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Non linear Image segmentation using fuzzy c means clustering method with thresholding for underwater images

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Abstract

The quality of underwater images is directly affected by water medium, atmosphere, pressure and temperature. This emphasizes the necessity of image segmentation, which divides an image into parts that have strong correlations with objects to reflect the actual information collected from the real world. Image segmentation is the most practical approach among virtually all automated image recognition systems. Clustering of numerical data forms the basis of many classification and system modelling algorithms. The purpose of clustering is to identify natural groupings of data from a large data set to produce a concise representation of a system's behaviour. In this paper we propose fuzzy c means clustering method with thresholding for underwater image segmentation. This paper focuses on comparison of fuzzy c means clustering algorithms with proposed method for underwater images. To evaluate the nonlinear image region segmentation, quantitative statistical measures have been used, such as the gray level energy, discrete entropy, relative entropy, mutual information and information redundancy. The assessment measures will further quantify the impact from image segmentation. The objective assessment approach has the potential to solve other image processing issues.The proposed method gives desirable results on the basis of energy, entropy, mutual information, redundancy, percentage of simplification and computer efficiency for underwater images.

Keywords *underwater images, fuzzy c means clustering, energy, entropy and mutual information*

I INTRODUCTION

Image segmentation is a major step for automated object recognition systems. In many cases, image processing is affected by illumination conditions, random noise and environmental disturbances due to atmospheric pressure or temperature fluctuation. Region segmentation is a crucial step towards automatic segmentation of images. Under some severe conditions of improper illumination and unexpected disturbances, the blurring images make it more difficult for target recognition, which results in the necessity of segmentation. The underwater images have quality degradation due to water dispersion and atmospheric fluctuations. Segmentation is thus needed to clarify feature ambiguity against stochastic disturbances. Region segmentation splits images into regions based on similarity measures, such as pixel intensities, locations and textures or combinations. It categorizes an image into separate parts, which correlates with objects involved.

The theory of fuzzy sets have immediately found its potential application in the fields of pattern recognition and image processing. The fuzzy c-means algorithm generalizes a hard clustering algorithm called the c-means algorithm, which was introduced in the ISODATA clustering method [6]. The (hard) c-means algorithm aims to identify compact, well-separated cluster.

The paper is organized as follows: Section II discusses the need for image segmentation. Section III presents the proposed fuzzy c means clustering algorithm for segmenting underwater images using thresholding. The simulation results with different non–linear parameter evaluation are presented in section IV. Finally, conclusions are given in section V.

II NEED FOR UNDERWATER IMAGE SEGMENTATION

Image segmentation is a major step for automated object recognition systems. In many cases, image processing is affected by illumination conditions, random noise and environmental disturbances due to atmospheric pressure or temperature fluctuations. The quality of underwater images is directly affected by water medium, atmosphere medium, pressure and temperature. This emphasizes the necessity of image segmentation, which divides an image into parts that have strong correlations with objects to reflect the actual information collected from the real world.

Due to unstableness in underwater surroundings, object recognition in underwater is no means an easy task. Light changing or current flow of underwater surroundings often occur rapidly, so the features (shape or color etc) of object may vary in short time and the segmentation process may not give proper results [2]. Therefore subsequent object recognition results are not reliable. The next session explains the algorithm taken for implementation.

III PROPOSED FUZZY C MEANS CLUSTERING METHOD WITH THRESOLDING

The fuzzy c means clustering method with thresholding is the combination of fuzzy algorithm, c means clustering and thresholding algorithm.

Fuzzy clustering

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The goal of a clustering analysis is to divide a given set of data or objects into a cluster, which represents subsets or a group [6]. The partition should have two properties:

- Homogeneity inside clusters: the data, which belongs to one cluster, should be as similar as possible.
- Heterogeneity between the clusters: the data, which belongs to different clusters, should be as different as possible.

The membership functions do not reflect the actual data distribution in the input and the output spaces. They may not be suitable for fuzzy pattern recognition. To build membership functions from the data available, a clustering technique may be used to partition the data, and then produce membership functions from the resulting clustering.

"Clustering" is a process to obtain a partition *P* of a set *E* of *N* objects *Xi* (*i*=1, 2,…, *N*), using the resemblance or disemblance measure, such as a distance measure *d*. A partition *P* is a set of disjoint subsets of *E* and the element *Ps* of *P* is called *cluster* and the centers of the clusters are called *centroids* or prototypes. Many techniques have been developed for clustering data. In this paper c-means clustering is used. It's a simple unsupervised learning method which can be used for data grouping or classification when the number of the clusters is known. It consists of the following steps:

Step 1:
Choose the number of clusters - K
Step 2:
Set initial centers of clusters c1, c2,…, ck;
Step 3:
Classify each vector $x_1 = [x_{11}, x_{12}, \dots x_{1n}]^T$ *into the closest center* c_i *by*
Euclidean distance measure:

$$\|x_i - c_i\| = \min \|x_i - c_i\|$$

Step 4:
Recompute the estimates for the cluster centers c_i *Let*

$$c_i = [c_{i1}, c_{i2}, \dots c_{in}]^T \quad ,$$

c_{im} *be computed by:*

$$c_{im} = \frac{\sum x_{li} \in cluster(i^{x \lim})}{N_i}$$

where N_i *is the number of vectors in the i-th cluster.*
Step 5:
If none of the cluster centers (c_i *=1, 2,…, k) changes in step 4 stop; otherwise go to step 3.*

C-means algorithm

The criterion function used for the clustering process is:

$$J(v) = \sum_{k=1}^{n} \Sigma k_x \in c_i \left| x_k - v_i \right|^2 ,$$

where v_i is the sample mean or the center of samples of cluster *i*, and *v*={*v*1,*v*2,…,*vc*}.

In the hard clustering process, each data sample is assigned to only one cluster and all clusters are regarded as disjoint collection of the data set. In practice there are many cases, in which the clusters are not completely disjoint and the data could be classified as belonging to one cluster almost as well to another. Therefore, the separation of the clusters becomes a fuzzy notion, and representation of the data can be more accurately handled by fuzzy clustering methods. It is necessary to describe the data in terms of fuzzy clusters. The criterion function used for fuzzy C-means clustering is

$$J(v) = \sum_{i=1}^{c} \sum_{k=1}^{n} u_{ik}^{m} \left| x_k - v_i \right|^2 ,$$

where:

$x_1, \dots\dots x_n -$ *'n'* data sample vectors;

$v_1, \dots\dots v_c -$ *'c'* denotes cluster centers (centroids);

$u = u_{ik}$ *cxm* matrix, where u_{ik} is the *i*-th membership value of the *k*-th input
sample *xk*, and the membership values satisfy the following conditions:

$$0 \le u_{ik} \le 1 ; \quad i = 1, \dots, c; \; k = 1, \dots, n;$$

$$\sum_{i=1}^{c} u_{ik} = 1 ; \quad k = 1, \dots, n;$$

$$0 < \sum_{k=1}^{n} u_{ik} < 1; \quad i = 1, \dots, c;$$

$m \in [1, \infty)$ is an exponent weight factor.

The Fuzzy Logic Toolbox command line function, fcm, starts with an initial guess for the cluster centers, which are intended to mark the mean location of each cluster. The initial guess for these cluster centers is most likely incorrect. Next, fcm assigns every data point a membership grade for each cluster. By iteratively updating

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the cluster centers and the membership grades for each data point, fcm iteratively moves the cluster centers to the right location within a data set.

Thresholding

This iteration is based on minimizing an objective function that represents the distance from any given data point to a cluster center weighted by that data point's membership grade. Here fuzzy c means clustering [3] is used based on thresholding. It works better than ostu method [4]. In normal fuzzy c means clustering the segmented part cannot be seen clearly. For that reasons, thresholding is applied to extract the segmented image part. Hence, the annexure I gives the clarity of underwater images after applying the thresholding method, this have proposed in this paper. Aneexure I gives the original underwater images and image after applying fuzzy c means clustering and fuzz c means clustering method with threshold.

Fig 1 original underwater Titanic image

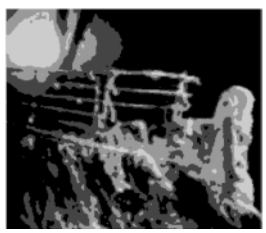

Fig 2 After applying FCM

Fig 3 After Applying FCMT

From the figure it can be observe that the difference between the normal fuzzy c means clustering and fuzzy c means threshold for underwater images. The fuzzy c means threshold method gives better image when compare to normal fuzzy c means clustering.

IV. EXPERIMENTAL SETUP AND EVALUATION

To test the accuracy of the segmentation algorithms, three steps are followed.

i) First, an underwater image is taken as input.

ii) Second, segmentation algorithm is applied for underwater image.

iii) Third, the non linear objective assessment is applied for fuzzy c means algorithm, for evaluation of underwater images.

The reconstruction of an image has the dimensions of 256 pixel intensity. The images in this contain a wide variety of subject matters and textures. Most of the images used are ship wreck, moor chain and mine in sonar images. The non linear assessment applied must be less value for an better image segmentation.

To estimate the quality of the reconstructed images, following non linear objective assessment parameters are used.
The different non linear objective assessment parameters used for evaluation are ,

i.) Energy
ii.) Relative Entropy (RT)
iii.) Discrete Entropy (DE)
iv.) Mutual Information (MI)
v.) Normalized Mutual Information (NMI)
vi.) Redundancy(RD)

i.) Energy

The gray level energy indicates how the gray levels are distributed. It is formulated as,

$$E(x) = \sum_{i=1}^{x} p(x)$$

where E(x) represents the gray level energy with 256 bins and p(i) refers to the probability distribution functions, which contains the histogram counts. The energy reaches its maximum value of 1 when an image has a constant gray level [2].

ii.) Relative Entropy

Suppose that two discrete probability distributions of the images have the probability functions of p and q, the rela.tive entropy of p with respect to q is then defined as the summation of all possible states of the system, which is formulated as,

$$d = \sum_{i=1}^{k} p(i) \log_2 \frac{p(i)}{q(i)}$$

iii.) Discrete Entropy (DE)

The discrete entropy is the measure of image information content, which is interpreted as the average uncertainty of information source. It is calculated as the summation of the products of the probability of outcome multiplied by the log of the inverse of the outcome probability, taking into considerations of all possible

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outcomes {1, 2, …, n} in the event {x1, x2, …, xn}, where n is the gray level; p(i) is the probability distribution, considering all histogram counts. It is formulated as

$$H(x) = \sum_{i=1}^{k} p(i) \log_2 \frac{1}{p(i)} = -\sum_{i=1}^{k} p(i) \log_2 p(i)$$

For image processing, the discrete entropy is a measure how many bits needed for coding the image data, which is a statistical measure of randomness. The maximal entropy occurs when all potential outcomes are equal. When the outcome is certainty, the minimal entropy occurs which is equal to zero. The discrete entropy represents average amount of information conveyed from each individual image.

iv.) Mutual Information (MI)

The notion of the mutual information can be applied as another objective metric. The mutual information acts as a symmetric function, which is formulated as,

$$I(X,Y) = \sum_{XY} P_{XY}(X,Y) \log_2 \frac{P_{xy}(X,Y)}{P_x(X)P_y(Y)}$$

$$= -\sum_{x} P_x(X) \log_2 P(X) + \sum_{x.y} P_{xy}(X,Y) \log_2 \frac{P_{xy}(X,Y)}{P_x(X)P_yY)}$$

$$= H(X,) - H(X \mid Y)$$

where I(X; Y) represents the mutual information; H(X) and H(X|Y) are entropy and conditional entropy values. It is interpreted as the information that Y can tell about X is equal to the reduction in uncertainty of X due to the existence of Y. At the same time, it also shows the relationship of the joint and product distributions. The results are shown in Table

v.) Normalized Mutual Information (NMI)

The normalized mutual information is a well defined measure covering contents from both discrete entropies and mutual information. It is formulated as

$$NMI = \frac{I(X;Y)}{\sqrt{H(X), H(Y)}}$$

where I(X, Y) is the mutual information; H(X) and H(Y)are the discrete entropies

Table 1 shows the performance evaluation of original image and segmented image using non linear objective assessments like energy, entropy and mutual information.

vi.) Redundancy (RD)

Another symmetric information measure can be used to indicate redundancy in image segmentation. It reaches the minima of zero when all variables are independent. It is formulated as

$$RD = \frac{I(X;Y)}{H(X) + H(Y)}$$

where H(X) and H(Y) are entropies of two images and I(X; Y) is the mutual information.

Table 1 Performance evaluation using fuzzy c means clustering method

Input Image	Non linear Objective Assessments	Original image	Fuzzy C Means Clustering(FCM)	Fuzzy C means Clustering plus thresholding (FCMT)
Underwater Titanic Image	Energy	0.8952	1.7324	0.1708
	Relative Entropy	0.4562	0.3392	0.0495
	Discrete Entropy	0.099	0.2472	0.1032
	Mutual Information	0.9841	1.7315	0.2062
	Normalized Mutual Information	1.2052	1.292	1.2492
	Redundancy	1.5234	0.9862	0.5000
	Computer efficiency in sec.	5.7560	3.6202	2.9606

Like that more number of underwater images are taken for experimentation and the results are give desirable for fuzzy c means clustering method with thresholding.

From table, in image segmentation, the less value of the non linear objective assessment like energy, relative entropy, discrete entropy, mutual information, normalized mutual information, redundancy and computer efficiency gives the Fuzzy C Means threshold (FCM threshold) method is better for underwater images when compare to Fuzzy C Means (FCM) clustering. When compare to original image fuzzy method gives simplified value. The percentage of simulation is also calculated. Its varied from 52% to 95% and the computer efficiency is also calculated using time in seconds. When compare to all performance evaluation it can be say that fuzzy c means threshold method give most suitable results when compare to fuzz c means method.

V CONCLUSION

The quality of underwater images is directly affected by water medium, atmosphere medium, pressure and temperature. This emphasizes the necessity of image segmentation, which divides an image into parts that have strong correlations with objects to reflect the actual information collected from the real world. Image segmentation are most practical approaches among virtually all automated image recognition systems. Clustering of numerical data forms the basis of many classification and system modelling algorithms. The purpose of clustering is to identify natural groupings of data from a large data set to produce a concise representation of a system's behaviour. In this paper the proposed fuzzy c means threshold clustering method gives desirable results when compare to FCM method by using non linear assessment like energy, relative entropy, discrete entropy, mutual information, normalized mutual information, redundancy and computer efficiency when compare to fuzzy c means method for underwater images...

REFERENCES

[1]. Wen-Xiong Kang, Qing-Qiang Yang, Run-Peng Liang, "The Comparative Research on Image Segmentation Algorithms," First International Workshop on Education Technology and Computer Science, pp.703-707, , vol. 2, 2009.

[2].Zhengmao ye, “objective assessment of Nonlinear Segmentation Approaches to Gray Level Underwater Images”, ICGST-GVIP Journal, pp. 39-46, No.2, Vol. 9, April 2009.

[3] Y. Ye, Z. Ye, J. Luo, P. Bhattacharya, H. Majlesein, R. Smith, "On Linear and Nonlinear Processing of Underwater, Ground, Aerial and Satellite Images", IEEE International Conference on Systems, Man and Cybernetics, pp.3364-8, Oct.10-12, 2005.

[4] R. Gonzalez, R. Woods, “Digital Image Processing,” 2nd Edition, Prentice-Hall, 2002.

[5] Mr. S. K. Korde Mrs. K.C. Jondhale, “Hand Gesture Recognition System Using Standard Fuzzy C-Means Algorithm for Recognizing Hand Gesture with Angle Variations for Unsupervised Users”, IEEE, First International Conference on Emerging Trends in Engineering and Technology, pp. 681-685, Nov 11 2008.

[6] Rumiana Krasteva “Bulgarian Hand-Printed Character Recognition Using Fuzzy C-Means Clustering”, Bulgarian Academy of sciences problems of engineering cybernetics and robotics, 53, pp. 112-117, 2002.

[7] Weina Wang, Yunjie Zhang, Yi Li and Xiaona Zhang, “The Global Fuzzy C-Means Clustering Algorithm”, Proceedings of the 6th World Congress on Intelligent Control and Automation, pp.33604-3607, June 21 - 23, 2006,.

[8] A.H.Hadjamthi, M.M.Hmayanpour and S.M.Ahadi, “Robust weighted fuzzy c means clustering”, IEEE International Conference on Fuzzy Systems, pp. 306-311, 2008.

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ANNEXURE I

Underwater image results for fuzzy c means clustering method with thresholding

Original underwater images	Underwater image after applying FCM	Underwater image after applying FCM threshold