A Survey on Different Salient Region Detection Methods

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Abstract – Salient region detection is one of a method which are commonly using in image processing. Image processing includes image compression, image retrieval, face recognition, collage making and also image retargeting. Salient regions are used as a preprocessing phase in many of these applications. A salient object can be computed by different detection methods. In this paper we study on different methods for salient region detection. Different results are compared with ground truth using MSRA dataset. In this paper we are considering color spatial variance map, segmentation map, and frequency tuned saliency map for comparing different salient detection methods.

Index Terms – Color spatial variance, Frequency tuned saliency, Image processing, Salient region detection, Segmentation.

1. INTRODUCTION

Saliency is a term mainly used to calculate whether an object in an image attracts viewers' attention or not. It always depends on their uniqueness or rarity. Many features are used in order to compute the most attracted regions. Humans identify salient regions by considering their shape, color and other attracted features which are the main characteristics for visual stimuli.

Visual saliency is a quality which makes some object in the scene pop out from their surroundings and immediately attract our attention. The process of reducing redundant information and detecting the most important parts of an image can significantly reduce the complexity of visual processing.

Humans always gave more attention to important regions in an image and thus effortlessly judge their importance. Detecting salient regions computationally in an image remains a significant goal, where it helps in allocating computational resources while image analysis. Salient regions are widely used in many computer vision application. Salient region objects are also used as a preprocessing method for many image processing applications. They can be used in image retrieval, image resizing, image compression, object recognition, face recognition and object-of-interest image segmentation. While creating saliency map the more salient pixels will be shown in white color, less salient pixels will be shown in black color as shown in Fig.1.

Figure shows original images and ground truth. Ground truth are human labelled one which are used to compare the output of a salient method. Salient region detection methods which are similar to a ground truth and can obtain in much lesser time are said to best detection methods.

Figure 1. Left: Original images. Right: Human labelled ground truths.

Saliency detection means detecting visually attracted regions in images. It is an aspect of exploring visual attention from a computer vision viewpoint. The human pays unequal attention to what is seen in the world. While considering one image, human mind will first access the most prominent area which can be in the centre or far from the centre. When looking at some images, people are usually attracted by a certain objects in an image. Other subjects appear uninteresting for them. Detecting those areas of attention is called saliency detection.

Selecting the best saliency detection method is very important. Saliency detection should always be very efficient to highlight the whole salient region. It should detect salient region border of the image, in the center of the image, or even far from the center of the image. Saliency detection should offer uniformly highlighted salient regions with well-defined boundaries, high efficiency and full resolution. Best saliency detection should reduce the presence of noise while always improving their

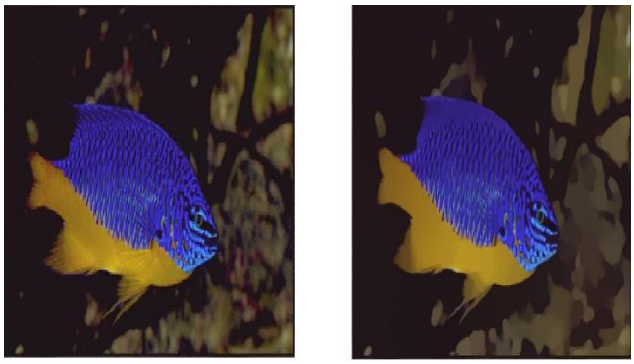

Figure 2. A demonstration of the L_0 smoothing filter: Left: The original image. Right: The smoothed image using L_0 smoothing filter.

Performance. Other important criteria for selection is giving strong performance with high complex images. Implementation should be in less cost also. Other thing should be noted that unique object in the background should also be as marked as salient along with the dominant salient objects.

2. SEGMENTATION

J. J. Ding, C. J. Kuo, and W. C. Hong [13] proposed a method for segmentation. They uses a region merging algorithm. But it is considered that there is no best segmentation algorithms are present. But a segmentation process can be developed into a more efficient one and thus can make them perfect. In some papers, segmentation algorithms are taken as a post process phase in order to make the result more improved.

ChienChi Chen, Jian-Jiun Ding [12] proposed such methods. They integrate three features color spatial variance, border measurement, local global contrast. Here border measurement is obtained using segmentation and L_0 smoothing filter [14]. L_0 smoothing filter is taken as a pre processing technique for segmentation. This method helps to get a perfect segmented image.

L_0 smoothing filter mainly reduce redundant information and thus preserving the prominent set of edges in an image. The L_0 smoothing filter is a sparse gradient counting scheme in an optimization framework to restrict the discrete number of intensity changes among neighboring pixels, which is mathematically related to the L_0 norm for the pursuit of information sparsity. It also preserves main color changes and strengthens the edges by increasing gradient of transition. Fig. 2 shows that the structure of the smoothed result is comparing with the original structure. The textures of background is actually smoothened, while the edges between them are actually sharpened.

For a given input image I , S denotes the computed result, and the gradient $\nabla Sp = (\partial_x S_p , \partial_y S_p)^T$ is used to calculate the colour difference between the neighbouring pixels along the x

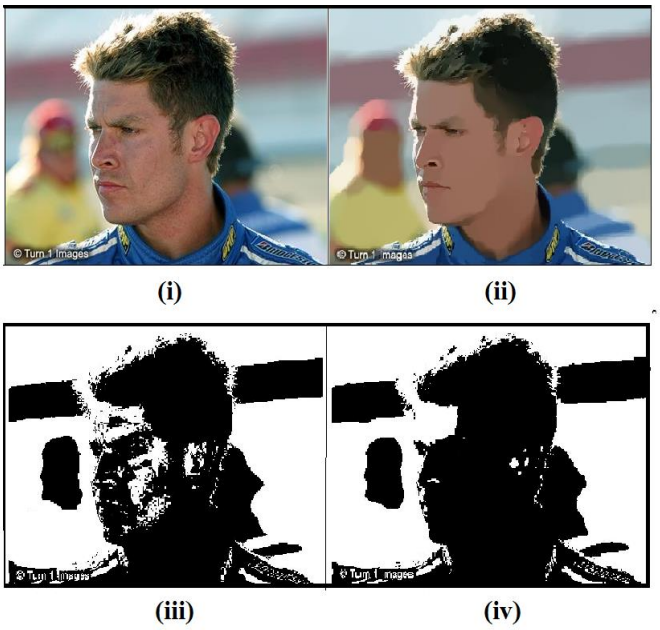

Figure. 3. (i) The original image, (ii) the smoothed image,(iii) the segmented image of original image, and (iv) the segmented image of smoothed image.

And y directions for each pixel, p. The gradient measure is defined as

$$C(S) = \#\{p \parallel \partial_x S_p \mid + \mid \partial_y S_p \mid \neq 0\} \quad (1)$$

Equation (1) determines the number of non-zero magnitudes $\partial_x S_p$, $\partial_y S_p$ in I. S is computed by

$$\min_S \{ \sum_P (S_P - I_P) + \lambda . C(S) \} \quad (2)$$

Here λ is recommended to be 0.01 and it shows the degree of smoothness in an image.

Fig 3 shows the segmented image with smoothening and without smoothening process. We can clearly see that smoothening helps to get more segmented image as we know smoothening will highlight the border and most prominent areas only, which can eventually helps in segmentation.

Segmentation helps in simplifying and representing the whole image into a more simpler and meaningful regions which helps to analyse the image easily. One of the method of image segmentation is thresholding method.

A global threshold value is used to turn a colour image into a binary image. So first is a global threshold of an image is selected. The pixel value greater than the global threshold is set as 1 and pixel values less than threshold is set as 0. So a binary image is obtained after segmentation. Image will be black and white image that is salient object will be white in color and other non prominent areas will be black in colour.

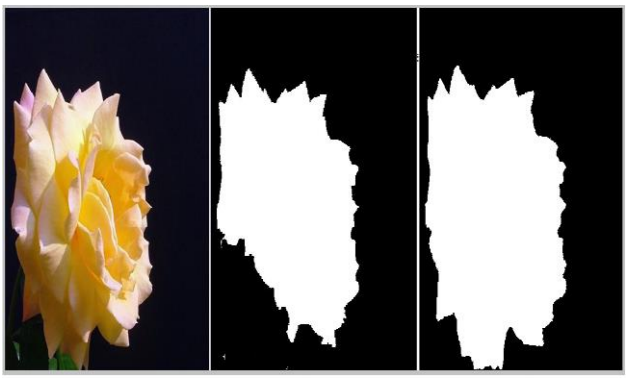

Figure 4: Segmentation Result:: Left: original image Middle: segmented image Right: ground truth

3. COLOR SPATIAL VARIANCE

It is based on a common assumption that, color which is extensively distributed in an image can be the background color. Based on the observation that salient objects are commonly less likely to be attached with the borders of an image.

Color spatial variance based on GMM, GMM stands for Gaussian Mixture Model , which is one of the most used methods for clustering[16][9]. Clustering helps to relate through the human visual system. Thus from this concept we can say that part where there is less and dark color in an image can be assumed to be a salient. They can also be a part of dominant salient object. Saliency map using color spatial variance is shown in fig 5. Each pixel in the GMM can be represented as

$$P(c|I_{X,Y}) = \frac{W_C N(I_{X,Y}|\mu_C \sum C)}{\sum_C W_C NI(X,Y|\mu_C \sum_C)} \quad (3)$$

Where Wc, μ_C, $\sum C$ 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 coordinate (x, y).

4. FREQUENCY TUNED SALIENCY

Achanta. R. Hemami . S, Estrada. F, and Susstrunk S proposed a frequency method [2] in order to detect a salient object.

This method is to estimate center surround contrast using color and luminance features. It uniformly highlight salient region with well defined boundaries. This method is fully computational. In this method a Gaussian pyramid of 9 levels is built with successive Gaussian blurring.

To get a frequency weight map is by the difference between arithmetic mean pixel value of the image and blurred version of the image. The saliency map S for an image I of width W and height H pixels can thus be formulated as:

$$S(x, y) = | I_\mu - I_{whc}(x, y) | \quad (4)$$

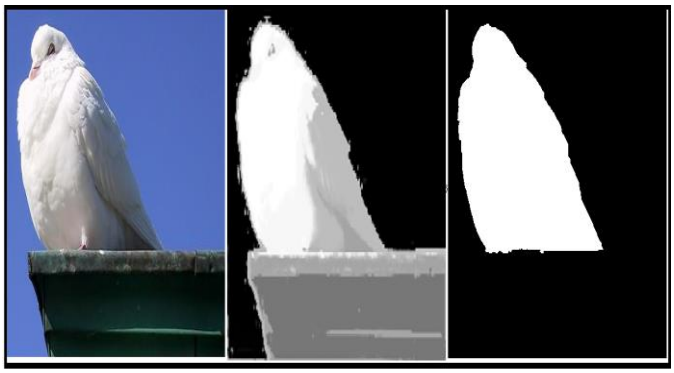

Figure 5: Left: original image Middle: color variance map Right: ground truth

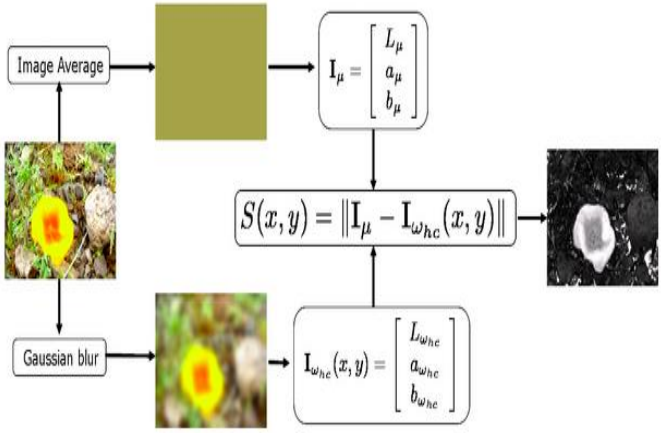

Figure 6: Frequency map representation

Where I is the arithmetic mean pixel value of the image and I_{Whc} is the Gaussian blurred version of the original image to eliminate noise, texture details as well as coding artifacts.

Main advantage of this method is that it highlight the salient region uniformly with full resolution well defined borders .But it consider only the first order average color which is insufficient to analyse a complex variations.

5. RESULTS AND DISCUSSIONS

All the above methods are evaluated on MSRA dataset with a ground truth in the form of accurate human-marked labels for the salient regions. The techniques are tested on MATLAB, to justify the effectiveness.

Visual comparison of saliency maps are given in Fig7. It is evident from the figure that different methods gives different saliency maps .Comparison is done in the figure given. The programming and simulation of the processes as well as analysis of results are implemented in MATLAB.

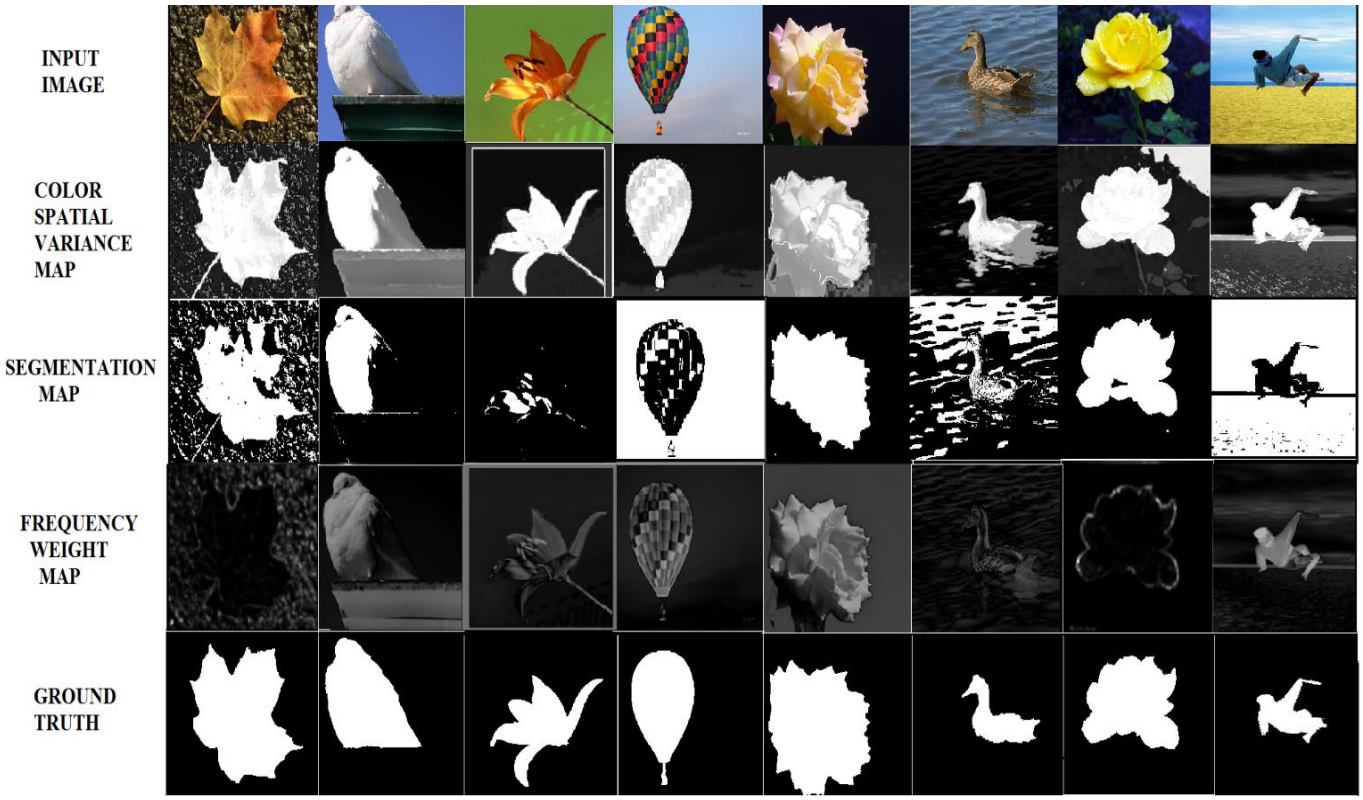

Figure 7 : Different Saliency maps are compared with ground truth method

Table 1 shows the computational time. The time taken by Segmentation, color spatial variance and frequency tuned map vary from the table we can conclude which methods are more efficient . That means which method provide accurate saliency map within a short time. For all the methods we used the author's implementations

Method	Time in seconds
Segmentation AC[1]	0.042
Frequecy tuned FT[6]	0.045
Color spatial variance	1.47

Table 1 The time consumed by each saliency detection methods

6. CONCLUSION

In this paper we propose different image salient region detection techniques, which include segmentation method, color spatial variance method and frequency tuned method. For the segmentation method, the procedure is easy to implement and also noise tolerant. They generate saliency map with same resolution. One of the limitation are they highlight large salient regions only leaving smaller ones. For color spatial variance method they highlight the main color highlighting uniform salient regions .They gave a clear object boundaries .One of the limitation is the time consumption. Next method is frequency tuned saliency method where it uniformly highlight the salient regions with well defined boundaries. It also gave high resolution. One of the limitations is they produce high saliency values near edges instead of uniformly highlighting salient regions. A successful salient region detection method requires combination of best different algorithms which can eventually reduce the limitations of other methods

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