EE 541 – Computational Introduction to Deep Learning

Project Proposal

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(**must be 2 team members unless agreed upon earlier with instructors**)

April 1, 2024

Project Title: Detecting Neuronal Cell Pixels in Light Microscopy Images

Topic summary

- Describe the problem that your project will address.

We propose to create a model to segment neuronal cells in light-microscopy images. We will train the model to delineate objects and cells of interest common in biological images of neurological disorders (Figure 1). Neuronal cell segmentation is a critical first step to quantify how neurological disorders respond to treatment. Current computer vision solutions are a poor-fit because neuronal cells have a unique, irregular, and concave morphology that differs from other cellular mask heads. A successful model will use the training phase contrast microscopy images to segment neuronal instances in novel images with a high level of accuracy.

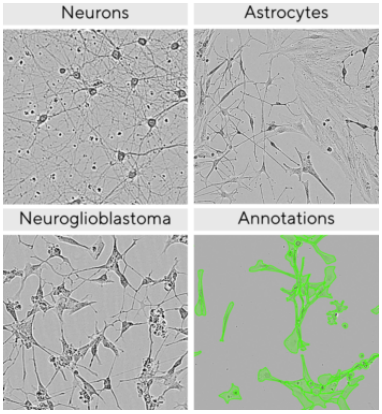

Figure 1: All good figures have a descriptive caption that describes each element of importance.

Introduction

- Explain the significance of the problem. Who benefits from a solution?
- Describe the impact on industry or to academic research. List examples, *e.g.*, Company X can benefit from using deep learning to do Y.

- Provide (short) inclusions of any theoretical, applied, or algorithmic background necessary to understand this proposal.

Related Work

- Who else has worked on this problem before?
- What did they find?
- How does the related work compare to your proposed topic?

Dataset description

https://www.kaggle.com/c/sartorius-cell-instance-segmentation

The dataset is 3.83 GB. It consists of 606 training images in png format. Each image is grayscale and is approximately 700x500 pixels. Segmentation masks and identifiers for 7340 distinct objects are included in a csv file.

We will measure model performance using mean average precision given by

$$\frac{1}{|thresholds|}\sum_{t}\frac{TP(t)}{TP(t)+FP(t)+FP(n)}$$

where the sum is over precision values over a range of thresholds $t = \{0.5, 0.55, \ldots, 0.95\}$.

Architecture Investigation Plan

We plan to first implement the U-net architecture described in reference [Ronneberger2015] and apply to our training data. We then will compare the results to a Mask R-CNN architecture which often performs well with only minimal transfer learning [Durkee2021]. Neuronal microscopy images do not have directionality and we will make heavy use of data augmentation increase the relative size of our dataset.

Estimated Compute Needs

Summarize the compute resources that you intend to use. These may include online compute resources with GPU acceleration (e.g., Kaggle or Google CoLab) or personal workstations (include a brief list of hardware, e.g. GPU, CPU, RAM).

Likely Outcome and Expected Results

Describe what you expect your final output measure to show in the case of a successful project. What are the most likely reasons for project *failure* – that is what is most likely to prevent your from achieving this outcome? What will you be able to conclude given your expected timeline and trajectory?

Primary References and Codebase

We propose to build on the approach used in

- J. Yi, P. Wu, D. J. Hoeppner and D. Metaxas, "Pixel-wise neural cell instance segmentation," 2018 IEEE 15th International Symposium on Biomedical Imaging (ISBI 2018), 2018, pp. 373-377, doi: 10.1109/ISBI.2018.8363596.
- Ronneberger O, Fischer P, Brox T. U-net: Convolutional networks for biomedical image segmentation. InInternational Conference on Medical image computing and computer-assisted intervention 2015 Oct 5 (pp. 234-241). Springer, Cham.
- Madeleine S. Durkee, Rebecca Abraham, Junting Ai, Jordan D. Fuhrman, Marcus R. Clark, Maryellen L. Giger, "Comparing Mask R-CNN and U-Net architectures for robust automatic segmentation of immune cells in immunofluorescence images of Lupus Nephritis biopsies," Proc. SPIE 11647, Imaging, Manipulation, and Analysis of Biomolecules, Cells, and Tissues XIX, 116470X (5 March 2021).
- Blog post: Astrocytes instance segmentation with Machine Learning
- Github codebases: Attentive Neural Cell Instance Segmentation, marshuang80/cell-segmentation