UNIVERSITY OF SOUTH FLORIDA

Defense of a Doctoral Dissertation

Active Deep Learning Method to Automate Unbiased Stereology Cell Counting

by

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For the Ph.D. degree in Computer Science and Engineering

Cell quantitation in histopathology images plays a significant role in understanding and diagnosing diseases such as cancer and Alzheimer's. The gold-standard for quantifying cells in tissue sections is the unbiased stereology approach. Unfortunately, unbiased stereology current practices rely on a well-trained human to manually count hundreds of cells in microscopy images. This human-based manual approach is time-consuming, labor-intensive, subject to human errors, recognition bias, fatigue, variable training, poor reproducibility, and inter-observer error. In this research, we investigated deep learning methods to automate unbiased stereology cell counting using microscopy images. Moreover, we developed an Active Deep Learning method to generate labels for unlabeled dataset of microscopy images. This method queries the most confident examples for verification by the user to be added to the training set prior to starting the next deep learning iteration. The best-known cell counting error rate is less than 1% and the Active Deep Learning reduced verification time by ~25% compared to the Iterative Deep Learning approach (i.e., a user verifies all masks generated for unlabeled dataset).

<u>Examining Committee</u>

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<u>Publications</u>

1) **Alahmari, S. S**., Goldgof, D., Mouton, P. R., & Hall, L. O. Challenges to the Reproducibility of Training Deep Learning Models. IEEE access Journal (To be submitted)

2) **Alahmari, S. S.,** Goldgof, D., Hall, L. O., & Mouton, P. R. A Review of Nuclei Detection and Segmentation on Microscopy Images using Deep Learning with Applications to Unbiased Stereology Counting, IEEE Transactions on Neural Networks and Learning Systems (To be submitted)

3) **Alahmari, S. S.,** Goldgof, D., Hall, L. O., & Mouton, P. R. (2019, October). Automatic Cell Counting using Active Deep Learning and Unbiased Stereology. In *2019 IEEE International Conference on Systems, Man and Cybernetics (SMC)* (pp. 1708-1713). IEEE.

4) **Alahmari, S.,** Goldgof, D., Hall, L., Dave, P., Phoulady, H. A., & Mouton, P. (2018, December). Iterative deep learning based unbiased stereology with human-in-the-loop. In *2018 17th IEEE International Conference on Machine Learning and Applications (ICMLA)* IEEE.

5) **Alahmari, S. S.,** Goldgof, D., Hall, L., Phoulady, H. A., Patel, R. H., & Mouton, P. R. (2019). Automated cell counts on tissue sections by deep learning and unbiased stereology. *Journal of chemical neuroanatomy*,

6) **Alahmari, S. S.,** Cherezov, D., Goldgof, D. B., Hall, L. O., Gillies, R. J., & Schabath, M. B. (2018). Delta radiomics improves pulmonary nodule malignancy prediction in lung cancer screening. *IEEE Access*,

7) Dave, P., Goldgof, D., Hall, L. O., **Alahmari, S.,** & Mouton, P. R. (2019). NOVEL STAIN SEPARATION METHOD FOR AUTOMATIC STEREOLOGY OF IMMUNOSTAINED TISSUE SECTIONS. *Innovation in Aging*, *3*(Suppl 1), S256.

8) Dave, P**., Alahmari, S.,** Goldgof, D., Hall, L.O., & Mouton, P.R. (2020). An Adaptive Semi-supervised Digital Stain Separation Method for Deep Learning-based Automatic Unbiased Stereology of Stained Tissue Sections. Journal of Microscopy (Submitted)

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