Università degli Studi di Cagliari

FACOLTÀ DI SCIENZE
Corso di Laurea Magistrale in Informatica

White blood cells segmentation using Vector Field Convolution

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Anno Accademico 2016-2017

To my family

Contents

Introduction

Blood is a body fluid deliver. It's contains an transport many of the nutrients substances that the man and the other animals use to live. That we call blood is principally a fluid divided in two elements: blood cells and blood plasma. Normally an individual has around 5 Litre of blood. The plasma blood constitutes the 55% of the total fluid. it is mostly water(92% by volume) and contains proteins, glucose, mineral ions, hormones and blood cells themselves.[3] Mainly the cells are red blood cells and white blood cells(WBCs). In this dissertation we going to focus on WBC especially we will study the shape of these last. White blood cells, also called leukocytes , are the cells with the task of controlling the body against both infectious disease and foreign invaders. All leukocytes have a nuclei that distinguishes them by other blood cells, in particular red blood cells and platelets. The generic term leukocytes includes very different cells population: neutrophil, granulocytes, basophilic granulocytes and eosinophilic granulocytes. This set of three categories is defined as polymorphonucleated granulocytes. The other set that includes monocytes and lymphocytes is defined agranulocytes mononuclear. In a nutshell leukocytes are dived in these two sets by the nuclei shape.1

White blood cells segmentation

Segment an image means divide an image in regions of interest. It's used to obtain a more compact image used to extract objects or to analyse an image. In this case the main feature is to find edges and white blood cells nuclei. At a first look seems a banal problem, because the we think that every single cell is strongly separated by the others, but obviously it is the best case that we can find. Commonly the microscope photos that we analyse contains noise and in particular the leukocytes overlaps both others leukocytes and red blood cells. For these reasons segment leukocytes is still an unresolved problem. As explain above there are 2 class of leukocytes that are dissimilar by the nuclei shape. this is an high problem because if the solution to find all the white blood cells was based on the search of circular shapes, it's trivial that it will be impossible to recognize a granulocytic from a monocyte.

There are a lot of heuristics and approaches that try to divide and classify

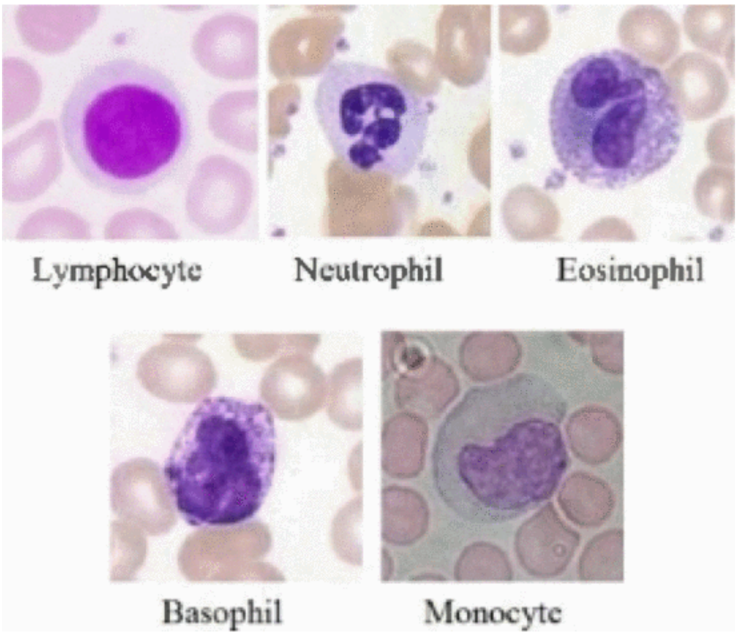

Figure 1: Example of the different kind of leukocytes[2]

white blood cells. This dissertation proposes a new approach of pure segmentation using the Vector Field Convolution, in particular tries to find a division between the overlaps between the cells. We choose this kind of field because the common practice to extract the features by the images utilizes thresholds, but what happens if the image has a low definition and all the cells are in overlap with their? Using that field to describe the image is possible to transcend by the shape of the features and focus themselves on the points that have a non-uniform virtual field. This technique then considers only the points that describe the edges of the white blood cells. After the image elaboration the result is an image that contains only leukocytes and when it is necessary dividing every kind of cells. With this result we can label every cell without human work.

Part I

Background

Chapter 1

Gold standard

1.1 Section

Part II

A title to summarize your contribution

Chapter 2

An overview about vector fields

Active contours, also called snakes, are curves that move inside the image following the energy of the field. There are two kinds of forces, one internal and anther external. Combining these two it's possible to create a curve that follows constraints gives by the forces. The internal and external forces are defined so that the snake will conform to an object boundary or other desired features within an image. Snakes are widely used in many applications, including edge detection, shape modelling and segmentation. There are two general types of active contour models in the literature today: parametric active contours and geometric active contours. Typically, the curves are drawn toward the edges by potential forces, which are defined to be the negative gradient of a potential function. Additional forces, such as pressure forces, together with the potential forces comprise the external forces. There are also internal forces designed to hold the curve together and to keep it from bending too much. There are two levels difficulties with active contour algorithms. First, the initial contour must be close to the true boundary or else it will likely converge to the wrong result. The second problem is that active contours have difficulties progressing into concave boundary regions. Although many methods such as multi resolution methods, pressure forces, distance potential forces, control points, and using solenoidal external fields have been proposed they either solve one problem or solve both but creating new difficulties. For example, multi resolution methods have addressed the issue of initialization, but specifying how the snake should move across different resolutions remains problematic. Another example is that of pressure forces, which can push an active contour into boundary concavities, but cannot be too strong or "weak" edges will be overwhelmed. But how works a snake if the objects to segment are overlapped? Snakes are able to find all the external edges of the object but in this case the edge can be consider an internal part of the object. With the active contours is impossible segment the overlapped cells because the snake cannot enter inside the cell region. For these reason we have used our virtual field following another lecture key.

2.1 Vector field convolution

Convolving a vector field with the edge of the map derived from the image you get an external force, the VFC. Active contours using the VFC external force are called VFC snakes. Like the GVF snakes instead of being Formulated using the standard energy minimization framework, VFC snakes are constructed from a state of equilibrium between the forces. The VFC snakes besides having a wide capture range and the ability to capture the concavities, are better resistant to noise image, have the ability to adapt the force field and reduce drastically the computational cost. Before to explain the VFC is right explain the vector field kernel

$$k(x, y) = m(x, y)n(x, y) \tag{2.1}$$

where n is the unit vector that points to the origin of the kernel

$$n(x, y) = [\frac{-x}{r}, \frac{-y}{r}] \tag{2.2}$$

and m is the magnitude of the vector . The authors of the VFC implemented two kind of magnitude. If we consider the origin as the point of interest, this vector field kernel has the desirable property that a free particle placed in the field is able to move to the point of interest. The external force that work in the VFC is defined in this way:

$$f_{vfc}(x, y) = u_{vfc}(x, y), v_{vfc}(x, y) \tag{2.3}$$

Since the map of the edge is non-negative and is wider near the edges of the image, the edges act to a greater extent on the VFC than homogeneous regions. Therefore, the free particles of homogeneous regions will be attracted to the edges. If we present the vector field kernel using a complex-valued range, the VFC is just the filtering result of the edge map, which does not depend on the origin of the kernel. The VFC field highly depends on the magnitude of the vector field kernel . Field VFC has the magnitude directly proportional to the vector field kernel (x, y). Knowing that the figure of interest has less influence on the particles away from it, the magnitude must be expressed as a positive function decreasing with respect to the distance of the origin. Below are propose two types of magnitude functions, given as

$$m_1(x, y) = (r + \epsilon)^{-\gamma} \tag{2.4}$$

$$m_2(x, y) = exp(-r^2\,\zeta^2) \tag{2.5}$$

where γ and ζ are positive parameters to control the decrease, ϵ is a small positive constant to prevent division by zero at the origin. $m_1(x, y)$ is inspired by Newton's law of universal gravitation in physics. Furthermore, the pixels in the edge map can be considered as objects of mass proportional to the strength of the edges and the field VFC would be the gravitational field generated by all objects. The influence of the figure of interest increases as γ decreases. In practice γ usually ranges from 1.5 to 3 for most images. $m_2(x, y)$ is a Gaussian shape function, where ζ can be viewed as the standard deviation. The influence of the figure of interest increases as ζ increases. In general, the influence of the figure of interest should be increased (decrease or increase) as the signal-to-noise ratio is decreased.[1]

2.2 New kind approach to segment leukocytes

Appendices

Appendix A

Appendix chapter

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A.1 Section

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Bibliography

[1] Scott T. Bing Li. "Active Contour External Force Using Vector Field Convolution for Image Segmentation". In: *Acton* (2007) (cit. on p. 11).

[2] Nikhil Vadera Shubham Manik Lalit Mohan Saini. "Counting and classification of white blood cell using Artificial Neural Network (ANN)". In: *IEEE* (2017) (cit. on p. 2).

[3] Wikipedia. *Blood*. 2007. URL: `https://en.wikipedia.org/wiki/Blood` (cit. on p. 1).