The image segmentation and cell tracking in macrophage data

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Abstract

We propose the methods of the image segmentation and cell tracking for erratic shapes and migration of cells. For complex shapes of the cells, it is a tricky task to segment them since they have a huge variability of image intensity. We suggest the image segmentation with three steps to capture properly those complicated shapes: space-time filtering, the local Otsu's method, and the SUBSURF (subjective surface segmentation) method.

In space-time filtering, the regularized Perona–Malik model is combined with the scalar function, called "curvature of Lambertian trajectory" to measure the coherence of objects in time slices. The local Otsu's method calculates an image threshold for every pixel in a way of the conventional Otsu's method in order to reflect local information of objects. The remaining background noise is removed by applying the SUBSURF method. Space-time filtering and the SUBSURF method are solved by using the semi-implicit scheme for time discretization and the finite volume method for space discretization.

In the segmented images, approximated cell centers of all segmented cells are computed by solving the time-relaxed Eikonal equation using the Rouy-Tourin scheme. Next, the approximate cell centers form trajectories when the segmented cells overlap each other in the temporal direction in order to trace each individual cell over time. Finally, these firstly formed trajectories are connected by computing a tangent allowing us to estimate the direction of movement of the cells. For the computation of tangents, we use simply backward and forward finite difference approximations with the third order accuracy. The two partial trajectories are connected when the estimated points obtained from the tangent calculation of a trajectory are close to the point of another trajectory within several time slices.

The proposed methods are implemented in videos of macrophages, one of the fastest moving cellular populations. The performance of the proposed image segmentation is presented by computing mean Hausdorff distances between the results of the semi-automatic and the proposed method. Also, the perimeter, area, and circularity are compared between the proposed method and other segmentation methods. The accuracy of the cell tracking method is evaluated by counting the number of correct links and the trajectories obtained from the proposed method are compared with the manually extracted trajectories by using the mean Hausdorff distance.