our data set. Accordingly, there are totally 2000 annotated masks of size 500×500 in the training set. They are the central cropped parts of the corresponding 776×776 original images. In the images, different colors stand for different units. Green is the cytoplasm, light blue is the nuclei, red is the inflammatory cell and black is the background.

As to the testing set, the components are the same with training set and the size of it is 50.

5 Related Work

U-Net (Ronneberger et al., 2015) released in 2015 showed how to use encoder-decoder network to work on biomedical image segmentation tasks. Like most existing medical image segmentation researches, our work will use U-Net as baseline to do further modification and improvement. Our work will consider multiple receptive fields for different types of cells in a network to improve the performance.

U-Net++ (Zhou et al., 2018) released in 2018 is also a inspiration for our work since it showed that it will be helpful to propose a net-work with multiple receptive fields. Our work will design and train a network which is similar to U-Net++ but is more suitable for image of cells.

Other related works including:

- Ke et al. (Ke et al., 2019b) proposed VGG and dilated convolutions network based on U-Net and analyzed the pros and cons of two networks in 2019.
- Ke et al. (Ke et al., 2019a) (Ke et al., 2019) proposed the idea to find the mask of inflammatory cells through CNN and apply improved patchmatch algorithm on it for image inpainting in 2019.
- Deng et al. (Deng et al., 2020) showed how to complete segmentation tasks of cells and subtype by designing a two-stage network in 2020.

6 Methodology

We will start from U-Net with different depth to show the importance of the receptive field size can affect the performance of cells with different size in cytology image segmentation. With the idea and relationship of receptive field size and performance of different size cells, we can provide a theoretical guide to design a U-Net++ like neural network for a our particular dataset.

Furthermore, to make the pruning algorithm in U-Net++ automatically, we will involve a "style classifier" to find out the cell size and decide the pruning part according to the classification result. The overall proposed model diagram is as following figure.2.

Some work schedule:

- **First Stage: Feb.5 to Mar.10**
  a. Complete the sanity check on U-Net with different depth, find out the relationship between cell size and receptive field size.
  b. Reproduction of the online code of U-Net++ and prepare for further update.
- **Second Stage: Mar.10 to Apr.15**
  c. Make update on the U-Net++.
  d. Complete the design and implementation of light weight style classifier.
- **Third Stage: Apr.15 to Apr.30**
  e. Report and poster edition.

7 Evaluation

We will use typical segmentation metrics to evaluate our result, which includes pixel accuracy, mean pixel accuracy and mean IoU.

8 Acknowledgments

We collected 49 positive and 100 negative whole slide clinical cytology images from Shanxi Tumor Hospital with ethics approval.

References

Junwei Deng, Yizhou Lu, and Jing Ke. 2020. An accurate neural network for cytologic whole-slide image analysis. In *Proceedings of the Australasian Computer Science Week Multiconference*. Association for Computing Machinery, New York, NY, USA, ACSW '20. https://doi.org/10.1145/3373017.3373039.

J. Ke, J. Deng, Y. Lu, D. Wang, Y. Song, and H. Zhang. 2019. Assessment and elimination of inflammatory cell: A machine learning approach in digital cytology. In *2019 Digital Image Computing: Techniques and Applications (DICTA)*. pages 1–8. https://doi.org/10.1109/DICTA47822.2019.8946065.

Jing Ke, Junwei Deng, and Yizhou Lu. 2019a. Noise reduction with image inpainting: An application in clinical data diagnosis. In *ACM SIGGRAPH 2019 Posters*. Association for Computing Machinery, New York, NY, USA, SIGGRAPH '19. https://doi.org/10.1145/3306214.3338593.

Jing Ke, Zhaoming Jiang, Changchang Liu, Tomasz Bednarz, Arcot Sowmya, and Xiaoyao Liang. 2019b. Selective detection and segmentation of cervical cells. In *Proceedings of the 2019 11th International Conference on Bioinformatics and Biomedical Technology*. Association for Computing Machinery, New York, NY, USA, ICBBT'19, page 55–61. https://doi.org/10.1145/3340074.3340081.

Jonathan Long, Evan Shelhamer, and Trevor Darrell. 2014. Fully convolutional networks for semantic segmentation. *CoRR* abs/1411.4038. http://arxiv.org/abs/1411.4038.

Olaf Ronneberger, Philipp Fischer, and Thomas Brox. 2015. U-net: Convolutional networks for biomedical image segmentation. *CoRR* abs/1505.04597. http://arxiv.org/abs/1505.04597.

Zongwei Zhou, Md Mahfuzur Rahman Siddiquee, Nima Tajbakhsh, and Jianming Liang. 2018. Unet++: A nested u-net architecture for medical image segmentation. *CoRR* abs/1807.10165. http://arxiv.org/abs/1807.10165.