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Kozhagulov Y.T.[1,2], Ibraimov M.K.[2],
Zhexebay D.M.[1,2*], Sarmanbetov S.A.[1,3]

[1]«Kazakhstan Innovation Technologies Company» LLP, Kazakhstan, Almaty
[2]Al-Farabi Kazakh national university, Kazakhstan, Almaty
[3]Institute of Experimental and Theoretical Physics, Al-Farabi Kazakh National University, Kazakhstan, Almaty, *e-mail: zhexebay92@gmail.com

FACE DETECTION OF INTEGRAL IMAGE BY VIOLA-JONES METHOD

Research is devoted to investigate on human face detection by Viola-Jones method, the fastest and effective methods of face detection. two Haar like features have been used to determine the area of the eye, because it reduces the number of possible false positives in detecting these functions and increases the accuracy of face detection. One of them measures the difference in intensity between the eye and upper cheek area. The second function compares the intensity in the eye with intensity through the nose bridge. It is shown that these two functions can determine the facial features with different sizes pattern.
Key words: Viola-Jones method, integral image, Haar cascade, face detection, MatLab.

Кожагулов Е.Т.[1,2], Ибраимов М.К.[2], Жексебай Д.М.[1,2*], Сарманбетов С.А.[1,3]

[1]ЖШС «Kazakhstan Innovation Technologies Company», Қазақстан, Алматы қ.
[2]Әл-Фараби ат. Қазақ ұлттық университеті, Қазақстан, Алматы қ.
[3]Эксперименттік және теориялық физика ҒЗИ, әл-Фараби ат. Қазақ ұлттық университеті, Қазақстан, Алматы қ., *e-mail: zhexebay92@gmail.com

Виола-Джонс әдісімен интегралды сурет арқылы бетті анықтау

Жұмыс бетті анықтаудың жылдам және тиімді әдістерінің бірі болып табылатын Виола-Джонс әдісі көмегімен адам бетін детектрлеу бойынша зерттеуге арналған. Көз аймағын анықтау үшін екі Хаар функциясы пайдаланылды, себебі детектрлеу кезхінде бұл функциялардың жалған іске қосылу саны азаяды және беттерді анықтау дәлдігі артады. Олардың біреуі көз аймағы мен беттің жоғарғы бөлігі арасындағы қарқындылықтың айырмашылығын өлшейді. Екінші функция көз аймағындағы қарқындылықты мұрын көпірі қарқындылығымен салыстырады. Көрсетілгендей, бұл екі функцияның көмегімен фигураның әртүрлі өлшемді суреттегі бет кескінін анықтауға болады.
Түйін сөздер: Виола-Джонс әдісі, интегралды сурет, Хаар каскады, бетті анықтау, MatLab.

Кожагулов Е.Т.[1,2], Ибраимов М.К.[2], Жексебай Д.М.[1,2*], Сарманбетов С.А.[1,3]

[1]ТОО «Kazakhstan Innovation Technologies Company», Казахстан, г. Алматы
[2]Казахский национальный университет им. аль-Фараби, Казахстан, г. Алматы
[3]НИИ экспериментальной и теоретической физики, Казахский национальный университет им. аль-Фараби, Казахстан, г. Алматы, *e-mail: zhexebay92@gmail.com

Интегральное изображение детектировании лиц методом Виолы-Джонса

Работа посвящена исследованию по детектированию человеческого лица с помощью метода Виолы-Джонса, который является одним из быстрых и эффективных методов обнаружения лиц. Были использованы две Хаар подобных функции для определения области глаз, так как уменьшается количество возможных ложных срабатывании этих функции при детектировании и

увеличивается точность определения лиц. Одна из них измеряет разницу в интенсивности между областью глаз и верхней щеки. Вторая функция сравнивает интенсивности в области глаз с интенсивностью через мост носа. Показано, что с помощью этих двух функции можно определить черты лица с разными размерами рисунка.
Ключевые слова: метод Виолы-Джонса, интегральное изображение, Хаар каскад, обнаружение лиц, MatLab.

Introduction

Face detection and recognition is an important task of machine and computer vision. There are many face detection algorithms [1-5]. One of the fastest and effective methods of face detection is a Viola-Jones method [6, 7]. This method is most clearly different from previous approaches by its ability to detect faces very quickly. The Viola-Jones algorithm of a certain threshold value provides fast detection and high accuracy. Average detection accuracy is 97.41% as described in research [8]. A large number of persons present in the image does not affect the calculation time, as well as detection speed. Calculation time increases when the image has a big size and high density.

Viola-Jones method consists of three basic object detection algorithms. The first is a new image representation in the form of an integral image that allows to evaluate objects very quickly. This algorithm does not work directly with the intensity of the image compared with the research [9]. But like these authors a set of features are applied that are reminiscent of the Haar basic functions. The integral image can be calculated through applying the multiple operations per pixel. Thereafter, Haar like function can be calculated at any scale or location in real time.

The second algorithm – a method of constructing the classifier by selecting a small number of important features applying AdaBoost [10]. In any image subband total number of Haar-like objects is very large, much larger than the number of pixels. To provide fast classification, the learning process should exclude the vast majority of the available functions and focus on a small set of critical functions. As a result each stage acceleration process that chooses a new class of weak, can be considered as feature selection process. AdaBoost learning algorithm provides an efficient and powerful assessment generalizations efficiency.

The third important algorithm is a method of combining successively more complex classifiers into the cascade structure that rapidly increases the speed detector, focusing on advanced areas of the image. The concept of the focus of attention is that often you can quickly determine where the object may occur in the image [11-13]. A more complex treatment is reserved only for these advanced areas.

Theoretical and experimental research backgrounds

Viola-Jones method applies Haar like features to identify the facial features. In order to reduce the calculation time of these functions the integral image representation is applied [6, 7, 14, 15]. Integral image representation – is the matrix, the same size of the original image. Each matrix element comprises sum of the intensities of all pixels located to the left of and above the element. For integral image matrix elements calculation the following formula is applied:

$$L(x,y) = \sum_{i=0,j=0}^{i\le x, j\le y} I(\mathrm{i},\mathrm{j}) \qquad (1)$$

where $I(\mathrm{i},\mathrm{j})$ – the brightness of the source image pixel. Figure 1 shows matrix of the starting and integral image.

0	10	20	30	40
50	60	70	80	90
101	112	123	134	145
156	167	178	189	200
211	222	233	244	255

→

0	10	30	60	100
50	120	210	320	450
151	333	546	790	1065
307	656	1047	1480	1955
518	1089	1713	2390	3120

Figure 1 – Integral image

By applying the integral images any rectangular amount can be calculated in four references to the array (Figure 2). It is clear that the difference between the two rectangular sums can be calculated in the eight references. Since the functions described above with two rectangles connected with adjacent rectangular sums, they can be calculated in six references to arrays.

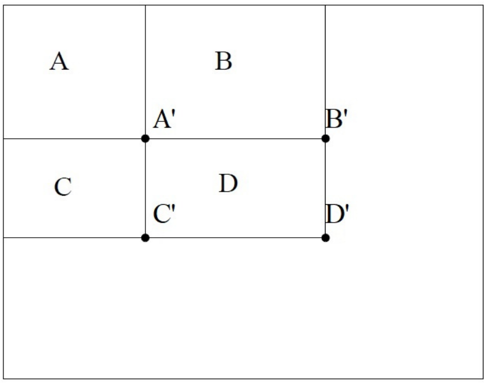


Figure 2 – Calculation of field D total intensity

The field D total intensity is calculated by the following formula:

$$D = D' + A' - \left(B' + C'\right) \quad (2)$$

According to this formula we will calculate a dark zone of integral image (Figure 3).

0	10		30	60	100	
50	120		210	320	450	
151	333		546	790	1065	
		A				B
307	656		1047	1480	1955	
518	1089		1713	2390	3120	
		C				D

Figure 3 – Calculation of the integral image total intensity

In this figure the area A consists of six (pixels), respectively equal to the sum of the intensity field 333 ($A' = 333$). Other areas are: B' = 1065. C' = 1089 and D' = 3120. The total intensity of the field $D = D' + A – (B' + C')$ = 3120 + 333 – 1065 – 1089= 1299. We check the correctness of the formula applying the original image (Figure 4):

0	10	20	30	40
50	60	70	80	90
101	112	123	134	145
156	167	178	189	200
211	222	233	244	255

Figure 4 – Original image

$$D = 178 + 189 + 200 + 233 + 244 + 255 = 1299$$

that proves the correctness of the formula (2).

Face detection based Haar-like features (Figure 5). To find the location of a human face the eyes need to calculate the function shown in Figure 5 (B). This function measures the difference in intensity between the eyes and the through upper cheek area, because the eye area is often darker in comparison with the cheeks.

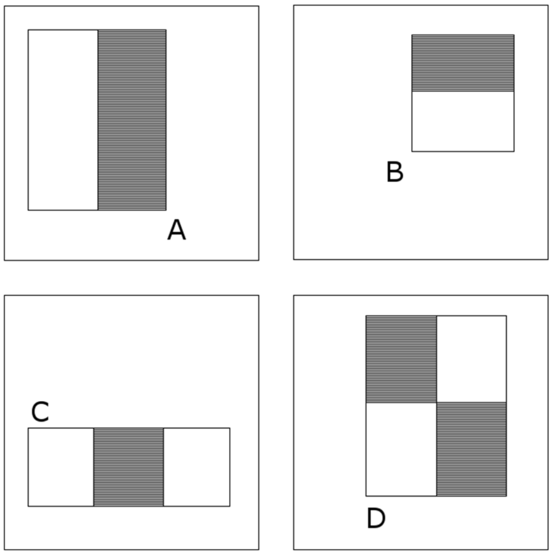


Figure 5 – Haar Features

Scan all Haar primitives for one picture can be time consuming. Therefore, through applying the AdaBoost classifier, you can select the needed primitives (Figure 6) [6, 7].

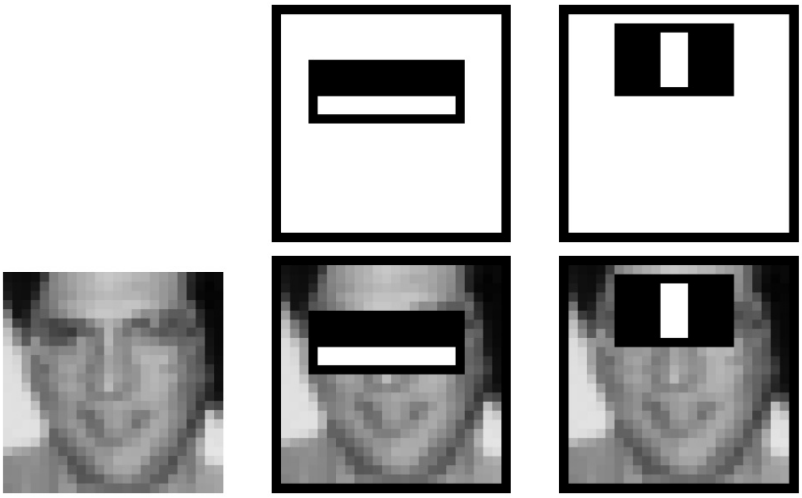


Figure 6 – The first and second functions are selected by applying AdaBoost

Classifiers cascade algorithm provides improved detection efficiency and significantly reduces the calculation time. The critical understanding is that they can be built smaller and therefore more effective, increasing classifiers rejecting many of the negative auxiliary window when it detects almost all positive specimens.

Simpler classifiers are applied to reject most of the sub-window, before more complex classifiers are designed to achieve low levels of false positives. The detection process general form is a process of degeneration of the decision tree, that called «cascading» (Figure 7). A first classifier positive result starts the evaluation of a second classifier that has also been adjusted to achieve very high detection rates. Second classifier positive result from the second classifier triggers the third classifier, etc. A negative result at any point leads to the immediate window rejection.

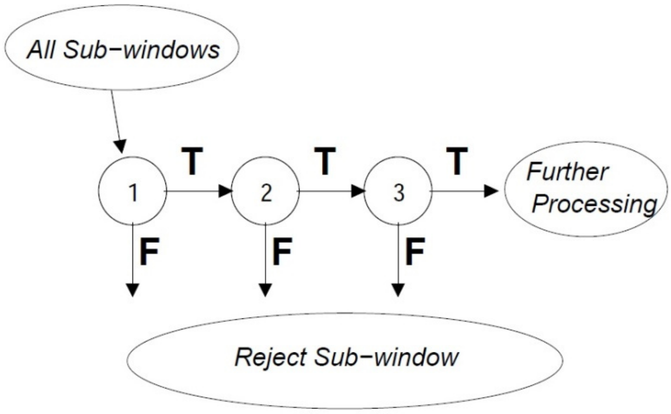
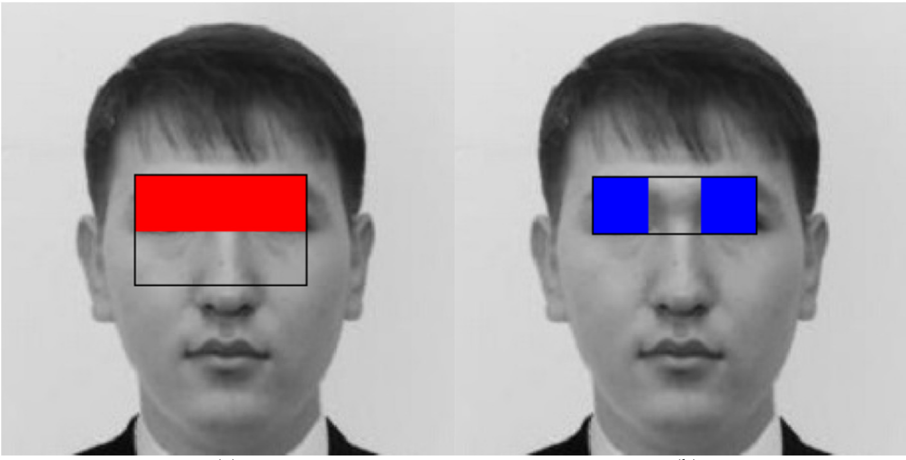


Figure 7 – Schematic drawing of the detection cascade

Research result

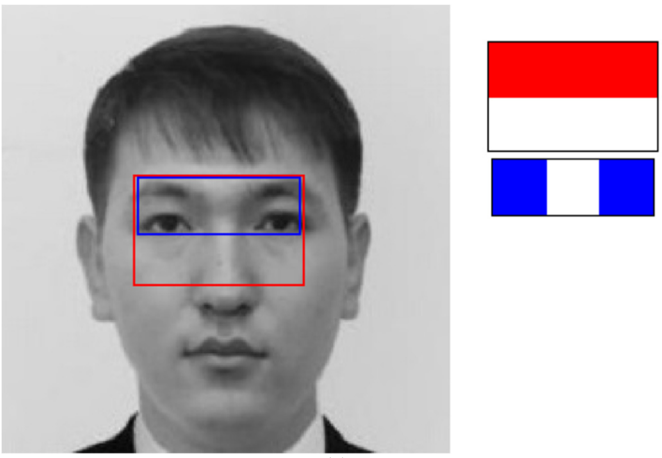
We applied two Haar like features to define facial features (Figure 8). Because the first function measures the difference in intensity between the area of the eyes and the upper cheek area, as the eye area is often darker in comparison with the cheeks. The second function compares the intensity of the eye areas with intensity through the bridge of the nose.

These two features can define the scope of the human eye. Applying one of them can not accurately determine the area of the face. Therefore, to increase the accuracy of the two functions were applied. Figure 9 shows the determination result of human face by applying Haar like functions.

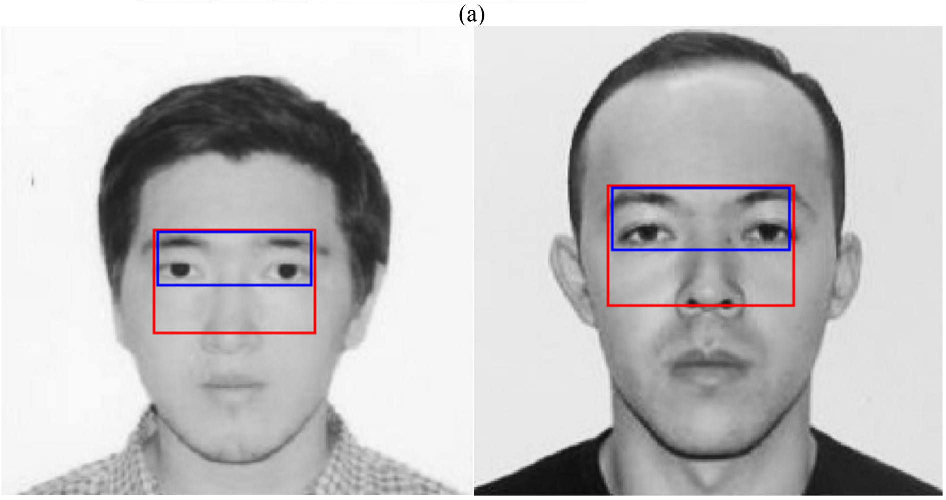


(a) (b)

Figure 8 – The first (a) and second (b) Haar like function to detect faces



(a)



(b) (c)

Figure 9 – Human face detection

The size and action threshold of these functions were the same for the three faces as shown in Figure 9. In this case, the resolution between the eyes were chosen identical. If the size of a human face is different (smaller or larger), the size of Haar like features to be changed. Here is an example of different sizes of the same human face (Figure 10). For the pattern of a size of 153 × 153 The first function was used to size 57 × 36 and the second function with the size 54 × 18. Figures with the size 230 × 230 and 307 × 307 for the detection of persons using the first function to the size 85 × 54 and 113 × 72 respectively, and the second function of the size of 81 × 27 and 108 × 36.

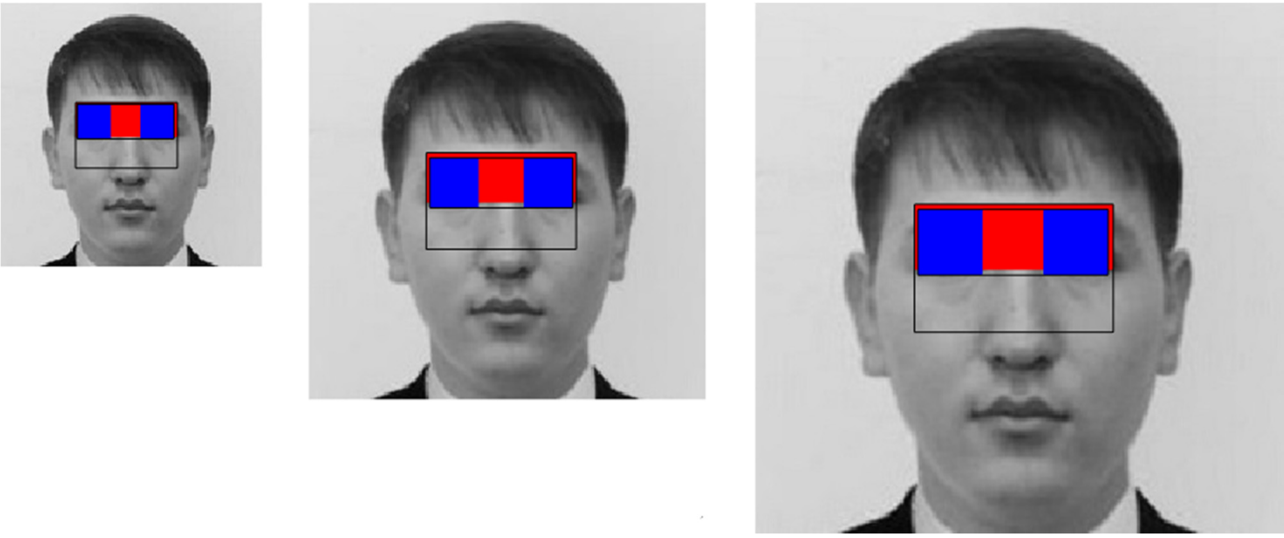


Figure 10 – Human faces detection in different Haar function sizes

Experimental results were obtained using MatLab software environment.

Conclusions

The obtained results prove that the Viola-Jones method provides face detection and the image processing to obtain high processing speed. By applying two Haar like functions human face area can be detected. The use of two or more Haar function increases the detection accuracy. By varying the size of the Haar function can detect faces of different sizes pattern. Integral image reduces the processing time upon detection of the face, because the size of Haar like features more than 2 × 2.

References

1 Singh S.K., Chauhan D.S., Vatsa M., Singh R. A robust skin color based face detection algorithm // Tamkang Journal of Science and Engineering. – 2003. – Vol. 6(4). – P. 227-234.

2 Hjelmås E., Low B.K. Face detection: A survey // Computer vision and image understanding. – 2001. – Vol. 83(3). – P. 236-274.

3 Hsu R.L., Abdel-Mottaleb M., Jain A.K. Face detection in color images // IEEE transactions on pattern analysis and machine intelligence. – 2002. – Vol. 24(5). – P. 696-706.

4 Zhang L., Chu R., Xiang S., Liao S., Li S.Z. Face detection based on multi-block lbp representation // International conference on biometrics. – Springer, Berlin, Heidelberg, 2007. – P. 11-18.

5 Li J., Wang Y., Tan T., Jain A.K. Live face detection based on the analysis of fourier spectra // Biometric Technology for Human Identification. – International Society for Optics and Photonics, 2004. – Vol. 5404. – P. 296-304.

6 Viola P., Jones M. Rapid object detection using a boosted cascade of simple features // Proceedings of the 2001 IEEE Computer Society Conference on Computer Vision and Pattern Recognition. – Kauai, Hawaii, USA, 2001. – Vol. 1. – P. 1-9.

7 Viola P., Jones M.J. Robust real-time face detection // International journal of computer vision. – 2004. – Vol. 57(2). – P. 137-154.

8 Soni L.N., Datar A., Datar S. Implementation of Viola-Jones Algorithm Based Approach for Human Face Detection // International Journal of Current Engineering and Technology. – 2017. – Vol. 7(5). – P. 1819-1823.

9 Papageorgiou C.P., Oren M., Poggio T. A general framework for object detection // Sixth International Conference on Computer Vision. – Bombay, India, 1998. – P. 555-562.
10 Freund Y., Schapire R.E. A decision-theoretic generalization of on-line learning and an application to boosting // Journal of computer and system sciences. – 1997. – Vol. 55(1). – P. 119-139.
11 Tsotsos J.K., Culhane S.M., Wai W.Y.K., Lai Y., Davis N., Nuflo F. Modeling visual attention via selective tuning // Artificial intelligence. – 1995. – Vol. 78(1-2). – P. 507-545.
12 Itti L., Koch C., Niebur E. A model of saliency-based visual attention for rapid scene analysis // IEEE Transactions on pattern analysis and machine intelligence. – 1998. – Vol. 20(11). – P. 1254-1259.
13 Amit Y., Geman D., Wilder K. Joint induction of shape features and tree classifiers // IEEE transactions on pattern analysis and machine intelligence. – 1997. – Vol. 19(11). – P. 1300-1305.
14 Wang Y.Q. An Analysis of the Viola-Jones face detection algorithm // Image Processing On Line. – 2014. – Vol. 4. – P. 128-148.
15 Deshpande N.T., Ravishankar S. Face Detection and Recognition using Viola-Jones algorithm and Fusion of PCA and ANN // Advances in Computational Sciences and Technology. – 2017. – Vol. 10(5). – P. 1173-1189.

References

1 S.K. Singh, D.S. Chauhan, M. Vatsa, and R. Singh, Tamkang J. of Science and Engineering, 6(4), 227-234 (2003).
2 E. Hjelmås and B.K. Low, Computer Vision and Image Understanding, 83(3), 236-274 (2001).
3 R.L. Hsu, M. Abdel-Mottaleb, and A.K. Jain, IEEE Transactions on Pattern Analysis and Machine Intelligence, 24(5), 696-706 (2002).
4 L. Zhang, R. Chu, S. Xiang, S. Liao, S.Z. Li, Intern. Conf. on Biometrics, Springer, 11-18 (2007).
5 J. Li, Y. Wang, T. Tan, and A.K. Jain, Biometric Technology for Human Identification, Intern. Society for Optics and Photonics, 5404, 296-304 (2004).
6 P. Viola and M. Jones, Proceedings of the 2001 IEEE Computer Society Conference on Computer Vision and Pattern Recognition, Kauai, 1, 1-9 (2001).
7 P. Viola and M.J. Jones, Intern. J. of Computer Vision, 57(2), 137-154 (2004).
8 L.N. Soni, A. Datar, and S. Datar, Intern. J. of Current Engineering and Technology, 7(5), 1819-1823 (2017).
9 C.P. Papageorgiou, M. Oren, and T. Poggio, Sixth Intern. Conf. on Computer Vision, Bombay, 555-562 (1998).
10 Y. Freund, and R.E. Schapire, J. of Computer and System Sciences, 55(1), 119-139 (1997).
11 J.K. Tsotsos, S.M. Culhane, W.Y.K. Wai, Y. Lai, N. Davis, and F. Nuflo, Artificial intelligence, 78(1-2), 507-545 (1995).
12 L. Itti, C. Koch, and E. Niebur, IEEE Transactions on Pattern Analysis and Machine Intelligence, 20(11), 1254-1259 (1998).
13 Y. Amit, D. Geman, and K. Wilder, IEEE Transactions on Pattern Analysis and Machine Intelligence, 19(11), 1300-1305 (1997).
14 Y.Q. Wang, Image Processing On Line, 4, 128-148 (2014).
15 N.T. Deshpande, S. Ravishankar, Advances in Computational Sciences and Technology, 10(5), 1173-1189 (2017).