An Efficient Boundary Detection and Image Segmentation Method Based on Perceptual Organization

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ABSTRACT : **In this paper, we presents a novel method for detecting the boundaries of the object in outdoor images by using most common properties of the images such as perceptual organization laws. Here the proposed segmentation scheme is based on perceptual organization and background recognition. This paper mainly concentrates to recognize the structurally challenging objects, which is generally combination of several constituent parts. Our new proposed method based on perceptual organization model can efficiently recognize the non-accidental relationships, which are perfectly structured from the constituent parts of the strictly structured objects. The simulation results of this paper show that the efficient and accurate image segmentation by using perceptual organization models.**

Key words: **— Energy function, image segmentation, perceptual organization.**

I. INTRODUCTION

In the field of computer vision one of the most important medium for conveying the information is Images. In today's technological life the data or information extracted from them can be used for several tasks like detection of cancerous cells, navigation of robots, and identification of an airport from remote sensing data.

Now there is a requirement of a specific method, with the help of which, we can observe the images and extract the data or objects. The concept of *"Image segmentation"* satisfies all the above needs. Thus, for the analysis of any image, image segmentation is the primary and important step. In some cases de-noising of image is required before performing the process of segmentation to avoid the selection of false contour and for successfully segment the image without loss of information or data.

Remaining part of this paper arranged as in section II the requirements of image segmentation and the complete process of image segmentation is discussed. Section III briefly explains about several types of image segmentation techniques, which is very helpful for further discussions. The complete related and necessary work for this paper clearly explained in section III with image segmentation algorithm and identification of Backgrounds in Outdoor Natural Scenes. Our proposed

Method for the contribution of this paper i.e. Perceptual Organization Method is clearly explained in section IV, which is the core part of this entire project. The simulation results and analysis of those results for our proposed scheme is present in section V.

II. IMAGE SEGMENTATION

The process of partitioning image into multiple segments is known as Image Segmentation. Here the partition has done based on the uniformity of the several factors like texture, intensity and colour [1]. In the real world the applications of image segmentation presents in several fields, such as Finger print Recognition, Face Recognition, Medical applications, Locate objects in satellite images etc... Several segmentation methods are available today. The choice of a segmentation technique is based on the type of considered image and the problem.

III. CURRENT SEGMENTATION TECHNIQUES

Several Image segmentation techniques are proposed by several researchers. But all the methods are not suitable for all types of images i.e. the algorithm proposed for a particularly one type of image is not suitable to apply for other types of images.

Therefore there are many challenges are raised while developing a unified segmentation approach for any kind of image. So there is no universally accepted method for image segmentation in decades of research. Therefore the concepts of image segmentation methods are categorized into following categories based on two properties of image

• Detecting Discontinuities

It uses the image segmentation scheme like edge detection. In this method the partition of an image is purely based on abrupt changes in intensity [1]

• Detecting Similarities

In this method the process of image partition is performed by making the regions which are very similar to each other. This method uses image segmentation schemes like region growing, region splitting, thresholding and merging.

A. SEGMENTATION BASED ON EDGE DETECTION

In this method, the process of image segmentation is performed by detecting the pixels or edges, which are presents between different regions. These edges or pixels contain rapid transition in intensity from one edge's pixel to another edge's pixel.

Generally there are two edge based segmentation schemes- gradient based method and gray histogram [4].

1. **Gradient Based Method** Gradient based method is best segmentation method for edge detection. The term *Gradient* referred as the very first derivative of an image f(x, y), when there is sudden change presents in intensity near to the edge. Several gradient convolutions are involved this method.

These edge pixels are used to form closed boundaries of the regions. Canny operator, sobel operator, Laplacian of Gaussian (LOG) operator, Laplace operator etc. are common operators used for edge detection in this scheme.

2. Gray Histogram Technique

Generally the edge detection technique depends on the value of threshold *'T'*. And finding the maximum and minimum value of intensity is a very complex task. Therefore the grey histogram is un equal for the impact of noise.

B. THRESHOLDING METHOD

A powerful and simple approach for image segmentation is *'Thresholding Method'*. This approach significantly designed for segmenting the images which contains light objects on dark background [1]. The Thresholding technique is based on the on characteristics of image [4]. The greatest advantage of thresholding operation is, it transforms the multi-level image into a binary image.

The process of thresholding is as follows:

To separate the objects from the back ground and to divide the image pixels into several regions carefully, choose the threshold *'T'*. If the intensity of any pixel (x, y) is greater than or equal to threshold value i.e., $f(x, y) \geq T$ then consider those pixel is belonging to the same region, otherwise it belongs to background. There are 2 types of thresholding methods are available for the selection of threshold *T* [12], *global and local thresholding*. Whenever the threshold T is constant then the approach is known as *global thresholding* otherwise it is known as *local thresholding*. Whenever the illumination of background is uneven then the global thresholding method is useless. Whereas for local thresholding the uneven illumination of image is compensated using multiple thresholds. The important limitation of the thresholding scheme is, since it generates two classes only it cannot be suitable for multichannel images.

C. REGION BASED SEGMENTATION METHODS

Region Based Segmentation Methods is more immune to noise and very simple compare to edge detection method. In edge based schemes the partition of an image is based on the uneven sudden changes presents in intensity, which is very near to edges. Whereas in region based scheme, the partition of an image into regions are performed that are very similar according to a set of predefined criteria [10, 1]. Segmentation algorithms based on region mainly include following methods: Region Growing and Region Splitting and Merging

D. SEGMENTATION METHODS BASED ON PDE (PARTIAL DIFFERENTIAL EQUATION)

In this scheme one cam using the segment the image by using partial differential equation methods and by solving the PDE equation using available numerical schemes. Generally PDE based Image segmentation schemes are carried out using snakes or active contour model. The basic idea of active contour model or snake is to Converting the segmentation problem into a PDE framework. The several methods for image segmentation are - snake, level set and Mumford-shah model.

Besides these methods several efficient methods are available for image segmentation such as Segmentation Based on Artificial Neural Network, Segmentation Based on Clustering, Multi objective Image Segmentation etc.

III. RELATED WORK

Several methods are available today for image decomposition. Most of the common method is *Bottom-up image segmentation method*. In Bottom-up image segmentation scheme most common features like textures, edges, and colours are utilized for image decomposition. Generally the Bottom-up image segmentation scheme categorized into two main forms, one is region based and another one is contour based schemes. Another efficient new method proposed by Shi and Malik which is efficiently avoids the several iterated complex problems while cutting the small sets of isolated nodes of the graphs. Similarly an efficient graph-based generic image segmentation scheme is proposed by Felzenszwalb and Huttenlocher.

IMAGE SEGMENTATION ALGORITHM

In this section we presents an image segmentation scheme for outdoor images which is mainly concentrates to detect the boundaries of the objects based on *perceptual organization laws*. The core contribution of this paper is POM. Generally the POM comprises a list of *Gestalt cues*. Therefore by implementing the gestalt cues in our paper, the POM can detect the boundaries of structured objects without having any object-specific knowledge of these objects.

The formal definition for the salient structured objects and object parts in images are:

Structured object: Any object with a detectable and independent physical boundary is known as structured object. Here the physical boundary referred as boundary of the object should not be combined with any other structured object i.e. unique boundary of the object For example; the window of a building should be treated as a part of the building because the whole physical boundary of the window is contained in the building's physical boundary.

Object part: The homogenous part of a structured object surface in an image is known as *object part.*

In the remaining of this section, we present a clear discussion for how to find out the very common background objects such as roads, vegetation in outdoor natural scenes, and skies. Then, we discuss about our POM scheme and the boundary detection schemes and finally, we describe the algorithm for image segmentation using the concept of POM scheme.

Identification of Background in Outdoor Natural Scenes

Mostly the objects identified in natural images are divided into two classes as unstructured and structured objects. Generally unstructured objects consists evenly distributed homogenous surfaces, and the structured objects generally have multiple constituent parts. Most probably the outdoor natural images consists of unstructured objects like trees, skies, roads, and grasses and this is very complex to distinguish these objects from other image parts. For example, a grass or a tree generally has a appearance with green colours; a sky, generally consists uniform appearance with white or blue colours

Therefore, these background objects can be accurately recognized solely based on appearance information.

Therefore to solve this problem an efficient key is required and key for this is termed as *texton.* For describing the textural perceptions of human the texton is used. The process of *textonization* is as follows: Initially the training images are transformed to the perceptually homogeneous CIE colour space. Then 17-D filter bank is used to convolve the transformed training images. Parallel use the same filter bank as Gaussian filters which has the Gaussians at 1, 2, and 4, derivatives of the Gaussians at 2, 4 and similarly Laplacians of Gaussians at scales 1, 2, 4, and 8. Here the Gaussians are applied to three colour channels only and other filters are used for the luminance channel. Therefore by performing this 17-D response of a training image pixel is obtained and then the 17-D response is augmented with the CIE, channels to create a 20-D vector. Then after the completion of augmentation process the three channels achieves higher accuracy. Then the cluster centers are generated by applying the Euclidean-distance –means clustering algorithm on 20-D vectors and these cluster centers are known as "*Texton"*. Therefore finally the texton map is generated after assigning the each pixel of each image to the nearest cluster centre. After the process of textonization, each region of the training

images is represented using a histogram of textons. Then use these training data to train a set of binary Adaboost classifiers to classify the unstructured objects. The classifiers also achieve high accuracy on classifying these background objects in outdoor images.

IV. POM SCHEME

Generally most of the images are combination of background and foreground objects. And most of the foreground objects have detectable and independent physical boundaries and consists of multiple parts. First we assume that to segment a image into even patches bottom-up method is used, then most of the structured objects are over segmented to multiple patches (parts).

Therefore here the challenge is how to segment the structured object. To tackle this, the efficient answer is POM model.

The image segmentation algorithm is divided into the following three steps.

1. Use a bottom-up method to segment the given image into uniform patches.
2. To identify the background patches use background classifiers.
3. Finally to group the remaining patches use POM

Even after the identification of background, large amount of parts are remaining. Then using Gestalt laws

Group these kinds of regions.

In simple words the entire process of works is as follows: Initially choose one part and then keep increasing the region and trying to group its neighbours with this region. This process will be stopped whenever none of the region's neighbours are grouped with the region. The goodness of the region depends on gestalt laws.

Among the constituent parts of a structured object, The POM efficiently captures the special structural relationships that obey the principle of non-accidentalness of the structured object. Therefore the proposed POM method will be applied to real-world natural scene images, only after segmenting the image into regions such that each region approximately belongs to an object part. In the process of implementation use the Felzenszwalb and Huttenlocher's approach to create initial super pixels for outdoor scene image. Again apply segment-merge method for further improvements of the quality of segmentation and to merge the small size regions. These small size regions are caused due to the texture of surfaces or due to the inhomogeneous portions of the surfaces. To improve the performance of POM merges these small size regions with their larger neighbours and if any adjacent regions have similar colours, then also merge them together. Therefore by performing it the quality of super pixels is improved.

Now turn to the process of image segmentation. First obtain the improved super pixels of the image by applying the segment-merge technique as described above. Use efficient image segmentation scheme proposed by Felzenszwalb and Huttenlocher based on graph-based generic image segmentation scheme.

Until all the components are grouped with other components, this perceptual organization scheme is repeated for several times. In real cases two times of grouping is good enough. Finally at last, merge or combine all the adjacent ground objects and sky together to generate final segmentation.

Thus a novel image segmentation scheme for outdoor scenes is to detecting the boundaries of the object based on most general properties of the real world objects, such as perceptual organization laws, without depending on specific knowledge of the object. The image segmentation algorithm is using a POM is the main contribution of this project. The POM scheme quantitatively consists of a list of Gestalt cues. By doing this, the POM can detect many structured object boundaries without having any object-specific knowledge of these objects

The choice of energy function to be minimised the behaviour of algorithm .given the parametric representation of the active contour v(s)=(x(s),y(s)) where s=[0,1] the energy function is given by

$$E_{snake} = \int_0^1 E_{snake}(v(s))ds$$

$$E_{snake} = \int [E_{\text{int}}(v(s)) + E_{image}(v(s)) + E_{ext}(v(s))]ds$$

Thus, the energy of contour corresponds to three different forces:(i)internal forces between points o f the contour,(ii)image force such as gray level and gradient magnitude that pull the snake two wards the optimal boundary position

(iii)external constraints such as user forces applied to the contour

Image quality metrics: - Two error metrics are used in order to compare various digital image compression techniques in nature they are:-

1. The Mean Square Error (MSE) and
2. The Probalistic Signal to Noise Ratio (PSNR).

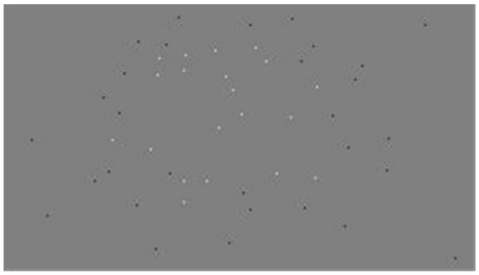
The MSE is the metric that is supposed to measure squared error between the compressed and the original digital image, on the other hand PSNR which measures the peak error in given image that can be mathematically written as

$$MSE = \frac{1}{MN} \sum_{y=1}^{M} \sum_{x=1}^{N} [I(x,y) - I'(x,y)]^2$$

PSNR = 20 * log10 (255 / sqrt (MSE))
Where I (x, y) is the original digital image, and I'(x, y) is the reconstructed image which is undergone through compression/decompression process and finally M, N are their dimensions of the images.

IV. SIMULATION RESULTS

Input image



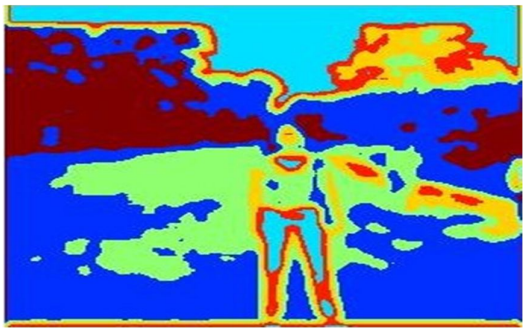
Seeded image

Segmented image

Background image

Fig 1 Region based segmentation

Input image

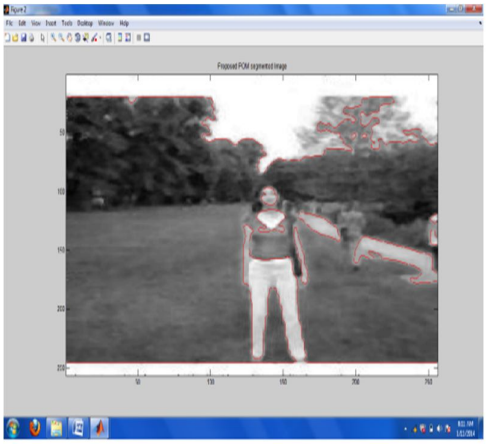


Gould class segmentation

Fig 2 Gould class segmentation

Gould segmented image

Fig 3 Gould segmented image



Efficient boundary detected image

Fig4 Efficient boundary detected image

By above analysis of results we can conclude that proposed POM method segmented images very efficiently and even after attacked with noise it recovers easily to shows its performance in secure manner by applying 3X3 mask median filter to remove noise from image.

IV. CONCLUSION

We present a novel method for detecting the boundaries of the object in outdoor images by using most common properties of the images such as perceptual organization laws. Here the proposed segmentation scheme is based on perceptual organization and background recognition. This paper mainly concentrates to recognize the structurally challenging objects, which is generally combination of several constituent parts. Our new proposed method based on perceptual organization model can efficiently recognize the non-accidental relationships, which are perfectly structured from the constituent parts of the strictly structured objects. The simulation results of this paper show that the efficient and accurate image segmentation by using perceptual organization models. We made comparison of other techniques to show its working and justification of image quality measures shows psnr of 8.863dB and mse of 8.23 is achieved with our method.

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BIO DATA

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