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NATURAL GRAY IMAGE SEGMENTATION USING DWT, DCT AND SOM

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Abstract

Natural image segmentation is the crucial need of image analysis which is helpful to detect objects. The challengeable issue lies in this task to segmentation with high accuracy. This paper proposes a new method to segment natural images using the k-means and Transform based Self-Organizing Map (TSOM). The K-means algorithm reduces the number of training samples which is used for TSOM. In the TSOM method, the transformed features values by DWT and DCT are used for training and testing of SOM. The DWT and DCT methods provide eight transformed features individually. So that sixteen features for a block is utilized for training and testing. These transformed values contain much energy than the normal intensity values. This method segments the natural images with the high energy compacted transform values so that the segmented accuracy is also increased.

Index Terms: Natural image Segmentation, TSOM, K-means, DWT, DCT.

1. Introduction

An image is a two dimensional matrix of square pixels arranged in rows and columns [2]. Every pixel represents the color or gray at a single point in the image. Natural image contains the number of visual patterns generated by very assorted stochastic processes in nature. Natural image processing is one of the fundamental problems in image processing and computer vision [1]. Natural photography refers to the big range of photographs taken outdoors and devoted to displaying the natural elements such as landscapes, wildlife, plants and close-ups of natural scenes and textures [1]. The partitioning of the digital image into multiple segments is called segmentation. The goal of the image segmentation is to change the representation of an image analysis too easier. Normally image segmentation is used to identifying the objects and boundaries in images. Image segmentation is the process of assigning a label to every pixel in an image such that pixels with the same label share certain visual characteristics [3]. The main challenges of natural image segmentation are insufficient contrast, luminance issues and noise environment. Keri Woods [9] proposed many adaptive methods which have been used for image segmentation, including genetic algorithms [10], neural networks [11], self-organizing map [7] and Fuzzy clustering [13].

2. Related Works

Self-Organizing Map (SOM) [2] is an unsupervised neural network method. The SOM convert patterns of arbitrary dimensionality into the responses of two dimensional arrays of neurons. One important characteristic of SOM is that the feature map preserves neighborhood relations of the input pattern [4]. SOM consists of input and output layer and each input is fully connected to all units. The initial weights are random and small, and their contribution for the final state decreases with the number of samples.

The SOM map has been studied in finding fraud user profiles and cellular phones [12]. SOMs are used widely in the segmentation of different types of images [4]. The SOM plays vital role in Natural image segmentation. The term self-organizing map signifies a class of mappings defined by error-theoretic considerations [8]. Awad et al. in [5] proposed an unsupervised cooperative approach which is a combination of Self Organizing Map (SOM). Marsella and Miranda in [6] proposed a classical neural network with fuzzy logic. This method works on segmenting an image by taking each time a window of fixed dimension. The pixel color values are the input to the neural network (SOM) and the number of input neurons is equal to the number of considered pixels in the window.

K-means clustering is the process of partitioning a group of data into a small number of clusters. For example, the items in a supermarket are clustered in categories (butter, cheese and milk are grouped in dairy products). K-means clustering is one of the qualitative kinds of partitioning. The goal of K-means clustering is to assign a cluster to each data point.

In this paper the proposed methodology segments the natural image in an efficient manner. The noise of natural image is removed using median filter. The K-means segmentation methodology is adopted to reduce the training sample. The transform based SOM methodology is applied for training purposes the T-SOM testing process is applied to get the segmented natural image.

The proposed methodology is described in section

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3. The experimental results are given in section 4. In chapter 5 the conclusion section briefs the observation. In the reference papers which are used in this paper are listed after conclusion.

3. Proposed Methodology

The concept of the proposed methodology is to achieve the segmented image from the input natural image. The input natural image is handled by median noise reduction, K-means clustering and Transform based SOM to gain healthier in natural image segmentation. The proposed segmentation method contains four modules. They are Median filter based noise reduction, K-means segmentation, Transform based SOM training, Transform based SOM testing.
The Fig.1 expresses the principles of the proposed method using block diagram.

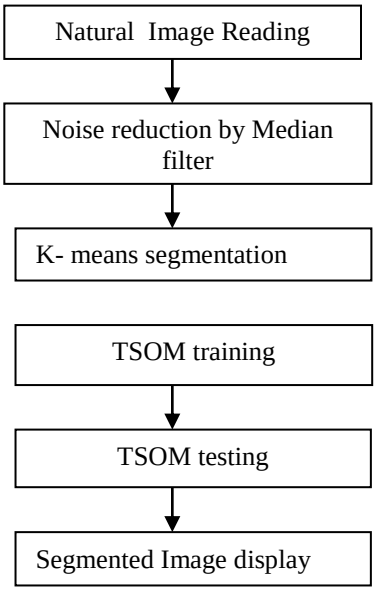

Fig.1. Block diagram of proposed SEG–TSOM segmentation technique.

A. Median filter based noise reduction

Natural image segmentation is much affected by noisy pixels. To increase the segmentation accuracy the noise reduction process is used. The noisy pixels of given natural image are restored as noise free pixels using a existing noise reduction method namely "Median filter based noise reduction" [14].

The noisy pixels which are marked by stage 1 process are restored using the restoration term Y(i,j) and the other pixels are leaved without any changes. This noise free image can be referred as $I_{NF.}$ For further detailed study of noise reduction procedure can be obtained by the paper [17].

B. K- Means Segmentation

The K-Means segmentation method is one of the best segmentation methods in image segmentation area. The membership value computation is the main part of K-Means algorithm. The main steps of K-means are followed:

- Initialization Process
- Distance calculation
- Cluster head computation
- Membership function
- Objective function
- Defuzzification

The initialization process contains the cluster head initialization, membership value initialization and parameter initialization. The total number of cluster parameter is also assigned in the initialization process. The distance function computes the difference between the cluster head and data elements. The cluster head computation is performed using membership values. The updated membership values are found using membership function. The objective function takes the decision about the convergence state of the process. The Defuzzification process reveals the output of the k-means segmentation. The detailed explanation of the K-means method can be known from the paper [17].

The enhanced natural image can be applied to the K Means algorithm for image segmentation. For segmentation process, the image information is converted into 2x2 size non overlapped blocks. The initialization process is proceeded with the number of clusters as 3(more than 3 is also allowed). The cluster head updation and membership updation processes are performed until the convergence state occurs. The defuzziifcation process allocates the data elements to the proper clusters. From this segmentation result, the training samples per cluster is collected and it is known as final training vectors.

C. TSOM Training

A Self-Organizing Map (SOM) [16] or Self-Organizing feature Map (SOFM) is a type of artificial neural network that is trained using unsupervised learning to produce a low-dimensional, discrete representation of the input space of the training samples, called map.

The Transform based SOM Training process is performed using the final training vectors which are obtained from the K-means segmentation. The trained transform based SOM yields the SOM weight vectors. The weight vector dimensionality is maintained as TotalClusters x VectorLength which can be expressed as 3x4. Here, the number 4 means total elements in the 2x2 size block.

The Discrete Wavelet Transform (DWT) [19] is applied on the 0th weight vector. The Daubechis 4 Wavelet Coefficients (db4) are used for wavelet transform. This DWT energy extraction is performed using the Equations 1 and 2.

$$E' = Dwt(WM(0)) \quad (1)$$

$$E_{Dwt} = [E'(0), E'(1), E'(2)] \quad (2)$$

where

DWT - Discrete wavelet transform
WM - Weight matrix of SOM training
E' - Energy Array
E_{DWT} - Energy vector based on DWT

The Discrete Cosine Transform (DCT) [20] is applied on the 0th weight vector. This DCT energy extraction is performed using the Equations 3 and 4.

$$E'' = Dct(WM(0)) \quad (3)$$

$$E_{Dct} = [E''(0), E''(1), E''(2)] \quad (4)$$

Where

Dct - Discrete cosine transform function
E" - Energy Array
E_{DCT} - Energy vector based on DCT

The fused energy vector is obtained using the concatenation of two transforms. The concatenation of DWT and DCT energy data generates totally 6 elements per cluster. It contains 1 x 6 dimensional fused energy data. In the proposed transform based SOM method, the SOM weight information are converted into transformed data format. This process is performed using Equation 5.

$$E_F = \{E_{Dwt}, E_{Dct}\} \quad (5)$$

Where

E_F - Fused Energy Vector

The same process is done for the 1st weight vector and a 1x6 energy vector is formed. The same is done for the 2nd weight vector. Finally a 3x6 (for total cluster count as 3 energy vector is constructed.

D. TSOM Testing

In this transform based SOM, testing process is performed by Euclidian distance. In Euclidian distance the subtraction process is performed in between the corresponding elements of the two participant vectors.

The similarity measurement is handled by two parameters and they are weight vector and block vector. The 2x2 size overlapped block is extracted from the noise free image. That block intensity data is converted into energetic data format using DWT and DCT transforms. The matrix shaped block information (2x2) is converted into linear vector shape (1x4). The block DWT energy is computed using equations 6 and 7.

$$EB' = Dwt(BV(0)) \quad (6)$$

$$EB'_{Dwt} = [EB'(0), EB'(1), EB'(2)] \quad (7)$$

where

$BV - Block\ related\ vector$
EB' – Block energy Array
$EB'_{Dwt} - Block\ Energy\ vector\ using\ Dwt$

The block DCT energy is computed using equations 8 and 9.

$$EB'' = Dct(BV(0)) \quad (8)$$

$$EB''_{Dwt} = [EB''(0), EB''(1), EB''(2)] \quad (9)$$

where

$BV - Block\ related\ vector$
$EB'' - Block\ energy\ array$
$EB''_{Dct} - Block\ Energy\ vector\ using\ Dwt$

The fused block energy data formation is based on the equation 10.

$$EB_F = \{EB_{DWT}, EB_{DCT}\} \quad (10)$$

Where

EB_F = Fused Block Energy

The Energetic similarity measurement is computed using the equations 11.

$$sim(k) = \sum_{j=0}^{5} \| EB_F(j) - E_F^K(j) EB_F \| \quad (11)$$

$k \in [0, totalcluster - 1]$

Where

k - Cluster indicator.
sim(k) - Similarity value related with k cluster.

The minimum value providing cluster k is found and this cluster index is used to fill the block data. So that the final segmented image is obtained after processing entire blocks.

4. Experimental Results and Analysis

The proposed Natural gray image segmentation method makes meaningful groups in input natural gray images. The proposed T-SOM method is applied in this paper for segmentation. The K means, T-SOM testing, and T-SOM methods are used to improve the segmentation quality.

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In this paper, the UCID database is used for gray natural image segmentation. This paper uses 140 images from UCID database to test the segmentation performance of the proposed method. In this analysis the proposed methodology is compared with three existing methods. The names of them are as follows:

Figure 1. Original image

1.Low-level Hierarchical Multi scale Natural Image segmentation [LHM – NIS] [21].

2. Un-Supervised Object Extraction by Contour Delineation and Texture Discrimination Natural Image Segmentation [UOT – NIS] [22].

The Figure 2 describes the T-SOM method's segmentation output.

Means Square Error (MSE) is a performance measurement parameter used to measure the segmentation quality. The MSE can be calculated using the equation 12. The lower MSE values indicate better segmentation quality in Natural image segmentation.

$$MSE = \frac{1}{m\,x\,n}\sum_{i=0}^{m-1}\sum_{j=0}^{n-1}(I_{Gnd(i,j)} - I_{seg(i,j)}) \qquad (12)$$

Where

m - image height

n - image width

$I_{Gnd(i,j)}$ - $(i,j)^{th}$ location of the ground truth image

$I_{seg(i,j)}$ - $(i,j)^{th}$ location of the segmented image

From the table 1 and figure 3 it can be understand that the proposed method holds less MSE when compared with the existing methods. The segmentation method UOT-NIS is the second best method in natural gray image segmentation in case of MSE.

Figure 2. Segmented output

Table 1: Mean Square Error Analysis

S.No	Natural Gray image name	Segmentation Method	MSE
1	Natural Gray image1.Bmp	LHM – NIS UOT - NIS Proposed	0.126 0.103 0.045
2	Natural Gray Image2.BmP	LHM – NIS UOT - NIS Proposed	0.060 0.045 0.019
3	Natural Gray Image3.Bmp	LHM – NIS UOT - NIS Proposed	0.055 0.046 0.040
4	Natural Gray image4.Bmp	LHM – NIS UOT - NIS Proposed	0.124 0.099 0.072

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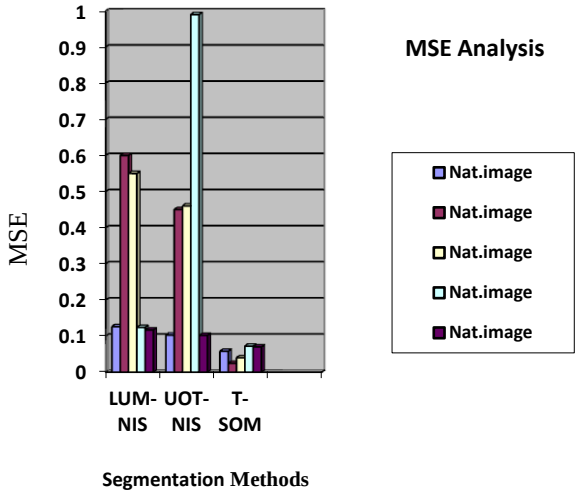

Figure 3. Mean Square Error Analysis

From the table 2 we can be observed the proposed method holds less average MSE compared with the previous methods.

The Peak Signal to Noise Ratio (PSNR) is used as a segmentation performance parameter to measure the segmentation quality. It can be computed from the equation 13. The higher PSNR value indicates better segmentation quality in natural image segmentation.

$$PSNR = 10log_{10}(255^2/MSE) \quad (13)$$

S.No	Natural image name	Segmentation method	PSNR (in db)
1	Natural Gray image1.Bmp	LHM – NIS UOT - NIS Proposed	57.1 58.2 60.5
2	Natural Gray image2.Bmp	LHM - NIS UOT - NIS Proposed	60.3 61.6 64.2
3	Natural Gray image3. Bmp	LHM - NIS UOT - NIS Proposed	60.8 61.4 62.1
4	Natural Gray image4.Bmp	LHM - NIS UOT - NIS Proposed	57.3 58.2 59.4
5	Natural Gray Image5.Bmp	LHM - NIS UOT - NIS Proposed	57.3 58.2 59.6

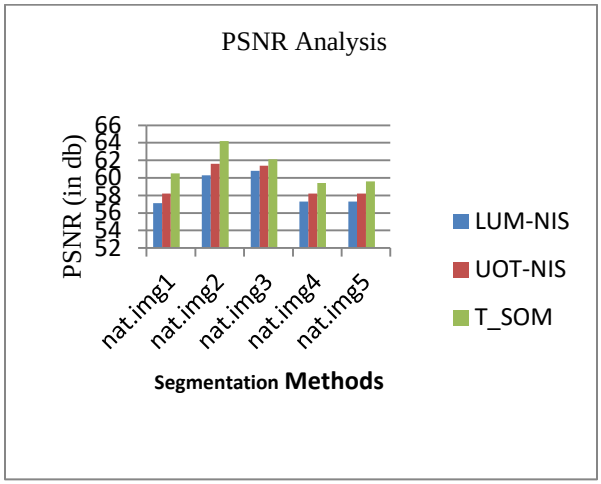

Figure 4. PSNR Analysis for 3 methods

From the table 2 and figure 4 it can be noticed that the proposed method holds high PSNR compared with the existing methods. The segmentation method UOT-NIS is the second best method in natural image segmentation.

Table 3. Accuracy Performance Measurement

S.No	Natural image	Segmentation method	Accuracy In (Percentage)
1	Natural image	LHM - NIS UOT - NIS Proposed	84.08 85.88 88.01
2	Natural image2	LHM - NIS UOT - NIS Proposed	85.8 86.9 90.38
3	Natural image3	LHM - NIS UOT - NIS Proposed	84.8 85.5 87.9
4	Natural image4	LHM - NIS UOT - NIS Proposed	86.3 87.1 89.24
5	Natural image5	LHM - NIS UOT - NIS Proposed	84.8 86.39 88.52

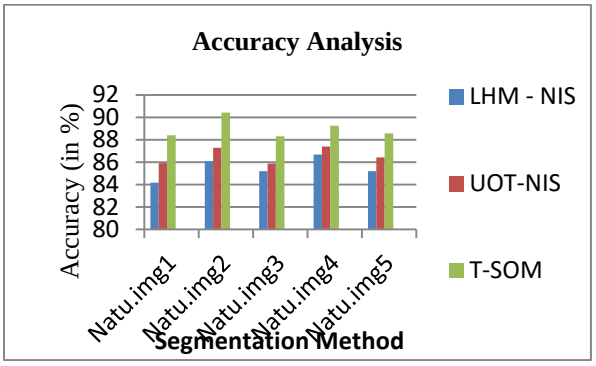

Figure 7. Segmentation Accuracy Analysis

From the table 3 and figure 4 it understand the proposed method holds high accuracy compared with the existing methods. The segmentation method UOT-NIS is the second best method in natural image segmentation in the case of Image segmentation accuracy.

5. Conclusion

The proposed natural image segmentation method segments the input image into multiple meaningful groups to help further valid image processing steps. To get better segmentation the noises from the image are removed using medial filter. The DWT and DCT transforms are used to construct the TSOM algorithm. The proposed method stays in better quality in cases of MSE and PSNR and accuracy analysis. By considering the overall gains from the proposed method, this paper concludes that the proposed TSOM based method is better than existing in case of natural segmentation. In future medical and satellite image can be considered.

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Biographies

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