Academic Journal of Computing & Information Science
ISSN 2616-5775 Vol. 3, Issue 5: 8-16, DOI: 10.25236/AJCIS.030502

The improved local and global contrast image saliency detection algorithm

Yao Fei

Jinan Engineering Polytechnic, Jinan 250200, Shandong, China

ABSTRACT. *Contrast description is a very important and commonly used feature description method in the image saliency detection, according to the difference of contrastive region, the detection algorithm can be divided into local and global contrast algorithm. In this paper, firstly, the local contrast AC algorithm is improved, from two aspects of distance calculation method, weighting coefficient and multi-scale average, to improve the problem of emphasizing small and medium-sized areas of significant targets in the original AC algorithm, the experimental results show the effectiveness of the improved scheme. Then the global contrast RC algorithm is analyzed and improved, and the original RC algorithm is improved from two aspects of image pre-segmentation Algorithm improvement and significant center position optimization, the experimental results show the effectiveness of the improved scheme.*

KEYWORDS: *Significance, Saliency value, Local; Global, Contrast*

1. Introduction

The saliency of the image can be explained as the ability to arouse people's attention, it plays a key role in visual perception processing. Image saliency detection has become a hot topic[1-2], researchers continue to analyze the different operating mechanisms of the visual system, and establist different simulation models, derive many different algorithms[3]. Image saliency detection has a wide range of applications, such as image retrieval[4-5], image compression[6-7], salience target recognition[8-10], video analysis[11-12], and so on, which has opened up a new idea for image analysis and processing, greatly improved the efficiency of image processing, and promoted the development of image processing technology.

In the image saliency detection, the contrast feature description is a very important and commonly used feature description. Contrast depend on the contrastive region, the saliency detection algorithms can be divided into two categories[13] according to the difference of contrastive region, the first is local contrast algorithm[14-15], which calculates the contrast of a pixel or a super-pixel in the local neighborhood of the image; Extended the contrast region to the whole image, and then another contrast based algorithm global contrast algorithm[16-17] is obtained.

ISSN 2616-5775 Vol. 3, Issue 5: 8-16, DOI: 10.25236/AJCIS.030502

2. The local contrast based AC algorithm and it's improvement

2.1 AC algorithm

The AC algorithm [18] is named after the first two letters of the name of the algorithm presenter Achanta. The algorithm uses the contrast between a region in the image and its adjacent regions to identify whether the region is a significant area of the image, which is called the local contrast. This algorithm selects the brightness and color of pixel two characteristics, firstly, the algorithm use the contrast neighborhood window of different scales to get the significant value of each pixel in each scale window, then accumulates the saliency map which with different scale windows, and the final saliency map is obtained.

2.2 The improvement of AC algorithm

In AC algorithm, saliency value of each pixel are expressed as the Euclidean distance of feature vector in Lab color space, multi-scale accumulation is adopted, there are three scales, the size are$\left\{\frac{w}{8},\frac{w}{4},\frac{w}{2}\right\}$, w is the smaller of the width and height of the original image. In the algorithm, three fixed size neighborhood scale brings some disadvantages, the goals whose size is less than the minimum scale neighborhood can be completely detected, so this little goals can also be detected by the other two neighborhood window, while the larger objects can only be partially detected, so that the small goals in image is more highlighted.

This paper improve the original AC algorithm from the aspects that distance calculation method and weighted coefficient and multi-scale average.

(1) Distance calculation method and weighted coefficient

The calculation method of the saliency value is improved, firstly, calculate the Euclidean distance between the feature vector of center pixel and the feature vector of its' neighborhood window pixels or super-pixels, then, weight the results of the previous step by area, the area is the pixels' number in neighborhood window, this operation can weaken the saliency value of the small area at a higher scale. When the window size d is given, the method of calculating the saliency value of each pixel in the neighborhood is shown as formula (1):

$$s_{i,j}=\frac{1}{N_2}\sum_{k=1}^{N_2}D\left[\left(V_{i,j},V_k\right)\right] \tag{1}$$

In formula (1), $D\left[\left(V_{i,j},V_k\right)\right]$ is the Euclidean distance between the feature vector $V_{i,j}$ of center pixel and the k-th pixel or super-pixel in the neighborhood window of a given scale.

(2) Multi-scale average

Based on the previous improvement, the mean values of different scales are further calculated.

ISSN 2616-5775 Vol. 3, Issue 5: 8-16, DOI: 10.25236/AJCIS.030502

Based on the above two aspects of improvement strategy, the calculation formula of the saliency value of the improved algorithm is shown as the following formula (2):

$$S = \frac{1}{M}s \tag{2}$$

In the formula (2), The saliency value s of a given scale is obtained by formula (1), M represents the species number of local contrast neighborhood window scale, it's value in the algorithm is 3.

2.3 Experimental results and analysis of improved AC algorithm

Experiments were carried out in the following conditions:

Processor: Intel(R) Core(TM) i5-5200U CPU @2.20GHz;

Memory: 4.00GB;

System type: 64 bits Windows 7 flagship version;

Experimental environment: MATLAB R2012a;

In order to better evaluate the experimental results, this paper use two evaluation indexes that the accuracy - recall rate curve (P-R curve) and the mean absolute error (MAE).Usually in the experimental study, using simple threshold segmentation to deal with saliency map to gain the accuracy - recall rate curve (P-R curve), in general, the higher the curve, the saliency detection algorithm is more excellent. When the MAE is less, the saliency map is more similar with the GT, and the effect of algorithm is better.

In this paper, we use the MSRA1000 data set to test the improved AC saliency detection algorithm and compare it with the original algorithm. The experimental results are shown in Figure1.

In figure 1, (a) is the original image, (b) is GT image, (c) is the saliency image obtained by original AC algorithm, (d) is the saliency image obtained by the improved AC algorithm. Observe the (c) column in figure (2), it can be seen that the original AC algorithm has a significant effect on the small region of the saliency goal in the image, as in the first doll image, the doll's eyes and nose are highlighted, and the integrity of saliency image is not good, in addition, in the saliency map obtained by the original algorithm, the edge of the target is enhanced. Observe the (c) column in figure 1, its' the result of the improved AC algorithm, compared with (c) column, the contrast of the small region in the saliency goal is weakened, and the integrity of the saliency goal is improved in a certain extent.

ISSN 2616-5775 Vol. 3, Issue 5: 8-16, DOI: 10.25236/AJCIS.030502

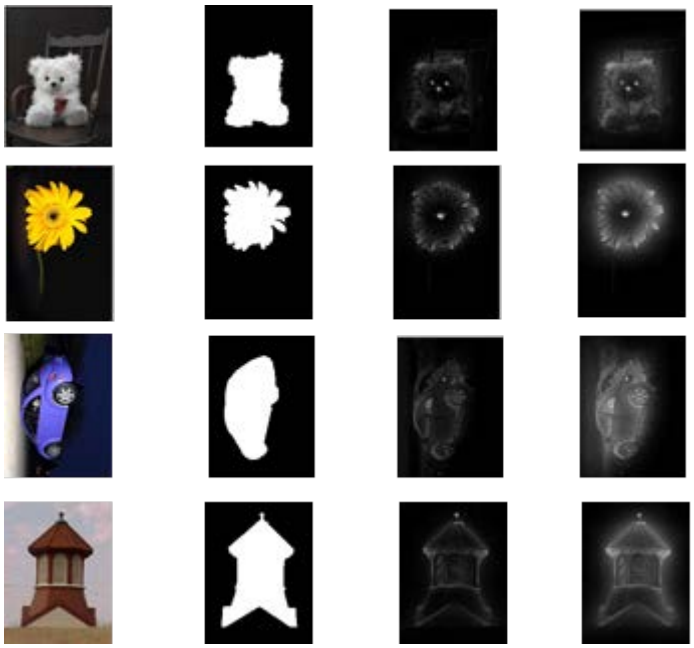


Figure 1 Comparison of the results of the improved AC algorithm and the original AC algorithm

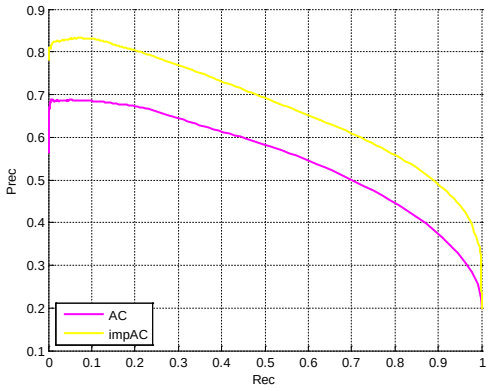


Figure 2 The P-R curve of the improved AC algorithm and the original AC algorithm

Figure 2 shows the P-R curve of the improved AC algorithm and the original AC

ISSN 2616-5775 Vol. 3, Issue 5: 8-16, DOI: 10.25236/AJCIS.030502

algorithm, where the yellow curve represents the improved AC algorithm curve, the red curve represents the original AC algorithm curve, it can be seen from the figure 2 that the P-R curve of the improved AC algorithm is higher than the original AC algorithm, which shows that the improved AC algorithm has higher accuracy and recall rate than the original AC algorithm.

3. The global contrast based RC algorithm and it's improvement

3.1 The principle of RC algorithm

The full name of the RC algorithm is Region Based Contrast[17], which is a global saliency detection algorithm based on regional contrast. In the RC algorithm, firstly, divide the whole image into a certain number regions, then calculate the regional color contrast, last, calculate saliency value of each region, the saliency value is defined as the weighted contrast sum between each region and the rest regions, because of the contrast with far regions is not easy to cause visual attention, on the contrary, the role of visual attention is also opposite, so the algorithm uses the spatial distance weighted[17].

3.2 The improvment of RC algorithm

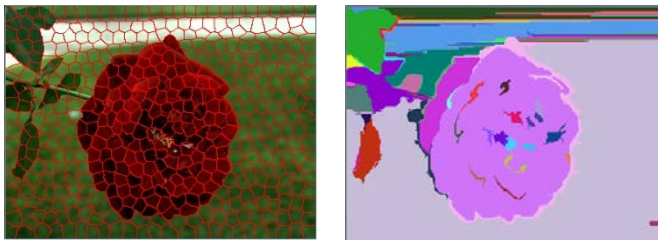
Based on the global contrast RC algorithm, not only select the Lab color space which contains the brightness and color information, but also consider the spatial location information, the algorithm divides the image into small pieces, which can overcome the noise to a great extent, and calculates the saliency in the region, which can speed up the calculation, improve the accuracy, and enhance the integrity of the saliency goal.

In RC algorithm, the graph based segmentation algorithm[20] is used to divide the original image into regions, the pixel regions produced by this segmentation algorithm can not fit the edge of the object very well, and the shape of the pixel regions are not compact enough, and the efficiency of the algorithm is low, however the quality of the saliency map depends on the segmentation algorithm to a great extent. In the algorithm, the position information is taken into account, but the acquisition of the position information is based on the prior theory of the image center whose limitations are relatively large. Through the above analysis, according to the existing problems in the original RC algorithm, this paper uses the following two aspects of the improvement strategy.

1) Improvement of image pre-segmentation algorithm

Improve the original RC algorithm using the SLIC super-pixel segmentation algorithm[7].

ISSN 2616-5775 Vol. 3, Issue 5: 8-16, DOI: 10.25236/AJCIS.030502



(a) SLIC super-pixel segmentation (b) Graph based segmentation

Figure 3 Segmentation results

As can be seen from the results of Figure 3, SLIC super-pixel segmentation algorithm to generate a more compact pixel, and the size of super-pixel is more uniform.

2) Saliency center location optimization

This paper optimizes the location of the saliency center to a certain extent.

In order to obtain the accurate saliency center, during the improvements, firstly gain the saliency center based on the improved AC algorithm, then calculate the distance between each pixels and the saliency center. After obtaining the saliency center, we need a model to well simulate the visual perception of the position information, the perception of the significant targets in an image is a probability problem in Mathematics, so uses normal distribution which is the most common model in probability distribution model. In summary, the optimization strategy of location information can be divided into the following two steps.

The first step, let the saliency map obtained by the improved AC algorithm as the primary saliency map to compute the saliency center, as shown in formula (3):

$$X = \frac{\sum_{i=1}^{n} x_i Sac_i}{M}, Y = \frac{\sum_{i=1}^{n} y_i Sac_i}{N} \tag{3}$$

In the formula (3), M is the size of the image in the X axis direction, N is the size of the image in the Y axis direction, x_i is the abscissa of the i-th pixel in the image, y_i is the ordinate of the i-th pixel in the image, Sac_i is the saliency value of the i-th pixel in the saliency map which obtained by the improved AC algorithm.

The second step is to use the normal distribution model to measure the effect that the distance between each pixel and the saliency center to the saliency value of each pixel, as the farther away from the saliency center, the lower the saliency value of the pixel, so the relationship between the independent variable and the dependent variable is negative correlation in the normal distribution model, which can be expressed as e^{-E}.

After the above two improvements, the formula for calculating the final saliency value is shown in formula (4):

ISSN 2616-5775 Vol. 3, Issue 5: 8-16, DOI: 10.25236/AJCIS.030502

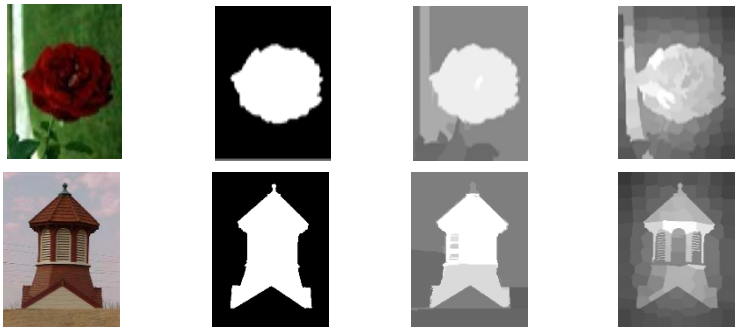
$$S(r_k) = e^{-\frac{D_k(r_k,C)}{\delta}} \sum_{r_k \neq r_i} e^{\frac{D_S(r_k,r_i)}{-\sigma_S^2}} w(r_i) D_r(r_k, r_i) \quad (4)$$

In the formula (4), $D_k(r_k, C)$ express the distance between region r_k and saliency center C, δ is the controlling parameter.

3.3 Experimental results and analysis

Experiment conditions and data set as the 3.2.3.

The experimental results are shown in Figure 4.



(a) (b) (c) (d)

Figure 4 Comparison of the results of the improved RC algorithm and the original RC algorithm

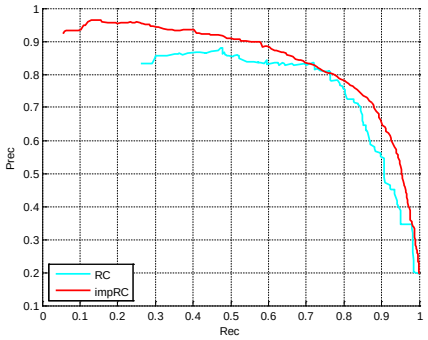


Figure 5 The P-R curve graph of the improved RC algorithm and the original RC algorithm

In the Figure 4, (a) is the original image, (b) is GT image, (c) is the saliency image of original RC algorithm, (d) is the saliency image of the improved RC

ISSN 2616-5775 Vol. 3, Issue 5: 8-16, DOI: 10.25236/AJCIS.030502

algorithm. Compare (c) and (d) columns in figure 4, it can be clearly seen, the pixel blocks in (d) are more uniform, and the internal details of the saliency goal are better, and the edge of the saliency goal is more accurate.

Figure 5 shows the P-R curve of the RC algorithm before and after the improvement, and the red curve represents the improved AC algorithm, the light blue curve represents the original AC algorithm, it can be clearly seen, the P-R curve of the improved RC algorithm is higher than the original RC algorithm, which shows that the improved RC algorithm has higher accuracy and recall rate than the original RC algorithm.

4. Summary

Two kinds of saliency detection algorithms based on contrast are discussed: local contrast and global contrast. In this paper, the improvement measures are put forward to solve the problem of over emphasizing the small region in the original AC algorithm, and obtain better result; the improvement measures are proposed to improve the quality of saliency image of RC algorithm in two aspects, the first is the image pre-segmentation algorithm, the second is the acquisition mode of saliency center.

References

[1] Wei Yu. Research on image saliency region detection method and its application [D]. Jinan: Shandong University, 2012.
[2] Jing Hui-Jun. Research on key technologies of visual saliency detection [D]. Haerbin: Harbin Institute of Technology, 2014.
[3] Xing Qing, et al. Image saliency detection based on color feature and contrast feature [J]. Semiconductor Optoelectronics, 2019, 40(3): 433-437.
[4] K. Hirata, E. Kasutani and Y. Hara. On image segmentation for object-based image retrieval[C]. Proc. IEEE Int. Conf. Pattern Recognit. 2002:1031-1034.
[5] J. Stottinger, A. Hanbury, N. Sebe and T. Gevers. Sparse Color Interest Points for Image Retrieval and Object Categorization [J]. Image Processing, IEEE Transactions on. 2012,21(5):2681-2693.
[6] Achanta R, Susstrunk S. Saliency detection for content-aware image resizing[C]. Proc. Image Processing(ICIP).2009:1005-1008.
[7] C. Christopoulos, A. Skodras and T. Ebrahimi. The JPEG2000 still image coding system: an overview[J]. IEEE Trans. Consumer Elec. 2002,46(4):1103-1127.
[8] Chen D, Wu C. Object-based multi-feature competitive model for visual saliency detection[C].Proc. the 2nd Internation Conference on Intelligent Systems Design and EngineeringApplications. 2012: 1079-1082.
[9] Ao Huanhuan, Yu Nenghai, Li Weihai. Image saliency modeling based on region feature[J]. Journal of the University of Science and Technology of China, 2013, 43(10)：837-842.
[10] X. Shen and Y. Wu, A unified approach to salient object detection via low rank

ISSN 2616-5775 Vol. 3, Issue 5: 8-16, DOI: 10.25236/AJCIS.030502

matrix recovery[C]. Proc. Computer Vision and Pattern Recognition (CVPR). 2012.
[11] Li Yong. Research on visual saliency detection algorithm based on region contrast [D]. Shanghai: Shanghai Jiao Tong University, 2013.
[12] E. Rahtu, J. Kannala, M, Salo, J. Heikkila. Segmenting salient objects from images and videos[C]. Proc. European Conference on Computer Vision,2010.
[13] Yang Jun. Research on the computation of visual saliency and its application [D]. South China University of Technology, 2014.
[14] Ma Y F, Zhang H J. Contrast-based image attention analysis by using fuzzy growing[C] //Proceedings of the 11th ACM International Conference on Multimedia. New York: ACM Press,2003: 374-381.
[15] Liu T, Yuan Z, Sun J, et al. learning to detect a salient object[J].IEEE Transaction on Pattern Analysis and Machine Intelligence,2011, 33(2): 353-367.
[16] Perazzi F, Krahenbuhl P, Pritch Y, et al. Saliency filters: contrast based filtering for salient region detection[C] //Proceedings of IEEE Conference on Computer Vision and Pattern Recognition. Los Alamitos: IEEE Computer Society Press,2012: 733-740.
[17] Cheng M M, Zhang G X, Mitra N J, et al. Global contrast based salient region detection[C] //Proceedings of IEEE Conference on Computer Vision and Pattern Recognition. Los Alamitos: IEEE Computer Society Press, 2015: 409-416.
[18] Achanta R, Estrada F, Wils P, et al. Salient region detection and segmentation[C] //Proceedings of the 6th International Conference on Computer Vision Systems. Heidelberg: Springer, 2008:66-75.
[19] Felzenszwalb P F, Huttenlocher D P. Efficient Graph-Based Image Segmentation[J]. International Journal of Computer Vision, 2004, 59(2):167-181.
[20] Radhakrishna Achanta, Appu Shaji, Kevin Smith, et al. SLIC Superpixels[J]. EPFL Technical Report no. 149300, 2010.