The Cell-Shape-Wizard
User Guidance for Active Contour-Based Cell Segmentation

Daniela Franz¹,², H. Huettmayer¹, Marc Stamminger², Veit Wiesmann¹, Thomas Wittenberg¹
¹Fraunhofer Institute for Integrated Circuits (IIS), Erlangen
²Computer Graphics Group, University of Erlangen-Nuremberg
daniela.franz@iis.fraunhofer.de

Abstract. Cell segmentation on fluorescent micrographs requires preprocessing, cell-background separation and cell-cell separation. The presence of touching or overlapping cells requires more sophisticated segmentation methods – such as Active Contours (AC) – for cell-cell separation, but the usage and parametrization of these methods is often infeasible for users with no image processing expertise. We present the Cell-Shape-Wizard which introduces an abstraction layer between a complex AC approach and the users. It couples tight user guidance with the benefits of interactive cell segmentation of fluorescence micrographs. We have evaluated the wizard in a small user study with four subjects. Results show, that the wizard concept is well applicable to cell segmentation. Segmentation results are compared to manual reference annotations and result in a mean Jaccard index of 0.72. With the Cell-Shape-Wizard life scientist are able to segment their fluorescence micrographs semi-automatically on their own, without being forced to acquire additional knowledge in image processing.

1 Introduction

Within virology or microbiology research, fluorescent cell micrographs are often evaluated manually. This approach is error-prone, not reproducible and only a small subset of the recorded images can be assessed within limited time. Automated cell segmentation methods increase the number of evaluated images and cells and increase validity and reproducibility of fluorescence micrograph evaluation. These methods typically consist of three steps: preprocessing, cell-background and cell-cell separation. When cells touch or overlap in the micrographs, cell-cell separation requires to use model knowledge about the cell shape [1]. To integrate such model knowledge in the segmentation process we use an active contours (AC) approach, enhanced by an active shape model (ASM). Sophisticated segmentation methods, like our method, are most often quite difficult to use and the parameter adaptations do not always lead to predictable changes in the segmentation. Especially, a naive user regarding image processing methods will not be able to fine-tune the parameters [2], because there exists a
“semantic gap” between image processing methods and their life scientist users. We bridge this “semantic gap” with the Cell-Shape-Wizard based on the concepts presented in [3]. The wizard is an abstraction layer between the image processing algorithms and the user and deals with parameter adaptation through interactive corrections. It separates a complicated task into a series of steps, each easy to solve [4]. The advantages of wizard-based segmentation are a reduced orientation phase within a new software tool and increased reproducibility of segmentation results. The disadvantage is a reduced flexibility, as the task’s structure and parameters are hidden. For our application scenario – cell segmentation tasks performed by life scientist – this is no disadvantage, because users are mainly interested in a correct, easy and quick solution. The Cell-Shape wizard uses cell nuclei as seed points for an initial cell segmentation on the cytoplasm and refines it with an ASM-supported AC approach.

In literature only a few cell segmentation tools provide explicit user guidance. The users of CellProfiler [5] design their own image processing pipelines from modules. A “help button” for each parameter describes the parameter and related guidelines for the adjustment of the parameter. MiToBo is a plugin for ImageJ and guides the user by grouping functionalities due to cell segmentation applications [6]. Both tools provide a high amount of functionality and wizards for parameter tuning or a problem oriented menu structure. In contrast to that, the presented Cell-Shape-Wizard is deliberately restricted in functionality and flexibility and tightly guides the user through a cell segmentation task.

2 Methods and materials

In the next section we give a brief overview of the used segmentation methods and their integration into the Cell-Shape-Wizard. Afterwards, we describe the used fluorescence micrographs and introduce our initial user study.

2.1 Segmentation approach

We enhance an AC approach with model knowledge from an ASM. The standard AC minimizes the energy function

$E_{AC} = k_{int}E_{int} + k_{ext}E_{ext}$

where the internal energy $E_{int}$ is influenced by features of the contour, like contour and curvature energy, and the external energy $E_{ext}$ is influenced by image features, such as edges [7]. We extend the standard AC cell segmentation pipeline with an energy term from an ASM.

$E_{AC} = k_{int1}E_{Contour} + k_{int2}E_{Curvature} + k_{ext1}E_{Edge} + k_{ext2}E_{ASM}$

$E_{Contour}$ and $E_{Curvature}$ are internal energies. The contour energy $E_{Contour}$ directs the AC to a smaller shape, the curvature energy $E_{Curvature}$ directs the AC to a more round shape. $E_{Edge}$ and $E_{ASM}$ are external energies. $E_{Edge}$ directs the AC towards image edges and $E_{ASM}$ directs the AC towards the ASM mean shape weighted with ASM model variances.