Optical result of seed detection affects the accuracy

Optical microscopy is widely usedto quantify single cell characteristic such as cell size or intracellulardensity. Accurate quantification is highly dependent on the cell segmentationresults in the microscope image. The cell segmentation algorithms do notconverge to a single solution with good performance and is developed withvarious algorithms depending on the characteristics of the target cell.

Theimaging hardwares and analysis software platforms 1 have developed rapidly, but such cell segmentation studies have been relatively lagging behind. Cell segmentation is challengingdue to the following three reasons. First, various experimental configurations, such as cell types or imaging protocols, produce images with different shapesor brightness characteristics. Second, since cells generally have dynamicallychanging shapes over time, we can not mathematically define the cell shape. Third, the boundaries of some cells that are in contact with each other during cleavageor migration may be unclear, and experts may have different opinion whether onecell or more cells are connected. In order to overcome the various brightness problem of cellsappeared by the image condition, representative image binarization methods suchas Otsu method 2-4 or Watershed transformation 5 were improved tobrightness-invariant localization or adaptive binarization.

These methods aresimple to use without any additional parameters, but it is difficult to expectgood performance in complicated backgrounds or splitting overlapping oradjacent objects. Energy-minimization based image segmentation techniques showbetter results than the intensity-based techniques in the above-mentioneddifficult environmental conditions. ACM (Active Contour Model) 6-9 is arepresentative energy-minimization technique that generates appropriate resultson noise images based on initial points defined by a user. GC (graph cut) 10-14, another segmentation method based on energy minimization, finds a globaloptimal solution for a given initial value.

Machine learning-based methods typically show more than a certainlevel of segmentation performance in various datasets 15-19. Especially, unsupervised-learning based cell segmentation method using blob detectorproduces boundaries similar to those perceived by humans 2021. Conventional cell segmentation studies usually consist of seeddetection to find the approximate location of a cell and cell split to divide theregion. In the conventional studies, due to the structure in which the resultof seed detection affects the accuracy of cell division, precise seed detectionmust be preceded.

Furthermore, since these techniques require a large number ofparameters and the parameters should be appropriately selected depending on thetype of the target cell and the imaging condition, the segmentation results aresensitive to the parameter configuration. In this paper, we propose a cell segmentation method using a cellregion discriminator R that detects a cell region and a multi-celldiscriminator M that determines whether a cell region is divided by anExpectation-maximization algorithm (see Fig. 1). R identifies regions ofinterest for cells using linear regression analysis and features of statisticalcell imaging and distribution characteristics for image brightness. The regionof interest (ROI) is divided into two cells using expectation-maximization tothe coordinates of the detected ROI and their local maximum point coordinatefeature.

In the process of dividing the region, M determines whether tore-segment the region by finding a hyperplane for the surface error in the cellarea and the area of the segment boundary. The research has the following twocontributions.? The proposed method does not require seed detection because itdivides the cell independently of the seed detection.? Using various learning techniques trained from each image data, ROIdetection and cell division show high accuracy without changing parametersaccording to data.