A Software for Automatically Tracking Cell Protrusions

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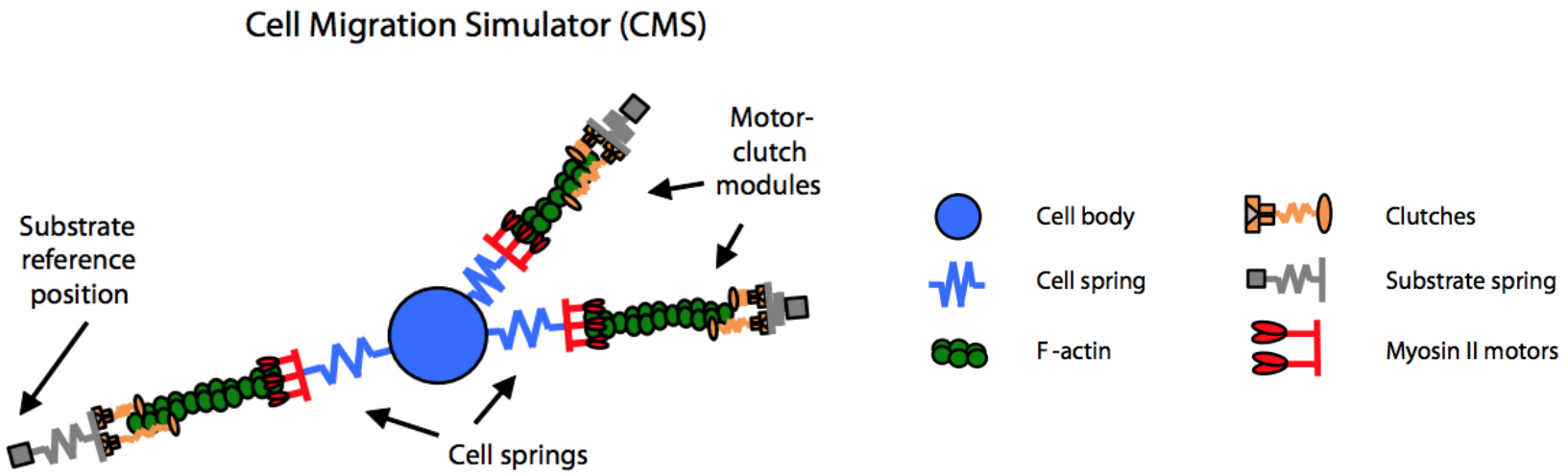
Goals

- Analyze cell protrusion dynamics to gain physical insight into cell migration simulator (CMS) parameter values and rules
  - v_{actin} – actin polymerization velocity driving protrusions
  - Θ – protrusion angle
  - k_{mod} – module birth rate
  - k_{cap} – module capping rate

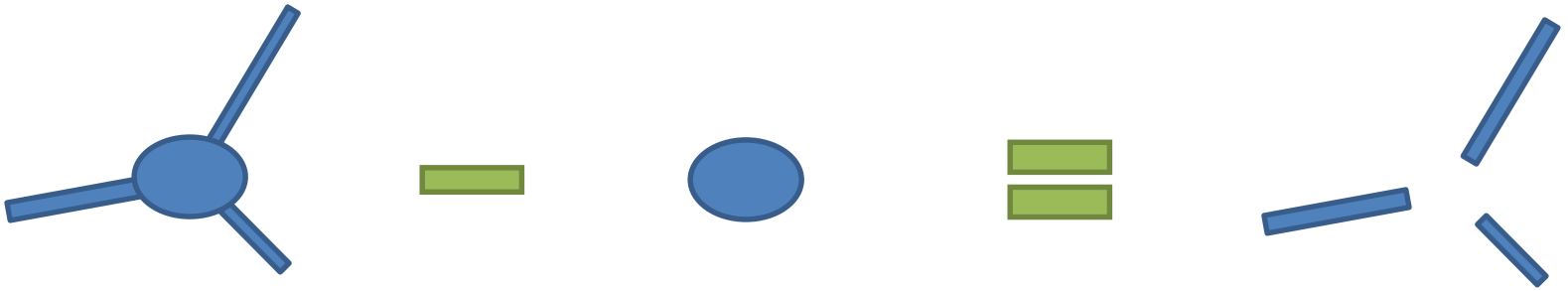
Cell Migration Simulator

- Protrusion tracking based loosely on CMSv2.0 model interpretation
  - Model has central cell body with protrusions extending out



From Prahl et al., Microtubule-based control of motor-clutch system mechanics in glioma cell migration. (In Preparation)

Protrusion Tracking Method

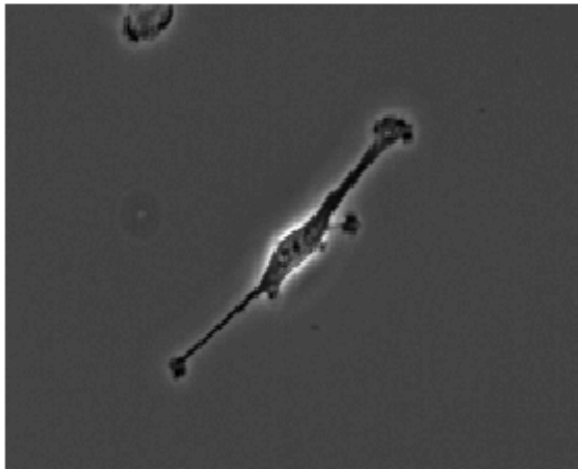


Cell with three protrusions

Subtraction of Cell body

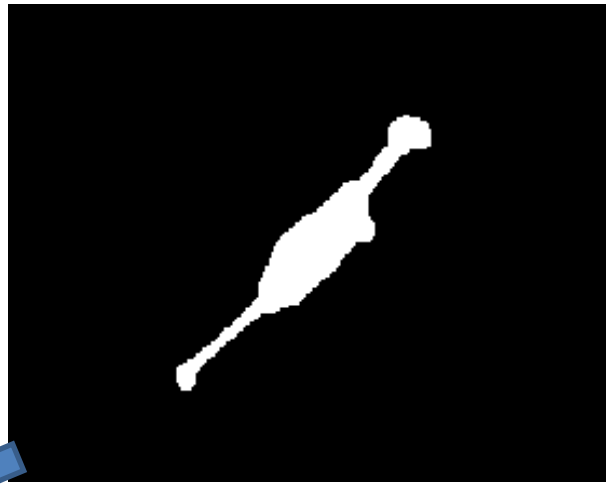
Detected protrusions

Implementation to Phase Contrast Time-Lapse Movies



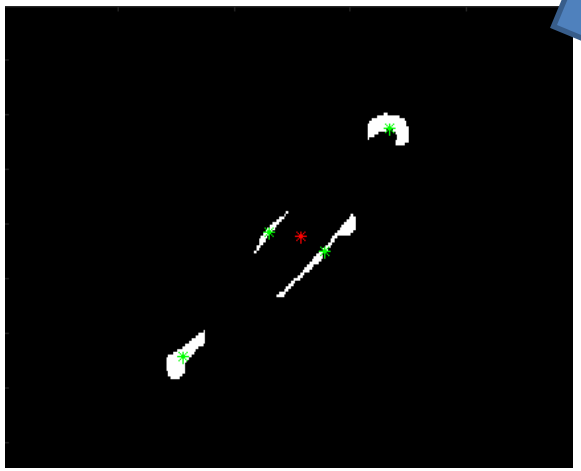
Phase Contrast Frame from Time-Lapse movie

Edge detection and thresholding



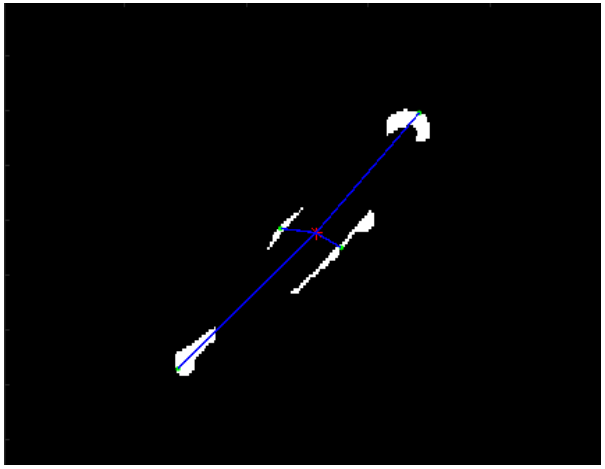
Binary image of cell

Cell body ellipse subtraction



Detected Protrusions

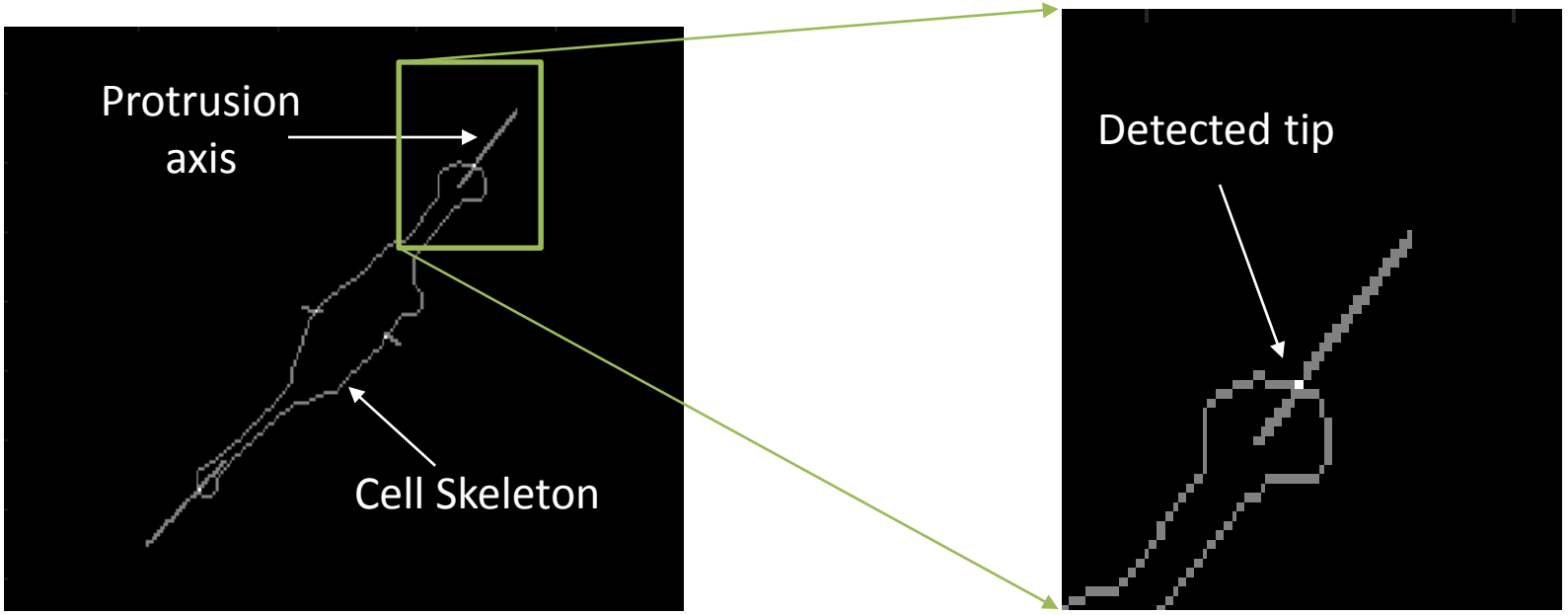
Tip detection



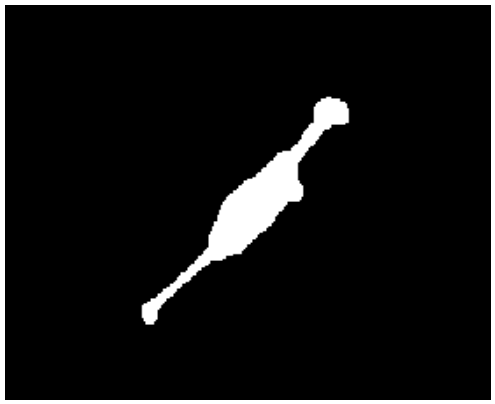
Detected protrusion tips

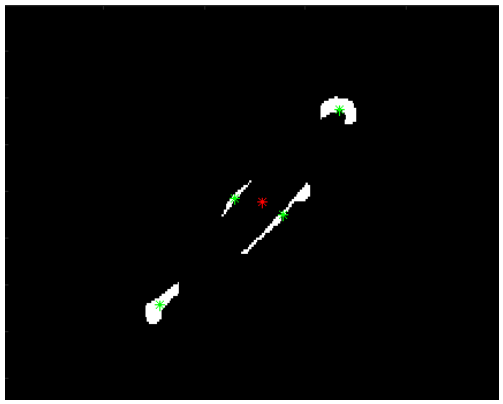
Tip Detection Method

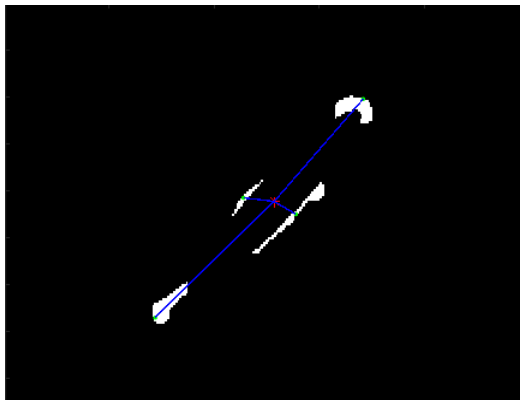
- Protrusion axis defined as line from cell centroid through protrusion centroid
- Tip defined as intersection of cell edge and protrusion axis



Information Extracted at Each Step





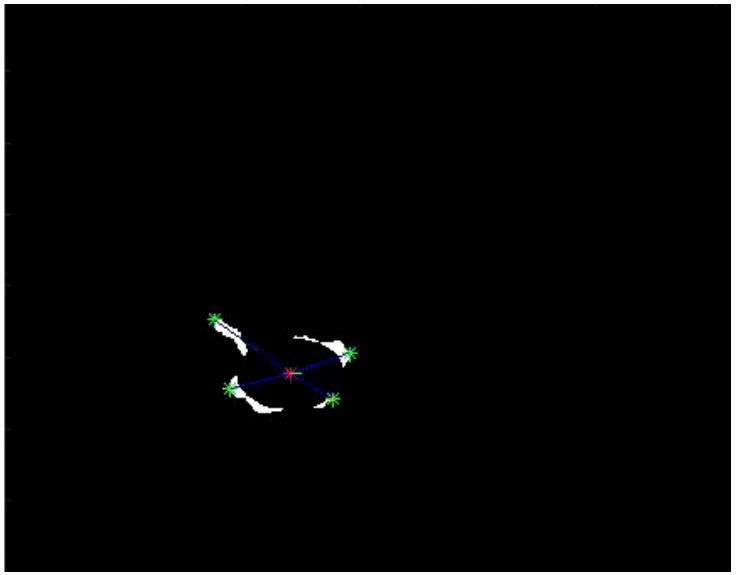


Cell Area, Aspect Ratio, Position, Centroid, and Orientation

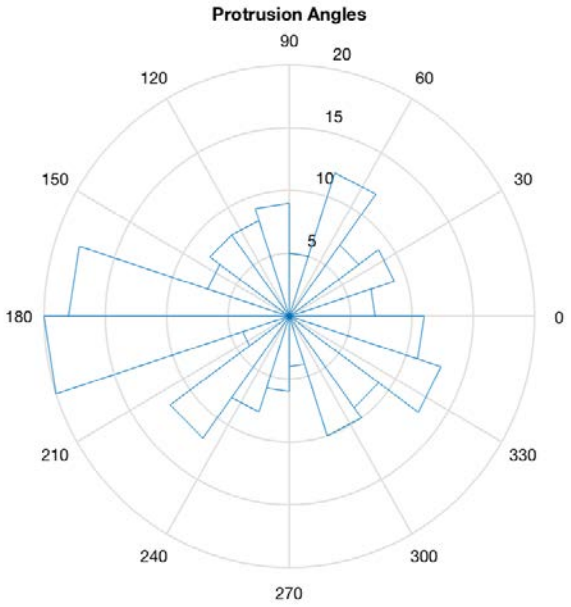
Number of Protrusions, Protrusion Centroid

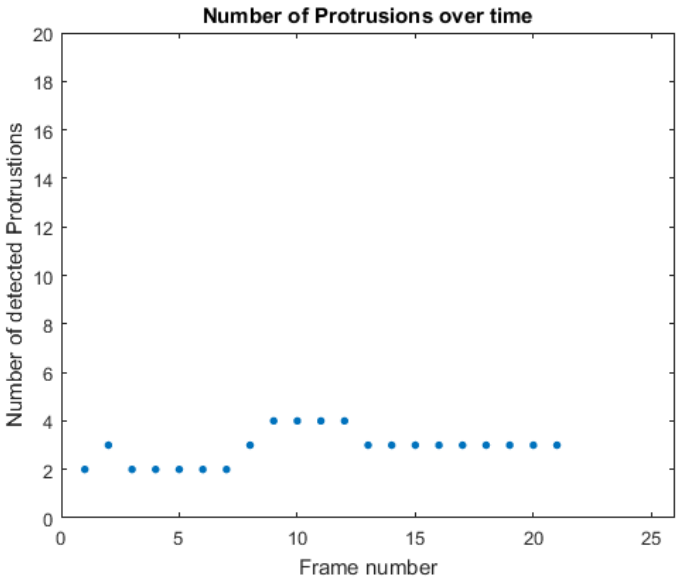
Protrusion angles, Distance of tip from cell centroid, position of tip

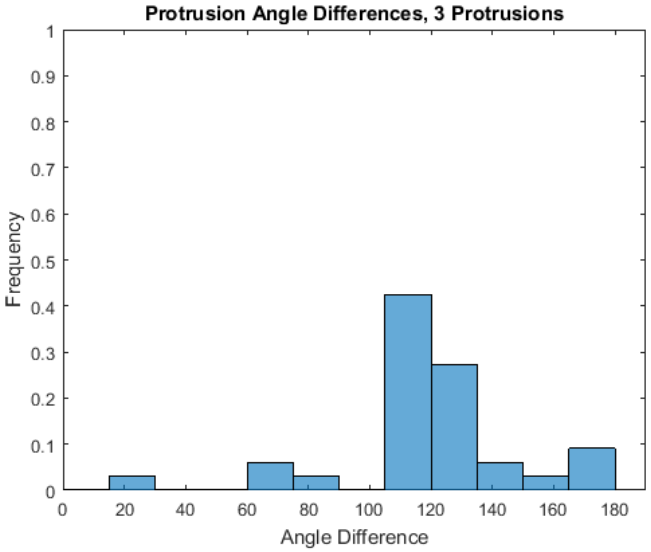
Phase Contrast Video Tracking Example

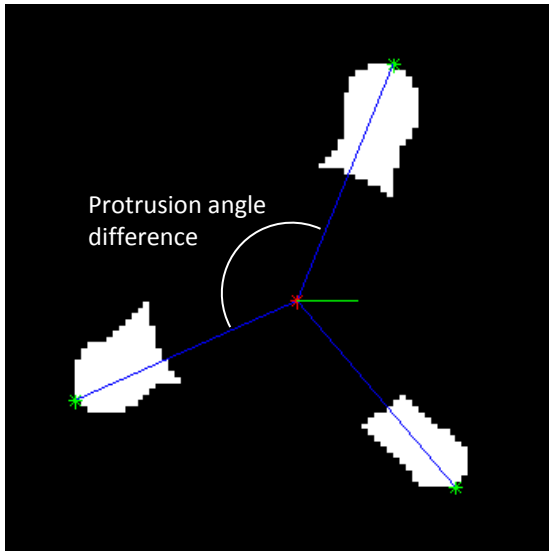


Sample Outputs

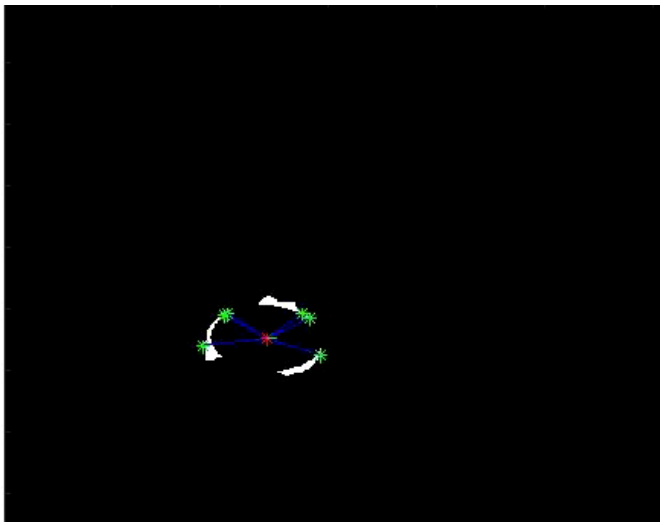




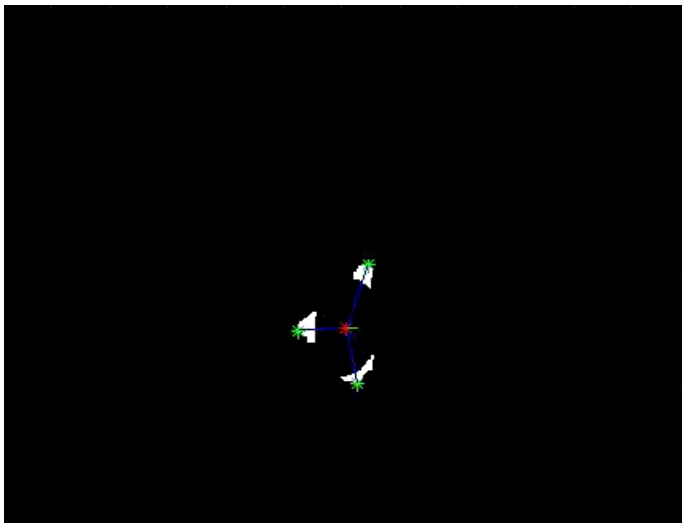




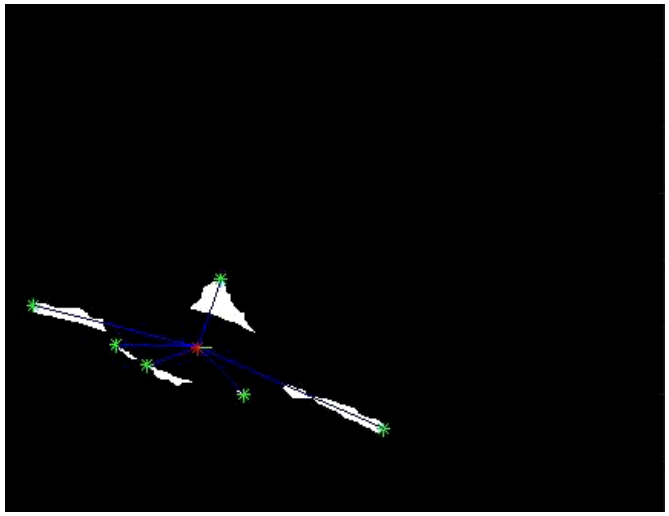
Examples of U251 on glass with different drugs



Control

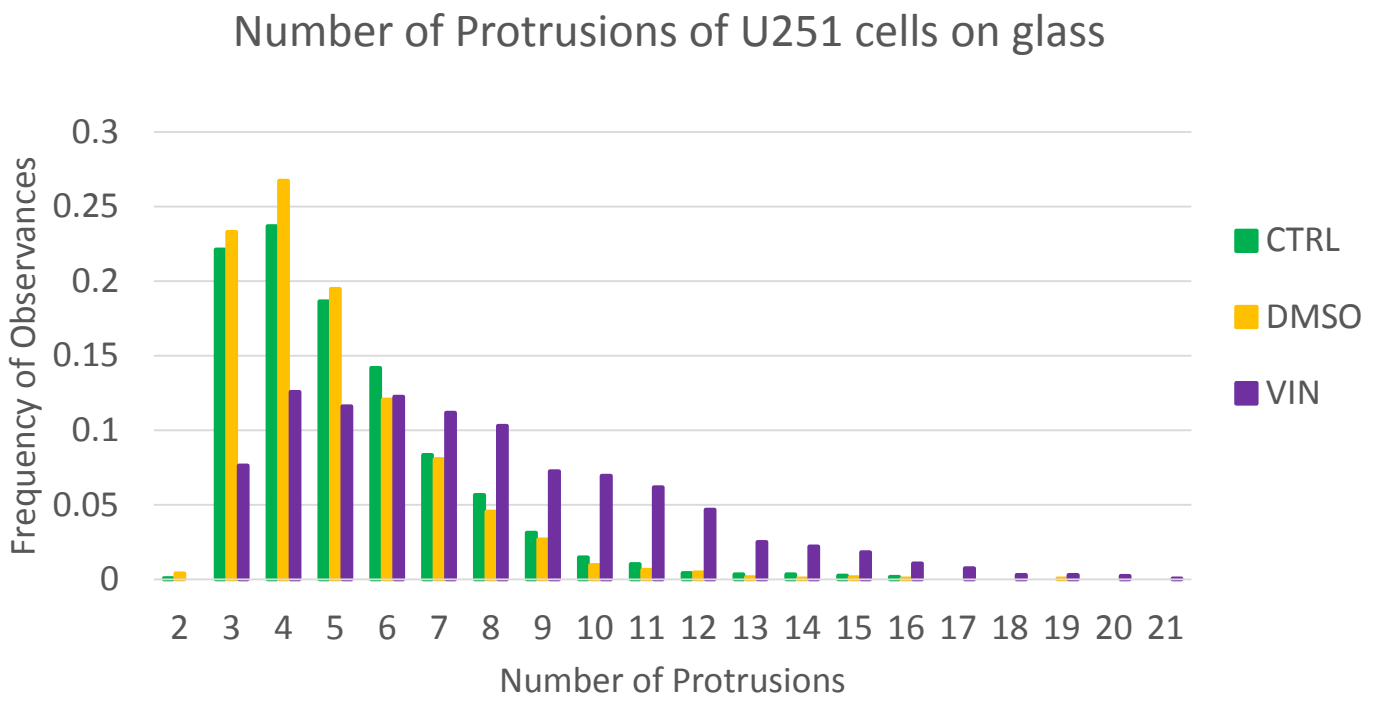


Dimethyl sulfoxide (DMSO)



100 µM Vinblastine (VIN)

Difference in detected protrusion number for cells treated with different drugs



	CTRL	DMSO	VIN
Average	5.194	4.960	7.663
Std. Dev	2.126	1.958	3.508
SEM	0.063	0.056	0.088
p-value		0.065	<0.001

Greater number of protrusions detected for rounded VIN cells

Future Directions

- Optimize individual protrusion tracking algorithm
  - Allows individual protrusion position vs. time analysis
    - Can give us v_{actin} and k_{cap}
- Collect data sets and analyze populations of U251 cells with taxol and vinblastine (chemotherapy drugs) on glass
  - Extract protrusion number, angle, v_{actin}, k_{cap}, and k_{mod}