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Novel Approach for Salient Region Detection Improved By Dynamic Region Merging and Boundary Analysis

A New way to detect salient regions

Archana Patil[1], Rahul Gaikwad[2]

PG Scholar, Department of Computer Engineering, GF'S GCOE, Jalgaon, Maharashtra, India

Asst. Professor, Department of Computer Engineering, GF'S GCOE, Jalgaon, Maharashtra, India

ABSTRACT: Detection of salient region detection is useful for several image processing applications such as security system for Airport, Medical imaging, Object reorganization, Criminal Investigation, Retrieval of image, filter design and Retargeting an Image. A novel approach to determine salient region of images is proposed in this paper. GMM if used for clustering the colour values in the L*a*b colour space into n classes and colour spatial variance is calculated. Then dynamic region merging segmentation algorithm is utilized to extract the high level information and to achieve full resolution saliency maps. Context- aware technique is used, which makes salient regions more brilliant in the saliency map. The segmented results of image are used to compute the saliency value based on the colour contrast computation and define the saliency for each region as the weighted sum of region contrast to all regions in the image to obtain better precision and recall. The results obtained from the three modules are combined to obtain the final saliency map which is then multiplied by center distance map.

KEYWORDS: Dynamic region Merging, Context- aware, salient region detection, SPRT, RAG, NNG

I. INTRODUCTION

EXTRACTING meaningful objects from an image or image sequences is a crucial problem in many image processing applications like object recognition, image resizing, image retrieval, context-aware image editing. Visual Saliency is a broad term used to refer the meaningful region of an image. Detecting a salient region is the process of referring to the meaningful region of an image. Whether the region is salient or not depends on its uniqueness, unpredictability and is highly related to boundaries, gradient, colour and edges. Salient region detection is used to evaluate whether an object attracts viewers attention or not. There are two stages of visual processing i.e. Bottom up and top down. The bottom up factors highlights the image regions that are different from their surroundings. Any algorithm designed for salient region detection must have the following characteristics:

- Highlight complete salient regions uniformly.
- Emphasize on the detection of large salient regions.
- Establishing well defined boundaries of salient regions.
- Produce resolution saliency map efficiently.
- Discarding high frequencies arising from texture, noise and blocking artifacts.

Saliency detection methods are broadly classified in two schemes: local contrast method and global contrast method. Local contrast method determines a salient feature of an image region with respect to small local neighbourhood. But the disadvantage of such a method is that these methods highlight the object boundary instead of entire object. These methods produce low resolution saliency map. While the global contrast method evaluate the saliency of an image region using its contrast with respect to entire image. The advantage of global contrast method is that, it produce the full resolution saliency maps, and uniformly highlight the entire object and provide the accuracy in terms of precision and recall rates. These methods are supposed to produce the saliency map as shown in following figure:

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(a) (b)

Figure1:- (a) Original Image (b) Saliency maps.[1]

The saliency maps in the proposed framework presented in this paper are extracted by three features: The colour spatial variance, border measurement, context- aware. The colour spatial variance is used to calculate the degree of colour distribution.

It is observed that when the colour is extensively distributed in an image, it may be the background colour. From the previous observations, it is clear that, the salient objects are less likely connected with the border of an image. The boundary information obtained from each segment is used to determine salient regions. Finally, I will use Context-aware method to achieve full resolution saliency map with well defined boundaries.

II. LITERATURE SURVEY

There are several studies related to salient region detection in the recent years. Ma and Zhang[4] used a fuzzy growth model to generate saliency maps. Harel at al. Combined the saliency maps of Itti et al. with the feature maps to highlight the distinctive regions of an image. Hou and Zhang[6] construct the saliency map by extracting the spectral residual of an image in the spectral domain. This method outputs low resolution saliency maps of size 64×64 pixels for any size input image. Achanta at al.[7] determines the salient region in images using low level luminance and colour features. This method produces the saliency maps of the same size as the input image and better highlights the smaller salient region than the larger one. Recently Goferman et al. [8] consider both local and global features to highlight the salient objects enhanced by means of visual organization. Zahi and Shah[9] defined the pixel level saliency by constructing spatial and temporal attention models. In 2011, Cheng et al.[3] used histogram and region based contrast to compute salient maps with higher precision and recall rates. The disadvantage of this method is that if there are any noisy regions, then this method may not detect right salient regions. Recently, Po-Hung Wu and Chien-Chi[1] proposed a method to calculate the saliency maps based on three features i.e. colour spatial variance, border measurement and PCA-CA method. The disadvantage of most of all existing salient region detection methods is that their computational complexity is very high; also they do not consider noise problems. Noise is independent of the image information such as text, spots and texture. This redundant information provides the high contrast region from local and global perspective which increases the difficulty in detecting the salient objects.

In the architecture of the existing system the three main components are included i.e. (1) Gassian Mixture model (GMM) and Colour Spatial Variance(CSV). (2) Image segmentation and Border Measurement(BM) (3) PCA-Context Aware method (PCA CA) and Boundary Scoring. The efficiencies of the second and third component is enhanced by L0 smoothing filter. The main purpose of using the L0 smoothing filter is to minimize the discrete number of intensity changes among neighbouring pixels subject to similar image structure. In the first component GMM model is used for clustering the colour values in L*a*b colour space into n classes and the colour spatial variance is calculated. In the second component segmentation algorithm is utilized to extract high level information and to achieve full resolution saliency maps. The performance of segmentation depends on segmentation algorithm and the context of images. This relationship is maintained by L0 smoothing filter. From the observation it is considered that a salient object is less likely connected to the image border. The number of pixels in each segment that overlaps the image border is counted to determine the saliency. To obtain the full resolution and the single region with the same saliency value, the segmentation result of the second component of the framework are applied to the third component. There are several segment based saliency detection techniques and their performance highly depends on segmentation results. We use the boundary of each segment to determine the saliency value rather than the entire segment. By using PCA CA method

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better precision and recall rates are achieved and computational complexity can be reduced. As compared to other segmentation based saliency detection technology, in this algorithm segment boundaries are used to calculate the saliency values rather than using the entire region, since the context aware method is more effective around edges. Finally the three feature maps obtained from three main components are averaged to obtain full saliency map, which is multiplied by center distance map.

III. PROPOSED FAMEWORK

In the proposed framework, the need L0 smoothing filter used in the existing system is replaced by the concept of dynamic region merging, which is the most dominant process for image segmentation. Also Instead of PCA CA method used for making a salient object more brilliant in the saliency map is replaced by the context aware (CA) method. Following figure shows the architecture of the proposed system:

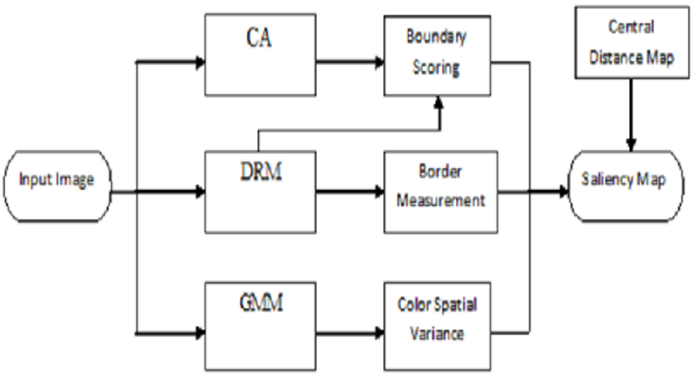

Figure2 – System architecture of the proposed framework.

The architecture include the three main modules: - The first module consist Gaussian Mixture Model and Colour Spatial Variance; Second module is Dynamic Region Merging and Border Measurement; and third module is Context-Aware and Boundary Scoring.

A. Colour Spatial Variance

GMM based colour spatial method, is one of the most statistically an efficient method for clustering, and is a widely used global feature that matches the human visual system [11]. If a colour is extensively distributed within an image, it may be the background colour. In other word we can say that a specific colour with a small spatial variance will attract greater attention, and it may be the part of salient pixel in the GMM can be represented as :

$$P(c \mid I(x,y)) = \frac{w_c N(I_{(x,y)} \mid \mu_c, \sum_c)}{\sum_c w_c N(I_{(x,y)} \mid \mu_c, \sum_c)} \quad (1)$$

Where w_c, μ_c and $\sum_c$ are the weight, mean and covariance of the c^{th} component, N(.) is the Gaussian model and I(x,y) is the pixel at the co-ordinate(x,y).

In the proposed framework maximum likelihood is used instead of probability models :

$$c^*_{I(x,y)} = \arg\max_{c \in C} p(c \mid I_{(x,y)}) \quad (2)$$

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Where, C is the set of all components. The horizontal and vertical spatial positions, $v_h(c^*)$ and $v_v(c^*)$, of each colour component can be further simplified as :

$$V_h(c) = \frac{1}{N} \sum_{I_{(x,y)}} \in c^* \, | \, x - \mu_x(c^*) \, | \, 2 \qquad (3)$$

$$Vv(c) = \frac{1}{N} \sum_{I_{(x,y)}} \in c^* \, | \, y - \mu_y(c^*) \, | \, 2 \qquad (4)$$

Where μ_x and μ_y are the means of x and y co-ordinates respectively. And N is the number of pixel with a maximum likelihood of c*. The colour spatial variance of the c^{*th} component can be defined as the maximum of the x and y co-ordinate variances:

$$V(c^*) = \max(v_h(c^*), v_v(c^*)) \qquad (5)$$

B. Image segmentation by DRM for Border Measurement

In the second module, a dynamic region merging segmentation algorithm is going to utilize to extract the high level information and to achieve the full resolution saliency maps. It is known that the segmentation algorithm is mainly responsible for efficiency of segmentation results, mostly depends on the context of the context of images.

The dynamic region merging segmentation algorithm is based on the similarities among the pixels within a region. In order to cluster the collection of pixels of an image into meaningful groups of regions or objects, the region homogeneity is used as an important segmentation criterion. The homogeneity criteria are essential to the region merging process. The proposed predicate can therefore interpreted as a combination of the consistency measure and the similarity measure. More specifically the extent of consistency tells whether the tested data belongs to the same group. It is measured by the two hypotheses according to the sequential probability test ration (SPRT): null hypothesis, i.e. “the tested data are consistent”, and alternative hypothesis, i.e. “the tested data are inconsistent”.

Overview of the system

- Partition the image into regions.
- This partition depends on predicate
- Check the consistency of regions
- Most consistence regions are merged first and so on.
- Merging follows the dynamic region merging consistency
- The process can be accelerated using nearest neighbour graph.

Consistency Check

This property checks if the regions are homogenous. The merging predicate on regions and could be thus “merge and if and only if they are the most similar neighbours in each other’s neighbourhood and follow the principle of consistency. Region information is usually presented by features extracted from the observed data. The choice of features can be gray level, colour, texture and so on. It will consider two hypothesis[7] according to sequentially probability ratio test.

X = X1 if neighbouring regions are same, then we merge the regions.
X = X2 if neighbouring regions are dissimilar.

DRM Algorithm

DRM algorithm started from a set of segmented regions. This is because the small regions can provide more stable statistical information than a single pixel and using the regions for merging can improve a lot of computational efficiency. The algorithm is as follows:

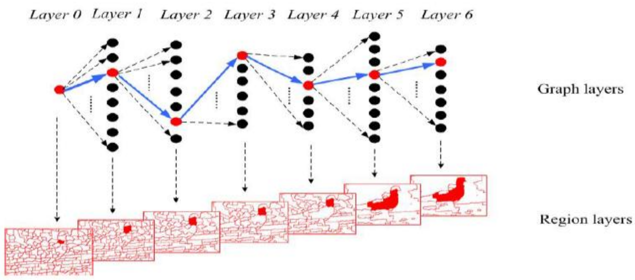

Figure3 - DRM Process

Step 1: For a given over segmented image assign each region as label.
Step 2: Consider n regions
Step 3: Assign initial label as L0 and final label as Ln.
Step 4: The label of each region is sequentially transited from initial to final.
Step 5: To finds the optimal sequence of merges which produces optimal merging of all regions we require minimization of objective function.
Step 6: For this original problem is broken into sub problems using dynamic programming.
Step 7: For each sub problem calculate minimum edge weight
Step 8: Obtain the merging result by shortest path.

In the DRM algorithm there is at least one pair regions to be merged during each iteration, before stopping criteria is satisfied. Dynamic region merging process as a shortest path in a layered graph (shown in Upper Row) the label transitions of a graph node (shown in lower Row). The corresponding image regions of each label layer. Starting from layer 0 (shown in red) the highlighted regions obtains a new label from its closest neighbour. If the region is merged with its neighbour, they will be assigned to the same name of label. The shortest path is shown as a group of (in blue) the directed edges shortest path algorithm is processed by two algorithms: i.e. Region Adjacency Graph , Nearest Neighbour Graph

Region adjacency graph

It is used to represent the segmentation data. Each node represents a region between two nodes if the corresponding regions are adjacent. (1) Form the initial regions in the image using thresholding followed by component labelling. (2) Prepare region adjacency graph (RAG) for the image. (3) For each region in the image perform the following steps: (a) Consider its adjacent region and test to see if they are similar. (b) If regions are similar, merge them. (4) Repeat step 3 until, no regions is merged. DRM perform a scan of a whole graph by which relations between neighbouring are indentified. If the number of regions to be merged will be very high and total computational cost in the proposed DRM algorithm will be very high, so we increase the speed of dynamic region merging algorithm by using nearest neighbour graph.

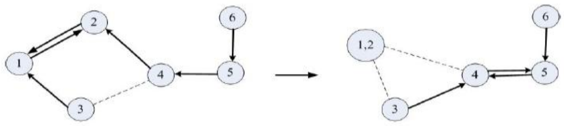

Figure 4 – (a) RAG (b) and Its NNG

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Nearest Neighbour Graph

Instead of scanning whole graph only a small portion RAG edges counts for the merging process, this process explains below:

- Along any directed edge in NNG, the weights are non-increasing.
- The maximum length of cycle is two.
- The NNG contains at least one cycle.
- The maximum number of cycles is half of number of edges.

After merging the regions, boundary information evaluates the region saliency, The boundary weight of region i can be defined as :

$$bw(i) = \frac{length(i)}{2\,(h + w)} \qquad (6)$$

Where length(i) is the length of the overlapping part of the image border and the boundary of region i, h and w is the height and width of the image. The boundary information is used to decide the threshold value used for region merging and new boundary information about overlapping the image border is used to construct border feature map. The segmented image obtained by dynamic region merging process is then passed to the third module of the system to obtain the saliency maps. These saliency maps are obtained by using Context aware method and boundary scoring technique. To obtain the final saliency map, the three feature maps are multiplied by center distance map.

C. Context – Aware and Boundary Scoring

In the third module the segmented result obtained from the second module is utilized to compute the saliency value based on the local and global contrast computation and define the saliency for each region as a weighted sum of region contrast to all regions in the image. Then the result of three modules is combined to obtain final saliency map. The context aware approach is based on the concept that salient regions are distinctive with their local and global surrounding. Context aware saliency has the following principles

- Low –level consideration such as contrast and colour.
- Global considerations which suppress frequently occurring features while maintaining the features that deviate from the norm.
- Visual organization rule which states that visual forms may processes one or several center of gravity about which the form is organized.
- High level factors, such as human faces.

There are several saliency based techniques [7], [14] and their performance highly depend on the segmentation result. In the proposed algorithm the boundary of each segment is going to be used to determine saliency value, rather than the entire segment, since the context-aware method is more effective around the edges. Consequently the utilization of boundary can lower the influences of an incomplete segmentation result. Each region boundary sequence is described as $G_i = [\, t_i^{(1)}, t_i^{(2)}, \ldots\ldots\ldots, t_i^{(ni)} \,]$ where $t_i^{(.)}$ is the co-ordinate vector of x and y (Co-ordinates of pixel) and n_i is the total number of the i^{th} region boundaries.. At the last, the feature map based on boundary score will be determined.

IV. CONCLUSION

This paper presents a novel framework for salient region detection using dynamic region merging and Context-aware. Dynamic region merging algorithm reduces the problem of over-segmentation. The efficiency of salient region detection depends upon the segmentation result. Context-aware is used to reduce noise and other redundant information. Furthermore, I will try to utilize the color spatial variance, border information and global-local contrast to construct saliency maps.

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