BLOOD CELL SEGMENTATION USING MINIMUM AREA WATERSHED AND CIRCLE RADON TRANSFORMATIONS

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Abstract In this study, a segmentation method is presented for the images of microscopic peripheral blood which mainly contain red blood cells, some of which contain parasites, and some white blood cells. The method uses several operators based on mathematical morphology. The cell area information which is estimated using the area granulometry (area pattern spectrum) is used for several steps in the method. A modified version of the original watershed algorithm [31] called minimum area watershed transform is developed and employed as an initial segmentation operator. The circle Radon transform is applied to the labelled regions to locate the cell centers (markers). The final result is produced by applying the original marker controlled watershed transform to the Radon transform output with its markers obtained from the regional maxima. The proposed method can be applied to similar blob object segmentation problems by adapting red blood cell characteristics for the new blob objects. The method has been tested on a benchmark set and scored a successful correct segmentation rate of 95.40%.

Keywords: Blood cell, watershed, area granulometry, minimum area watershed transform (MAWT), circle Radon Transform (CRT)

Introduction

The first step in a computerized microscopic blood cell image analysis system is segmentation. The blood cells have to be segmented into separate regions for further analysis. The term "blood cell segmentation" has been used to refer to different notions in the literature. In white blood cell (WBC) segmentation papers [32], [15], [21], "blood cell segmentation" tends to refer to the localization of white blood cells and segmentation of the white blood cell body into the structures such as cytoplasm and nucleus. As opposed to this, here "the blood cell segmentation" refers to the segmentation of an image of

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mainly red blood cells (RBC) into separate labelled regions each representing an individual blood cell for further analysis.

Some methods exist which are directly related to the red blood cell segmentation as described in this paper [7], [6], [24], [22], [4], [2]. Several techniques have been proposed for segmentation and preventing under-segmentation: granulometries and regional extrema analysis [7], [6] distance transform and area tophats [24], [22], Bayesian colour segmentation and watershed segmentation improved by discrete chamfer distance [4]. However, most of the studies do not provide evaluation of the segmentation performance nor do they solve the under-segmentation problem completely. Hence, the under-segmentation remains a problem in blood cell segmentation. In blob segmentation, a common technique to reduce under-segmented regions is to utilize the distance transform on the binary image [24]. However, we observed that this approach also produces over-segmented regions when dividing the under-segmented regions.

Here, we develop a blood cell segmentation method using the watershed transformation [31] and the Radon transformation [28]. The method employs the watershed transformation in two different stages. First, we introduce the minimum area watershed transform (MAWT) to obtain an initial segmentation. After extracting markers from this segmentation using the circle Radon transformation, a marker-controlled watershed transformation [26] is applied to the Radon transformed image to obtain a new final segmentation. Most of the steps in the proposed method use blood cell radius (or area) as an attribute. The radius and the area are estimated using area granulometry (area pattern spectrum) [23]. Furthermore, a benchmark set has been prepared manually for evaluating segmentation performance. The proposed algorithm and an earlier algorithm proposed by Rao *et.al.* [24], [22] are compared by testing on the same benchmark set.

In section 2 the method will be explained in details. In section 3 the experimental method will be explained and a comparison table given for the evaluated segmentation performances. Concluding remarks and discussions are given in the last section.

1. Method

The proposed method will be explained in three major steps. The first step is the estimation of the cell area and radius. Next, the input image will be roughly segmented by applying a constrained watershed transform on the morphological gradient [25] using this area information. The output of this rough segmentation does not eliminate background regions which do not contain cells and includes under-segmented regions which contain more than one cell. The background regions will be eliminated by a morphological thresholding tech-