Research on the Segmentation Method of Micro Algae Image

Xianjiu Guo [1] Haiying Liu[2] Fengjiao Jiang[3]
[1,3] School of Information and Engineering, [2] School of Ocean Engineering,
Dalian Ocean University, Dalian, Liaoning, China,116023.

Abstract

According to the feature of micro algae, a segmentation method of micro algae image is presented in the paper. The method includes image de-noising, image enhancement, edge extraction, dilation and erosion etc. The experiments demonstrate that the method presented in the paper can segment the micro algae image effectively.

Keywords: micro algae, Micro algae image, Image segmentation

1 Introduction

Micro algae occupy an important position in ocean. Micro algae not only provide food resource for marine organisms but also reflect the status of eutrophication of waters in ocean and the level of water pollution. So the number of sorts of micro algae and the quantity of micro algae are regarded widely as the important indicator for detection of ocean ecological environment and evaluation of water pollution in many countries. Presently the micro algae is distinguished, classified and counted under a microscope by professional staff. This needs heavy workload and the speed is slow. In the area of spatial and temporal scale investigation of ecological environment, these need consuming a large amount of manpower, resources, time and financial resources. The forecast of ocean ecological environment will be significance if real-time images of micro algae can be extracted, the number of sorts of micro algae and the quantity of micro algae can be made clearly, and the early monitoring of the development of the algae can be performed [1, 2].

Micro algae are small, the sizes of algae are from a few to hundreds microns, so more of them can be seen under microscope. The morphostructures of the micro algae are simple and the opacity is evident. Almost all images gained by microscope and digital camera possess defects, such as dark background, weak contrast, vague edges and noise pollution etc. All the defects mentioned above bring difficulties to image processing. A segmentation method of micro algae image is presented in the paper. The method includes image de-nosing, image enhancement, edge extraction, dilation and erosion etc. The work in the paper makes a foundation for the next statistics and identify of marine micro algae.

The paper is divided as follows. Section 2 gives the framework of image preprocessing. It includes image de-noising and image enhancing. Section 3 gives the detail content about image segmentation. It includes edge extraction of micro algae image, dilation and erosion of micro algae image. In section 4 some experimental results are presented. Section 5 is the conclusion of this paper.

2 Image Preprocessing

2.1 Image de-noising

In the paper Donoho and Johnstone's wavelet shrinkage method are used for image de-noising. The basic principle of this method is as follows. The wavelet transform is added on the initial signal at first. Then the threshold shrinkage methods are used on the coefficients of wavelet. Finally the inverse transform are performed at the changed signal. The hard threshold function and the soft threshold function of this method are described as below [3, 4]:

$$d_{ji} = \begin{cases} d_{ji} & if \quad \left| d_{ji} \right| > \lambda \\ 0 & otherwise \end{cases} \tag{1}$$

$$d_{j,i} = \begin{cases} d_{j,i} - \lambda & if \quad d_{j,i} \geq \lambda \\ 0 & if \quad \left| d_{j,i} \right| < \lambda \\ d_{j,i} + \lambda & if \quad d_{j,i} \leq -\lambda \end{cases} \tag{2}$$

In the formula $d_{j,i}$ represents the i-th wavelet coefficients of the j-th layer, the threshold $\lambda = \sigma\sqrt{2 \log N}$ occurs, N represents the number of the sample and σ is the value of the standard deviation of estimation. In the process of de-noising, the choice of the threshold is the key and the Stein unbiased likelihood estimation of threshold is used in the paper. By this algorithm the squares of wavelet coefficient at some layer are arranged according to the decrease in size. The vector gained by the algorithm is

$$P = \{P_1, P_2, \cdots, P_N\}$$

The parameters satisfy $P_1 \leq P_2 \leq \cdots \leq P_N$. The parameter N represents the number of the wavelet coefficients. So the risk vector $R = \{R(1), R(2), \cdots, R(N)\}$ satisfies

$$R(k) = [N - 2k + (N-k)P_k + \sum_{i=1}^{k} P_i]/N \tag{3}$$

The k-value of the minimum risk point at the risk curve $R(k)$ is marked by $k_{\min}$ when $k = 1,2,\cdots,N$ occurs. Then the gained thresholds are marked by

$$\lambda = \sigma\sqrt{P_{k_{\min}}}\,. \tag{4}$$

In the paper micro algae microscopic images are processed by the Haar wavelet transform. The initial image is decomposed for two layers and the choice of thresholds is determined by Stein unbiased likelihood estimation. In the process of image handling, the hard thresholds are adopted at the high frequency coefficients of the first layer and the soft thresholds are used at the high frequency coefficients of the second layer. The double thresholds method can not only eliminate noise effectively but also retain edge information at the most extent. This is favorable for image segmentation at the following step.

2.2 Image enhancement

It is difficult for image segmentation if the contrast between the edge and the background of images are not very high, or there are some blurred parts of image. So the image enhancement is adopted for improving the quality of image. The histogram equalization algorithm is used for image enhancement in the paper. Suppose $f(i, j)$ and $g(i, j)$ be the initial image and the enhancement image respectively with $i = 1,2,\cdots,N$ and $j = 1,2,\cdots,M$. The level of the gray is marked by R and in the paper $R = 256$ occurs. The number of values of $f(i, j) = k$ is defined as $h_f(k)$ and $k = 0,1,2,\cdots,R-1$. The classical image histogram equalization algorithm can be represented as

$$g(i, j) = (R-1)\cdot\sum_{l=0}^{k}\frac{h_f(l)}{N_f}, \quad k = 0,1,2,\cdots,R-1. \tag{5}$$

The number of total pixels of image can be represented as $N_f = N \times M$ .When the formula (5) is used for image enhancement. At the meantime the image details are not expressed very well and it leads the lost of the image detail easily. In the paper the improved image histogram equalization algorithm [5] is adopted for micro algae image enhancement. The algorithm can be described as

$$g(i, j) = (R-1)\cdot\sum_{l=0}^{k}\frac{h'_f(l)}{N'_f} - h'_f(k), \quad k = 0,1,2,\cdots,R-1 \tag{6}$$

Where $h'_f(k) = \ln[h_f(k)+1]$, $N'_f = \sum_{k=0}^{R-1} h'_f(k)$ and $k = 0,1,2,\cdots,R-1$ occur.

3 Image Segmentation

3.1 Edge extraction of micro algae image

The edge detection operator of Prewitt [6] is used for the edge detection of micro algae images. As the gradient greater than or equal to the threshold, the corresponding pixel value is 1, or else is 0, i.e.

$$g(i, j) = \begin{cases} 1 & \nabla g \geq T \\ 0 & \nabla g < T \end{cases}. \tag{7}$$

A great deal of observation about micro algae images show that the gray histogram contains a single peak usually. There is a clear jump of the gray value before the emergence of the single peak like fig.3. The jumped point can be found and it is defined as the threshold of edge extraction of image.

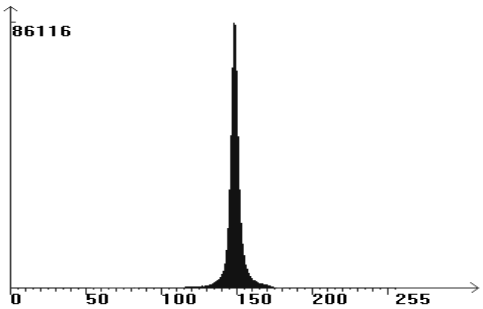


Fig.3 the Algae histogram

The jump point detection algorithm of gray values is given in the paper due to the different gray values at the jump points of each micro algae image.

Given $Search(x)$ be the detection function and x represents the gray value of image with the scope from 0 to 254. The formula of the function is

$$search(x) = e^{Hist(x+1)Hist(x)}, x \in [0,254] \tag{8}$$

The steps for detecting gray jump points are as follows.

(1) Substitute the value of gray x from 0 to 244 in turn to the function $Search(x)$ the corresponding value of function $Search(x)$ can be computed. The bigger of the differences in proportion between the pixels of adjacent gray values to the total pixel values is accompanied by the bigger the value of function $Search(x)$.

(2) Given the threshold of the difference in proportion between the pixels of adjacent gray values to the total pixel values is 1000, x is the jump point of gray values when the value of $Search(x)$ is greater than 1000.

(3) Then x is the threshold of edge detection of gray values of this image.

3.2 Dilation and erosion of micro algae image

In the process of edge detection the contour of target would be atrophy or insufficiency. In order to gain closed contour for segmentation, dilation and erosion should be acted in turn on the edge binary image with morphology.

The sets are operands in binary morphology [7]. Suppose A be image set and B be structure element, fix an origin, which is the reference point of morphology computation that structure element taking part in, for every structure element. Origin can be included in the structure of the elements or out the structure of the elements.

Definition 1. The reflection B^s of set B is defined as

$$B^s = (-b : b \in B).$$

Definition 2. Suppose B_z represent the translation from set B to $Z = (Z_{1,}Z_2)$, B_z can be described as

$$B_z = (c \mid c = a + Z, a \in B).$$

(1) Dilation

Suppose A and B are sets of $E = Z^2$, A dilation by B can be defined as

$$A \oplus B^s = (z \in E : B_z \cap A \neq \phi). \quad (9)$$

(2) Erosion

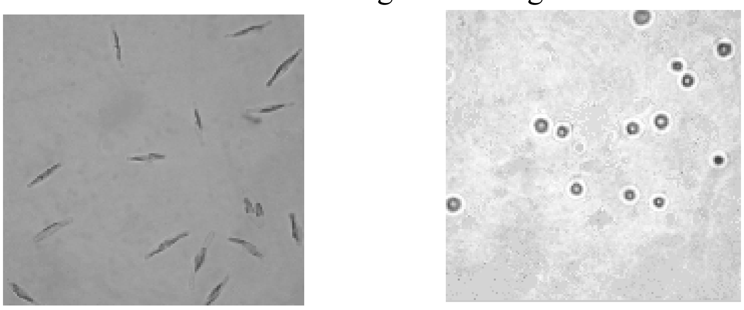
For the sets A and B of $E = Z^2$, A erosion by B can be defined as

$$A \Theta B^s = (z \in E : B_z \cap A) \quad (10)$$

The contour curve should be smoothness after dilation and erosion. The isolated point can be removed, the sharpen corner can be weakened, and the cracks and the pore can be complemented.

4 Experimental results

The simulation experiment about Nitzschia closterium Eh and Chlorella is taken according to the method presented in the paper. Fig.4.1 gives the initial gray image. The de-noising images by wavelet are shown in fig.4.2. The images after edge extraction by Prewitt operator are shown in fig.4.3. The images after dilation are shown in fig.4.4. Because the pores in the image should be filled, the filling is performed with the mode 'holes' and the results are in the fig.4.5. The images after erosion are shown in fig.4.6. After dilation and erosion, there are some minuteness disturbances in the image. In order to do away with the disturbances, the median filter method is done for the image with the models 5×5 and 7×7. The result images are in fig.4.7.



(a) Nitzschia closterium Eh (b) Chlorella

Fig.4.1 The initial gray images of micro algae

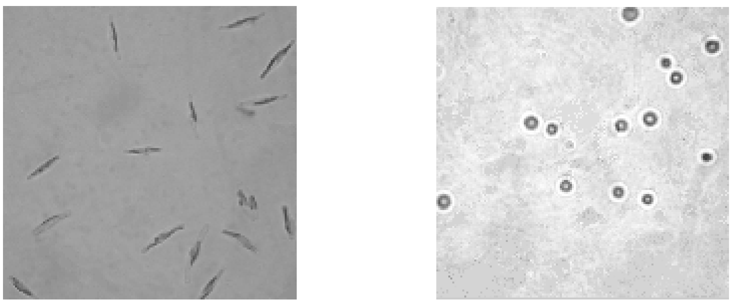


Fig.4.2 The de-noising image of micro algae by wavelet

Fig.4.3 The image after edge extraction by Prewitt operator

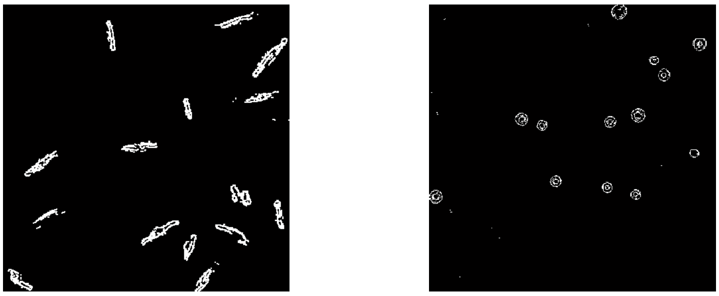


Fig.4.4 The image after dilation

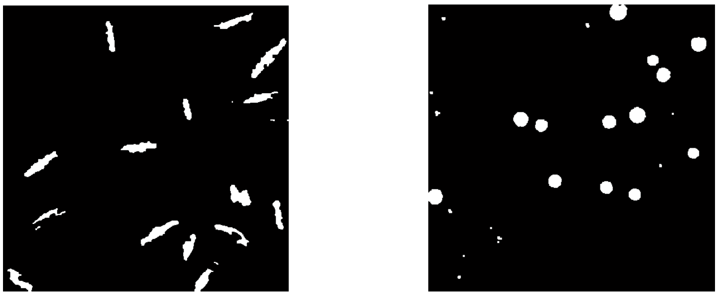


Fig.4.5 The image after filling

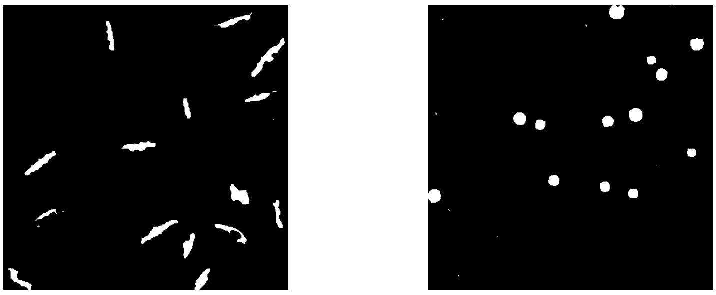


Fig.4.6 The image after erosion

Fig.4.7 The image after median filter

5 Conclusion

The samples of micro algae in ocean are adopted by microscope and ccd in the paper. A segmentation method of the micro algae is presented according to the features of the algae images. It includes de-noise, enhancement, edge extraction, dilation and erosion. The simulation experiments demonstrate that the micro image can be segmented strongly by the method presented in the paper. This takes the foundation for the statistics of the micro algae and the identification of different kinds of algae.

References

[1] J.Z. Li, Y.Y. Wu, et al:The application of Digital Microimage Processing in Algae Classifying and Counting. *Gui Zhou Science*, **3**(2006),25-27.

[2] X.M. Wang, L. Zhang, M.S. Wang: Image Processing for Automated Identification of Harmful Algae. *Journal of Computer-Aided Design & Computer Graphics*,**2**(2004), 58-162.

[3] D.L. Donoho: De-noising by soft-thresholding, *IEEE Trans on Information Theory* , **3**(1995),613-627.

[4] D.L. Donoho, I.M. Johnstone: Ideal spatial adaptation by wavelet shrinkage, *Biomet -rika*, **3**(1994), 425-455

[5] G.Q. Wang, W.B. Zhong: Study on Modification and Actualization at Algorithm of Gray Image Manipulation, *Application Research of Computers*, **12**(2001),175-176.

[6] Y.D. Jia: Machine Vision [M]. Science Press, Beijing, 2000.

[7] R.C. Gonazalez, R.E.Woods: Digital Image Processing (Second Edition). Publishing House of Electronics Industry, Beijing, 2003

Academic backgrounds:

09/1987 – 07/1990	Master’s course of Graduate School of Northeast Norma Univer -sity, Changchun, Jinlin, China
09/2002 – 07/2006	Doctor’s course of Graduate School of Dalian University of Technology, Dalian, Liaoning, China
07/1985 – 05/1995	Department of Electronics, Bohai Universiry, Jinzhou, Liaoning, China
06/1995 – 11/2010	School of Information and Engineering, Dalian Ocean Univer -sity, Dalian, Liaoning, China
Research field:	Image processing, Electronics in fishery, Information and engi -neering