

Proposal

Focused Research Question: What mathematical feature detection and transformation functions can be performed on unlabeled neurovascular microscopy images in order to detect and isolate cellular features that can be used to train a neural network?

Hypothesis: If I perform mathematical analysis, such as edge-based segmentation, histogram-based segmentation, and connected component analyses on neurovascular microscopy images, I can automatically produce a massive dataset that can be used to train a 2D or 3D convolutional neural network to achieve satisfactory feature identification results.

How I will test my hypothesis: I have access to a vast amount of advanced neurovascular microscopy images, but they are all unlabeled. I plan to acquire a small human-generated ground truth dataset, and create a moderately sized “training” dataset to experiment on with my transformational techniques. I will then not only evaluate the ability of the transformations to create more “ground-truth-like” images from the training set, evaluating my performance using my test set, but I will also use either U-net or DeepMedic to train a CNN using this generated data and use the CNN’s performance as a benchmark as well.

Citations:

[1] Dou, Q., Chen, H., Yu, L., Zhao, L., Qin, J., Wang, D., . . . Heng, P. (2016). Automatic Detection of Cerebral Microbleeds From MR Images via 3D Convolutional Neural Networks. *IEEE Transactions on Medical Imaging*, 35(5), 1182-1195.
doi:10.1109/tmi.2016.2528129

Summary: This paper proposes and tests a novel idea for brain MR image segmentation. The authors describe challenges with conventional 3D medical image processing, wherein the actual classification takes far too long to be useful. So, they trained 2 3D CNN models: one model had a very high stride and simply outputted the probability of a feature in a large 3D space. The second model classified the features in this 3D space. I believe that the strategies used in this paper will be very useful to the 3D CNN aspect of my project because they achieved great results on very similar images, and their strategies may allow me to implement a much more powerful segmentation system.

- [2] Sharma, N., Ray, A., Shukla, K., Sharma, S., Pradhan, S., Srivastva, A., & Aggarwal, L. (2010). Automated medical image segmentation techniques. *Journal of Medical Physics*, 35(1), 3. doi:10.4103/0971-6203.58777

Summary: This paper describes various medical image segmentation tasks, and outlines what challenges exist for each task. It then describes various automated methods, such as histogram thresholding, edge detection, connected components, and atlas-based detection. Finally, it relates these strategies to the problems that they solve most effectively. This paper will be very useful for my experiments because it provides for me a reference guide for automatic segmentation strategies.

- [3] Ronneberger, O. (2017). Invited Talk: U-Net Convolutional Networks for Biomedical Image Segmentation. *Informatik Aktuell Bildverarbeitung Für Die Medizin 2017*, 3-3. doi:10.1007/978-3-662-54345-0_3

Summary: This paper describes U-Net, a CNN network structure that uses a large amount of feature channels in the upsampling section, making the network diagram shaped like a U. This allows for a 2D CNN that is ‘optimized’ for medical image segmentation and also allows, with proper augmentation, the network to be trained with very little data. This paper will be useful in my research for a few reasons. Firstly, U-Net can be used as a benchmark for my training set generation. Secondly, U-Net could be used as a basis of a backup strategy in which I attempt to train a CNN using very little training data.

Hurdles:

- 1) One hurdle will occur in discovering and implementing the correct transformations on my training data. This will be very trial-and-error based, and could end up not working out in the end.
- 2) Another hurdle will be configuring and fine-tuning the CNN model that I use as a benchmark. In the end, I may even end up implementing and training my own CNN if the

data is satisfactory, and thus, I will need to discover the optimal settings (layers, batch size, preprocessing) for this final network.

- 3) A third hurdle will be deducing the proper CNN process to produce optimal output. For example, some authors have used multiple CNNs to complete previously untenable tasks by increasing the computational intensity as probabilities of features in certain areas increase.