EFFICIENT SPLITTING OF CELL CLUSTERS FROM 3D CONFOCAL IMAGES AND POTENTIAL APPLICATIONS IN SIMUALTION OF CELL DIVISIONS

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Introduction

Segmentation of the intact cells from 3D images of thick tissue sections is an important step in quantitative evaluation of cellular features. One of the major complications in the automatic segmentation of cellular images arises due to the fact that the cells are often closely clustered. Cluster division to isolate individual cell objects is a challenging task in the automatic segmentation of cells and cell nuclei. In this paper, an efficient 3D cluster splitting algorithm based on concavity analysis by considering the axial (z-depth) information is proposed to separate the touching or overlapping cells or nuclei.

Method

Cell contours are detected by traditional boundary detection method and is used as input image for the cluster splitting algorithm after polygonal approximation. As a first step of cluster splitting algorithm, concave points along the contour are extracted. Next step is to search for the splitting path based on certain criterions in order to connect the detected concave points in an appropriate way so as to divide the clustered cells or nuclei into individual cell or nucleus. Obviously, 2D cluster splitting algorithms developed can be applied to segment individual cells or nuclei in each 2D slices of 3D image. However, this 2D slice-by-slice based cluster splitting for a 3D volume without considering the depth (z) information may fail simply because the stacking of individually segmented 2D cells or nuclei does not necessarily form the complete 3D cells or nuclei in 3D image. For reliable cluster splitting of confocal cell images, analysis of the images is needed in 3D by considering the inter-slice connectivity. Hence in our algorithm, we proposed a two step 3D layered based split path selection. As a first step, we select an optical section, z_m, as the reference section and find the best split path between the detected concave points based on certain selection criteria. Secondly, we estimate the split path for the rest of the sections using the relationship of spatial coherence with its previous section.

Results

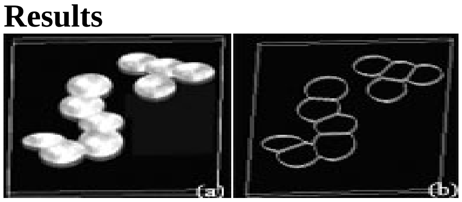

Figure 1..Illustration of the 3D cluster splitting algorithm on phantom dataset

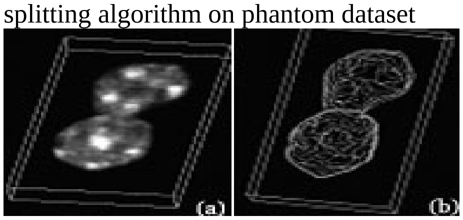

Figure 2. Illustration of the 3D cluster splitting algorithm on confocal dataset

Both 3D phantom image and 3D microscopic images are used to test the proposed algorithm. Figure 1 (a) shows a 3D projection of volume rendered stacks of phantom volume dataset with multiple cluster objects. Figure 1(b) shows the result of our proposed 3D cluster splitting algorithm. Figure 2 illustrates the results of the proposed algorithm, tested on an image stack showing nuclei in a section of mouse brain, labeled with To-Pro-3 that bleaches rapidly. Figure 2 (a) shows a 3D projection of volume rendered stacks of a To-Pro-3-labelled nuclei dataset. Figure 2(b) shows segmented nuclei which are the result of the proposed 3D cluster splitting algorithm. This research is part of the efforts to simulate the cell division process and the splitting of cell clusters will serve as a tool to generate 3D cellular models for this simulation applications.

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