**Comp 590/790 Project Proposal: Cell Migration Tracking**

I work in a cell biology lab that studies the cytoskeleton, the network of proteins that gives cells their shape and allows them to move, or migrate. Our lab studies the signaling pathways that drive directed cell migration in response to various environmental cues. An important part of this research is the measurement of cell migration, which requires collecting the sequence of cell positions (“tracks”) and measuring the net movement in the direction of a particular cue (and there are some other important motion metrics). Traditionally this is done by hand using tools to click on the rough center of cells through a time lapse movie, but this is time consuming and prone to human error as the definition of the “center” of a cell is largely ill-defined and a subjective decision on the part of the user. Additionally, although quantitative imaging techniques like fluorescent microscopy enable algorithmic cell mask generation, the necessity to detect small changes in migratory behavior requires tracking of a large number of cells, necessitating brightfield (low-magnification) microscopy which is not quantitative. Thus, machine learning based techniques are required to enable automated cell detection.

My project proposal involves exploring several techniques to solve the challenge of automated cell tracking. From a strategy perspective, there are multiple potential avenues, involving different degrees of machine learning: one could instance or semantically segment individual frames, then use the centroids of the masks; one could use object detection to directly acquire cell centers for individual frames; in both individual-frame cases, track generation would be done via linear assignment problem on adjoining frames. Alternatively, video-based segmentation could be used, or end-to-end video object tracking. This gives four strategies to test, with several potential models for each. There are multiple strategies to frame-by-frame linking to test in the individual-frame case, and several hyperparameters, like clip length, to be varied for the video models.

The primary dataset will be hand-tracked cells and hand-segmented cell masks in experimental movies I have collected. **The training data sample is relatively small**, so few-shot fine-tuning quality will be of utmost importance. I will likely expand the hand-segmented dataset using an existing (CNN-based) model for human-in-the-loop training data generation, as the total amount of hand segmented data is somewhat low (it really takes a while). To compare versus a dataset with more training data, I will use a brightfield dataset from the Cell Migration Lab, and I will also test intermediate training on one of these datasets (<https://github.com/CellMigrationLab/Datasets?tab=readme-ov-file#image-data>) followed by fine tuning on my relatively small dataset.