Salient object detection

Advisor

Dr. Maryam abedi

Student

Mohammad shahpouri arani

fall

2021

Table of Contents

Table of Figures

1- What is Salient Object Detection

“Salient object detection” or “Salient object segmentation” is divided into two part: 1) detecting the most salient object and 2) segmenting the accurate boundary of that object. The first stage does not necessarily need to be limited to one object. The majority of existing models have attempted to segment the most salient object, although their prediction maps can be used to find several objects in the scene. The second stage falls in the realm of classic segmentation problems in computer vision but has certain differences.

2- Salient Object Detection Models

In the past decades, a lot of approaches have been proposed for detecting salient or interesting objects in images. These approaches share the following two major attributes:

(1) Block-based vs. Region-based analysis. In existing works, there are mainly two kinds of visual subsets, including blocks and regions 2 , that are used to detect salient objects. Blocks are usually adopted by many early approaches, while regions are increasingly popular with the development of superpixel algorithms.

(2) Intrinsic cues vs. Extrinsic cues. Intrinsic cues are extracted only from the input image itself to pop-out targets and suppress distractors. However, intrinsic cues are insufficient for complex images that targets and distractors may share some common visual attributes to distinguish them. Therefore, they incorporate extrinsic cues such as user annotations, depth map, or statistical information of similar images to facilitate detecting salient objects in the image.

we divide most of existing salient object detection approaches into three major subgroups according to such two attributes, including block-

based models with intrinsic cues, region-based model with intrinsic cues, and models with extrinsic cues.

2-1- Block-based Models with Intrinsic Cues

In this subsection, intrinsic cues are extracted from blocks. These refrences, [1]-[2]-[3]-[4]-[5]-[6]-[7]-[8]-[9]-[10]-[11]-[12], proposed block-based models to utilize intrinsic cues.

2-2- Region-based Models with Intrinsic Cues

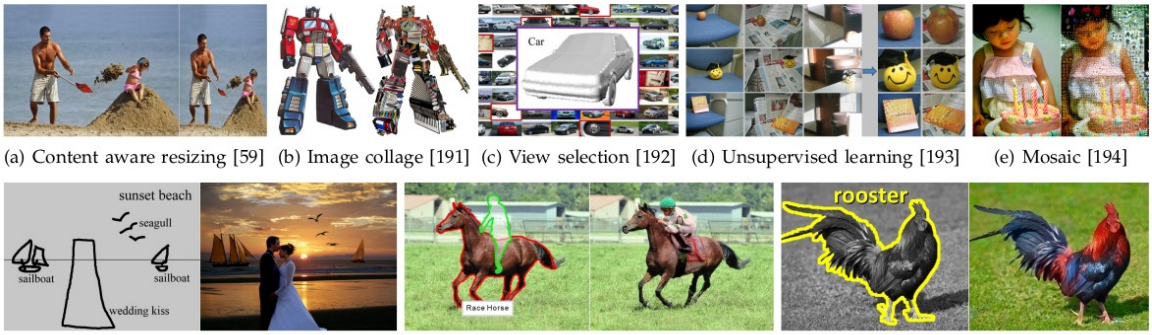
In the second subgroup adopt intrinsic cues extracted from image regions to estimate their saliency scores. References belong to this subgroup: [3]-[13]-[14]-[15]-[16]-[17]-[18]-[12]-[19]-[20]-[21]-[22]-[10]-[23]-[24]-[25]-[8]-[26]-[27]-[28]-[29]-[30]-[31]-[32]-[33]-[34]-[35]-[36]-[37]

2-3- Models with Extrinsic Cues

Models utilize extrinsic cues to detect salint objects are categorized in third subgroup. Models are proposed approaches in this subgroup: [38]-[39]-[40]-[41]-[42]-[43]-[44]-[45]-[46]-[47]-[48]-[49]-[50]-[51]-[52]-[53]-[54]-[55]-[56]

2-4- Applications of Salient Object Detection

Salient object detection models have been utilized for several applications such as object detection and recognition [57]–[63], image and video compression [64], [65], video summarization [66]–[68], photo collage/media re-targeting/cropping/thumb-nailing [69]–[71], image quality assessment [72]–[74], image segmentation [75]–[78], content-based image retrieval and image collection browsing [79]–[81], [82, p. 2], image editing and manipulating [83]–[86], visual tracking [87]–[93], object discovery [94], [95], and human-robot interaction [96], [97]. Fig. 1 shows some example applications.



(a) Content aware resizing [59] (b) Image collage [191] (c) View selection [192] (d) Unsupervised learning [193] (e) Mosaic [194]

(f) Image montage [195] (g) Object manipulation [196] (h) Semantic colorization [197]

Figure 1: Sample applications of salient object detection.

3- Datasets for Salient Object Detection

In this section, Datasets for evaluating salient object detection algorithms are introduced. MSRA-A, MSRA-B, SED1, SED2, ASD, SOD, iCoSeg, MSRA5K, Infrared, ImgSal, CSSD, ECSSD, MSRA10K, THUR15K, DUT-OMRON, Bruce-A, Judd-A, PASCAL-S, UCSB, OSIE, RSD, STC.

4- Evaluation Measures

Evaluation metrics, which were used in papers those addressed here, are listed. Precision-recall (PR), F-measure, Receiver operating characteristics (ROC) curve, Area under ROC curve (AUC), Mean absolute error (MAE)

References

[1] L. Itti, C. Koch, and E. Niebur, "A model of saliency-based visual attention for rapid scene analysis," *IEEE Trans. Pattern Anal. Mach. Intell.*, vol. 20, no. 11, pp. 1254–1259, 1998, doi: 10.1109/34.730558.

[2] R. Achanta, F. Estrada, P. Wils, and S. Süsstrunk, "Salient Region Detection and Segmentation," in *Computer Vision Systems*, Berlin, Heidelberg, 2008, pp. 66–75. doi: 10.1007/978-3-540-79547-6_7.

[3] F. Liu and M. Gleicher, "Region Enhanced Scale-Invariant Saliency Detection," in *2006 IEEE International Conference on Multimedia and Expo*, Jul. 2006, pp. 1477–1480. doi: 10.1109/ICME.2006.262821.

[4] Y. Hu, D. Rajan, and L.-T. Chia, "Robust subspace analysis for detecting visual attention regions in images," in *Proceedings of the 13th annual ACM international conference on Multimedia*, Hilton, Singapore, Nov. 2005, pp. 716–724. doi: 10.1145/1101149.1101306.

[5] P. L. Rosin, "A simple method for detecting salient regions," *Pattern Recognit.*, vol. 42, no. 11, pp. 2363–2371, Nov. 2009, doi: 10.1016/j.patcog.2009.04.021.

[6] R. Valenti, N. Sebe, and T. Gevers, "Image saliency by isocentric curvedness and color," in *2009 IEEE 12th International Conference on Computer Vision*, Sep. 2009, pp. 2185–2192. doi: 10.1109/ICCV.2009.5459240.

[7] R. Achanta, S. Hemami, F. Estrada, and S. Susstrunk, "Frequency-tuned salient region detection," in *2009 IEEE Conference on Computer Vision and Pattern Recognition*, Jun. 2009, pp. 1597–1604. doi: 10.1109/CVPR.2009.5206596.

[8] T. Liu, J. Sun, N.-N. Zheng, X. Tang, and H.-Y. Shum, "Learning to Detect A Salient Object," in *2007 IEEE Conference on Computer Vision and Pattern Recognition*, Jun. 2007, pp. 1–8. doi: 10.1109/CVPR.2007.383047.

[9] D. A. Klein and S. Frintrop, "Center-surround divergence of feature statistics for salient object detection," in *2011 International Conference on Computer Vision*, Nov. 2011, pp. 2214–2219. doi: 10.1109/ICCV.2011.6126499.

[10] X. Li, Y. Li, C. Shen, A. Dick, and A. V. D. Hengel, "Contextual Hypergraph Modeling for Salient Object Detection," in *2013 IEEE International Conference on Computer Vision*, Dec. 2013, pp. 3328–3335. doi: 10.1109/ICCV.2013.413.

[11] S. Goferman, L. Zelnik-Manor, and A. Tal, "Context-Aware Saliency Detection," *IEEE Trans. Pattern Anal. Mach. Intell.*, vol. 34, no. 10, pp. 1915–1926, Oct. 2012, doi: 10.1109/TPAMI.2011.272.

[12] R. Margolin, A. Tal, and L. Zelnik-Manor, "What Makes a Patch Distinct?," in *2013 IEEE Conference on Computer Vision and Pattern Recognition*, Jun. 2013, pp. 1139–1146. doi: 10.1109/CVPR.2013.151.

[13] Z. Yu and H.-S. Wong, "A Rule Based Technique for Extraction of Visual Attention Regions Based on Real-Time Clustering," *IEEE Trans. Multimed.*, vol. 9, no. 4, pp. 766–784, Jun. 2007, doi: 10.1109/TMM.2007.893351.

[14] M.-M. Cheng, N. J. Mitra, X. Huang, P. H. S. Torr, and S.-M. Hu, "Global Contrast Based Salient Region Detection," *IEEE Trans. Pattern Anal. Mach. Intell.*, vol. 37, no. 3, pp. 569–582, Mar. 2015, doi: 10.1109/TPAMI.2014.2345401.

[15] Z. Jiang and L. S. Davis, "Submodular Salient Region Detection," in *2013 IEEE Conference on Computer Vision and Pattern Recognition*, Jun. 2013, pp. 2043–2050. doi: 10.1109/CVPR.2013.266.

[16] F. Perazzi, P. Krähenbühl, Y. Pritch, and A. Hornung, "Saliency filters: Contrast based filtering for salient region detection," in *2012 IEEE Conference on Computer Vision and Pattern Recognition*, Jun. 2012, pp. 733–740. doi: 10.1109/CVPR.2012.6247743.

[17] C. Scharfenberger, A. Wong, K. Fergani, J. S. Zelek, and D. A. Clausi, "Statistical Textural Distinctiveness for Salient Region Detection in Natural Images," in *2013 IEEE Conference on Computer Vision and Pattern Recognition*, Jun. 2013, pp. 979–986. doi: 10.1109/CVPR.2013.131.

[18] K. Shi, K. Wang, J. Lu, and L. Lin, "PISA: Pixelwise Image Saliency by Aggregating Complementary Appearance Contrast Measures with Spatial Priors," in *2013 IEEE Conference on Computer Vision and Pattern Recognition*, Jun. 2013, pp. 2115–2122. doi: 10.1109/CVPR.2013.275.

[19] M.-M. Cheng, J. Warrell, W.-Y. Lin, S. Zheng, V. Vineet, and N. Crook, "Efficient Salient Region Detection with Soft Image Abstraction," in *2013 IEEE International Conference on Computer Vision*, Dec. 2013, pp. 1529–1536. doi: 10.1109/ICCV.2013.193.

[20] H. Jiang, J. Wang, Z. Yuan, T. Liu, and N. Zheng, "Automatic salient object segmentation based on context and shape prior," in *Procedings of the British Machine Vision Conference 2011*, Dundee, 2011, p. 110.1-110.12. doi: 10.5244/C.25.110.

[21] Q. Yan, L. Xu, J. Shi, and J. Jia, "Hierarchical Saliency Detection," in *2013 IEEE Conference on Computer Vision and Pattern Recognition*, Jun. 2013, pp. 1155–1162. doi: 10.1109/CVPR.2013.153.

[22] X. Li, H. Lu, L. Zhang, X. Ruan, and M.-H. Yang, "Saliency Detection via Dense and Sparse Reconstruction," in *2013 IEEE International Conference on Computer Vision*, Dec. 2013, pp. 2976–2983. doi: 10.1109/ICCV.2013.370.

[23] X. Shen and Y. Wu, "A unified approach to salient object detection via low rank matrix recovery," in *2012 IEEE Conference on Computer Vision and Pattern Recognition*, Jun. 2012, pp. 853–860. doi: 10.1109/CVPR.2012.6247758.

[24] W. Zou, K. Kpalma, Z. Liu, and joseph Ronsin, "Segmentation Driven Low-rank Matrix Recovery for Saliency Detection," in *Procedings of the British Machine Vision Conference 2013*, Bristol, 2013, p. 78.1-78.11. doi: 10.5244/C.27.78.

[25] H. Peng, B. Li, R. Ji, W. Hu, W. Xiong, and C. Lang, "Salient Object Detection via Low-Rank and Structured Sparse Matrix Decomposition," presented at the Twenty-Seventh AAAI Conference on Artificial Intelligence, Jun. 2013. Accessed: Oct. 06, 2021. [Online]. Available: https://www.aaai.org/ocs/index.php/AAAI/AAAI13/paper/view/6290

[26] Y. Wei, F. Wen, W. Zhu, and J. Sun, "Geodesic Saliency Using Background Priors," in *Computer Vision – ECCV 2012*, Berlin, Heidelberg, 2012, pp. 29–42. doi: 10.1007/978-3-642-33712-3_3.

[27] C. Yang, L. Zhang, H. Lu, X. Ruan, and M.-H. Yang, "Saliency Detection via Graph-Based Manifold Ranking," in *2013 IEEE Conference on Computer Vision and Pattern Recognition*, Jun. 2013, pp. 3166–3173. doi: 10.1109/CVPR.2013.407.
[28] B. Jiang, L. Zhang, H. Lu, C. Yang, and M.-H. Yang, "Saliency Detection via Absorbing Markov Chain," in *2013 IEEE International Conference on Computer Vision*, Dec. 2013, pp. 1665–1672. doi: 10.1109/ICCV.2013.209.
[29] K.-Y. Chang, T.-L. Liu, H.-T. Chen, and S.-H. Lai, "Fusing generic objectness and visual saliency for salient object detection," in *2011 International Conference on Computer Vision*, Nov. 2011, pp. 914–921. doi: 10.1109/ICCV.2011.6126333.
[30] P. Jiang, H. Ling, J. Yu, and J. Peng, "Salient Region Detection by UFO: Uniqueness, Focusness and Objectness," in *2013 IEEE International Conference on Computer Vision*, Dec. 2013, pp. 1976–1983. doi: 10.1109/ICCV.2013.248.
[31] Y. Jia and M. Han, "Category-Independent Object-Level Saliency Detection," in *2013 IEEE International Conference on Computer Vision*, Dec. 2013, pp. 1761–1768. doi: 10.1109/ICCV.2013.221.
[32] W. Zhu, S. Liang, Y. Wei, and J. Sun, "Saliency Optimization from Robust Background Detection," in *2014 IEEE Conference on Computer Vision and Pattern Recognition*, Jun. 2014, pp. 2814–2821. doi: 10.1109/CVPR.2014.360.
[33] J. Zhang and S. Sclaroff, "Saliency Detection: A Boolean Map Approach," in *2013 IEEE International Conference on Computer Vision*, Dec. 2013, pp. 153–160. doi: 10.1109/ICCV.2013.26.
[34] N. Li, J. Ye, Y. Ji, H. Ling, and J. Yu, "Saliency Detection on Light Field," in *2014 IEEE Conference on Computer Vision and Pattern Recognition*, Jun. 2014, pp. 2806–2813. doi: 10.1109/CVPR.2014.359.
[35] Y. Xie, H. Lu, and M.-H. Yang, "Bayesian Saliency via Low and Mid Level Cues," *IEEE Trans. Image Process.*, vol. 22, no. 5, pp. 1689–1698, May 2013, doi: 10.1109/TIP.2012.2216276.
[36] E. Rahtu, J. Kannala, M. Salo, and J. Heikkilä, "Segmenting Salient Objects from Images and Videos," in *Computer Vision – ECCV 2010*, Berlin, Heidelberg, 2010, pp. 366–379. doi: 10.1007/978-3-642-15555-0_27.
[37] R. Liu, J. Cao, Z. Lin, and S. Shan, "Adaptive Partial Differential Equation Learning for Visual Saliency Detection," in *2014 IEEE Conference on Computer Vision and Pattern Recognition*, Jun. 2014, pp. 3866–3873. doi: 10.1109/CVPR.2014.494.
[38] H. Li and K. N. Ngan, "A Co-Saliency Model of Image Pairs," *IEEE Trans. Image Process.*, vol. 20, no. 12, pp. 3365–3375, Dec. 2011, doi: 10.1109/TIP.2011.2156803.
[39] L. Marchesotti, C. Cifarelli, and G. Csurka, "A framework for visual saliency detection with applications to image thumbnailing," in *2009 IEEE 12th International Conference on Computer Vision*, Sep. 2009, pp. 2232–2239. doi: 10.1109/ICCV.2009.5459467.
[40] H. Fu, X. Cao, and Z. Tu, "Cluster-Based Co-Saliency Detection," *IEEE Trans. Image Process.*, vol. 22, no. 10, pp. 3766–3778, Oct. 2013, doi: 10.1109/TIP.2013.2260166.

[41] K. Desingh, M. K. K, D. Rajan, and C. Jawahar, “Depth really Matters: Improving Visual Salient Region Detection with Depth,” in *Procedings of the British Machine Vision Conference 2013*, Bristol, 2013, p. 98.1-98.11. doi: 10.5244/C.27.98.
[42] K.-Y. Chang, T.-L. Liu, and S.-H. Lai, “From co-saliency to co-segmentation: An efficient and fully unsupervised energy minimization model,” in *CVPR 2011*, Jun. 2011, pp. 2129–2136. doi: 10.1109/CVPR.2011.5995415.
[43] M. Wang, J. Konrad, P. Ishwar, K. Jing, and H. Rowley, “Image saliency: From intrinsic to extrinsic context,” in *CVPR 2011*, Jun. 2011, pp. 417–424. doi: 10.1109/CVPR.2011.5995743.
[44] S. Lu, V. Mahadevan, and N. Vasconcelos, “Learning Optimal Seeds for Diffusion-Based Salient Object Detection,” in *2014 IEEE Conference on Computer Vision and Pattern Recognition*, Jun. 2014, pp. 2790–2797. doi: 10.1109/CVPR.2014.357.
[45] Y. Niu, Y. Geng, X. Li, and F. Liu, “Leveraging stereopsis for saliency analysis,” in *2012 IEEE Conference on Computer Vision and Pattern Recognition*, Jun. 2012, pp. 454–461. doi: 10.1109/CVPR.2012.6247708.
[46] P. Siva, C. Russell, T. Xiang, and L. Agapito, “Looking Beyond the Image: Unsupervised Learning for Object Saliency and Detection,” in *2013 IEEE Conference on Computer Vision and Pattern Recognition*, Jun. 2013, pp. 3238–3245. doi: 10.1109/CVPR.2013.416.
[47] P. Khuwuthyakorn, A. Robles-Kelly, and J. Zhou, “Object of Interest Detection by Saliency Learning,” in *Computer Vision – ECCV 2010*, Berlin, Heidelberg, 2010, pp. 636–649. doi: 10.1007/978-3-642-15552-9_46.
[48] L. Mai, Y. Niu, and F. Liu, “Saliency Aggregation: A Data-Driven Approach,” in *2013 IEEE Conference on Computer Vision and Pattern Recognition*, Jun. 2013, pp. 1131–1138. doi: 10.1109/CVPR.2013.150.
[49] N. Li, J. Ye, Y. Ji, H. Ling, and J. Yu, “Saliency Detection on Light Field,” in *2014 IEEE Conference on Computer Vision and Pattern Recognition*, Jun. 2014, pp. 2806–2813. doi: 10.1109/CVPR.2014.359.
[50] P. Mehrani and O. Veksler, “Saliency Segmentation based on Learning and Graph Cut Refinement,” in *Procedings of the British Machine Vision Conference 2010*, Aberystwyth, 2010, p. 110.1-110.12. doi: 10.5244/C.24.110.
[51] H. Jiang, J. Wang, Z. Yuan, Y. Wu, N. Zheng, and S. Li, “Salient Object Detection: A Discriminative Regional Feature Integration Approach,” in *2013 IEEE Conference on Computer Vision and Pattern Recognition*, Jun. 2013, pp. 2083–2090. doi: 10.1109/CVPR.2013.271.
[52] J. Kim, D. Han, Y.-W. Tai, and J. Kim, “Salient Region Detection via High-Dimensional Color Transform,” in *2014 IEEE Conference on Computer Vision and Pattern Recognition*, Jun. 2014, pp. 883–890. doi: 10.1109/CVPR.2014.118.
[53] E. Rahtu, J. Kannala, M. Salo, and J. Heikkilä, “Segmenting Salient Objects from Images and Videos,” in *Computer Vision – ECCV 2010*, Berlin, Heidelberg, 2010, pp. 366–379. doi: 10.1007/978-3-642-15555-0_27.
[54] Y. Li, B. Sheng, L. Ma, W. Wu, and Z. Xie, “Temporally Coherent Video Saliency Using Regional Dynamic Contrast,” *IEEE Trans. Circuits Syst. Video Technol.*, vol. 23, no. 12, pp. 2067–2076, Dec. 2013, doi: 10.1109/TCSVT.2013.2270367.

[55] T. Liu, N. Zheng, W. Ding, and Z. Yuan, "Video Attention: Learning to Detect a Salient Object Sequence," in *2008 19th International Conference on Pattern Recognition*, Dec. 2008, pp. 1–4. doi: 10.1109/ICPR.2008.4761406.
[56] Y. Zhai and M. Shah, "Visual attention detection in video sequences using spatiotemporal cues," in *Proceedings of the 14th ACM international conference on Multimedia*, Santa Barbara, CA, USA, Oct. 2006, pp. 815–824. doi: 10.1145/1180639.1180824.
[57] A. Borji, M. N. Ahmadabadi, and B. N. Araabi, "Cost-sensitive learning of top-down modulation for attentional control," *Mach. Vis. Appl.*, vol. 22, no. 1, pp. 61–76, Jan. 2011, doi: 10.1007/s00138-009-0192-0.
[58] U. Rutishauser, D. Walther, C. Koch, and P. Perona, "Is bottom-up attention useful for object recognition?," in *Proceedings of the 2004 IEEE Computer Society Conference on Computer Vision and Pattern Recognition, 2004. CVPR 2004.*, Jun. 2004, vol. 2, p. II–II. doi: 10.1109/CVPR.2004.1315142.
[59] F. Moosmann, D. Larlus, and F. Jurie, "Learning saliency maps for object categorization," Graz, Austria, May 2006. Accessed: Oct. 09, 2021. [Online]. Available: https://hal.archives-ouvertes.fr/hal-00203726
[60] H. Shen, S. Li, C. Zhu, H. Chang, and J. Zhang, "Moving object detection in aerial video based on spatiotemporal saliency," *Chin. J. Aeronaut.*, vol. 26, no. 5, pp. 1211–1217, Oct. 2013, doi: 10.1016/j.cja.2013.07.038.
[61] Z. Ren, S. Gao, L.-T. Chia, and I. W.-H. Tsang, "Region-Based Saliency Detection and Its Application in Object Recognition," *IEEE Trans. Circuits Syst. Video Technol.*, vol. 24, no. 5, pp. 769–779, May 2014, doi: 10.1109/TCSVT.2013.2280096.
[62] C. Kanan and G. Cottrell, "Robust classification of objects, faces, and flowers using natural image statistics," in *2010 IEEE Computer Society Conference on Computer Vision and Pattern Recognition*, Jun. 2010, pp. 2472–2479. doi: 10.1109/CVPR.2010.5539947.
[63] A. Borji and L. Itti, "Scene classification with a sparse set of salient regions," in *2011 IEEE International Conference on Robotics and Automation*, May 2011, pp. 1902–1908. doi: 10.1109/ICRA.2011.5979815.
[64] C. Guo and L. Zhang, "A Novel Multiresolution Spatiotemporal Saliency Detection Model and Its Applications in Image and Video Compression," *IEEE Trans. Image Process.*, vol. 19, no. 1, pp. 185–198, Jan. 2010, doi: 10.1109/TIP.2009.2030969.
[65] L. Itti, "Automatic foveation for video compression using a neurobiological model of visual attention," *IEEE Trans. Image Process.*, vol. 13, no. 10, pp. 1304–1318, Oct. 2004, doi: 10.1109/TIP.2004.834657.
[66] Y.-F. Ma, X.-S. Hua, L. Lu, and H.-J. Zhang, "A generic framework of user attention model and its application in video summarization," *IEEE Trans. Multimed.*, vol. 7, no. 5, pp. 907–919, Oct. 2005, doi: 10.1109/TMM.2005.854410.
[67] Y. J. Lee, J. Ghosh, and K. Grauman, "Discovering important people and objects for egocentric video summarization," in *2012 IEEE Conference on Computer Vision and Pattern Recognition*, Jun. 2012, pp. 1346–1353. doi: 10.1109/CVPR.2012.6247820.

[68] Q.-G. Ji, Z.-D. Fang, Z.-H. Xie, and Z.-M. Lu, “Video abstraction based on the visual attention model and online clustering,” *Signal Process. Image Commun.*, vol. 28, no. 3, pp. 241–253, Mar. 2013, doi: 10.1016/j.image.2012.11.008.
[69] H. Huang, L. Zhang, and H.-C. Zhang, “Arcimboldo-like collage using internet images,” in *Proceedings of the 2011 SIGGRAPH Asia Conference*, Hong Kong, China, Dec. 2011, pp. 1–8. doi: 10.1145/2024156.2024189.
[70] S. Goferman, A. Tal, and L. Zelnik-Manor, “Puzzle-like Collage,” *Comput. Graph. Forum*, vol. 29, no. 2, pp. 459–468, 2010, doi: 10.1111/j.1467-8659.2009.01615.x.
[71] J. Wang, L. Quan, J. Sun, X. Tang, and H.-Y. Shum, “Picture Collage,” in *2006 IEEE Computer Society Conference on Computer Vision and Pattern Recognition (CVPR’06)*, Jun. 2006, vol. 1, pp. 347–354. doi: 10.1109/CVPR.2006.224.
[72] A. Li, X. She, and Q. Sun, “Color image quality assessment combining saliency and FSIM,” in *Fifth International Conference on Digital Image Processing (ICDIP 2013)*, Jul. 2013, vol. 8878, pp. 82–86. doi: 10.1117/12.2030719.
[73] A. Ninassi, O. Le Meur, P. Le Callet, and D. Barba, “Does where you Gaze on an Image Affect your Perception of Quality? Applying Visual Attention to Image Quality Metric,” in *2007 IEEE International Conference on Image Processing*, Sep. 2007, vol. 2, p. II-169-II–172. doi: 10.1109/ICIP.2007.4379119.
[74] H. Liu and I. Heynderickx, “Studying the added value of visual attention in objective image quality metrics based on eye movement data,” in *2009 16th IEEE International Conference on Image Processing (ICIP)*, Nov. 2009, pp. 3097–3100. doi: 10.1109/ICIP.2009.5414466.
[75] M. Johnson-Roberson, J. Bohg, M. Björkman, and D. Kragic, “Attention-based active 3D point cloud segmentation,” in *2010 IEEE/RSJ International Conference on Intelligent Robots and Systems*, Oct. 2010, pp. 1165–1170. doi: 10.1109/IROS.2010.5649872.
[76] C. Qin, G. Zhang, Y. Zhou, W. Tao, and Z. Cao, “Integration of the saliency-based seed extraction and random walks for image segmentation,” *Neurocomputing*, vol. 129, pp. 378–391, Apr. 2014, doi: 10.1016/j.neucom.2013.09.021.
[77] Q. Li, Y. Zhou, and J. Yang, “Saliency based image segmentation,” in *2011 International Conference on Multimedia Technology*, Jul. 2011, pp. 5068–5071. doi: 10.1109/ICMT.2011.6002178.
[78] M. Donoser, M. Urschler, M. Hirzer, and H. Bischof, “Saliency driven total variation segmentation,” in *2009 IEEE 12th International Conference on Computer Vision*, Sep. 2009, pp. 817–824. doi: 10.1109/ICCV.2009.5459296.
[79] S. Feng, D. Xu, and X. Yang, “Attention-driven salient edge(s) and region(s) extraction with application to CBIR,” *Signal Process.*, vol. 90, no. 1, pp. 1–15, Jan. 2010, doi: 10.1016/j.sigpro.2009.05.017.
[80] J. Sun, J. Xie, J. Liu, and T. Sikora, “Image Adaptation and Dynamic Browsing Based on Two-Layer Saliency Combination,” *IEEE Trans. Broadcast.*, vol. 59, no. 4, pp. 602–613, Dec. 2013, doi: 10.1109/TBC.2013.2272172.
[81] L. Li, S. Jiang, Z.-J. Zha, Z. Wu, and Q. Huang, “Partial-Duplicate Image Retrieval via Saliency-Guided Visual Matching,” *IEEE Multimed.*, vol. 20, no. 3, pp. 13–23, Jul. 2013, doi: 10.1109/MMUL.2013.15.

[82] T. Chen, M.-M. Cheng, P. Tan, A. Shamir, and S.-M. Hu, “Sketch2Photo: internet image montage,” *ACM Trans. Graph.*, vol. 28, no. 5, pp. 1–10, Dec. 2009, doi: 10.1145/1618452.1618470.
[83] C. Goldberg, T. Chen, F.-L. Zhang, A. Shamir, and S.-M. Hu, “Data-Driven Object Manipulation in Images,” *Comput. Graph. Forum*, vol. 31, no. 2pt1, pp. 265–274, May 2012.
[84] R. Margolin, L. Zelnik-Manor, and A. Tal, “Saliency for image manipulation,” *Vis. Comput.*, vol. 29, no. 5, pp. 381–392, May 2013, doi: 10.1007/s00371-012-0740-x.
[85] A. Y.-S. Chia *et al.*, “Semantic colorization with internet images,” *ACM Trans. Graph.*, vol. 30, no. 6, pp. 1–8, Dec. 2011, doi: 10.1145/2070781.2024190.
[86] H. Liu, L. Zhang, and H. Huang, “Web-image driven best views of 3D shapes,” *Vis. Comput.*, vol. 28, no. 3, pp. 279–287, Mar. 2012, doi: 10.1007/s00371-011-0638-z.
[87] G. M. García, D. A. Klein, J. Stückler, S. Frintrop, and A. B. Cremers, “Adaptive Multi-cue 3D Tracking of Arbitrary Objects,” in *Pattern Recognition*, Berlin, Heidelberg, 2012, pp. 357–366. doi: 10.1007/978-3-642-32717-9_36.
[88] A. Borji, S. Frintrop, D. N. Sihite, and L. Itti, “Adaptive object tracking by learning background context,” in *2012 IEEE Computer Society Conference on Computer Vision and Pattern Recognition Workshops*, Jun. 2012, pp. 23–30. doi: 10.1109/CVPRW.2012.6239191.
[89] D. A. Klein, D. Schulz, S. Frintrop, and A. B. Cremers, “Adaptive real-time video-tracking for arbitrary objects,” in *2010 IEEE/RSJ International Conference on Intelligent Robots and Systems*, Oct. 2010, pp. 772–777. doi: 10.1109/IROS.2010.5650583.
[90] S. Stalder, H. Grabner, and L. Van Gool, “Dynamic Objectness for Adaptive Tracking,” in *Computer Vision – ACCV 2012*, Berlin, Heidelberg, 2013, pp. 43–56. doi: 10.1007/978-3-642-37431-9_4.
[91] S. Frintrop and M. Kessel, “Most salient region tracking,” in *2009 IEEE International Conference on Robotics and Automation*, May 2009, pp. 1869–1874. doi: 10.1109/ROBOT.2009.5152298.
[92] G. Zhang, Z. Yuan, N. Zheng, X. Sheng, and T. Liu, “Visual Saliency Based Object Tracking,” in *Computer Vision – ACCV 2009*, Berlin, Heidelberg, 2010, pp. 193–203. doi: 10.1007/978-3-642-12304-7_19.
[93] J. Li, M. D. Levine, X. An, X. Xu, and H. He, “Visual Saliency Based on Scale-Space Analysis in the Frequency Domain,” *IEEE Trans. Pattern Anal. Mach. Intell.*, vol. 35, no. 4, pp. 996–1010, Apr. 2013, doi: 10.1109/TPAMI.2012.147.
[94] S. Frintrop, G. M. García, and A. B. Cremers, “A Cognitive Approach for Object Discovery,” in *2014 22nd International Conference on Pattern Recognition*, Aug. 2014, pp. 2329–2334. doi: 10.1109/ICPR.2014.404.
[95] A. Karpathy, S. Miller, and L. Fei-Fei, “Object discovery in 3D scenes via shape analysis,” in *2013 IEEE International Conference on Robotics and Automation*, May 2013, pp. 2088–2095. doi: 10.1109/ICRA.2013.6630857.
[96] Y. Sugano, Y. Matsushita, and Y. Sato, “Calibration-free gaze sensing using saliency maps,” in *2010 IEEE Computer Society Conference on Computer Vision and Pattern Recognition*, Jun. 2010, pp. 2667–2674. doi: 10.1109/CVPR.2010.5539984.

[97] D. Meger *et al.*, “Curious George: An attentive semantic robot,” *Robot. Auton. Syst.*, vol. 56, no. 6, pp. 503–511, Jun. 2008, doi: 10.1016/j.robot.2008.03.008.