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Interactive Image Segmentation based on Seeded Region Growing and Energy Optimization Algorithms

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***Abstract*—The proposed system develops a novel image super pixel segmentation approach using energy optimization algorithm. This algorithm with self-loops has the merit of segmenting weak boundaries by the new global probability maps and the commute time strategy. But it is difficult to find and track exact contours of an object in case of complex images using energy optimization algorithm. In order to mitigate this problem and to improve segmentation quality, this paper presents a seeded region growing algorithm (SRG) along with energy optimization algorithm. In this paper, we discuss about popular seeded region growing methodology used for segmenting weak boundaries. This method use centroid calculation of the different regions appeared in an image and can withstand for almost each and every shape appear in the mage. This work is divided in to two stages, in first stage calculate the region of interest and then place the seed at the centroid of that region. In second stage region starts to grow from the initial seed until the homogeneity criteria satisfied. The experimental results have demonstrated that this method achieves better performance than previous approaches.**

***Index Terms*— Image Segmentation, Region Growing, Seed Placement, Commute Time, Optimization, Texture.**

I. INTRODUCTION

Image segmentation is the division of an image in to regions or categories, which correspond to different objects or parts of objects. The purpose of dividing an image is to analyse each of object present in the image and to extract some high level information. Most of the segmentation techniques are either edge-based or region-based. An edge or linear feature is manifested as an abrupt change or a discontinuity in digital number of pixels along a certain direction in an image. Edge based segmentation is the location of pixels in the image that correspond to the boundaries of the object seen in the image. The region based segmentation is portioning of an image in to similar areas of connected pixels through application of similarity criteria among candidate set of pixels. Application fields of image segmentation aresecurity systems, object recognition, computer graphics, medical imaging, satellite images etc. Pixels are the basic building blocks of an image. Super pixels are commonly defined as contracting and grouping uniform pixels in an image. The main merit of super pixel is to provide meaningful representation of an image. It reduces the number of image primitives and improves segmentation efficiency.

The proposed system develops a super pixel image segmentation approach using energy optimization algorithm. This approach consists of two main steps. The first step is to obtain the super pixels using LRW algorithm with initial seed points. In the second step, optimize the initial super pixels to improve the

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performance. Energy optimization includes two items: the data items makes the super pixels more homogenous with regular size by relocating the seed positions, and the smooth items makes the super pixels more adhering to the texture edges by dividing the large irregular super pixels in to small regular ones. Then LRW algorithm is performed to obtain the better boundaries of super pixels with new seed positions. Super pixel optimization and LRW steps are executed iteratively to achieve the final result. It is an efficient algorithm to obtain better image segmentation. Butin case of complex images it is difficult to find and track exact contours of an object, especially to track the objects received from satellites. In such cases to improve efficiency and to enhance the segmentation quality, seeded region growing algorithm is added along with the energy optimization algorithm. With this enhancement the merit of segmenting the weak boundaries and complicated texture regions can be achieved.

Seeded region growing algorithm consists of two stages, in the first stage calculate the area of interest (specific part of an image) based on background and objet properties of image. The area or region generated is used to find the centroid in order to place the seed. In the second stage region starts to grow from initial seed placed in the first stage. The growth of region depends upon the intensity value of the neighbouring pixels as well as threshold value. If the intensity value of the neighbouring eight pixels i.e. (left, right, up, down, top right, bottom right, top left, bottom left) is same and it lies in the given threshold value the region will start to grow. It also checks the previously visited pixels. If a pixel is already grown i.e. part of region it will not be visited again no matter if it comes as a neighbouring pixel. This will reduce computational overhead. When this regionstarts to grow in the second stage, there is a need of some stopping gradient which limits the growth of region up to the area of interest. This happens by calculating the intensity value of neighbours. If the intensity value of the neighbouring pixels changes abruptly then the region stop to grow at that point. So finally grown region will be the required segmented region.

II. PROPOSED SYSTEM

The proposed system is a super pixel image segmentation based on energy optimization algorithm. This method begins with initializing the seed positions and the initial super pixels are iteratively optimized by the energy function, which is defined on the commute time and texture measurement. Commute time in this algorithm computes the return time from the seeds to pixels. The labelled boundaries of super pixels are obtained from the commute time as follows:

$$R(x_i) = \text{argmin} l_k CT(c_{lk}, x_i) = \text{argmax} l_k f_{lk}(x_i) \quad (1)$$

Where c_{lk}denotes the centre of the super pixel, and the label $l_k$is assigned to each pixel $x_i$to obtain the boundaries of super pixels.The energy optimization algorithm can find optimal path from the seed to the pixel. Then the label of the seed with the minimal commute time is assigned to the corresponding pixel as the final super pixel label.

The performance of super pixels are improved with the following energy function:

$$E = \sum_l \quad (Area(S_l) - Area(S))^2 + \sum_l \quad \widetilde{W}x CT\,(C_l^n x)^2 (2)$$

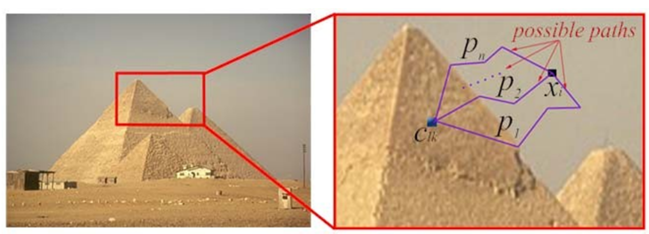

Figure 1. Illustration of computing the commute time

Where the first term is the data item and the second term is the smooth item. The data item makes the texture information of image to be distributed uniformly in the super pixels, which produces more homogeneous super pixels. The smooth item makes the boundaries of super pixels to be more consistent with the object boundaries in the image.When the commute time CT (c_l,x)between seed point $c_l$and pixel x is small, $\widetilde{W}x$

(penalty function)will be a large value. This makes theoptimized super pixel to be more compact and more homogeneousin texture regions. But in case of complex images it is difficult to obtain the correct boundaries.

Figure 2.Input image with user seeds

Figure 3. Probability map obtained by energy optimization method

Figure 4.Segmentation result obtained by energy optimization method

Figure 2. Showing the input image selected for segmentation, where green line is used to select foreground and the blue line is used to select the background.
Figure 3 and 4 are the probability map and the segmentation result obtained by energy optimization algorithm only. It shows that in the complicated regions it is difficult to get the proper segmentation.

III. SEEDED REGION GROWING METHOD

Seeded region growing is a simple and robust method of segmentation, which is rapid and free of running parameters. User control over the high level knowledge of image components in the seed selection process makes it a better choice for easy implementation and applying it on a larger dataset. Seeded region growing is based on the conventional growing postulate of similarity of pixels within regions.SRG is controlled by choosing a (usually small) number of pixels known as seeds .This form of control and the corresponding result is readily conceptualized, which allows relatively unskilled users to be able to achieve good segmentation on their first attempt.

IV. REGION GROWING PROCESS

The goal of region growing is to map the input image data in to a sets of connected pixels, called regions according to a prescribed criterion which generally examines the properties of local groups of pixels. The growing starts from a pixel in the proximity of the seed point initially selected by the user. The pixel can be chosen based on either its distance from the seed points or the statistical properties of the neighbourhood. Then each of 4 or 8 neighbours of that pixels are visited to determine if they belong to the same region. This growing expands further by visiting the neighbours of each of these 4 or 8 neighbour pixels. This recursive process continues until either some termination criterion is met or all pixels in the image are examined. The result is as a set of connected pixels determined to be located within the region of interest.

Advantages:
1. Region growing method can correctly separate the regions that have same properties we define.
2. Region growing method can provide the original images which have clear edges with good segmentation results.
3. The concept is simple.
4. We can determine the seed points and the criteria we want to make.
5. We can choose the multiple criteria at the same time.
6. It performs well with respect to noise.

V. SEEDED REGION GROWING ALGORITHM

Seeded region growing approach to image segmentation is to segment an image in to regions with respect to a set of q seeds. Given the set of seeds S1, S2 …Sq, each step of SRG involves identifying one additional pixel from one of these seed sets. These initial seeds are further replaced by centroids of the generated homogenous regions R1, R2………Rq, by involving the additional pixels step by step. The pixels in the same regions are labelled by the same symbol and the pixels in the variant regions are labelled by different symbols. All these labelled pixels are called the allocated pixels and the others are called the unallocated pixels.

The algorithm is presented as follows:

1. Select seed pixels within the image.
2. From each seed pixel grow a region:

2.1 Set the region prototype to be the seed pixel;
2.2 Calculate the similarity between region prototype and the candidate pixel;
2.3 Calculate the similarity between candidate and its nearest neighbour in the region;
2.4 Include the candidate pixel if both similarity measures are higher than experimentally set thresholds;
2.5 Update the region prototype by calculating the new principal component;
2.6 Go to the next pixel to be examined.

VI. INTERACTIVE IMAGE SEGMENTATION

Image segmentation is the process that partitions an image in to region. Although many literatures studied automated image segmentation, it is still difficult to segment region of interest in any kind of images. Automatic segmentation method are not generic, it requires some form of an interventions to correct anomalies in segmentation. Automatic segmentation methods are still far from human segmentation performance, which have several problems such as finding the faint object boundaries and separating the object from the complicated background in natural images. In order to solve these problems, an interactive segmentation method is often preferred. Thus manual segmentation is important yet.

Interactive image segmentation is the process of extracting an object in an image with additional hints from the user. Interactive segmentation aims to separate an object of interest from the rest of an image. In order to shorten the processing time and to decrease the effort of users, there has many interactive image segmentation methods based on various technologies. One of such method is the interactive image segmentation based on region growing algorithm. In an interactive image segmentation a user views the image and based on personal judgement choose the seed points.

Figure 6.Showing the segmentation result obtained after doing enhancement along with the energy optimization method over the same input image as shown in figure 2. It gives better segmentation result with proper segmentation in the complex regions.

VII. CONCLUSION

In this paper we have presented a novel image segmentation approach using energy optimization and seeded region growing algorithms. Here first runs energy optimization algorithm to obtain the initial result by placing the seed positions on input image and further optimize the labels of super pixels to improve the performance. But in case of complex images it is difficult to track the object, in order to mitigate this problem add seeded region growing algorithm with the energy optimization algorithm to improve the performance.It consists of two stages, in stage1 calculate the area of interest (specific part of an image) based on background and objet properties of image. The area or region generated is used to find the centroid in order to place the seed.In stage2, region start to grow from initial seed placed in stage1. Growth of region depends upon the intensity value of the neighbouring pixels as well as threshold value. If the intensity value of the neighbouring eight pixels is same and it lies in the given threshold value the region will start to grow. It also checks the previously visited pixels. If a pixel is already grown i.e. part of region it will not be visited again no matter if it comes as a neighbouring pixel. This will reduce computational overhead. When this region starts to grow in stage2, there is a need of some stopping gradient which limits the growth of region up to the area of interest. This algorithm is capable of obtaining good boundary adherence in the complicated texture and weak boundary regions and improves the quality of segmentation.

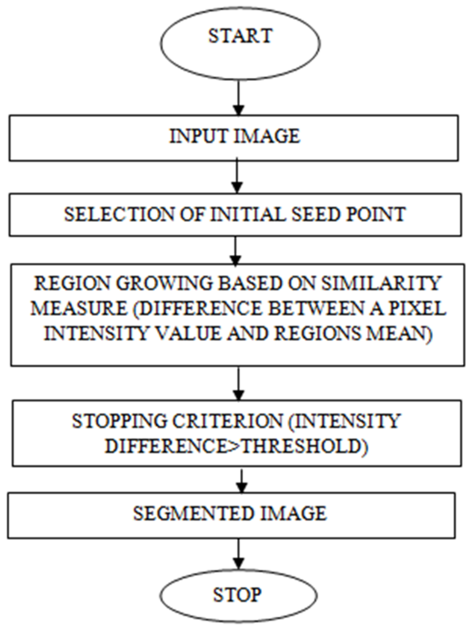

Figure 5. Flow chart of region growing algorithm

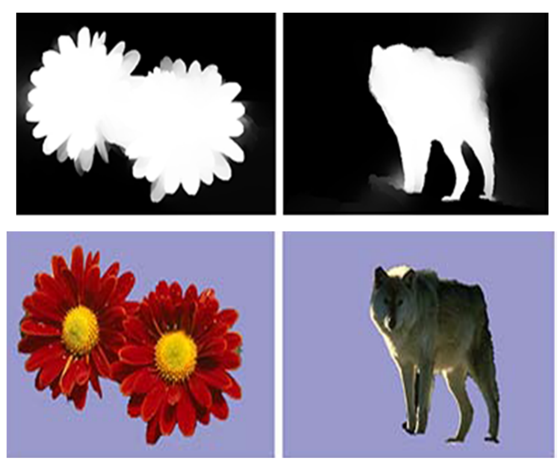

Figure 6. Segmentation obtained by adding SRG along with energy optimization

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