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Colour–Texture based Image Segmentation Using Effective Algorithms: Review

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Abstract: Image segmentation for analysis is a major aspect of perception and till date it is challenging issue for machine perception. Many years of study in computer vision prove that segmenting an image into meaningful regions for subsequent processing (e.g., pattern recognition) is just as hard problem as invariant pattern recognition. This paper discusses the major color-texture image segmentation approaches which treat the colour and texture pattern separately or integrally. And then review the various algorithms with most representative method with their advantages and limitations. Finally summarize the image segmentation methods designed to integrate more feature information, with high accuracy and satisfactory visual entirety.

Keywords: image segmentation, colour texture integration, feature extraction, colour texture analysis, pattern recognition.

I. INTRODUCTION

Image segmentation is fundamental task in computer vision. Colour texture classification of Image is very essential and critical step in image processing and pattern recognition. In particular the segmentation of natural images are challenging task, since these images exhibit no significant uniformity in colour and texture and also they are often characterized by a high degree of complexity, randomness and irregularity. The main task of segmentation is to segment image into meaningful regions. Over the years, researchers have studied different approaches for image segmentation, so that images can be segmented by using minimum user interaction or an unsupervised way. Advancement in science and technology and progress of society has greatly improved the segmentation performance in recent years. Still high accuracy and reliability is challenging issue for researcher of image segmentation methods. Algorithm/Methods proposed in early time are generally entwined with specific application. For example to calculate texton for blood cell analysis segmentation algorithm uses colour information [1]. So it has the limited functionality and not suitable for segmenting natural images as they have rich texture information. Another example of image segmentation algorithm with specific application is surface inspection of granite images. Such algorithm uses combination of chromatic information with microscopic texture information [1]. To capture relevant structural information by extracting texture feature using colour clustering and binary blob images together is complex process, also it is difficult to analyse random colour texture pattern. Another example is to segment the bone marrow cell colour images. Therefore we can say that the methods appeared in early time were designed for specific application and lack in modelling general concept of colour texture modelling. These methods were unable to describe the multi scale structure and the microscopic structure. So it was necessary to find new methods which can integrate multiple feature information for image segmentation. The field of image segmentation based on colour along with texture descriptors has been developed extensively over past three decades publishing huge no of algorithm between years 2007 and 2014. More than 1000 papers have been published between the year 1984 and 2009[2]. So it is important to note the fact that colour texture analysis is one of the most researched areas in image processing and computer vision. The aim of this paper is to review the concept and strategies which are developed and applied in the process of colour texture integration to attempt robust image segmentation. Though there are several methods which evaluates colour feature alone or texture feature alone, we are not aware of the literature present which is concerned with systematic analysis of concept and methodologies investigated in process of development of colour –texture image segmentation algorithms. So we would like to mention that review present in this paper is particularly concerned with published work related to unsupervised colour texture image segmentation designed by integrating various corresponding method to capture more feature information. The review mentioned below contains the methods which have achieved some impressive segmentation results and have gained wide attention in computer society. The methods compared below have categorized into three aspects of image segmentation that is colour-texture descriptor, advance determination of valid class no and reduction method of over/error segmentation. In section II we are discussing the most widely used approaches for image segmentation. In section III we are discussing image segmentation algorithm which have set benchmark in history with their advantages and limitations, followed by brief conclusion. Fig 1 shows the comparison of results among the most used algorithm [1].

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II. COLOUR IMAGE SEGMENTATION: APPROACHES

This section provides the brief review of existing colour-texture image segmentation methods based on integration in segmentation process. Based on the approach used for extraction and integration, these methods can be classified into three categories as: extraction of colour texture feature using implicit approach, extraction of colour texture feature using succession approach, extraction of colour texture feature separately and then integrating them during segmentation process.

A. Extraction of colour- texture feature using implicit approach

In this approach features are extracted from single or multiple color channels [1] [2]. The algorithms are based on the assumption that the color and texture are interdependent pattern. Segmentation process is typically embedded with bottom –up approach.

The related algorithm is proposed in paper Panjwani and Healey in 1993 suggests a region-based approach that uses color Gaussian Markov Random Field (GMRF) model. The model considers spatial interaction within each of spectral band along with interactions between color planes. maximum likelihood method is used for estimating parameter of GMRF.The algorithm has two step, in first step image is sliced into square region until a uniformity criterion is upheld.in second step algorithm merge similar characteristics region to form texture boundaries. Similar approach is used in [1], here in first step LUV color space gradient information is calculate and in second step this information is use to merge region by watershed transformation method. Though results of this method are satisfactory; it is specifically designed for granite blob images. Another work proposed in paper [15] by yang et al. uses the compression based texture merging (CTM). At first step this algorithm extracts texture information from all channels of lab color space separately. To reduce dimension Principal component analysis (PCA) is used. In second step to represent probability distribution function (PDF) of texture feature, degenerate Gaussian mixture distribution is used. The limitation of this algorithm is that its segmentation performance depends on choice of texture difference threshold. That is small threshold have scattered segmentation problem and high threshold narrows interested regions.

B. Extraction of color texture feature using succession approach

This approach alleviates the limitation associate with implicit color texture image segmentation algorithm by providing alternative methodologies. This approach is one of the most popular approaches adopted by many researchers [1]. The main motivation is that the approaches belong to this category generated from the intuitive observation that there are not explicit rules that tells the inter dependency of color and texture during process of image formation. The extraction of color and texture feature is considered as successive process. The main idea behind this is that image segmentation can be formulated as a multi-phase approach based on bottom up image partitioning procedure.

In paper [16] proposed work is based on similar approach. This paper have used feature integration scheme to extract multi scale perceptual image tower which emulates human perception when looking at input image from different distances. In this method convolution matrices are calculated using weighted sum of Gaussian kernels to obtain image data. The result of this filtering process use to characterize texture of input image in multi scale scene. In next step the core color cluster are extracted and further steps are defined as probabilistic process. This algorithm is compared with method edge flow proposed by Ma and Manjunath and the result says that Mirhmedi and Petrou's method is better as it preserves the objects boundaries during segmentation process.one of the method proposed by Deng and Manjunath[3] called JSEG considered as benchmark in computer vision field. JSEG segmentation process has two phases. In first phase grouping filter is use to quantify the extracted color feature into 10-20 prototype. In second phase local homogeneity is calculated in the quantitative J-image and then for clustering multi scale region growing method is use. The limitation of this algorithm is that [1] simultaneous analysis of color similarity and spatial relationship among neighboring pixels is difficult. Another method proposed by Hedjam and Mignotte [4] uses Hierarchical graph-based Markovian Clustering (HMC) method. In this paper Markov Random Field (MRF) model is used for segmentation of input image into some predefined clusters which results in over segmentation. Classical Region Adjacency Graph (RAG) method is use to model the labeling results, where to measure the color–texture similarity between adjacent regions each edge is associated with a weight. The limitation of this algorithm is that extracted texture features are dependent on choice of window size therefor not suitable to describe irregular or large scale texture image.

C. Extraction of colour texture feature separately and then integrating them during segmentation process.

This approach assumes that color and texture share different patterns and the segmentation model is energy function which combines these two type of information [1] [2]. Methods belonging to this category can be subdivided into two distinct category, Based on the concepts behind this integration strategy.in first sub-category color and texture feature are extracted and integrates them using region-based feature integration schemes such as region growing and active contours, split and merge. This approach is one of the most investigated segmentation schemes in the field of color–texture analysis [2]. In second sub category statistical and probabilistic strategies are use for integration [2].

In paper [5] GSEG segmentation method is proposed where region growing and multi-resolution merging are used for integration of energies of color and texture. But this method produces large number of small region i.e. over segmentation problem. Method proposed by Brox et

al. In [6] framework of level sets are used to integrate the color, texture and movement information, and contours of interested objects are located by reducing some specially designed energy functions. The limitation of this method is that results are dependent on location and contours of user interaction. In paper [7] unsupervised graph cuts (UGC) method is proposed by Kim and Hong. Here RGB space is used for extraction of color information and 1D Gabor-based text on used to represent texture. The disadvantage of UGC is that it may lose some scale discriminating ability. Also text on 's accuracy is depends on the k-means algorithm due to which determination of valid clustering number in advance is not possible. In [8] chen et al. uses MAP-ML (maximum a posterior and maximum likelihood) estimation algorithm for colour texture image segmentation.

III.COLOUR –TEXTURE SEGMENTATION ALGORITHM

To achieve impressive segmentation results with minimum user interaction there are three aspects of image segmentation that is color-texture descriptor, advance determination of valid class no and reduction of over/error segmentation need to be improved.

A. The Color Texture Descriptor Algorithm

The color texture descriptor needs to improve the feature description capability. Only color based segmentation algorithm produce region on basis of color differences only so it will not be suitable for images containing rich texture information.as result contain small non semantic regions. If we consider the texture feature several major categories are available such as geometrical, statistical, structural, model-based and signal processing methods. The signal processing method has gained wide attention in computer society as it can simulate visual perception, and has plenty of filtering techniques, some of them are dyadic Gabor filter banks, ring/wedge filters , optimized Gabor filters, wavelet transforms, Laws masks, wavelet packets and wavelet frames and so on [4].

Though many kinds of Gabor wavelet and wavelet algorithm are available still Gabor wavelet and wavelet are most common and effective than other [1]. Manjunath[10] have put forward the Gabor wavelet, and it owns powerful multi-scale analytical ability; but the performance of this method is depended on choice of Gabor filters also there is lot of information redundancy[1]. Dimension reduction technique can be used to avoid problem of high dimension; But this require large memory and high computational time for convolution and Fourier transform. Another method proposed by Han et al. [9] is semi-supervised and two-label color–texture image segmentation method; here to describe the texture multi scale nonlinear structure tensor (MSNST) method is applied. This method treats the colour and texture feature separately, therefore can ignore the relationship between different features. The proposed algorithm can model regular and concentrated distributed texture region. But it will not work for the large scale texture. This problem can be addressed by total variation (TV flow) flow algorithm. TV flow can widen the differences among different texture regions simultaneously. More effective algorithm is proposed by Yong yang et al. [1] integrates the compact MSST texture, TV flow and RGB color.

B. Algorithm to Determine Valid Class Number in Advance

The second aspect of segmentation process is to determine valid class number in advance. Generally valid class no cannot be determine in advance as different images contains different color texture patterns.so the no is set manually and it is set large enough. But this may lead to massive calculation taking more time and unsatisfied segmentation result. The solution to this problem is provided by [12]. Here self-organizing map (SOM) network method is used to estimate the valid class number. Limitation of this method is that valid class number is determined separately from initial clustering process and it is constant throughout segmentation process.
Therefore this method does not provide satisfactory solution. The traditional Gaussian mixture models (GMM) is less effective than multivariate mixed student's t-distribution (MMST)[1]. MMST performs more robustly when filtering noises and can adaptively adjust the kurtosis of probability distribution by changing the degrees of freedom parameter. The paper [1] uses the multivariate mixed student's t-distribution (MMST) to model the colour–texture probability distribution.

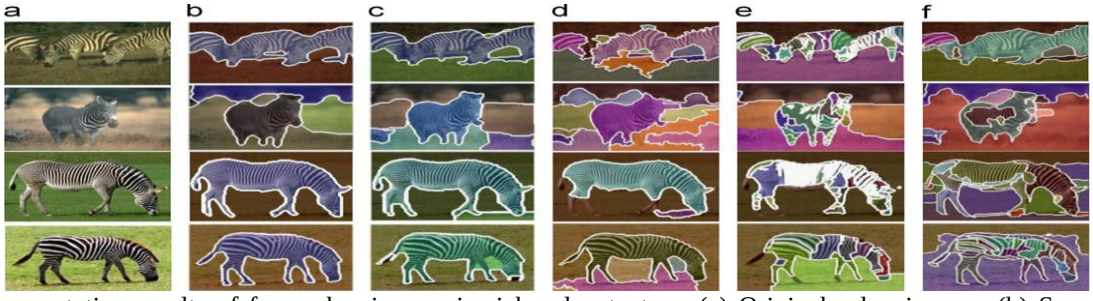

Fig.1 Segmentation results of four zebra images in rich color–texture. (a) Original zebra images. (b) Segmentation results multivariate mixed student's t distribution and regional credibility merging approach. (c) Segmentation results of the MSNST + Lab method. (d) Segmentation results of the JSEG method. (e) Segmentation results of the MAP–ML method. (f) Segmentation results of the CTM method , [ref.1]

A. Algorithm to Reduce Over/Error Segmentation

The third aspect of image segmentation is mainly concern with reduction of over/error segmentation.so many causes are there for over/error segmentation such as large no of small noise region. Many of these small noise regions are meaningless because of which visual entirety get disturbed. Similarly segmentation accuracy and speed of convergence reduced by over/ error segmentation. One of the papers by chen [13] has addressed this problem and suggested relabeling method to reduce error segmentation. This method relabelled those regions which have no spatial connection but shares the same label. This method corrects these false labelling and helpful to reduce error segmentation. The limitation of this method is that it addresses the only problem of error segmentation, no solution is provided for over segmentation problem. Another paper by Mignotte et al. [14] proposed method for over segmentation call as label merging strategy which is based on MRF model. This method calculates the probabilistic rand index (PRI) at pixel level. As this method produces very less no of segmentation results, Gibbs distribution is difficult to establish. Some theories proposed earlier are based on traditional decision merging techniques, such as Bayesian theory, fuzzy logic and Dempster–Shafer theorem. But the limitation of these methods is that it is difficult to merge and discriminate the region which have different label with same posterior probability distribution. Method proposed by Yong yang et al. [1] named as regional credibility merging (CRM) integrates the more than two method. Common edge between regions, regional adjacency relationship, regional colour–texture Dissimilarity and region size are integrated to form the CRM which gives the better result than the method mention previously. This paper designs an effective iteration convergence criterion, to ensure that the image segmentation process can be performed in an unsupervised way. This method got the superior result by using KL divergence for MMST, to achieve the segmentation process adaptively and combining the negative logarithm of probability for all colour-texture features.

IV. CONCLUSIONS

The major objective of this paper is to categories the approaches used in segmentation process, on the basis of integration of the color-texture descriptor and to analyse the direction of research. After evaluating papers it is found that the earlier methods used for segmentation was application specific. Such methods owned the limited functionality to segment natural images and lack the general concept of colour-texture modelling. So it was important to propose new promising methods for rich colour-texture image segmentation. The three major approaches in the development of colour–texture segmentation namely implicit feature integration algorithm, Extraction of colour texture feature using succession, and Extraction of colour texture feature separately and then integrating them during segmentation process. Section 3 discusses the algorithms that have set the benchmark in the image segmentation field. In this section we discuss the various algorithms for colour-texture descriptor, algorithm to determine valid class number adaptively, and the algorithm used for reduction of error/over segmentation, with their advantages and limitations. The algorithms discussed here are outperforming and can obtain the satisfactory colour-texture segmentation results, with high accuracies.

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