ISBN 978-952-5726-04-6 (Print), 978-952-5726-05-3 (CD-ROM)
Proceedings of the International Symposium on Intelligent Information Systems and Applications (IISA'09)
Qingdao, P. R. China, Oct. 28-30, 2009, pp. 055-058

# A Novel Method for Saliency Detection

Qiaorong Zhang[1], Junya Lv[1],and Huimin Xiao[2]
[1]College of Computer and Information Engineering, Henan University of Finance and Economics, Zhengzhou, China
Email: zhangqiaorongs@sina.com
[2]Department of Mathematics, Henan University of Finance and Economics, Zhengzhou, China
Email: huiminxiao@126.com

***Abstract*—Researches in computer vision, image processing show that some pivotal regions contain most information of an image which are called salient regions. Many approaches have been proposed to saliency detection in images, but the results are not satisfying in some circumstances. Firstly, intensity, color and orientation features of the input image are extracted. For each feature map, a conspicuity map is computed based on three kinds of saliency which are local saliency, global saliency and rarity saliency. Secondly, a integrated saliency map is generated using a new feature integration strategy. To evaluate the proposed approach, we have tested it on many images. We also compare our method with other saliency detection methods. Experiment results show that other method performances much better than other methods.**

***Index Terms*—saliency detection, saliency map, visual attention, feature integration**

## I. INTRODUCTION

During the researches on computer vision and image processing, people find that most of the information often lies in some small key regions in the image. These key regions are so-called salient regions or regions of interest and so on. If we can extract these salient regions correctly and pay more attention to them, we can reduce the computational complexity and improve the speed of image processing significantly.

There have been some saliency detection methods. Most of the existing methods to compute saliency are based on feature integration theory that the saliency of every part in the image can be indicated by the difference of some feature values of it and its surroundings. Itti *et al.* have developed a biologically inspired computational model for computing visual saliency [1] [2]. They compute saliency maps using center-surround operation on features of intensity, color and orientation at different scales. They gave four combination strategies in [2]. The weights of different features were equal or computed by learning. And those methods didn't analyze the effects of different features and just summed these normalized feature maps together.

Ma *et al.* proposed a computational method to detect salient regions by computing color contrast of every pixel in [3]. But they only use color feature. It can't give the right saliency result if the actual contrast resides in other features. Zhang *et al.* used the similar method to compute the feature contrast in [4]. They used multiple features like intensity, color and texture. But they didn't analyzing the different effect of each feature and just summed them up.

Hou *et al.* presented a spectra residual method to compute visual saliency in [5]. This method is simpler and more efficient than other existing method. But only intensity feature was used in the method. It could not get the right result if intensity was not the useful feature. And it could detect the right regions if the background was clustered and the salient region was flat [6].

Therefore, a more robust method for saliency calculation is required. Some methods have been presented to solve above problems [7] [8] [9]. But these methods need image segmentation or learning and the complexity is high and the results are not satisfying.

In this paper, a new method for saliency detection is proposed. This paper is organized as follows. Section II describes the outline and details of the proposed saliency detection method. Section III gives some experimental results and discussion. Section IV presents our conclusions and prospects.

## II. SALIENCY DETECTION

Fig. 1 shows the framework of our proposed approach for saliency detection.

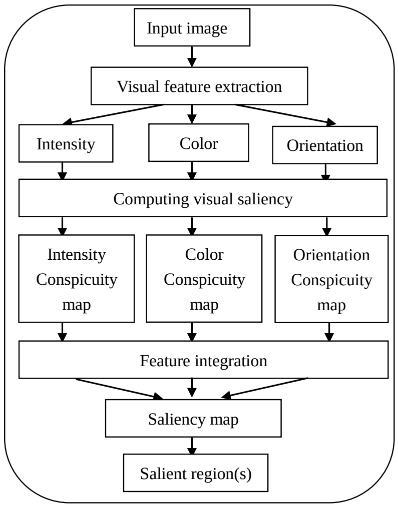


Figure 1. Block diagram of salient regions detection

### A. Visual Feature Extraction

Early vision features have significant effects on saliency of the regions in the image. If the region has intensity information that is different from its surrounding intensity information, the region is remarkable in the intensity feature. If the region has different color information from its surrounding color information, the


AP-PROC-CS-09CN003

region is salient in the color feature map. In this paper, we use intensity, color and orientation as the basic features of the saliency map [1].

Firstly, the input image is transformed from RGB space to HSI space. Then we use I (intensity) channel to represent intensity feature of the input image. H (hue) channel and S (saturation) channel are used to describe the color feature of the image. Four orientation feature maps can be obtained by filtering the intensity feature map using four Gabor filters with orientation 0°, 45°, 90°, 135° respectively.

### *B. Computing Visual Saliency*

Most of the existing methods have some shortcomings in saliency computing and feature integration strategy. Firstly, the saliency maps generated by those methods often provide some wrong salient locations which are not really salient. Otherwise, some regions are really salient but their saliency values are very low.

Therefore, to get a more robust saliency map our proposed method considers three kinds of saliency which are local saliency, global saliency and rarity saliency.

*1) Local saliency:* Whether a region is salient in the image or not depends on the distinctness between itself and its environment [3]. Here we use local saliency to represent the difference between a region and its surroundings. Different from other methods which compute saliency in spatial domain, we analyze the local saliency in frequency domain. The process is described as follows.

*a) Discrete Fourier transform:* Transform the input image from spatial domain into frequency domain using (1).

$$\begin{aligned} F(u,v) &= DFT(f(x,y)) \\ &= R(u,v) + jI(u,v) \end{aligned} . \qquad (1)$$

Where *f(x,y)* means the feature map with dimension *M*N*. The values *F(u,v)* are the DFT coefficients of *f(x,y)*.

*b) Extract phase spectrum:* Compute the phase spectrum using (2).

$$P(u,v) = \arctan\left(\frac{I(u,v)}{R(u,v)}\right) . \qquad (2)$$

*c) Compute local saliency:* Reconstruct the image with phase spectrum using (3) and get the local saliency map.

$$S_{local}(x,y) = IDFT(j * P(u,v)) . \qquad (3)$$

*2) Global saliency:* Only considering local saliency is not enough because high local saliency values often lie in boundaries between salient areas and the background. The saliency values inside the salient object are low. So we use global saliency as well.

Global saliency map of a feature map can be computed using (4).

*3) Rarity saliency:* Rarity saliency means the less a feature value occurs the more possible it belongs to a salient area.

$$\begin{cases} S_{Global}(x,y) = e^{\frac{\left|f(x,y) - f_{avg}(x,y)\right|}{f_{avg}(x,y)}} \\ f_{avg}(x,y) = \dfrac{1}{M*N}\sum_{x=1}^{M}\sum_{y=1}^{N} f(x,y) \end{cases} . \qquad (4)$$

The areas that have novel and rare feature values often attract people's attention and become salient areas in the image. The easiest method to measure the rarity of a feature value is to count the number it occurs in the image. The higher the number is, the lower the saliency is. The histogram of an image is an adequate statistical tool to count the number of each pixel feature value occurs. So the rarity saliency can be computed using (5).

$$S_{Rarity}(x,y) = \frac{1}{hist(f(x,y))} . \qquad (5)$$

Where *f(x,y)* is the feature value of pixel *(x,y)* in the feature map and *hist(•)* is the histogram of the feature map.

*4) Feature saliency map:* Finally, local saliency map, global saliency map and rarity saliency map need to be combined into a feature conspicuity map. Different weights need to be applied to each saliency result. To compute the weight of each saliency result, the variance *Vi* of each saliency result is calculated first. The higher the variance is, the more important the saliency result is. Then the feature conspicuity map can be generated using (6).

$$\begin{cases} V = \dfrac{1}{M*N}\sum_{i=1}^{M}\sum_{j=1}^{N}\left| f(x,y - \dfrac{1}{M*N}\sum_{i=1}^{M}\sum_{j=1}^{N} f(x,y)\right| \\ w_i = \dfrac{V_i}{\sum_{i=1}^{3} V_i} \\ C_F = w_1 * S_{Local} + w_2 * S_{Global} + w_3 * S_{Rarity} \end{cases} . \qquad (6)$$

The process of generating intensity conspicuity map is shown in Fig. 2. Firstly, the intensity feature of the input image is extracted. Then local saliency, global saliency and rarity saliency of the intensity map are calculated. Then these three kinds of saliency results are combined into an intensity conspicuity map.

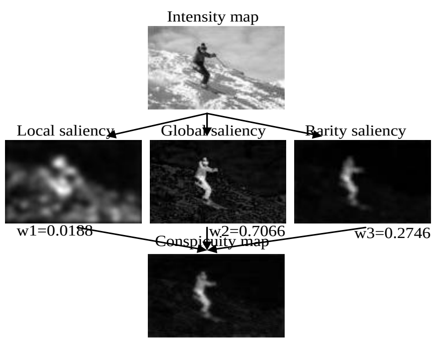


Figure 2. Example of feature conspicuity map

### *C. Feature Integration*

We need to integrate these feature conspicuity maps into an integrated saliency map. In this paper, a novel and reasonable feature integration strategy is used to combine these feature conspicuity maps into a final saliency map.

The strategy and process of feature integration are described as follows. We use salient area, salient point location and salient point distribution to measure the importance of the feature conspicuity maps and compute their weights.

*1) Salient points extraction:* Simply threshold these feature saliency maps using a threshold T which can be computed using (7) [10]. The pixels whose values are bigger than the threshold are considered as salient points.

$$T = \arg\max_t \left(-\sum_{i=1}^{t} p_i * \log_2 p_i - \sum_{i=t+1}^{L} p_i * \log_2 p_i\right). \quad (7)$$

Where, $T$ is the threshold. $L$ is the total gray level of the feature conspicuity map and $p_i$ is the frequency that the gray value $i$ occurs in the feature saliency map.

*2) Salient area calculation:* We compute the number of salient points as the salient point area using (8). The experiment results show that this method is simpler and more effective than the method of [9].

$$W_{area} = N. \quad (8)$$

Where, $W_{area}$ means the weight of salient point area and $N$ represents the number of salient points. If the area of salient points is larger than 70% of the area of the whole image, the weight of the feature saliency map is set to zero.

*3) Salient location calculation:* Compute the average distance between the salient points and the image center as the location criterion using (10).

$$W_{location} = \frac{1}{N}\sum_{i=1}^{N} Dist(sp_i, center). \quad (9)$$

Where, $W_{location}$ is the weight of salient point location. $N$ is the number of salient points. $sp_i$ means each salient point and *center* means the center of the image. *Dist* means the distance between two points.

*4) Salient points distribution:* Compute the spatial distribution of salient points using (11) as another criterion.

$$W_{distribution} = \frac{1}{N}\sum_{i=1}^{N} Dist(sp_i, centroid). \quad (10)$$

Where, $W_{distribution}$ is the weight of salient point spatial distribution. *centroid* means the center of the salient points.

*5) Feature integration strategy:* The weight of each feature map can be computed dynamically using (11).

$$\begin{cases} W_i = \dfrac{\frac{1}{W_{fi}}}{\sum_{i=1}^{m}\frac{1}{W_{fi}}} \\ W_{fi} = W^i_{area} + W^i_{location} + W^i_{distribution} \end{cases}. \quad (11)$$

Where, $W_i$ means the weight of each feature conspicuity map and $m$ is the number of feature conspicuity maps.

Then the final integration saliency map can be generated using (12).

$$SM = \sum_{i=1}^{m} W_i * C^i_F. \quad (12)$$

Where, $SM$ is the integration saliency map and $CF_i$ means each feature saliency map. Fig. 3 shows an example of feature integration.

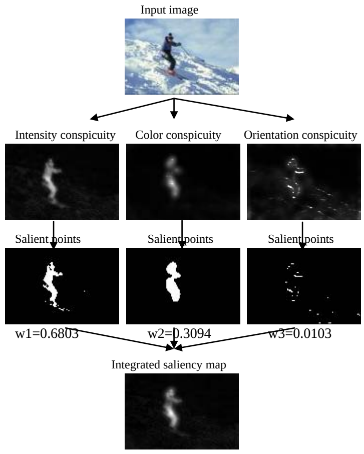


Figure 3. Example of feature integration

## D. Salient Region Detection

After generating the integration saliency map, we should threshold it to get a binary image $BM$ using (13). Here the value of the threshold $T$ can be computed using (7).

$$BM(x,y) = \begin{cases} 1 & SM(x,y) \geq T \\ 0 & SM(x,y) < T \end{cases}. \quad (13)$$

Then salient regions can be extracted by adding the binary image to the original image. Fig. 4 shows the process of detecting salient region.

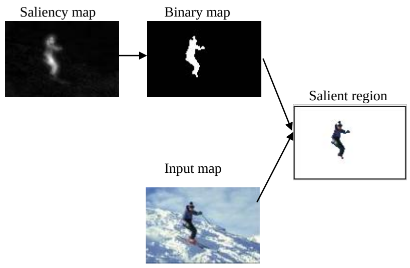


Figure 4. Example of salient region detection

# III. EXPERIMENT RESULTS

The proposed approach was extensively tested with many natural images to ensure proper functioning. We have collected many image sources from image search engines and selected more than 100 images each of which contains at least a salient region to test our approach. This section presents experimental results and analysis of the proposed salient region detection approach.

Fig. 5 shows the simulation results of the proposed method. Primary images are shown in column 1, saliency maps are shown at column 2, binary images are presented at column 3 and the salient regions are shown at column 4.

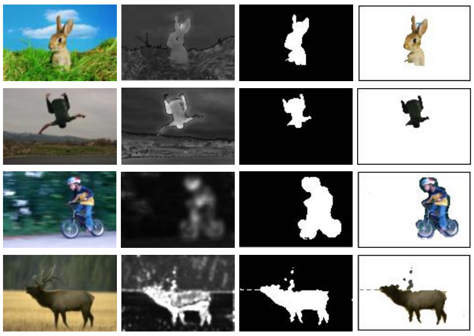

Figure 5. Results of our proposed method

The detection results of salient regions from our proposed approach are compared with results from other methods [1] [5] [8] for the same input images. The comparison results are shown in Fig. 6.

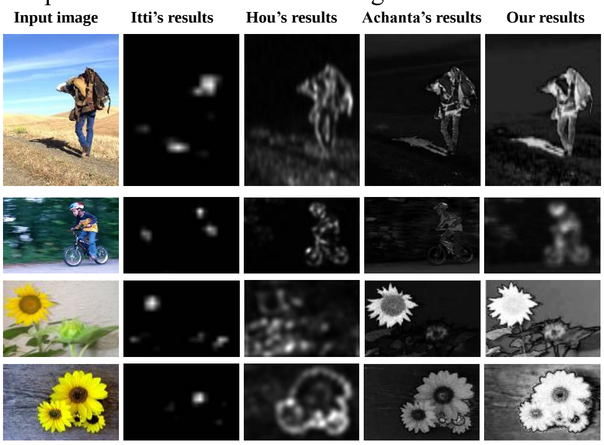


Figure 6. Results of comparison

If the input image is very complex and clustered or there is no very salient region in the image, our proposed method will fail to extract salient regions. Fig. 7 shows some examples that our method cannot extract salient regions.

Figure 7. Examples of failure

Therefore, only those images which at least have one salient region are chosen in our experiments. The proposed experiment results have shown that our proposed method has performed well in most cases. More than 85% results have successfully extracted salient regions from the background and matched the ground truth images.

## IV. CONCLUSION

A new method for salient region detection is proposed in this paper. Multiple features like intensity, color and orientation are analyzed. It computes local saliency, global saliency and rarity saliency to construct the saliency map and according to the saliency map to extract salient regions. The process is entirely unsupervised. It does not need user intervention. The proposed model is not domain-specific and does not impose limits on the variety of images. It can be used for all kind of images provided that there is at least one meaningful salient region.

Early vision features are important to construct the saliency map. A simple feature can not entirely represent the character of the salient region. In this paper, we consider colors, intensity and orientations as the features of the image. However, it is very likely that there are some other features such as edge and symmetry feature which also should be considered. What feature and how many features should be extracted according to the target will also be included in future work.


## ACKNOWLEDGMENT

This work was supported in part by a grant from National Natural Science Foundation of China (No. 60774041) and Science Technology Project of Henan Province of China under Grant (No. 072102210001 and No. 082102320020).


## REFERENCES


[1] Itti L, Kouch C, and Niebur E, "A model of saliency-based visual attention for rapid scene analysis," *IEEE Transactions on Pattern Analysis and Machine Intelligence, USA*, vol. 20, pp. 1254-1259, November 1998.

[2] Itti L, Kouch C, "Feature combination strategies for saliency-based visual attention systems," *Journal of Electronic Imaging*, vol. 10, pp.161-169, January 2003.

[3] Yufei Ma, Hongjiang Zhang, "Contrast-based Image Attention Analysis by Using Fuzzy Growing," *Proceedings of the 11th ACM International Conference on Multimedia*, March 2003, pp. 374-381.

[4] Zhang Peng, Wang Runsheng, "Detectiong salient regions based on location shift and extent trace," *Journal of Softwarer, China*, vol. 15, pp. 891-898, June 2004.

[5] Xiaodi Hou, Liqing Zhang, "Saliency Detection: A Spectral Residual Approach," *IEEE Conference on Computer Vision and Pattern Recognition*, June 2007, pp.1-8.

[6] Zheshen Wang, Baoxin Li, "A Two-Stage Approach to Saliency Detection in Images," *IEEE ICASSP 2008*, April 2008, pp. 965-96.

[7] Tie Liu, Jian Sun, and Nanning Zheng, "Learning to detect a salient object," *IEEE Conference on Computer Vision and Pattern Recognition*, June 2007.

[8] R. Achanta, F. Estrada, P. Wils, and S. S¨usstrunk, "Salient region detection and segmentation," *International Conference on Computer Vision Systems*, 2008.

[9] Yiqun Hu_, Xing Xie, and Wei-Ying Ma, "Salient Region Detection Using Weighted Feature Maps Based on the Human Visual Attention Model", *LNCS 3332*, 2004, pp. 993-1000.

[10] ZHANG Yong-liang, WANG Yang, LU Huan-zhang, "Block objects detection based on entropy of brightness", *Systems Engineering and Electronics*, vol. 33, pp. 201-204, February 2008.