Proceedings of 2012 4th International Conference on Machine Learning and Computing
IPCSIT vol. 25 (2012) © (2012) IACSIT Press, Singapore

Texture Image Segmentation using FCM

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Abstract. Texture analysis such as segmentation and classification plays a vital role in computer vision and pattern recognition. It is widely applied to many areas such as industrial automation, bio-medical image processing and remote sensing. An image segmentation system called "Colour Texture segmentation using fuzzy c-means clustering (CTSFCM)" is proposed. CTSFCM uses the perceptually uniform CIEL*U*V* colour space for segmentation. To speed up segmentation algorithm and reduce the computational complexity for clustering, prominent pixels are selected. Clusters and their labels are automatically found out using Fuzzy c-means (FCM) clustering technique. In the proposed method fuzzy entropy is used to decide number of clusters. Image pixels are classified to relevant clusters based on minimum Euclidian distance. A post-processing filtering stage is applied to improve segmentation quality. One of the advantages of this method is that it does not need to specify the priori information to segment a colour region besides; there is no apparently distortion or colour change after segmentation. Experimental results show that the system has desired ability for segmentation of colour images in a variety of vision tasks. An application of the proposed method is presented. The effectiveness of proposed method has been demonstrated by various experiments.

Keywords: Segmentation, Texture segmentation, Fuzzy colour image segmentation.

1. Introduction

Image segmentation is a fundamental problem in image analysis and computer vision. In recent years research has focused on segmentation of colour images, since gray scale images can not satisfy the needs in many application domains. Colour image segmentation techniques divide an image into a set of disjointed regions which are homogeneous with respect to some properties consistent with human visual perception such as colours or textures [1]. In this paper, we consider the problem of colour texture segmentation based on colour and texture information. In the field of computer vision, texture plays an important role in low level image analysis and understanding. Its potential application range has been shown in various areas such as analysis of remote sensing images, industrial monitoring of product quality, medical imaging, content-based image and video retrieval [2]. Segmentation of textured images has long been an important and challenging topic in image processing society. A number of texture segmentation algorithms are reviewed in the literature [3][4]. Texture segmentation usually involves the combination of texture feature extraction techniques with a suitable segmentation algorithm. The most popular feature extraction techniques used for texture segmentation are Gabor filters, Markov random fields, texture features and wavelets, split-and-merge, region growing and clustering. Wavelets have provided a new dimension to the field of computer vision. Due to its multi-resolution property, many studies have been conducted utilizing wavelets in texture segmentation. Promising results have been reported in [5][6]. However, most of the texture segmentation algorithms currently available still require the number of textures to be provided. It is inconvenient for particular application area such as content-based retrieval of art and museum images, where segmentation is to be performed on several thousand images. It is therefore inefficient to expect number of textures to be manually provided for all such images. An automatic texture detection and segmentation algorithm which we termed as unsupervised segmentation is therefore needed to suit this kind of application. In this paper, we propose a

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system capable to perform multilevel texture image segmentation using FCM clustering technique. One of the advantages of this method is that it does not require a priori knowledge to segment a region. The number of objects in the image is found out automatically. The Outline of paper is as follows. Section 2 elaborates description of the proposed method. Section 3 presents an experimental result. Section 4 describes an application of the proposed method. Section 5 draws a conclusion.

2. Colour Texture Segmentation using FCM Clustering

2.1. CTSFCM Architecture Overview

The proposed block diagram of CTSFCM is as depicted in Figure 1. CTSFCM uses perceptually uniform CIEL*U*V* space for segmentation. Each point in this colour space can be regarded as a point in L*U*V* three dimensional colour space so that the difference of two colours can be calculated as a Euclidian distance between two colour points. The ability to express colour difference of human perception by Euclidian distance is very important to colour image segmentation. CIEL*U*V* model is having approximately uniform chromaticity scale. i.e. they match the sensitivity of human eyes with computer processing [2]. It is better than RGB colour transformation since there exists a high correlation among three colour components such as R, G and B which makes these components dependent upon each other and associate strongly with intensity. Hence RGB colour space is very difficult to highlights, shadows and shading in colour image. CTSFCM system consists of mainly three computational modules such as prominent pixel selection; entropy based clustering, segmentation and post-processing.

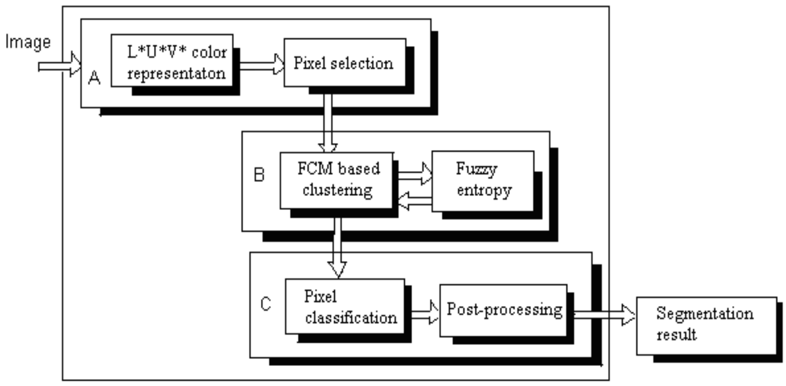


Fig. 1: Block diagram of CTSFCM System

2.2. Prominent Pixel Selection (A)

Prominent pixel selection consists of selection of pixel system itself and the pre-processing (L*U*V* transformation) of an image. The purpose of this block is to find out number of prominent pixels used for clustering. In case of large size of colour images to reduce number of computations and the computational complexity for clustering moreover, to increase the speed of segmentation algorithm it is preferable to have an image having selected number of pixels. This is done by scanning an image matrix rows. A pixel is selected for clustering process if the absolute difference between current pixel and its previous pixel is greater than a predefined threshold (T). The threshold value used to carry out all experiments is four (4). Experimentally, it is found out that four (4) is a suitable threshold value for most of the images. With the aim of keeping the system totally adaptive there is a need of an automatic way to determine number of clusters. In the proposed work this was done using FCM clustering technique. The main aim here is to find out number of clusters without a priori knowledge of the image. To accomplish this first the colour image is transformed to CIEL*U*V*colour space. Clusters and their labels for the objects are found automatically by applying FCM clustering algorithm on prominent pixels. Fuzzy entropy is used to decide number of clusters. Cluster centroids are considered as a target value. The system is forced towards a minimum fuzzy entropy state to obtain segmentation. The image pixels are classified to respective clusters using minimum Euclidian distance.

2.3. Entropy based Clustering (B)

Entropy based clustering consists of clustering system and fuzzy entropy calculation. Recently there has been an increasing use of fuzzy theory for colour image segmentation [7]. Zadeh [8] introduced the concept of fuzzy sets in which imprecise knowledge can be used to define an event. A fuzzy set A is represented using eq (1).

$$A = \{ \mu_A(x_i) / x_i , i = 1,2,3,...,n \} \tag{1}$$

where $\mu_A(x_i)$ gives the degree of belonging the element to the set A.

Many clustering algorithms exist in pattern recognition literatures. Among them FCM clustering is one of the best known clustering algorithms. FCM clustering technique has received the extensive attention. Based on fuzzy clustering principle, Bezdek [9] et al. developed a low level segmentation methodology in which the approach utilizes region growing concepts and the pyramidal data structures (PDS) for hierarchical analysis of aerial images. Since in their approach a higher level image was acquired by averaging its four level images block effects are observed in segmentation result.

A prominent pixel selection block (A) transforms an image X into M selective pixels used for clustering. Where, M is a 3-D matrix. Given a no. of clusters K, FCM clustering attempts to organize the data set M into the set of clusters C = {C1,C2,C3,…,Ck} such that the vectors in cluster Ci are 'more similar' than the vectors belonging to other clusters. In the proposed work fuzzy entropy is utilized to calculate an error of the system. The partition entropy (PE) is calculated using eq (2) described by Bezdek [9]. Here aim of the system is to reduce degree of fuzziness of the input colour image.

$$PE = -\frac{1}{n \ln\left(\frac{1}{C}\right)} \sum_{k=1}^{n} \sum_{i=1}^{C} \left[\mu ik \ \ln\left(\mu ik\right)\right] \tag{2}$$

2.4. Segmentation and Post-Processing (C)

Segmentation and post-processing (C) includes final pixel labelling and post-processing steps. Let the set of cluster centroids after clustering be *Z = {Z1, Z2,, Z3,,…,Zk).* The criterion of minimum distance is defined as a Euclidian distance between cluster centroids and the image pixels using eq. (3)

$$D = \sqrt{\sum_{i=1}^{k} (Z_i - M_i)^2} \tag{3}$$

The procedure of pixel classification of an image is to search the appropriate cluster centroid that minimizes the Euclidian distance. A post-processing stage is often found to be necessary to produce the coherent regions. The spatial filters are generally used for noise reduction. Order-statistics filters are the nonlinear spatial filters whose response is based on ordering (ranking) of pixels contained in an image area encompassed by the filter and replacing the value of center pixel with a value determined by the ranking result. A variety of filters e.g. Median, Max, Min may be applied. The best known example in this category is a median filter. As its name implies, replaces the value of a pixel by the median of gray levels in the neighbourhood of that pixel using eq (4)

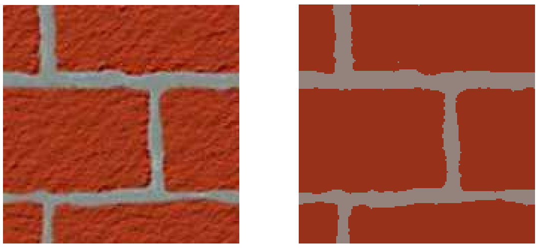
$$f^{\wedge}(x,y) = \underset{(s,t)\in S_{xy}}{median} \{g(s,t)\} \tag{4}$$

Median filters are quite popular because for noise reduction capabilities with considerably less blurring effect than linear smoothing filter of similar size. In the proposed method it is used to illustrate the viable post-processing techniques. Median filtering is particularly effective in forcing the points with distinct colours to be more like their neighbours by eliminating isolated colours. Most of the misclassified pixels are removed which results in improving the segmentation quality. As shown in the filtered image of Figure 2(b), segmented regions are relatively uniform.

3. Experimental Result

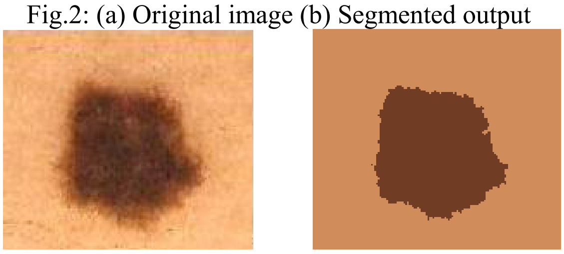
The proposed system is a general purpose tool for segmentation of colour Texture images. We have tested the proposed algorithm by applying it on a variety of colour texture images. Performance of the system on different types of colour textured images is discussed here. Experimental results on some of the images are illustrated here.

The proposed algorithm has been implemented in Matlab environment. For all experiments the proposed method uses 4 as a threshold value. Experimentally, it is found that 4 is a suitable threshold value for most of the images. To see effectiveness of CTSFCM, the algorithm is tested on various colour images of different types. Experimental results are illustrated to estimate performance of the proposed algorithm. Segmentation results for the Figures 2(a)-5(a) are depicted in Figures 2(b)-5(b) respectively. It can be observed from the Figures 2(b)-5(b) that without a priori knowledge system could isolate the objects properly and are labelled with their mean colours.



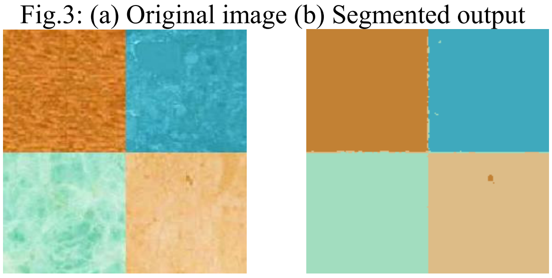
(a) (b)

Fig.2: (a) Original image (b) Segmented output



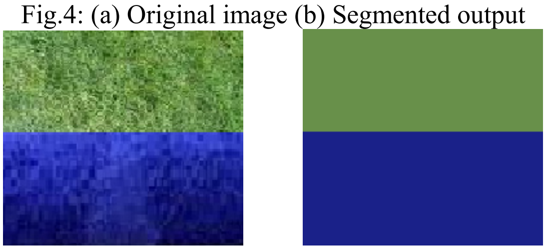
(a) (b)

Fig.3: (a) Original image (b) Segmented output



(a) (b)

Fig.4: (a) Original image (b) Segmented output



(a) (b)

Fig.5: (a) Original image (b) Segmented output

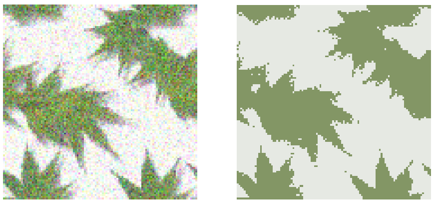
4. Application

4.1. Performance on Noisy Images

Application of the proposed system is demonstrated here. The proposed system has been employed in object extraction problem from noisy environments. The images are distorted with different types of noise immunity such as “Gaussian”, “Salt & Pepper”, and “Speckle” with mean 0 and variance 0.1, 0.01, 0.02 respectively. Figures 6(b)-8(b) shows the segmentation results of distorted image respectively. Robust performance of the proposed system on noisy images can be observed from the experimental results.

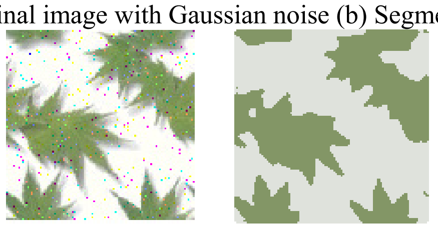
5. Conclusion

In this paper we proposed a novel segmentation technique for colour texture image segmentation. The main issue of colour image segmentation is systematically addressed including *perceptual uniformity* in colour representation and clustering. The segments in colour images are found automatically using FCM clustering technique based on minimum fuzzy entropy criterion. One of the advantages of proposed system is that it does not require a *priori* information about the number of objects present in the image. In addition there is no distortion or colour change after segmentation. The proposed method is believed to be conceptually simpler than most of the techniques found in the literature on colour texture segmentation. CTSFCM is tested on various images of different types. Illustrative examples show that performance of the proposed system is robust and gives good results. A post-processing scheme utilizes image spatial information to successfully transform a segmented image with uniform regions. An application of the proposed system for noisy images is presented. Robust performance can be seen from the experimental results. Generality of the system makes it applicable in a wide range of computer vision tasks.



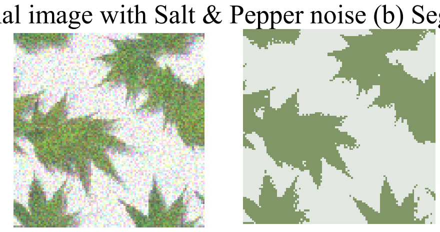
(a) (b)

Fig.6: (a) Original image with Gaussian noise (b) Segmented output



(a) (b)

Fig.7 (a) Original image with Salt & Pepper noise (b) Segmented output



(a) (b)

Fig.8: (a) Original image with Speckle noise (b) Segmented output

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