

### 3D Motion Estimation in 3D Light Microscopy Image Sequences: Application to Cell Migration

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Three dimensional (3D) motion estimation for light-sheet microscopy is of paramount importance to the quantification of the mechanisms underlying cellular behavior. However, a complete estimation of the 3D motion field is challenged by the heterogeneous scales and nature of intracellular dynamics [2, 3, 4]. As typical examples in cell imaging, blebbing of a cell has smaller motion magnitude while cell migration may show large displacement between frames. To tackle this problem, we present a coarse-to-fine 3D optical flow method extending the two-dimensional PatchMatch [1, 2] paradigm to 3D data. We compare several similarity measures to match voxels between two successive volumes. We exploit multiple spatial scales to explore the possible range of intracellular motions. Our findings show that the metric based on Census transform [6] is more robust to noise present in the images and to intensity variation between time steps. Since this approach estimates only discrete displacements, we additionally consider a 3D variational optical flow computation stage to obtain a refined sub-voxelic flow map. The variational approach still involves a data fidelity term based on the Census transform. The combination of the PatchMatch and the variational stage is able to capture both large and small displacement.

We assessed the performance of our method on data acquired with two different light sheet microscopes [7, 8] and compared it with a couple of other methods. The dataset depicts blebbing and migration of MV3 melanoma cells, and collagen network displacement induced by cell motility. As seen in Fig. 1, our method is able to estimate various range of motion during cell migration and blebbing.

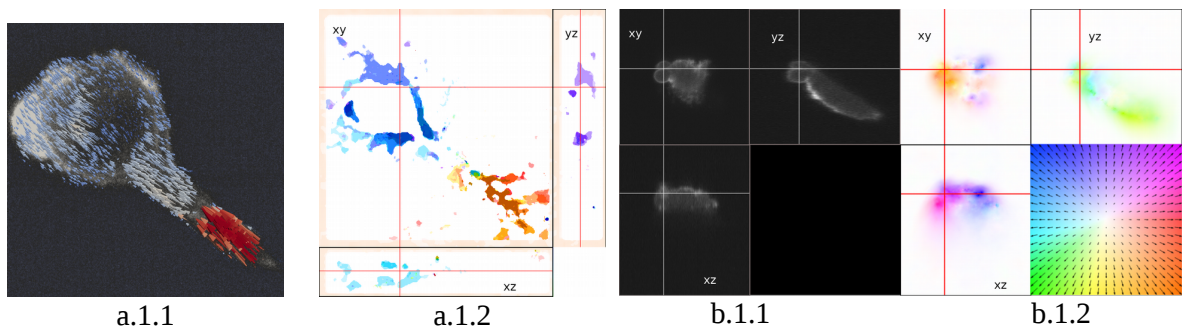


Figure 1: (a) Migration of MV3 melanoma cell in collagen; (a.1.1) Depicting 3D flow field in a slice of cell data with glyphs. Larger motion magnitude is coded in warm colors and smaller motion in cold colors. (a.1.2) Depicting motion map of collagen channel in 3 orthogonal planes. (b) Blebbing of MV3 cell in a cover-slip; (b.1.1) Depicting 3 orthogonal planes of cell data. (b.1.2) Depicting motion map of the cell data in 3 orthogonal planes. The motion map is color coded as shown in lower-right corner of b.1.2.

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