THYROID CELLS EXTRACTION USING NEW COMPONENTWISE HISTOGRAM TECHNIQUE

Belotserkovsky A.M., Ablameyko S.V.

United Institute of Informatics Problems, National Academy of Sciences of Belarus, Surganov str, 6, Minsk 220012, Belarus. Emails: abelotser@newman.bas-net.by, abl@newman.bas-net.by

Abstract. New hierarchical componentwise technique described here is based on profile-analysis of thyroid cell images of different classes, hue and saturation histogram thresholding and applied to process these images. The results obtained by using such a method allow to contour more clearly the lymphocytes, thyrocytes and aggregates.

Introduction

The most difficult task in medical image (cytological or histological) analysis is the automatic cell extraction and its classification (e.g. cells or cell nuclei of thyroid glands). At present time color images are used very often by medical specialists, the segmentation of these images is not a trivial job. Besides that even images of same nature or images of similar objects in medical sense may be divided into several different classes [1]. The result of processing of cytological or histological images depends in many respects on electronic microscope resolution, preparatory work quality concerned with colorant admixing to material under consideration and so on, at last it depends on type of objects to be extracted (cell nuclei, aggregates) [2]. The attempt to find an optimal solution by hs-profile analyzing and farther new segmentation method applying was made and described in this paper. The proposed color image segmentation method based on hierarchical componentwise histogram processing in HSB color space.

Biomedical Objects Extraction

Contouring operation prefixed with image segmentation is used in cytological images analyzers [3,4]. Extracted object vector description receiving is not proposed in this paper although it is also very important part in whole diagnostic process. There are already exist good-working methods of point coordinates getting (contouring) by processing binary images [5,6], and the result of segmentation step is exactly to get the binary raster.

The developed segmentation methods can be roughly divided into the eight groups [7]. The more often used approaches are based on thresholding, morphological operations and edge detection operations. Another quite big group of algorithms is based on snakes and Hough transform. And the third group of approaches that are quite rare used is based on Neural networks and Fourier transform. Many new developed algorithms are based on combination of the thresholding, edge detection, thinning and etc. A substantial part of cell image segmentation process can be built up with a suitable combination of them even in case of color images. Object characteristics, color characteristics histograms and new color spaces or combination of existed ones are used in color image segmentation [8]. The most popular problem encountered in raster biomedical analyzers is the necessity of binary image grinding and trash-pixels removing in manual mode. Another specific problem is the nonautomated mode of aggregates extraction.

HSB-histogram Segmentation Technique

Color image profile-analysis. Taking into account all advantages of HSB-family spaces it is useful to make a preliminary analysis of three classes of cytological thyroid cells images [1]. Going farther we change the original test images by increasing the value of brightness and analyze both hue and saturation components. Original grb-profile and new hue and saturation profiles of fragment of first class specimen are shown on Fig. 1. The profiles are built along the left-to-right path (the central horizontal scan-line of the fragment) and the hue values are normalized to compare with rgb-profile conveniently. The saturation values are situated in [0;1] interval by definition of this characteristic. Perturbances in object places are clearly seen on the hue-profile and the result will never depend on shade or shadow "places" on object pixels. Fig. l,e illustrates the result of brightness incrementing although this example shows that using hue gives us better results. In view of this fact hue and saturation components are used in our segmentation technique without negative influence to each other. Moreover combination of these characteristics in described way brings to us much better results in other images.

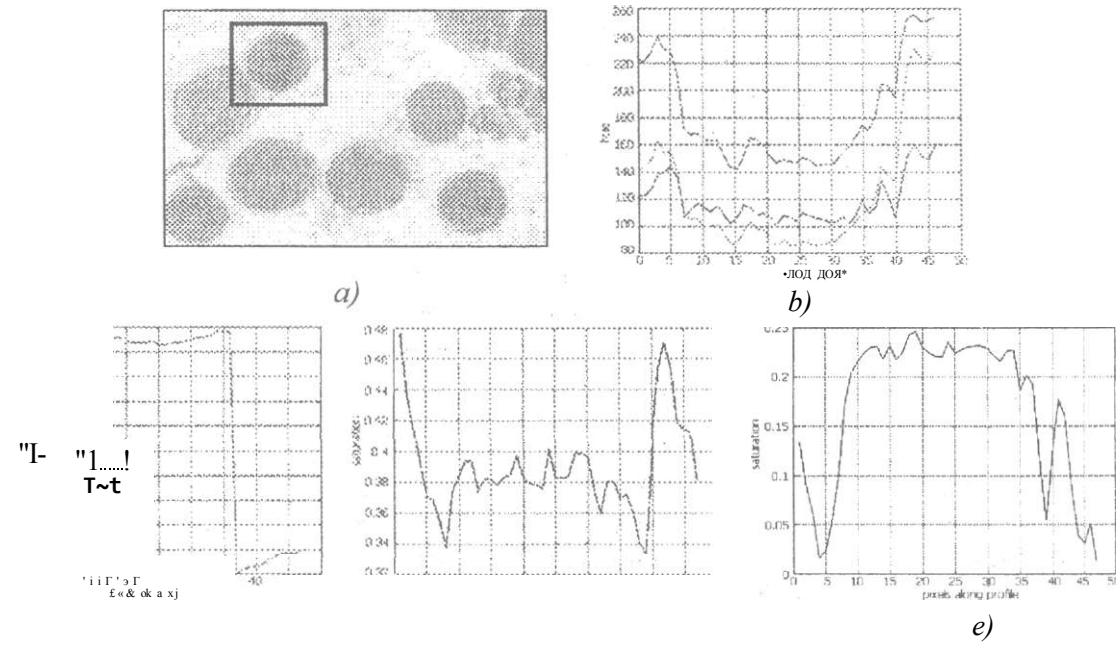


Fig. 1. Profile-analysis of first-class image: a) original image; b) rgb-profile before brightness incrementing c) hue-profile before brightness incrementing; d) saturation-profile after brightness incrementing

Fig.2 depicts the behavior of hue and saturation of second-class thyroid cell nuclei images depending on whether brightness is incremented or not. In such way saturation-profile shown on Fig2,d has less nonzero values that profile on Fig2,c. It is useful for farther statistical processing. This case illustrates that saturation information is quite enough to extract nucleus but not enough to entrap all the aggregate. So we insist that some more statistical information which can be brought to us by the simple hue and modificated hue histograms.

There is an example of thyroid cell images of third class on Fig.3,a. The framed area of this image captured a fragment of interesting cell aggregate and along standing nuclei

out of interest. As one can see from the profile shown on Fig.3,d the saturation after brightness incrementing is less sensitive than before incrementing (Fig.3,d). Thus it gives a chance to extract more clearly the area of interest by thresholding the saturation histogram and than using the most "saturated" pixels with their hue values since thresholding hue histogram only would give much pure results (Fig.3,b).

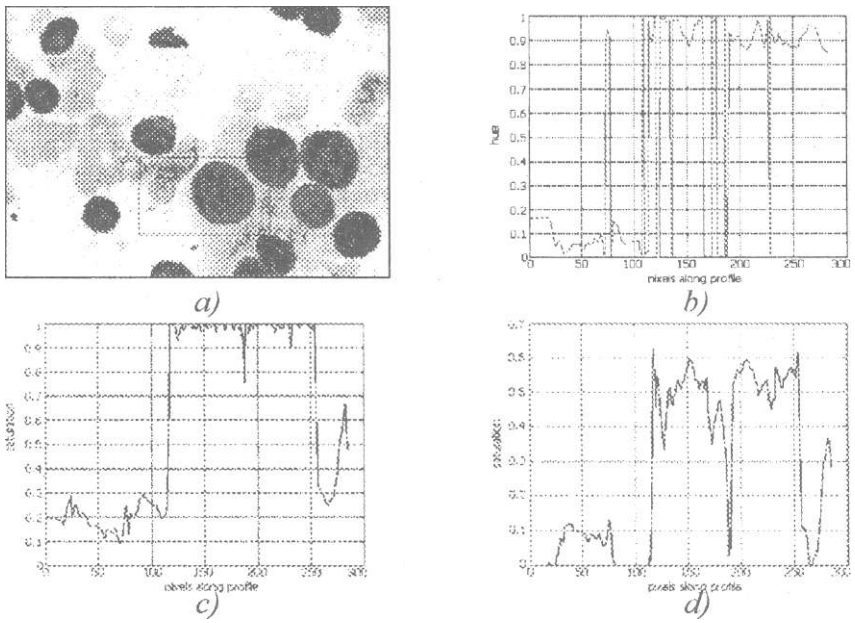


Fig. 2. Profile-analysis of second class image: a) original image; b) hue-profile after brightness incrementing c) saturation-profile before brightness incrementing; d) saturation-profile after brightness incrementing

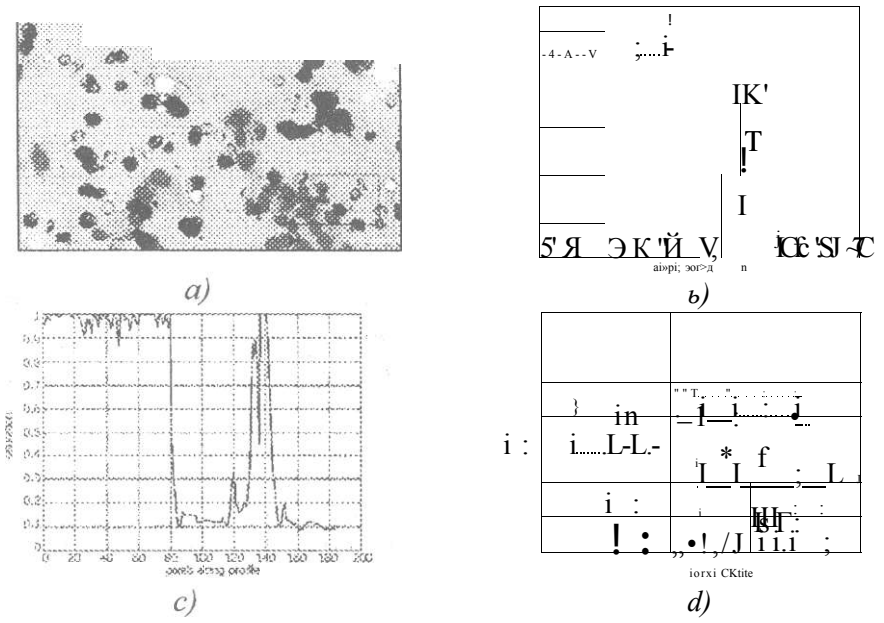


Fig.3. Profile-analysis of third class image: a) original image; b) hue-profile after brightness incrementing c) saturation-profile before brightness incrementing; d) saturation-profile after brightness incrementing

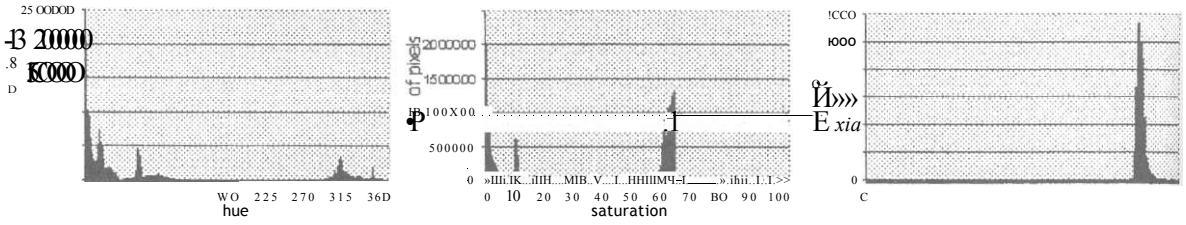
Segmentation algorithm description. According to our profile-analysis and farther supposing about using the hue and saturation histograms and hue histogram for "saturated" pixels, the first step of the segmentation algorithm is the intensity values increasing until the brightness become equal 100%. In order to find out the enlarging value for pixel intensity one may build hue histogram or hue-profile, consider pixels possibly belonged to an object region and then determine the enlarging value. In our case the value equal to 100 had been set for the reason of simplifying the segmentation process. This value we add to each of R, G and B components. The saturation histogram after applying this procedure shown on Fig.4,b. Assuming that object pixels are the most "saturated", we can build another one hue-histogram for such pixels (Fig.3,c). Histogram for the most "saturated" pixels that are presumably the object pixels is build satisfying following condition:

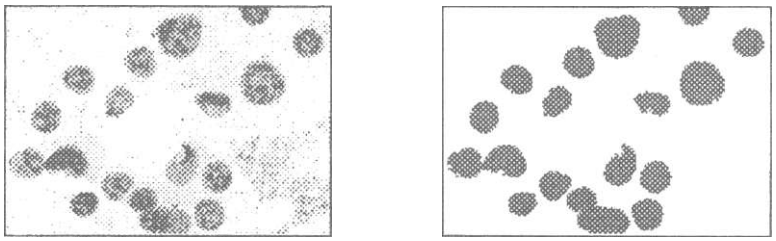
$$HueHist^{m} = \sum_{i=0}^{M} \sum_{j=0}^{N} H_{ij}, \quad if \quad S_{ij} = Sat^{thresh}, \qquad (1)$$

where :

Hu and S_{ij} - hue and saturation values of current pixel (i,j) of image MxN;

Sat^{thresh} the very right threshold value extracted the very right peak on saturation histogram.





d) e)

Fig. 4. Histogram analysis and segrrientation results: a) original image hue histogram; b) saturation histogram after brightness increment; c) hue histogram for "saturated" pixels (modificated hue histogram); d) original image; e) segmented image

So the last stage of the segmentation process now looks quite simple - last modificated histogram thresholding considering that all peak pixels of hue histogram must compose peaks on new modified hue histogram after intensity increment. We can represent the initial image as a region assemblage with following fragmentation:

$$p\_\_\_\_I\ p\ background \quad p\ object\_\_\_\_\_p\ HueHist \ \hat{}\ p\ HueHist^{m} \ \backslash \qquad \hat{}\ \hat{}$$

where:

piwckgioumJ _ c|ass pj xc|s belonged not to objects (background);

p Hm Hisi p/hu Hist _ c|ass 0f pixels composing peaks on original and modificated hue histogram, respectively.

Summarizing all aforesaid the proposed segmentation algorithm consists of following steps:

1. Pixel intensity increasing and RGB-HSB transformation;
2. Hue and saturation histogram building and thresholding;
3. Saturated pixels finding and modificated hue histogram building;
4. Histogram thresholding and image segments generating.

Conclusion

New hierarchical componentwise technique described here is based on profile-analysis of thyroid cell images of different classes and applied to these images. The results obtained by using such a method allow to contour more clearly the objects of interest (lymphocytes, thyrocytes or aggregates) and to make the farther vector description. Although the proposed algorithm can process different classes of images mentioned above with positive result it is still not a universal remedy for other images and may brings to us poor results due to difficult specific visual object recognition on some images. The main positive feature of the algorithm is the short processing time irrespective of images class due to simple algorithm procedures.

This work was partly supported by INTAS project 00-626.

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