Decomposing Non-rigid Cell Motion via Kinematic Skeletonization

Video and PDF at http://www.stanford.edu/~cyrus/siggraph

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Motivation

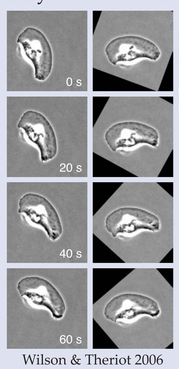
The cell's frame of reference

When studying the organization of components and processes within a cell, it is useful to express observations and measurements in the spatial context of the cell interior.

What if the cell moves?

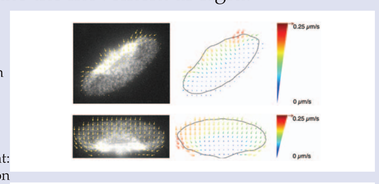
Simplest case: "rigid" motion

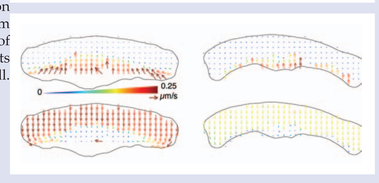
For certain cells which maintain their shape as they move—not an easy feat—we can approximate the movement as rigid.



Left: Rigid motion subtracted from cell position & orientation.

Right: Rigid motion subtracted from velocities of actin filaments within the cell.

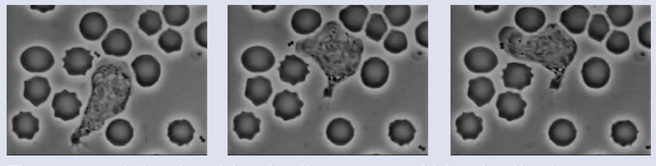




Wilson & Theriot 2006 — Top: Yam *et al*. 2007 — Bottom: Wilson *et al*. submitted

Non-rigid motion

What about the more typical case?



The neutrophil (white blood cell) among red blood cells above quickly changes direction as well as shape as it closely pursues and ultimately engulfs a bacterium.

Representing complex motion intuitively

Can we compromise between a reasonably accurate representation of non-rigid cell motion while remaining conceptually accessible?

References:

Wilson, C.A. & Theriot, J.A. 2006. *IEEE Trans Image Process* **15, 7,** 1939-51

Yam, P.T., Wilson, C.A., Ji, L., Hebert, B., Barnhart, E.L., Dye, N.A., Wiseman, P.W., Danuser, G. & Theriot, J.A. 2007. *J Cell Biol* in press

Shi, J. & Tomasi, C. 1994. *Proceedings CVPR '94,* 593-600

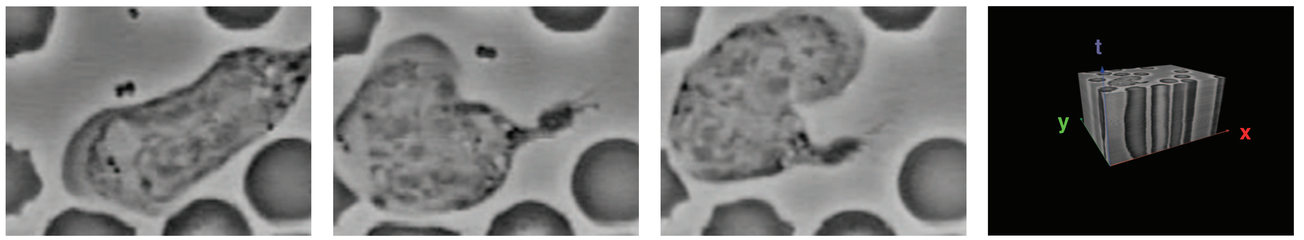
Approach and preliminary implementation

Test case movie:

This movie of a neutrophil (a type of white blood cell) chasing a bacterium is a classic among cell biologists.

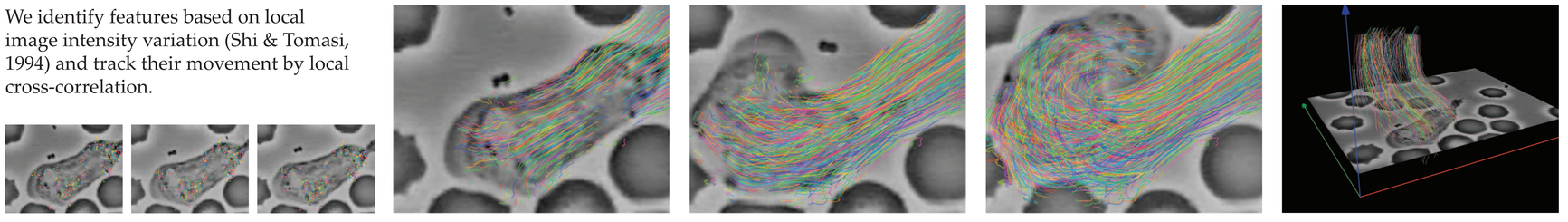
As a test case we use a short segment of the movie in which the neutrophil folds back on itself.

original movie by David Rogers



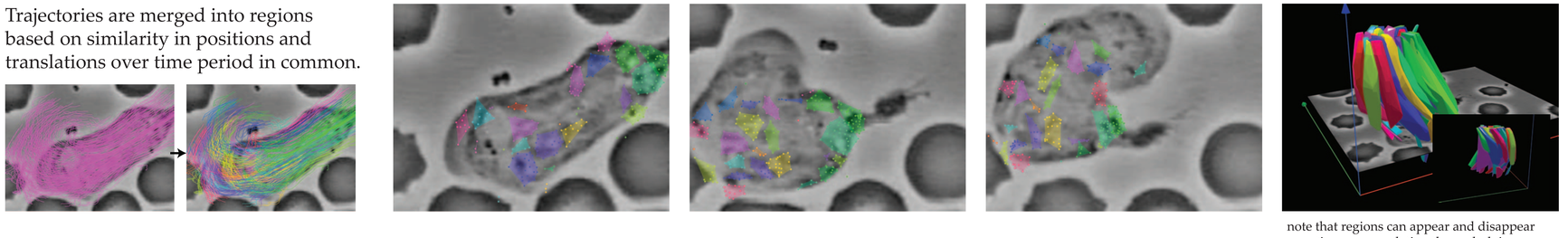
Track features:

We identify features based on local image intensity variation (Shi & Tomasi, 1994) and track their movement by local cross-correlation.



Cluster trajectories to form regions:

Trajectories are merged into regions based on similarity in positions and translations over time period in common.



note that regions can appear and disappear over time, accomodating the underlying assembly and disassembly of cellular structures

Cluster regions to make connections:

Regions are merged based on similarity of motion, with more degrees of freedom at higher levels in the hierarchy.*