Australian Journal of Basic and Applied Sciences, 8(18) December 2014, Pages: 283-287

AENSI Journals

Australian Journal of Basic and Applied Sciences

ISSN:1991-8178

Journal home page: www.ajbasweb.com

Automatic Cervical Image Segmentation using Arithmetic and Threshold Concept

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ARTICLE INFO

Article history:
Received 19 August 2014
Received in revised form
19 September 2014
Accepted 29 September 2014
Available online 3 December 2014

Keywords:
Cell segmentation, thresholding, localization, histogram equalization, filter, contrast stretching.

ABSTRACT

Cell segmentation is a challenging problem due to both the complex nature of the cells and uncertainty present in cervical image. Cell segmentation is very important in clinical and laboratory test. The nucleus features are used to identify the type of the cell in most of the case. The traditional morphology test that is done by a hematology expert to look at the cell under the microscope is a time consuming and tedious jobs. Thus, we require automated methods for doing such kind of task in efficient way. In this paper, a novel method is proposed to segment the nucleus and cytoplasm automatically using arithmetic and automatic thresholding method. In this, first the localization of the cell nucleus is carried out based on automatic contrast stretching, histogram equalization and image arithmetic operation. Next, the image is segmented using global thresholding method. Finally minimum filter is applied on the segmented image to increase the intensity value of the nucleus. The experimental results showed that the proposed method provides the accuracy up to 98% .

To Cite This Article: S.AnanthaSivaprakasam and Dr. E.R.Naganathan., Automatic Cervical Image Segmentation using Arithmetic and Threshold Concept. ***Aust. J. Basic & Appl. Sci.,*** *8(18): 283-287, 2014*

INTRODUCTION

The primary aim of image segmentation is to extract the significant objects presented in the image either by partitioning the image into connected semantic regions or by extraction of one or more specific objects from the image (Kies, K .and N. Benamrane, 2008). Medical images are considered to be one of the most important tools and techniques used for many clinical diagnosis and decision making. Even though number of segmentation methods is in the field, still it is a challenging area because of intrinsic nature of the cell. Hence, we need automatic segmentation system that can make the segmentation easier and faster and the amount of the data that can be analyzed is more than what the clinician can handle. The main object of medical image processing and analysis is to collect useful information about the region of interest in the image, extract statistical measurement that can lead to early, accurate diagnosis, hence cost-saving an providing better monitoring and evaluation in the progress of the treatment. In medical image processing, the segmentation is the process of identifying regions or image that have common properties and segregating the regions that are similar and dissimilar. The segmentation process is critical because the result from this step serves as basis for all subsequent analyses, such as extraction of the shape of nucleus and cytoplasm. Cell segmentation is also one of the most challenging problem due to complex biological nature of the cell and technical problem that are caused by staining method. Anoraganingrum (1999) described the cell segmentation with median filtering and mathematical morphology. Even though the staining method is a simple procedure, but it could easily fail or be less effective and poor resolution of image acquired using different camera specification. Segmentation can be categorized into supervised and un-supervised method. Different segmentation methods namely, threshold based, edge based, region based and clustering based such as K-means, and Fuzzy-c-means etc. were developed. Giridhar Akula et..al .(2007) described the enhanced procedure for image segmentation and smoothing.

Ostu (1979) developed threshold method in which the threshold was selected with simple recursive methods derived from maximizing the interclass variance between gray, dark and bright regions. Cseke (1992) used the mathematical morphology to segment and smooth the region of interest. This technique produced 90% accuracy. The edge detection methods poorly perform on the cell image because of not all cell details is sharp. So it is difficult to get the edge information and locate the cell exactly. Piuri and Scotti (2004) developed the edge detection methods which performed well on cell image if contrast between background and the gray internal of membrane of the cell is stretched using contrast stretching filter.

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A new edge operator was defined by Kumar *et al* (2002) to highlight the nucleus boundary, which is very effective segment the nuclei from cell images. Normally, the cytoplasm boundary is more complex. So it is not possible to extract the cytoplasm region using this method. Kumar *et al*. used simple morphological method to segment the cytoplasm from the background and Red Blood Cell which required some assumptions that may be untenable in many cases. Jiang *et al*. (2003) developed a novel white blood cell segmentation method by means of joining two techniques, such as, Scale space filtering and watershed clustering which effectively avoid problems due to spatial variety and complexity in image space. In this, two component of WBC, nucleus and cytoplasm are extracted respectively using different methods. First, a sub image containing WBC is separate from the cell image. Then, the scale space filtering is applied to extract the nucleus region from the sub image. Later, watershed clustering in 3-D HSV histogram is applied to extract cytoplasm region. Finally, morphological operations are performed to obtain the entire connective scheme successfully. Dr. E.R.Naganathan *et al* (2013).developed enhanced colour image segmentation on cervical cytology image in which first the image was enhanced using de-correlation method and then the image was segmented using K-means algorithms. In this method, the over segmentation cannot be fully eradicated. Krishna Priya (2011) described Fuzzy-c-means method for Colour Image Segmentation with L*u*v colour transformation. The computation time of fuzzy-c-means segmentation is always high. This paper described the automatic segmentation of cervical image using arithmetic and thresholding method. In this paper segmentation is carried out by means of combining the automatic contrast stretching, histogram equalization and image arithmetic operation, global thresholding and minimum filter.

MATERIALS AND METHODS

Contrast Stretching:

Contrast is referred as the difference in gray levels or luminance values over some areas of the image. Low contrast images can be created because of poor illumination, lack of dynamic range in the imaging sensor, or even wrong setting of a lens aperture during image acquisition. Contrast stretching, simple image enhancement technique improves the contrast in an image by `stretching' the range of intensity values it contains to span a desired range of values, e.g. the full range of pixel values that the image type allows. In the contrast enhancement technique, linear or non-linear scaling transform is applied to obtain a new modified image.

Linear Contrast Stretching:

The linear contrast stretching (Salem Saleh Al-amri, *et al*. 2010) linearly expands the original digital values of the remotely sensed data into a new distribution. By expanding the original input values of the image, the total range of sensitivity of the display device can be utilized. It obviously makes slight variation within the data. These types of enhancements are more suitable to remotely sensed images with Gaussian or near-Gaussian histograms, meaning, all the brightness values fall within a narrow range of the histogram.

Adaptive Histogram Equalization (AHE):

It is a more advanced version of histogram equalization. This algorithm divides the image into smaller tiles, applies histogram equalization to each title, and then interpolates the results. It is suitable for improving the local contrast of an image and brings out more detail.

AHE Algorithm:

```
for each (x,y) in image
{  rank =0;
for each (i,j) in contextual region of (x,y)
{ if image[x,y]  > image [i,j] then
  rank = rank +1
}
Output[x.y] = rank*max_intensity
}
```

Proposed Method:

This paper introduces the simple and novel method to extract the nucleuses from the cytoplasm. In this, first localization of the cell nucleus is carried out based on automatic contrast stretching, histogram equalization and image arithmetic operation. Next, the image is segmented using global threshold method. Finally, minimum filter is applied on the segmented image to increase the intensity value of the nucleus.

At the beginning, RGB image is converted into grayscale image so that the nucleus part of the cell will appear as the darkest past of the image. Then first copy of the image will be enhanced with a linear contrast stretching (referred as L) and another copy will be enhanced with histogram equalization (referred as H). The result from L is added to the resultant image from H to form R1 that is specified in the equation 1.

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$$R1(i,j) = L(i,j) + H(i,j) \quad (1)$$

By doing the image addition the entire resultant pixel which intensity value is greater than 255, is truncated to 255 which brighten most of the details of the image except nucleus. Then it is essential to highlight all the objects and its border in the image including nucleus. For doing this, H ie. Histogram equalized image, is subtracted from the R1 to form R2 which is specified in the equation 2.

$$R2(i,j) = R1(i,j) – H(i,j) \quad (2)$$

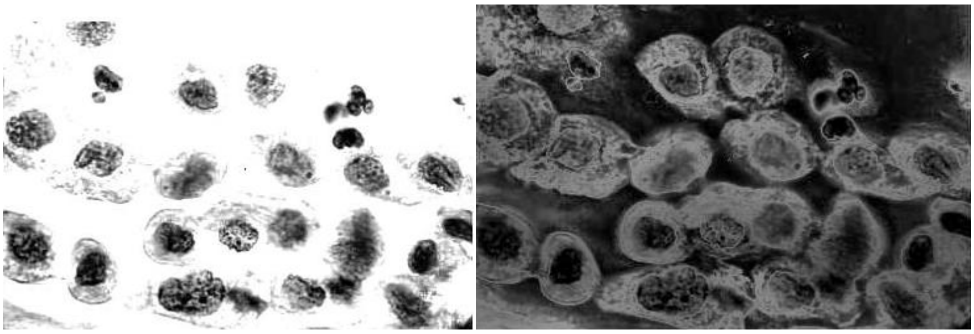

Fig. 1: a) R1b) R2.

Next task is to remove all other components except nucleus with minimum effect of distortion on the nucleus. By doing this, R1 is added with R2 to form R3 which is specified in the equation 3.

$$R3(i,j) = R1(i,j)+R2(i,j) \quad (3)$$

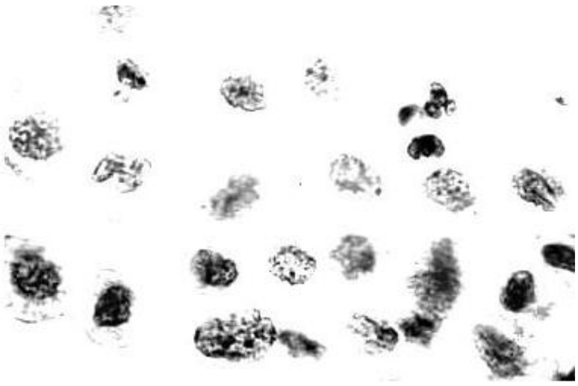

Fig. 2: Result R3 on a image.

After this operation is completed, a global threshold using Otsu's method is applied to segment the image. At this stage, due to automatic threshold, one problem is arised that will lead to miss-segmentation of some part of the nucleus because of distortion occurred due to last arithmetic operation. To avoid this problem, a [3 by 3] minimum filter is applied to increase the intensity value of nucleus . Finally, in order to remove the small groups the morphological opening is applied on the image.

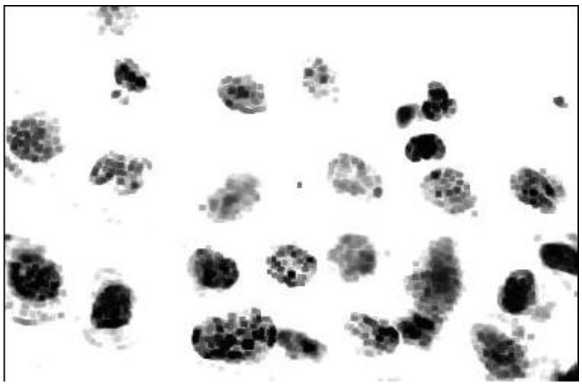

Fig. 3: After applying the minimum filter.

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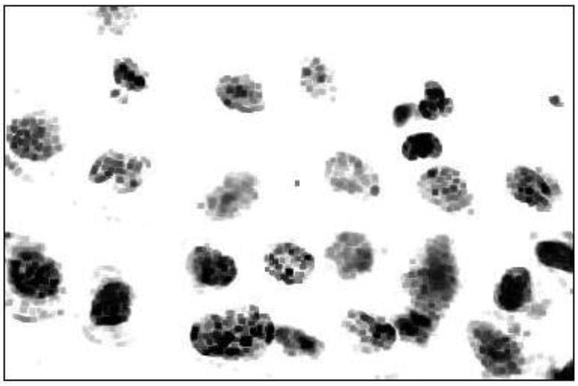

Fig. 4: After applying the automatic thresholding.

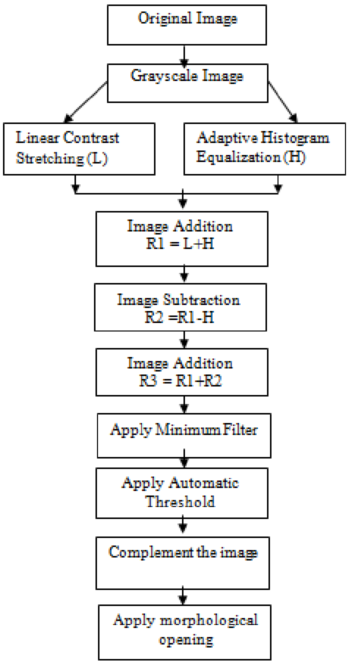

Fig. 5: The basic structure of the proposed method.

Results:

The proposed algorithm has been executed on a set of images. The algorithm tests grayscale images. In this paper, the image is first localized, arithmetic operation is applied and minimum filter is applied. Then global threshold method is applied and finally image opening operation is carried out for removing the small groupds This system was developed using Matlab V7.10.

Fig. 6: a) Original Image b) Original image with white spot c) Final Segmented Image over the nucleus.

Conclusion:

The prominent aspect of this method is the ability to find all nucleated cells in the image and remove all the remaining components. The main issues in the system are to perfectly localize the nucleus and distinguish from other components. The nucleus information can give the valuable information about whether nucleus is normal or abnormal. We used cervical image in Jpg format. In this, first localization is performed on the image in order to remove all other components except nucleus. Then, the arithmetic operations are carried out based on the linear contrast stretching and histogram equalization. In order to make nucleus natural look, minimum filter is applied. To segment only the nucleus, the global threshold technique is applied. Finally, morphological opening is applied for removing the small groups. This method produces 98% accuracy in segmenting the nucleus. Future work may be extended to count the number of nucleus and classify the nucleus as normal and abnormal cell.

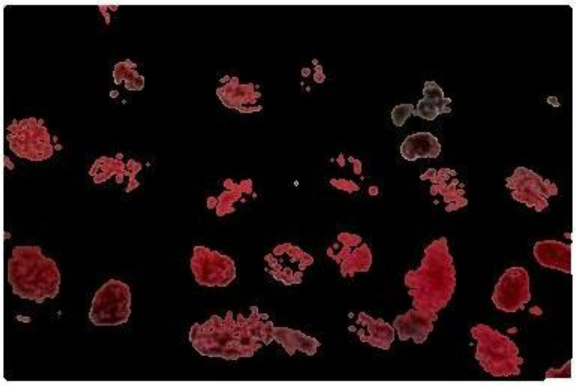

Fig. 7: Final Segmented image after superimposing.

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