图像处理专题

之

视觉显著性检测及其应用

——视觉显著性检测的前世今生

今日内容

一.视觉显著性检测的起源、追溯、分类、及代表性工作

二.视觉显著性检测的应用

三.显著性物体检测的细化分类

四. 总结

显著性检测的定义

显著性检测?

“一言以蔽之”

利用算法/模型检测图像/场景中吸引人视觉注意力的地方

一.显著性检测的追溯、分类、及代表性工作

视觉显著性检测的分类

视觉显著性检测(Saliency detection)

- 1.人眼注视预测
- 2.显著物体/显著区域检测
- 3.似物性（Objectness）检测

人眼注视预测(Eye fixation prediction), 1998

显著物体/显著区域检测, 2009

似物性（Objectness）检测, 2010

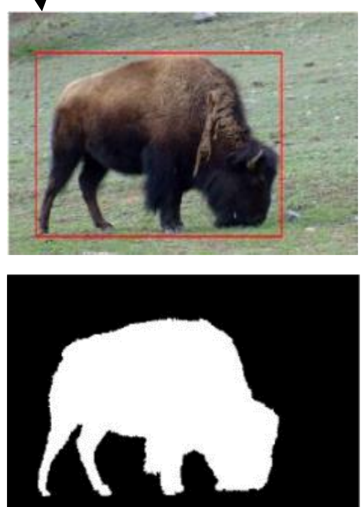
一.显著性检测的追溯、分类、及代表性工作

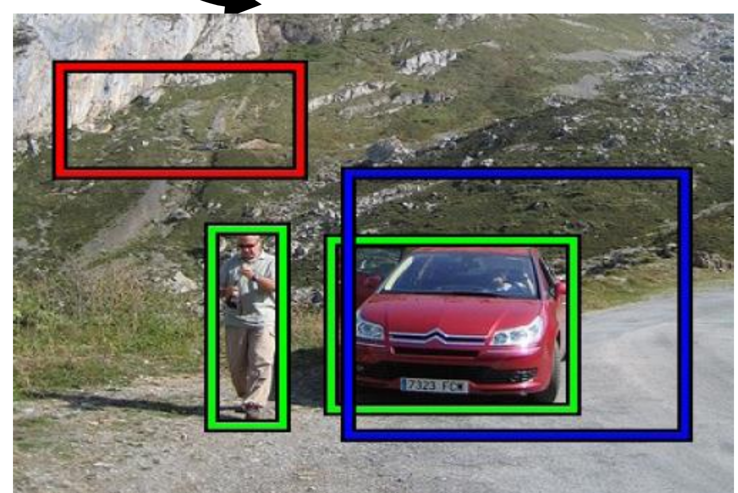
视觉显著性检测的分类

人眼注视预测(Eye fixation prediction), 1998

显著物体/显著区域检测 (SOD), 2009

似物性（Objectness）检测, 2010





一.显著性检测的追溯、分类、及代表性工作

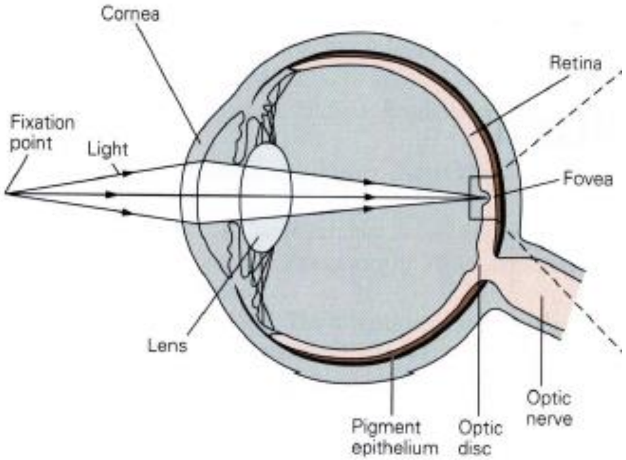
视觉显著性检测的追溯

- 最早追溯到认知心理学家Triesman和Gelade在1980年提出的特征整合论（Feature Integration Theory）

A. Triesman and G. Gelade, "A feature-integration theory of attention," *Cognitive Psychology*, vol. 12, no. 1, pp. 97–136, 1980.

- Treiasman假定，视觉早期阶段只能检测独立的特征，包括颜色、尺寸、方向、反差、倾斜性、曲率和线段端点等，还可能包括运动和距离的远近差别。

- 人的知觉系统把彼此分开的特征（特征表征）正确联系起来，形成能够对某一物体的表征。

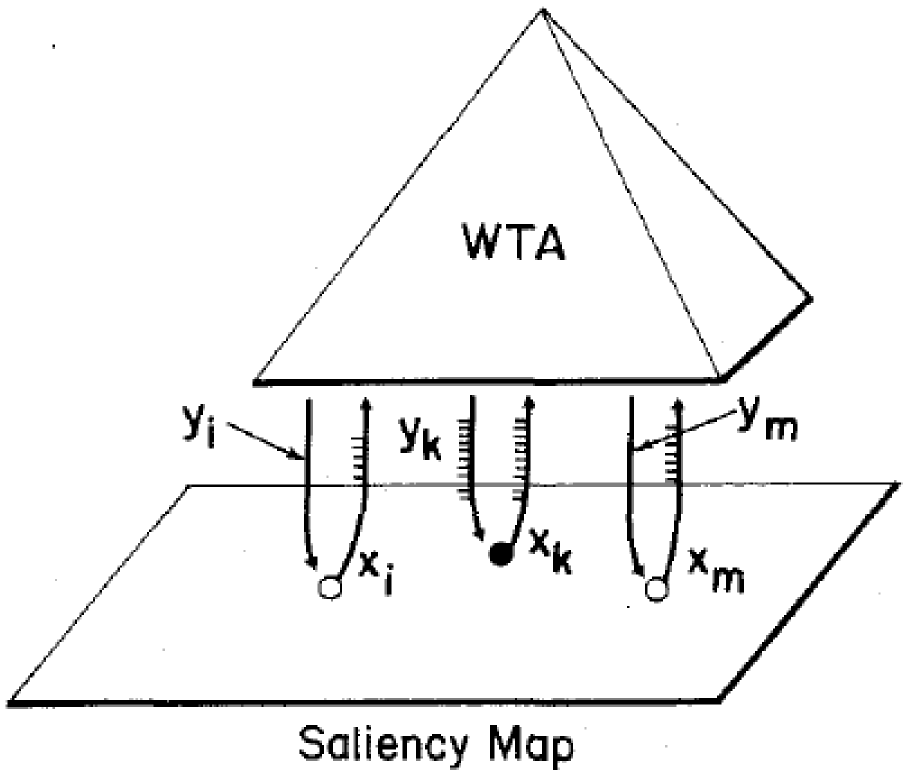


一.显著性检测的追溯、分类、及代表性工作

视觉显著性检测的追溯

- 基于Triesm… Koch和Ullman于1987年首次提出生… 拟人的注意力，并…

spicuity wi…
assess the g…
assume the…
the *saliency*…
individual …
The points…
feature ma…



In order to…
…ion, we will
…nap, termed
…ation of the
conspicuity.
… elementary
…y map. The

cess. The saliency map may be localized either within the lateral geniculate nucleus (LGN) or within the striate cortex (V1). The

丘脑外侧膝状体
视觉信息的主要处理器

纹状皮层
即初级视皮层

视觉显著性检测的追溯

- 1998年，Itti等人首次使用计算机视觉方法完整地实现Koch和Ullman的模型，并提出“中心-周围差异”算子来作为某个区域显著性水平的度量。该算子由DoG (Difference of Gaussians) 算子实现。

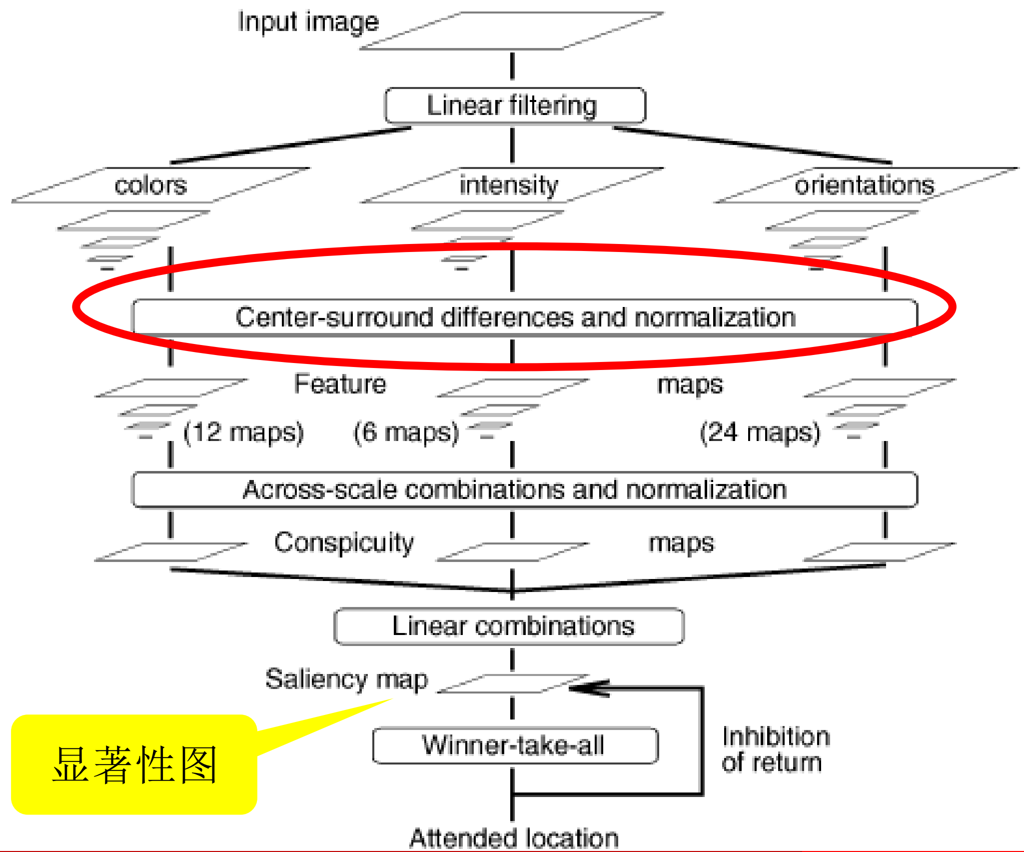
A Model of Saliency-Based Visual Attention for Rapid Scene Analysis

Laurent Itti, Christof Koch, and Ernst Niebur

Abstract—A visual attention system, inspired by the behavior and the neuronal architecture of the early primate visual system, is presented. Multiscale image features are combined into a single topographical saliency map. A dynamical neural network then selects attended locations in order of decreasing saliency. The system breaks down the complex problem of scene understanding by rapidly selecting, in a computationally efficient manner, conspicuous locations to be analyzed in detail.

Index Terms—Visual attention, scene analysis, feature extraction, target detection, visual search.

TPAMI 1998



一.显著性检测的追溯、分类、及代表性工作

视觉显著性检测的追溯

- 1998年，Itti等人首次使用计算机视觉方法完整地实现Koch和Ullman的模型，并提出“中心-周围差异”算子来作为某个区域显著性水平的度量。该算子由DoG (Difference of Gaussians) 算子实现。

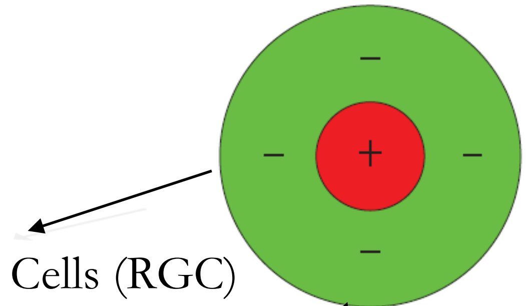
Each feature is computed by a set of linear “center-surround” operations akin to visual receptive fields (Fig. 1): Typical visual neurons are most sensitive in a small region of the visual space (the center), while stimuli presented in a broader, weaker antagonistic region concentric with the center (the surround) inhibit the neuronal response. Such an architecture, sensitive to local spatial discontinuities, is particularly well-suited to detecting locations which stand out from their surround and is a general computational principle in the retina, lateral geniculate nucleus, and primary visual cortex [12]. Center-surround is implemented in the

一.显著性检测的追溯、分类、及代表性工作

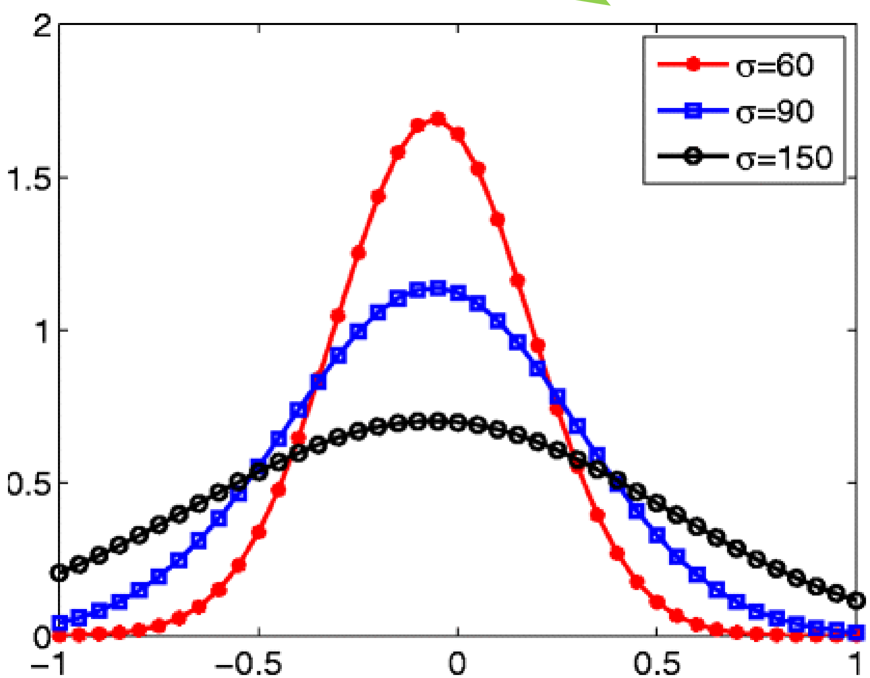
视觉显著性检测的追溯

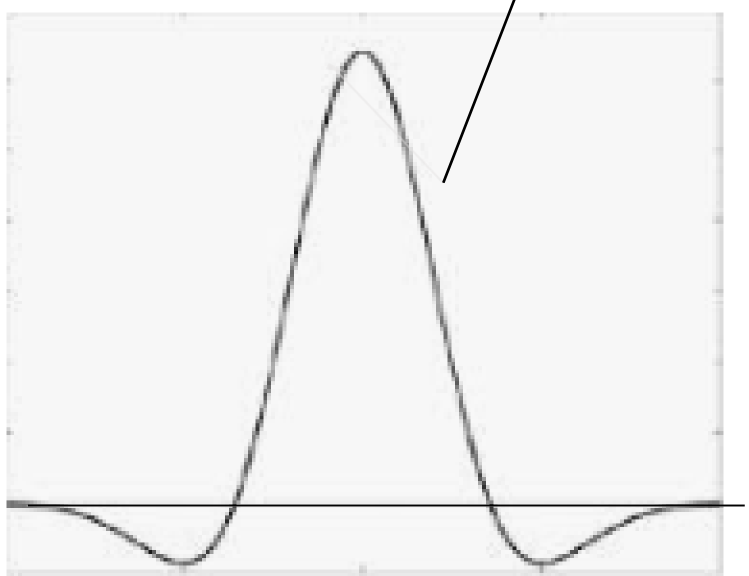
- DoG (Difference of Gaussians) 算子反应“中心-周围”差异

$$g(x)=\frac{1}{\sigma\sqrt{2\pi}}e^{-\frac{x^2}{2\sigma^2}}$$



Retinal Ganglion Cells (RGC)
视网膜神经节细胞

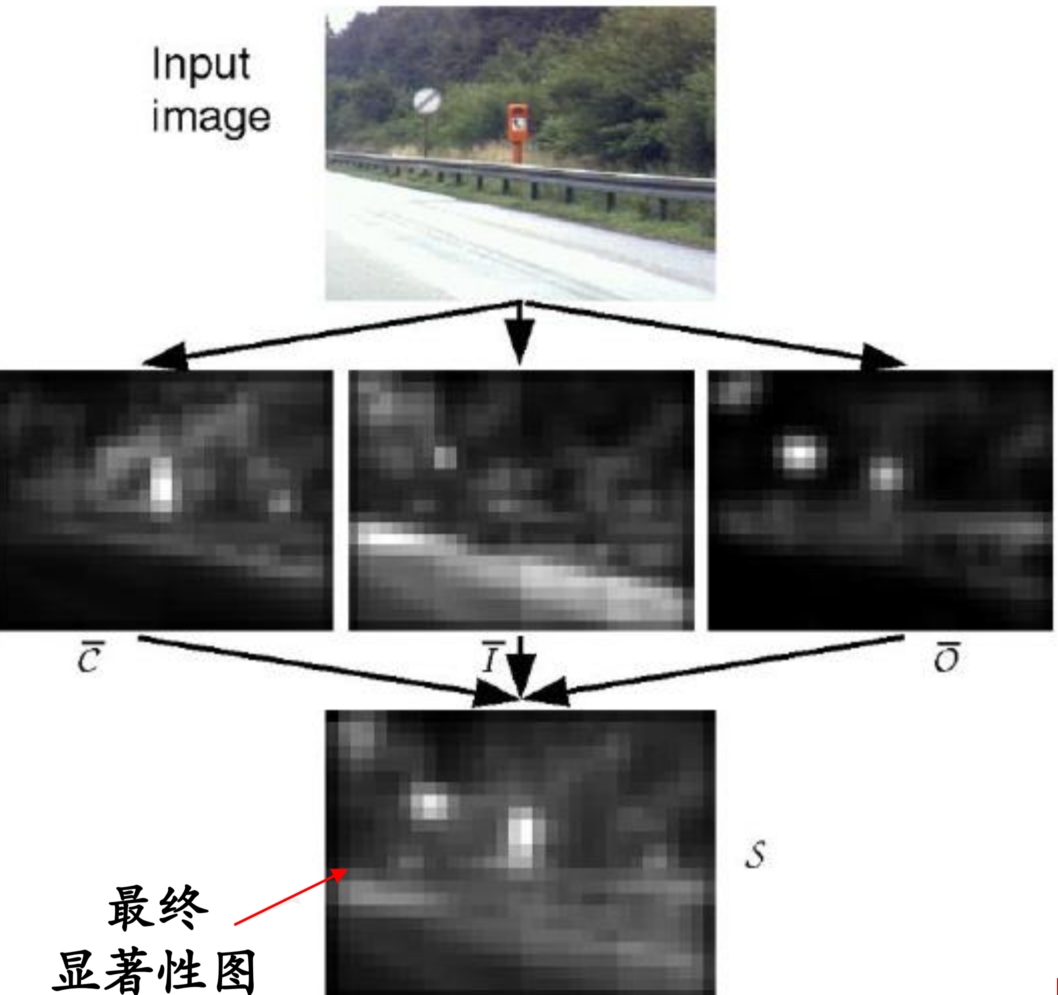




一.显著性检测的追溯、分类、及代表性工作

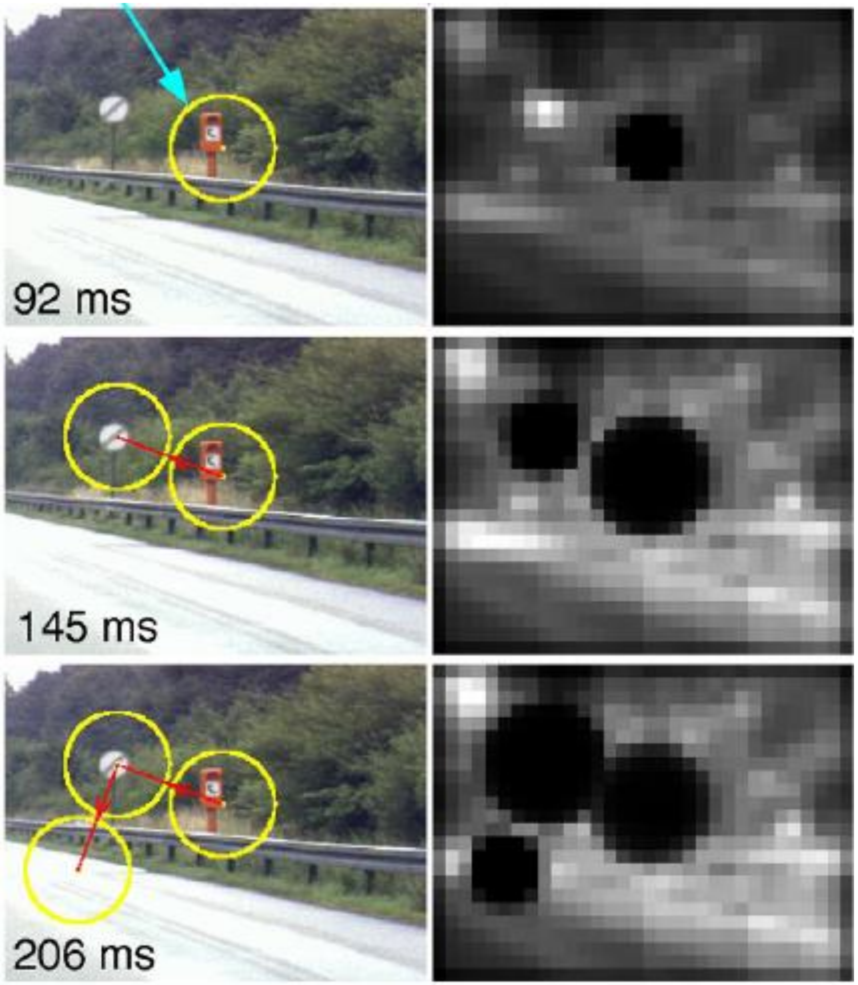
视觉显著性检测的追溯

- Itti等人得到的显著性图结果：



最终
显著性图

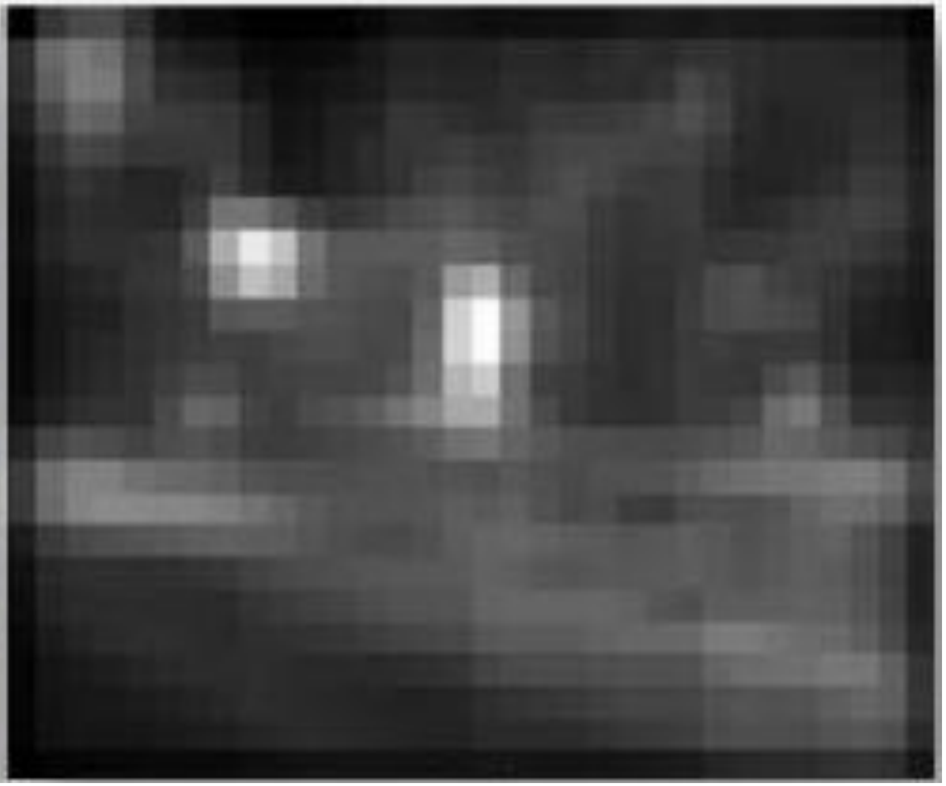
用WTA+返回抑制来模拟人眼移动



一.显著性检测的追溯、分类、及代表性工作

Itti的工作开启了显著性检测在CV界的新篇章……

输入图像



显著性图

A model of saliency-based visual attention for rapid scene analysis. PAMI1998, Itti et al.
Saliency detection: A spectral residual approach. CVPR2007, Hou et.al.
Graph-based visual saliency. NIPS2006, Harel et.al.
State-of-the-art in visual attention modeling. PAMI2013, Borji et al.

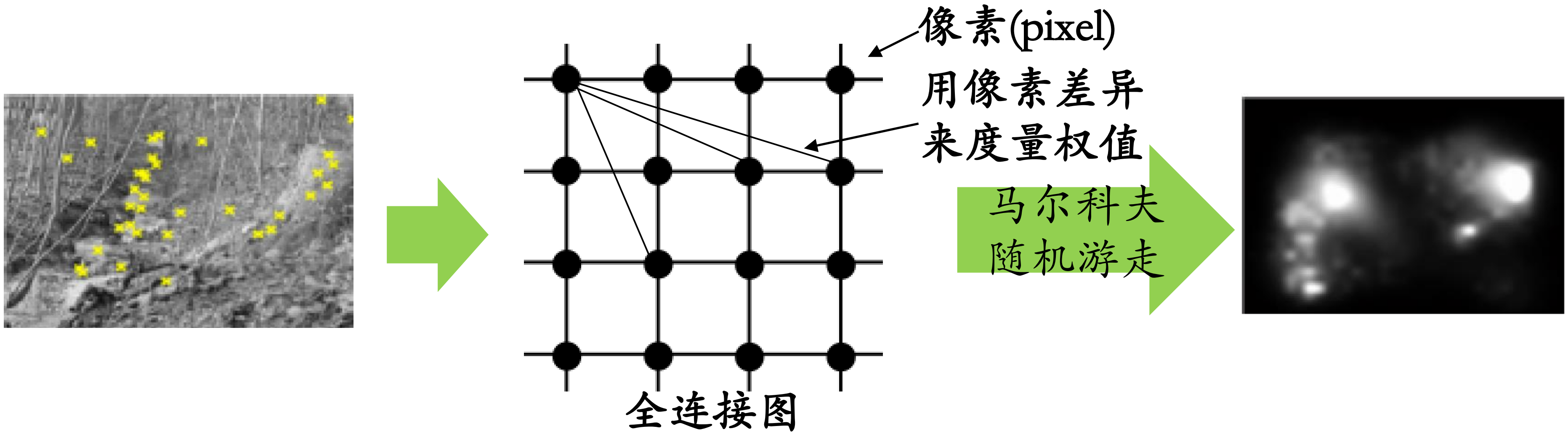
一.显著性检测的追溯、分类、及代表性工作

人眼注视预测(Eye fixation prediction)代表性工作2

Graph-Based Visual Saliency

NIPS2006

Jonathan Harel, Christof Koch, Pietro Perona
California Institute of Technology
Pasadena, CA 91125
{harel,koch}@klab.caltech.edu, perona@vision.caltech.edu



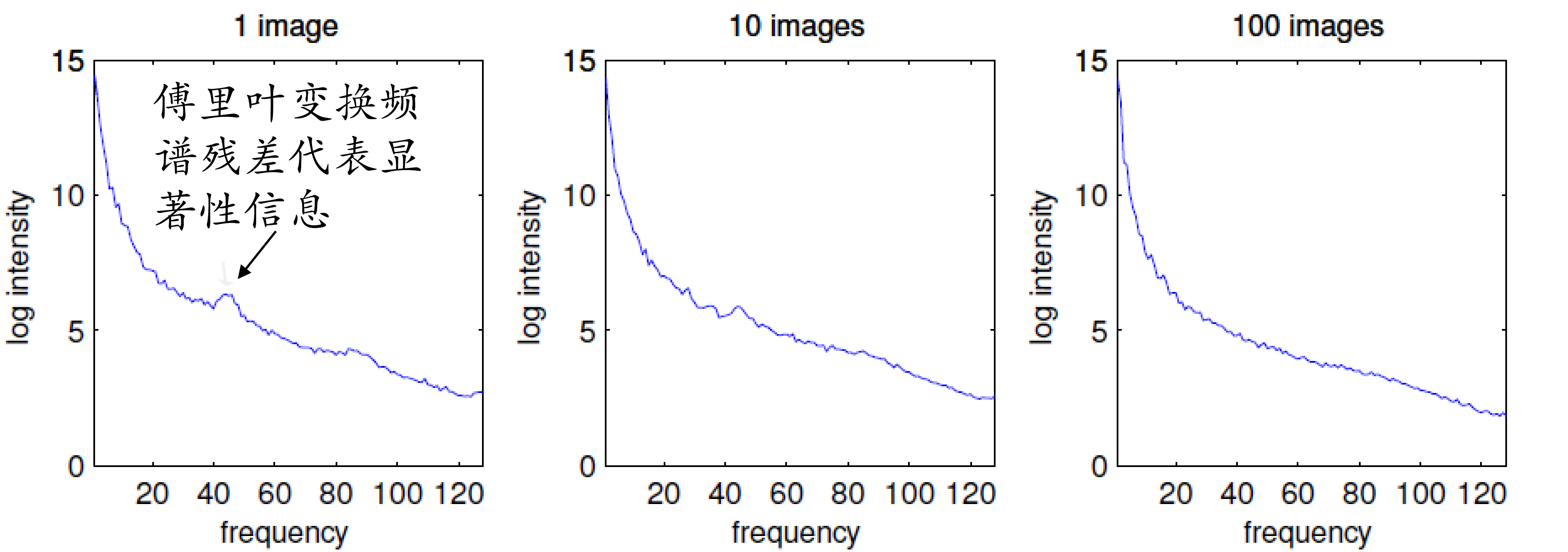
一.显著性检测的追溯、分类、及代表性工作

人眼注视预测(Eye fixation prediction)代表性工作3

Saliency Detection: A Spectral Residual Approach

CVPR 2007

Xiaodi Hou and Liqing Zhang
Department of Computer Science, Shanghai Jiao Tong University
No.800, Dongchuan Road, Shanghai



一.显著性检测的追溯、分类、及代表性工作

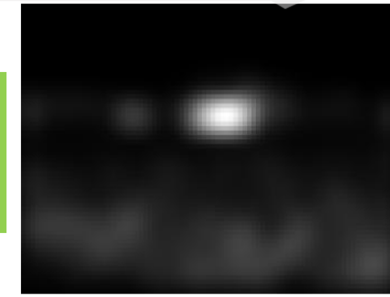
人眼注视预测(Eye fixation prediction)代表性工作3

傅里叶变换计算图像幅度谱和相位谱

计算幅度谱残差，保持相位谱不变

傅里叶反变换

高斯滤波



Matlab 代码12行……

```
%% Read image from file
inImg = imread('img.jpg');
inImg = im2double(rgb2gray(inImg));
inImg = imresize(inImg, [64, 64], 'bilinear');

%% Spectral Residual
myFFT = fft2(inImg);
myLogAmplitude = log(abs(myFFT));
myPhase = angle(myFFT);
mySmooth = imfilter(myLogAmplitude, fspecial('average', 3), 'replicate');
mySpectralResidual = myLogAmplitude - mySmooth;
saliencyMap = abs(ifft2(exp(mySpectralResidual + i*myPhase))).^2;

%% After Effect
saliencyMap = imfilter(saliencyMap, fspecial('disk', 3));
saliencyMap = mat2gray(saliencyMap);
imshow(saliencyMap, []);
```

一.显著性检测的追溯、分类、及代表性工作

人眼注视预测(Eye fixation prediction)代表性工作4

Spatio-temporal Saliency Detection Using Phase Spectrum of Quaternion Fourier Transform

CVPR 2008

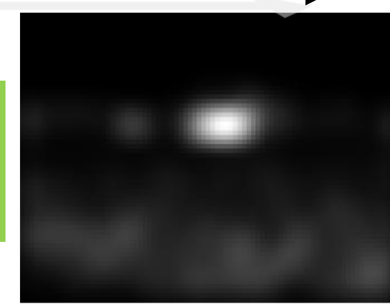
Chenlei Guo, Qi Ma and Liming Zhang
Department of Electronic Engineering, Fudan University
No.220, Handan Road, Shanghai, 200433, China
http://homepage.fudan.edu.cn/~clguo , ma.lance@gmail.com, lmzhang@fudan.edu.cn

傅里叶变换计算图像幅度谱和相位谱

丢掉幅度谱（置为常数），保持相位谱不变

傅里叶反变换

高斯滤波



也就是说，计算频谱残差是没有必要的！

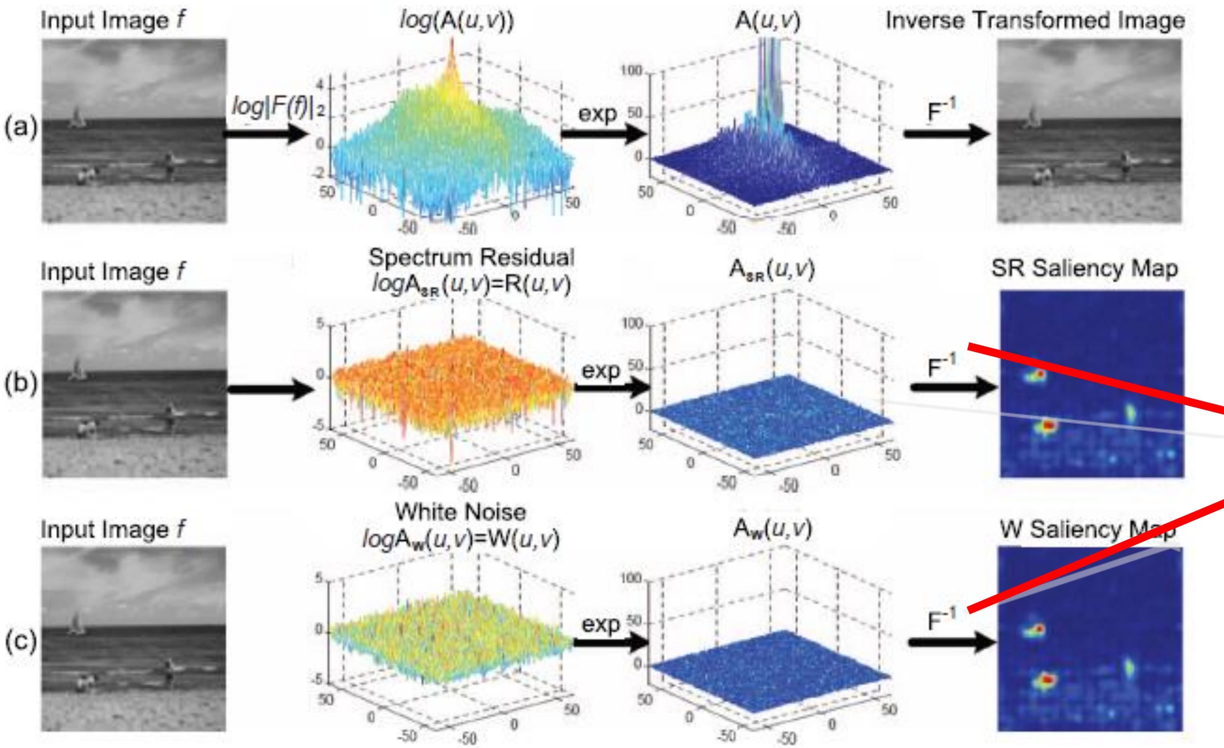
傅里叶变换后的
幅度谱表示不同频率成分强度
相位谱表示不同频率成分出现的位置

人眼注视预测(Eye fixation prediction)代表性工作5

Visual Saliency Based on Scale-Space Analysis in the Frequency Domain

TPAMI 2013

Jian Li, *Student Member, IEEE*, Martin D. Levine, *Fellow, IEEE*, Xiangjing An, *Member, IEEE*, Xin Xu *Member, IEEE* and Hangen He

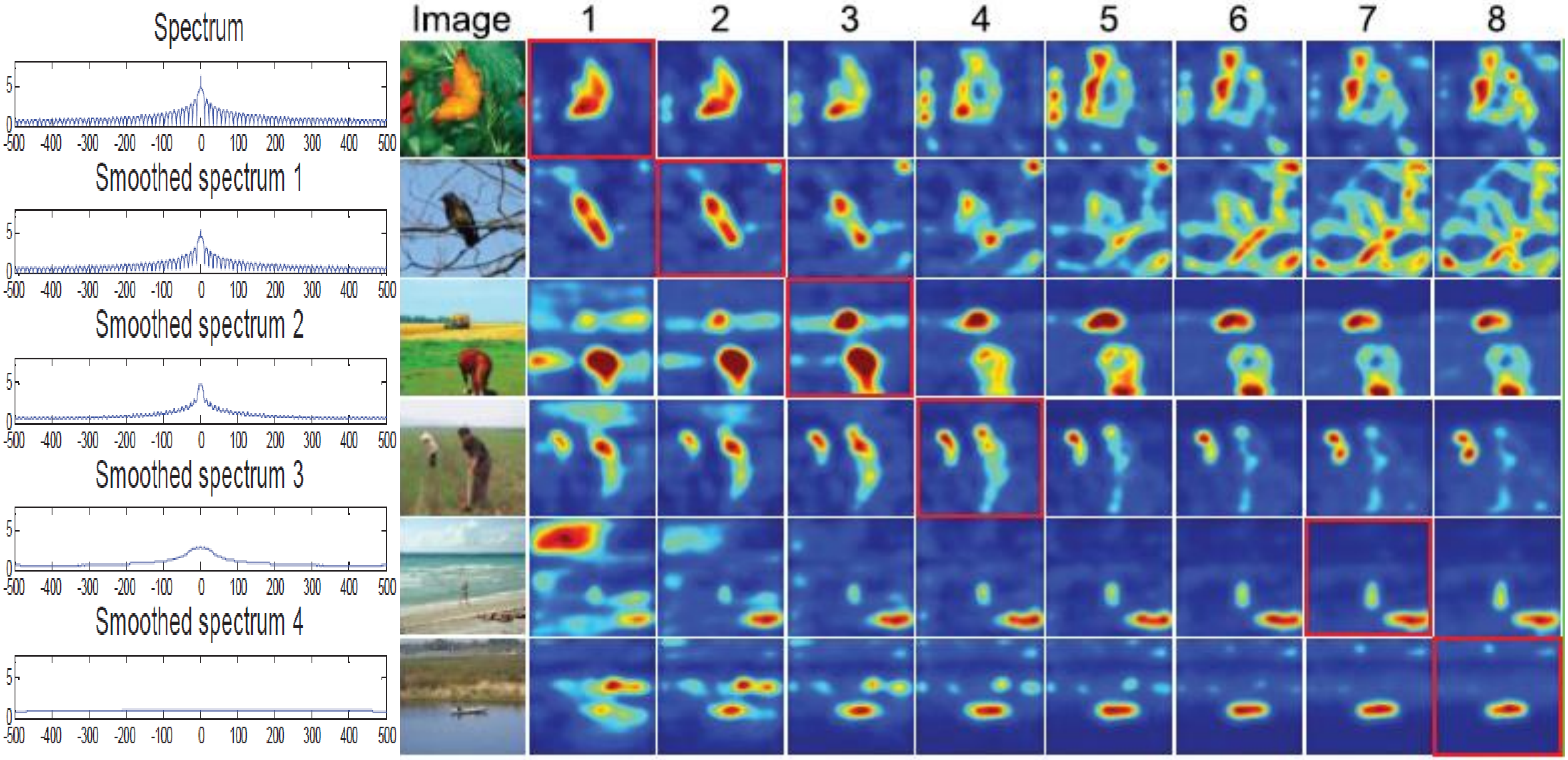


不管用频谱残差还是白噪声代替原来的幅度谱，都相当于用一个平面来对图像进行高频增强，即突出图像的边缘（与DOG联系…）

一.显著性检测的追溯、分类、及代表性工作

人眼注视预测(Eye fixation prediction)代表性工作5

Convolution of the amplitude spectrum with a low-pass Gaussian kernel equals a saliency detector……



一.显著性检测的追溯、分类、及代表性工作

人眼注视预测(Eye fixation prediction)代表性综述

State-of-the-art in Visual Attention Modeling

Ali Borji, *Member, IEEE,* and Laurent Itti, *Member, IEEE*

TPAMI 2013

Abstract—Modeling visual attention — particularly stimulus-driven, saliency-based attention — has been a very active research area over the past 25 years. Many different models of attention are now available, which aside from lending theoretical contributions to other fields, have demonstrated successful applications in computer vision, mobile robotics, and cognitive systems. Here we review, from a computational perspective, the basic concepts of attention implemented in these models. We present a taxonomy of nearly 65 models, which provides a critical comparison of approaches, their capabilities, and shortcomings. In particular, thirteen criteria derived from behavioral and computational studies are formulated for qualitative comparison of attention models. Furthermore, we address several challenging issues with models, including biological plausibility of the computations, correlation with eye movement datasets, bottom-up and top-down dissociation, and constructing meaningful performance measures. Finally, we highlight current research trends in attention modeling and provide insights for future.

Saliency Prediction in the Deep Learning Era: Successes and Limitations

Ali Borji, *Member, IEEE*

TPAMI 2021

Abstract—Visual saliency models have enjoyed a big leap in performance in recent years, thanks to advances in deep learning and large scale annotated data. Despite enormous effort and huge breakthroughs, however, models still fall short in reaching human-level accuracy. In this work, I explore the landscape of the field emphasizing on new deep saliency models, benchmarks, and datasets. A large number of image and video saliency models are reviewed and compared over two image benchmarks and two large scale video datasets. Further, I identify factors that contribute to the gap between models and humans and discuss the remaining issues that need to be addressed to build the next generation of more powerful saliency models. Some specific questions that are addressed include: in what ways current models fail, how to remedy them, what can be learned from cognitive studies of attention, how explicit saliency judgments relate to fixations, how to conduct fair model comparison, and what are the emerging applications of saliency models.

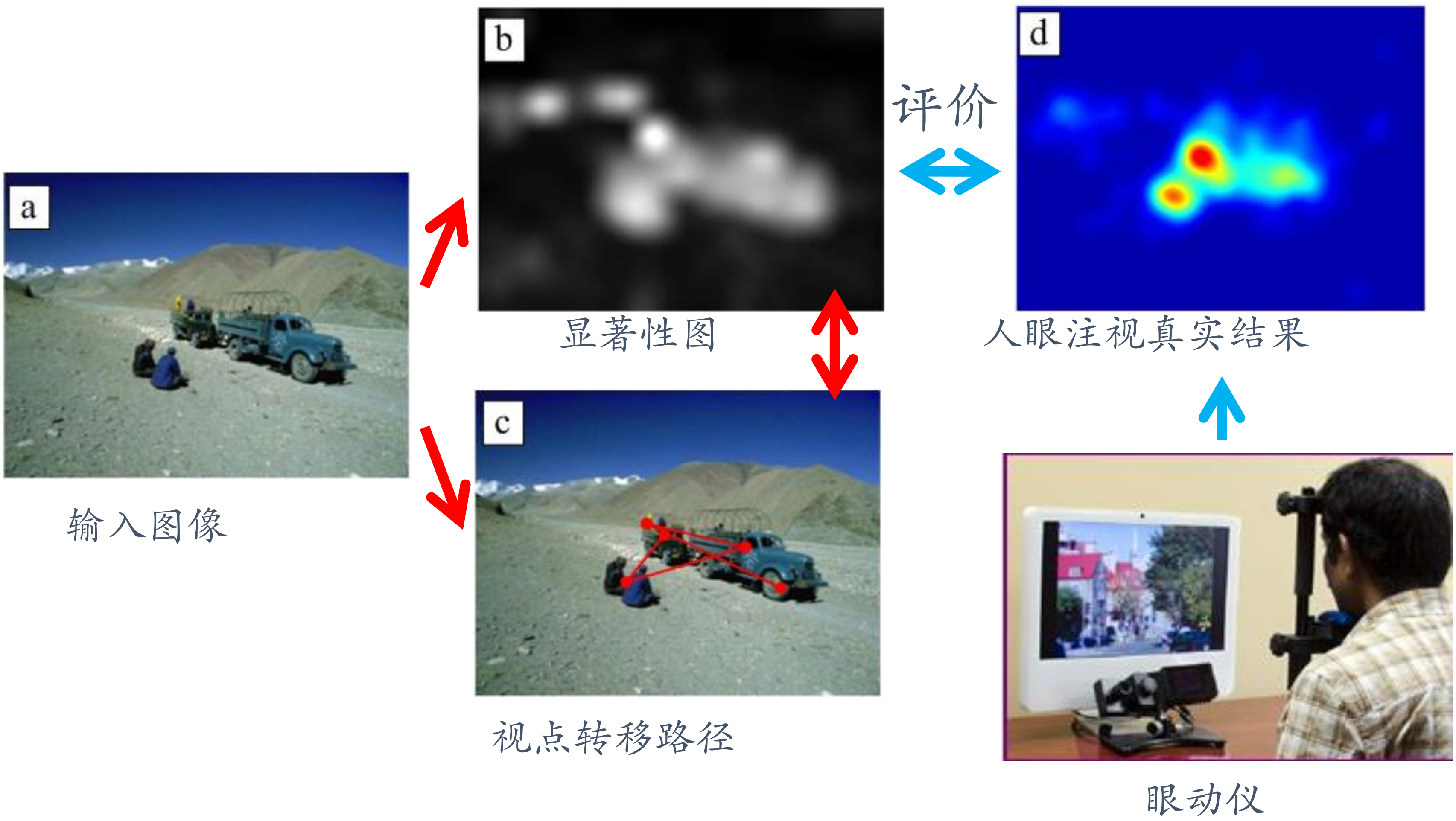
一.显著性检测的追溯、分类、及代表性工作

人眼注视预测(Eye fixation prediction)的评估准则

- 眼动仪（Eye tracker）
  - 真实地记录人眼观察图片所注视的位置

一.显著性检测的追溯、分类、及代表性工作

人眼注视预测(Eye fixation prediction)的评估准则



一.显著性检测的追溯、分类、及代表性工作

视觉显著性检测的追溯

人眼注视预测(Eye fixation prediction), 1998

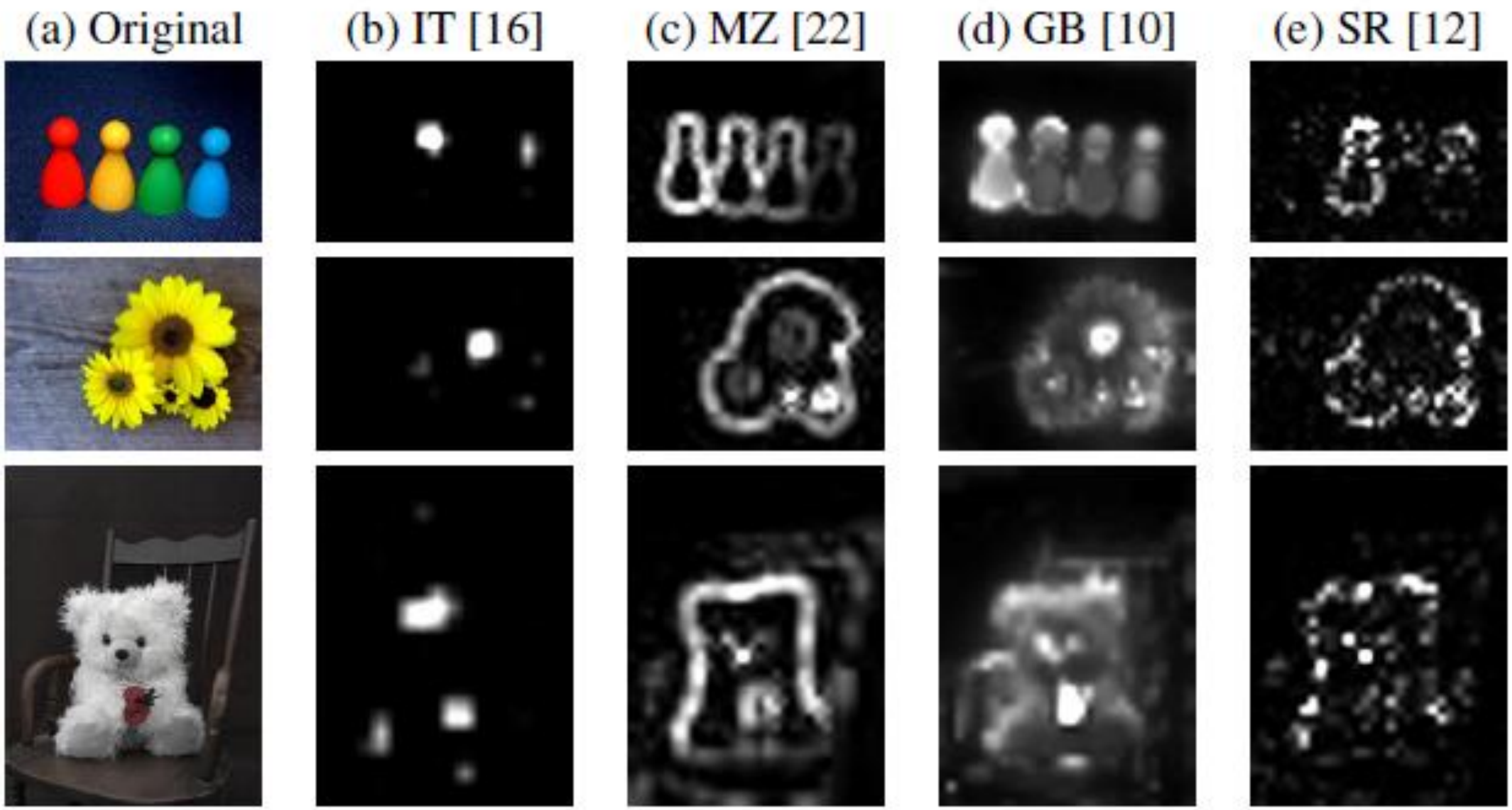
显著物体/显著区域检测, 2009

似物性（Objectness）检测, 2010

一.显著性检测的追溯、分类、及代表性工作

显著物体/显著区域检测的兴起

- 2009年，Achanta等人提出传统的人眼注视预测(Eye fixation prediction)不能很好的检测出较大尺度物体……



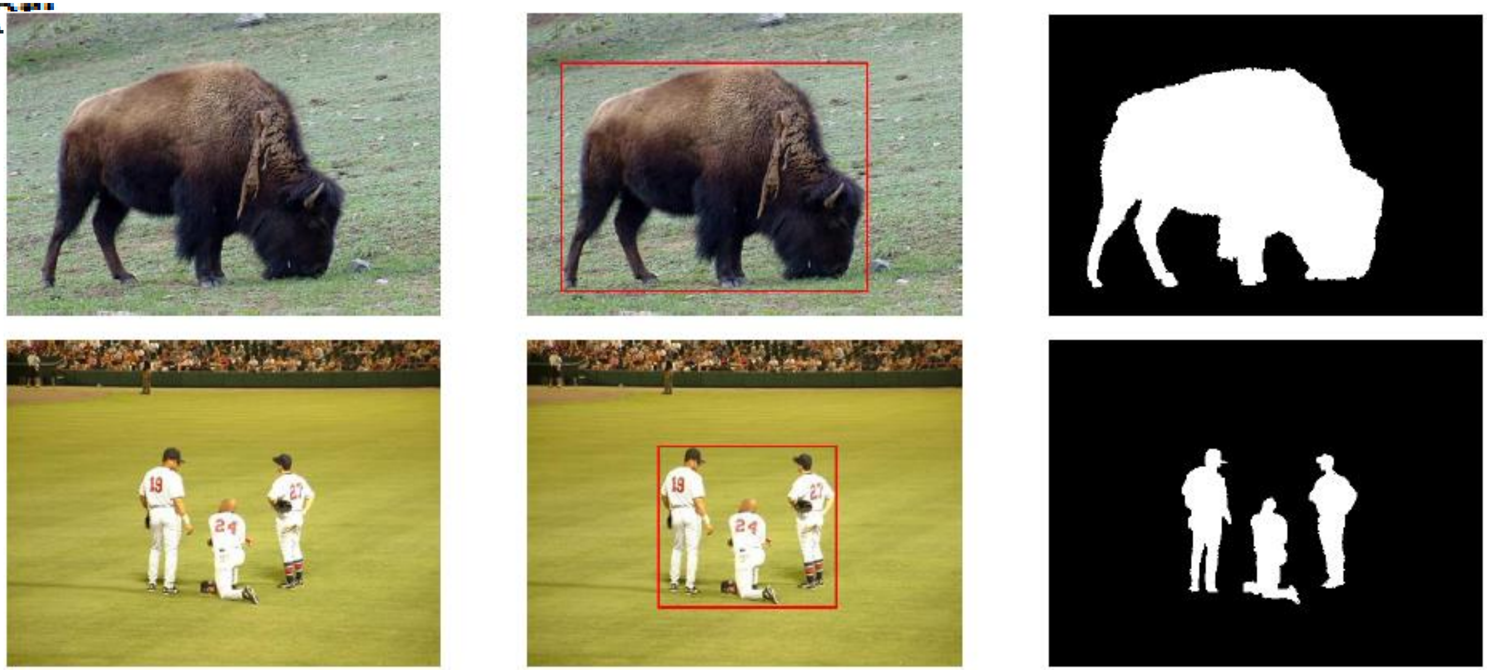
一.显著性检测的追溯、分类、及代表性工作

显著物体/显著区域检测的兴起

- 基于此， Achanta等人根据需求提出对显著性图的要求:

4.1. Requirements for a saliency map

We set the following requirements for a saliency detec-
to



一.显著性检测的追溯、分类、及代表性工作

显著物体/显著区域检测的兴起

- Achanta等人结合多尺度DoG提出Frequency-tuned的显著区域检测方法：

$$DoG(x,y) = \frac{1}{2\pi}\left[\frac{1}{\sigma_1^2}e^{-\frac{(x^2+y^2)}{2\sigma_1^2}} - \frac{1}{\sigma_2^2}e^{-\frac{(x^2+y^2)}{2\sigma_2^2}}\right]$$
$$= G(x,y,\sigma_1) - G(x,y,\sigma_2)$$

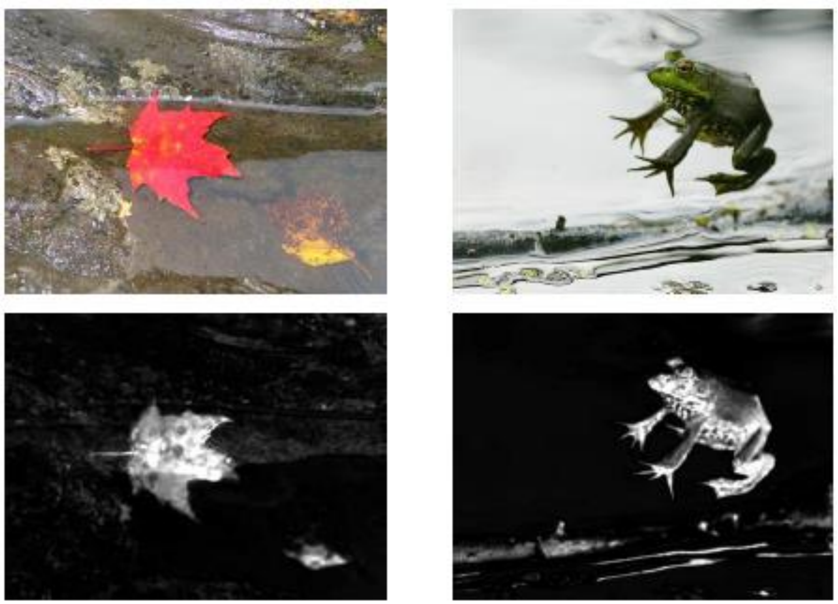
带通滤波器

$$\sum_{n=0}^{N-1} G(x,y,\rho^{n+1}\sigma) - G(x,y,\rho^{n}\sigma)$$
$$= G(x,y,\sigma\rho^{N}) - G(x,y,\sigma)$$

近似的全通滤波器

$$S(x,y) = |I_{\mu} - I_{\omega_{hc}}(x,y)|$$

小尺度高斯滤波后的像素到图像均值的距离，一行代码即可实现！



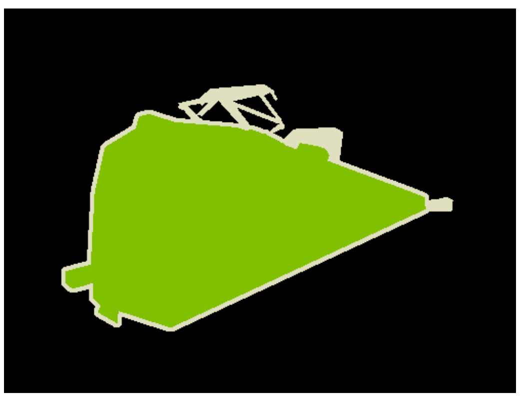
一.显著性检测的追溯、分类、及代表性工作

显著物体/显著区域检测的兴起（自2009）

- 显著物体/显著区域检测任务的定义

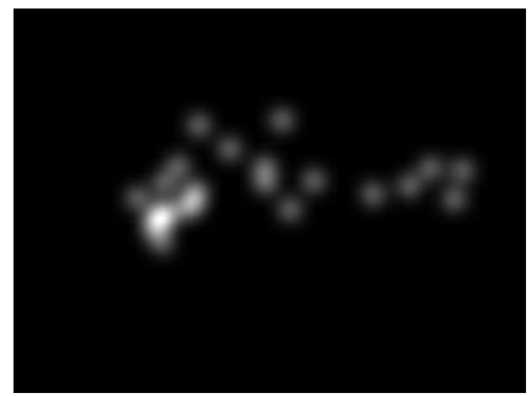
——检测出整个显著物体并且将其边界精确的分割出来~

- 如何定义完整的显著物体?



完整语义物体

输入图像



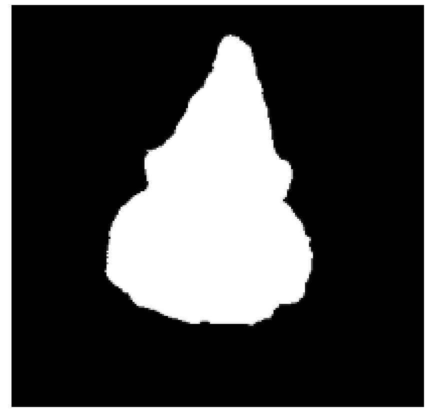
人眼注视（眼动仪）

一.显著性检测的追溯、分类、及代表性工作

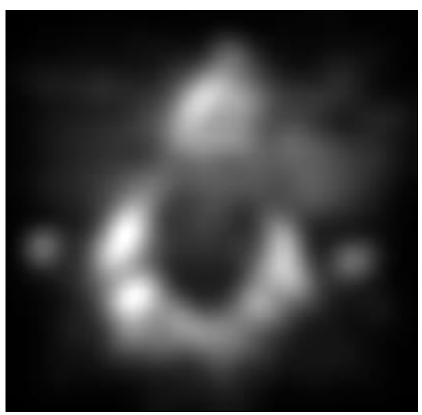
显著物体/显著区域检测的兴起（自2009）

- 人眼注视预测与显著物体/显著区域检测的区别?

Input image



Ground truth

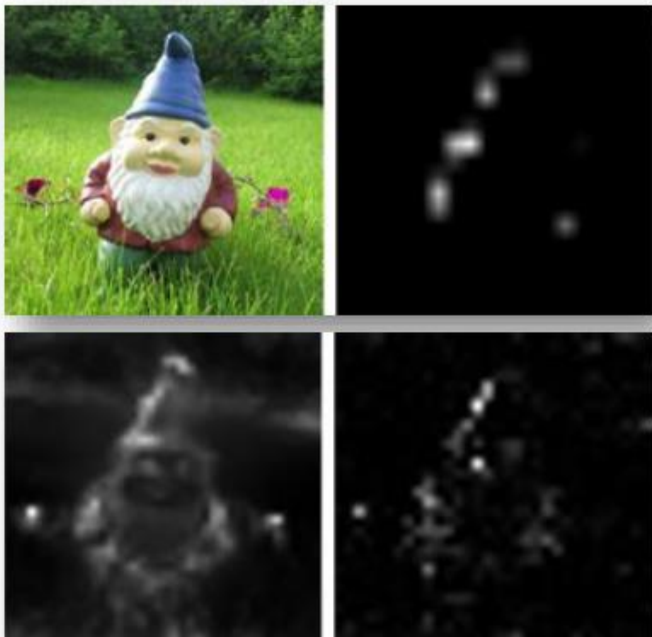


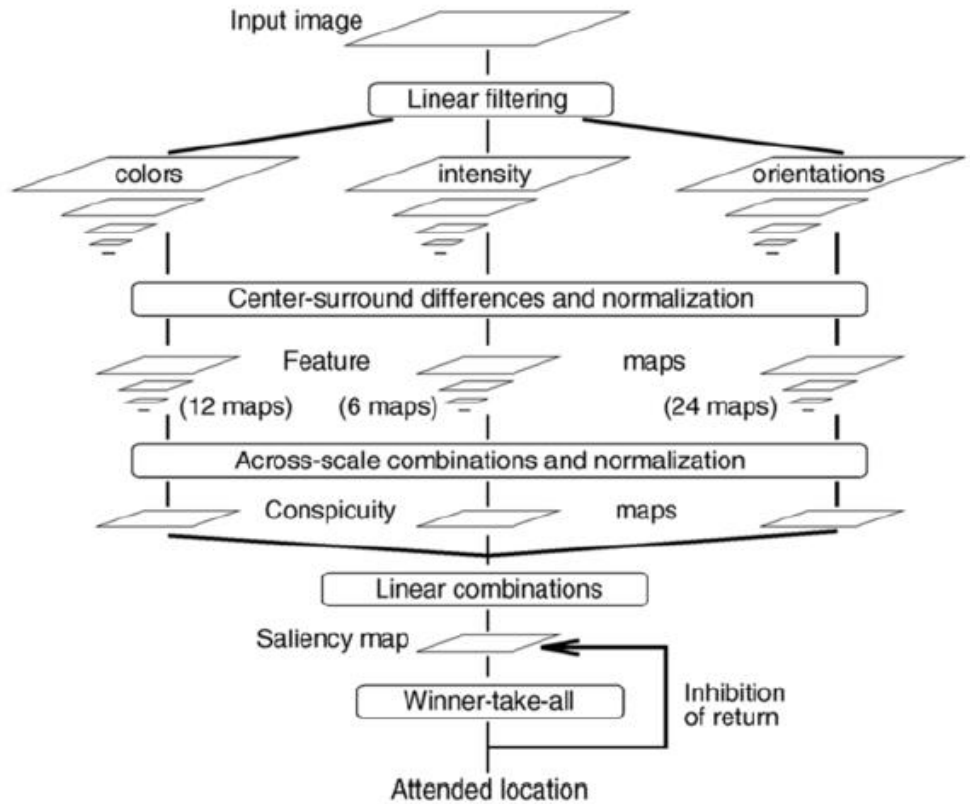
Eye fixation prediction model

Salient object detection model

显著物体/区域检测：假设1——局部对比度

- Local contrast





A Model of Saliency-Based Visual Attention for Rapid Scene Analysis, IEEE TPAMI 1998, Itti et al.

一.显著性检测的追溯、分类、及代表性工作

显著物体/区域检测：假设2——全局对比度

- Global contrast

Spatial weighting

Region size

$$S(r_k) = \sum_{r_k \neq r_i} \exp\left(-D_s(r_k, r_i)\right) w(r_i) D_r(r_k, r_i)$$

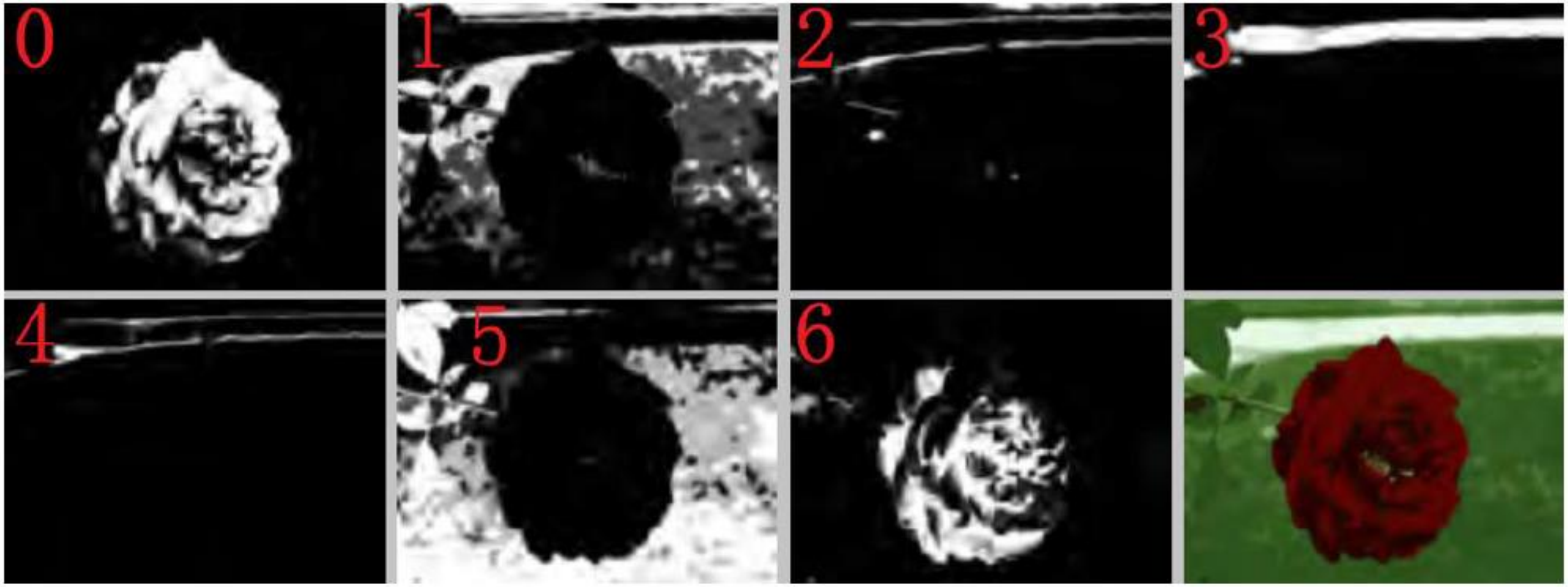
Region contrast by sparse histogram comparison.

Global Contrast based Salient Region detection. IEEE TPAMI 2015 (CVPR 2011), Cheng et al.

一.显著性检测的追溯、分类、及代表性工作

显著物体/区域检测：假设3——特征空间分布

- Spatial distribution



Learning to Detect a Salient Object, IEEE TPAMI 2011 (CVPR 2007), Liu et al.
Efficient Salient Region Detection with Soft Image Abstraction, ICCV 2013, Cheng et al.

显著物体/区域检测：假设4——背景低秩性

- Sparse noises
  - Background residing in a low dimensional space with salient objects as sparse noises

A Unified Approach to Salient Object Detection via Low Rank Matrix Recovery, CVPR 2012, Shen et. al.

一.显著性检测的追溯、分类、及代表性工作

显著物体/区域检测：假设5——图像聚焦程度

- Focusness

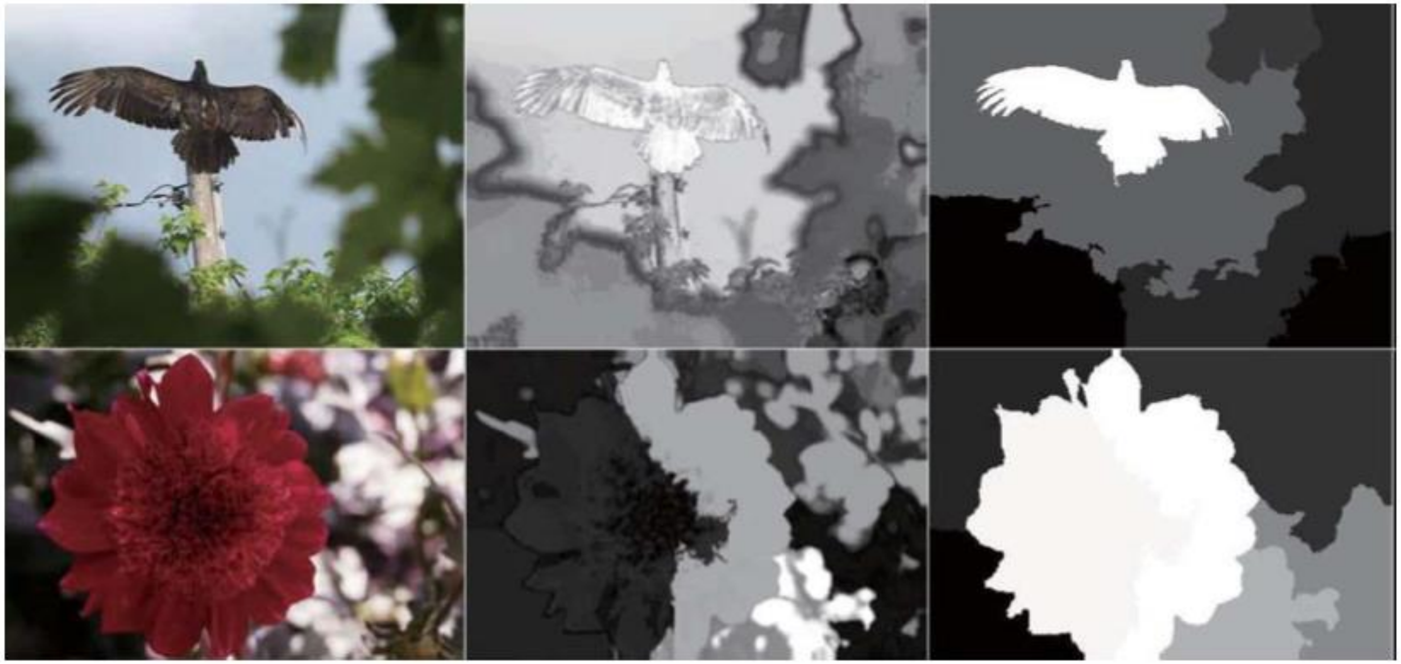


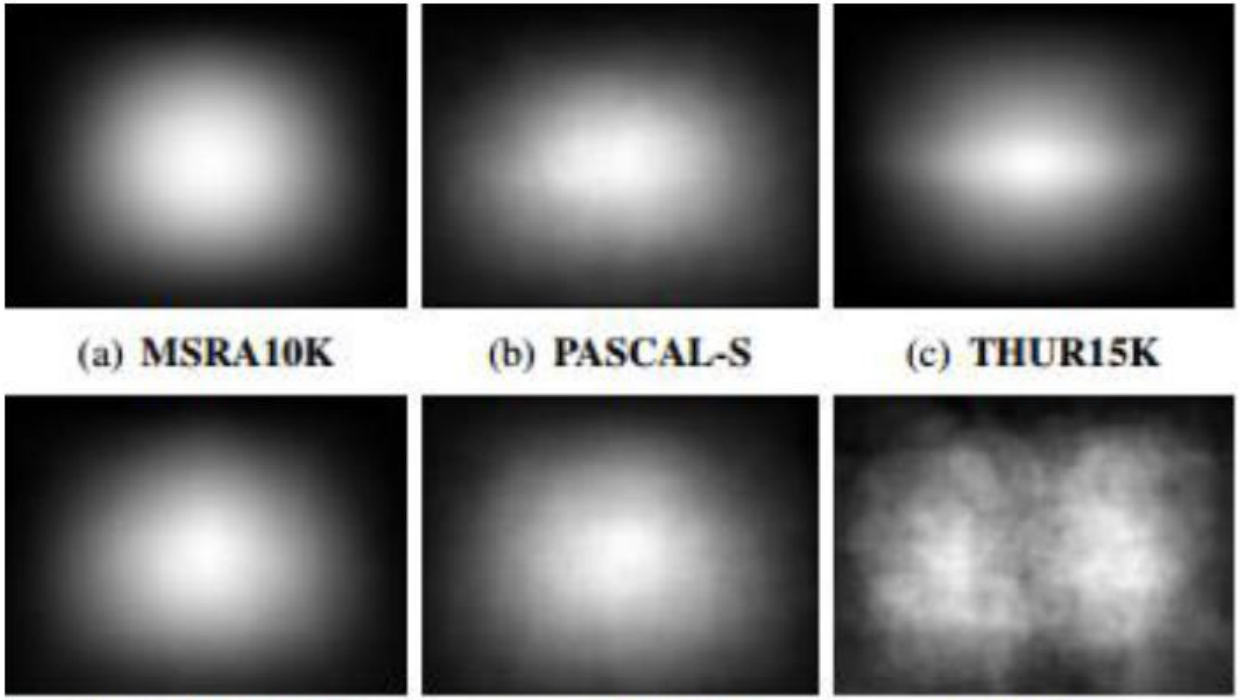
Image　　Uniqueness　　Focusness

Salient Region Detection by UFO: Uniqueness, Focusness and Objectness, ICCV 2013, Jiang et al.

一.显著性检测的追溯、分类、及代表性工作

显著物体/区域检测：假设6——图像中心先验

- Center prior/bias

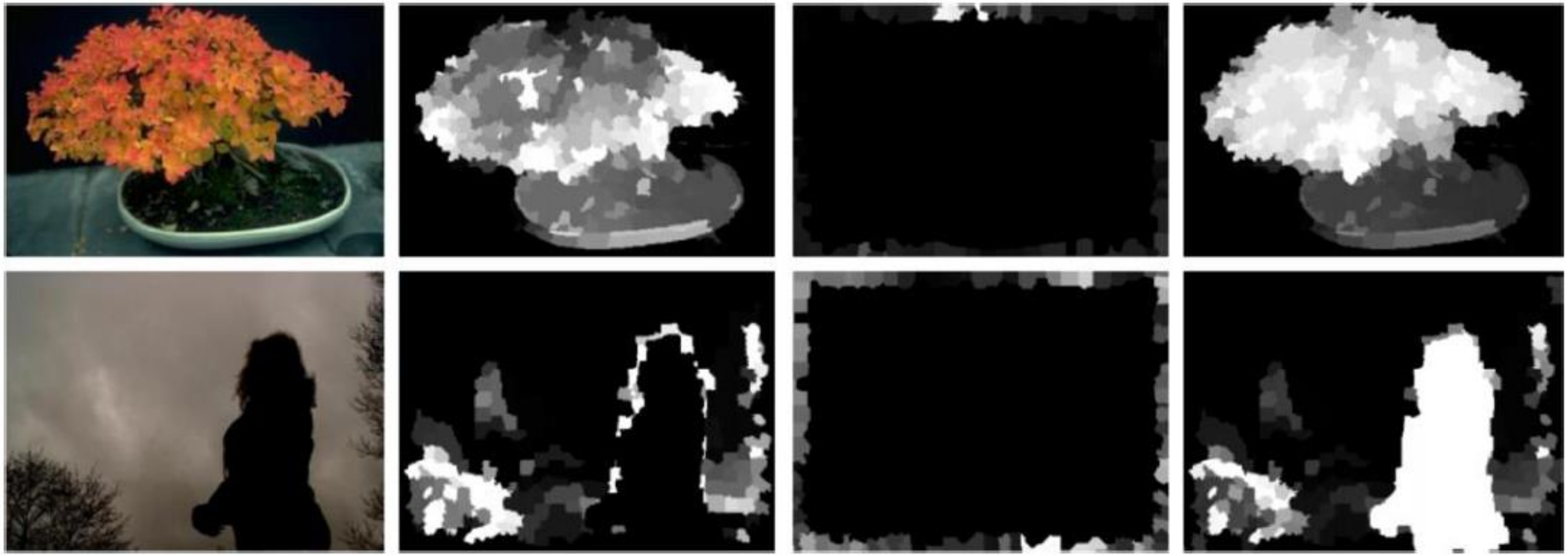


(a) MSRA10K (b) PASCAL-S (c) THUR15K
(d) DUT-OMRON (e) JuddDB (f) SED2

Salient object detection: a benchmark, arXiv 2015, Ali et. al.

显著物体/区域检测：假设7——背景连通性

- Backgroundness



Geodesic saliency using background priors, ECCV, 2012, Wei et al.

一.显著性检测的追溯、分类、及代表性工作

显著物体/区域检测：假设8——似物性先验

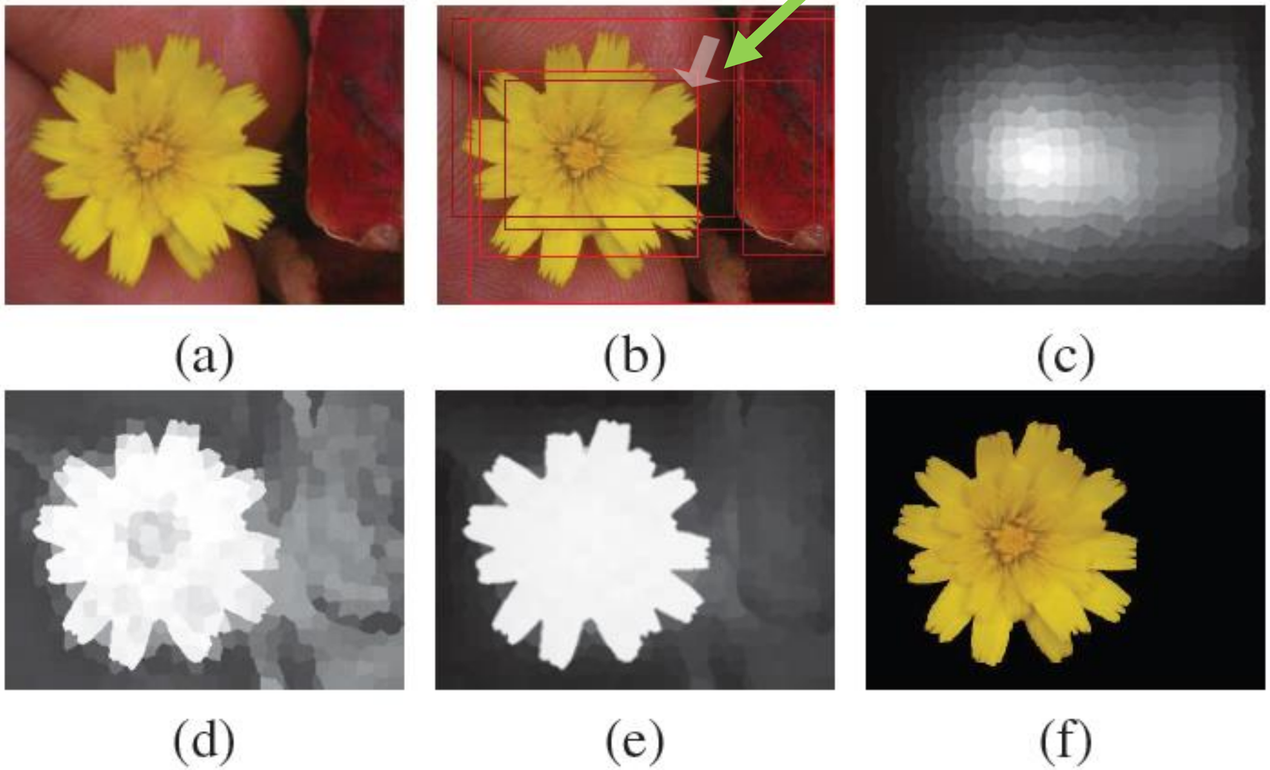


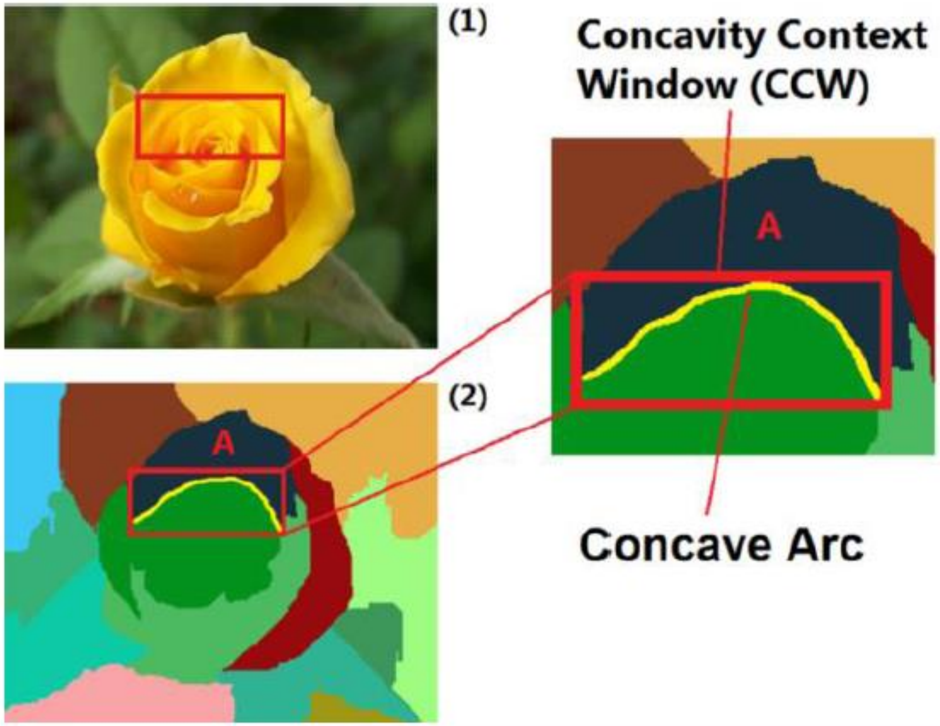
Figure 1. An illustration of our approach from images to the final saliency map: (a) Input Image (b) objectness detections, (c) saliency prior from objectness, (d) diverse density scores for pixels, (e) the final saliency map, and (f) the segmented object.

Category-independent object-level saliency detection, ICCV 2013, Jia et. al.

一.显著性检测的追溯、分类、及代表性工作

显著物体/区域检测：假设9——边缘凸性

- Convexity



Salient object detection using concavity context, ICCV 2011, Lu et al.

一.显著性检测的追溯、分类、及代表性工作

显著物体/区域检测综述

Salient Object Detection: A Benchmark

Ali Borji, Ming-Ming Cheng, Huaizu Jiang, and Jia Li

TIP 2015

该文有140篇参考文献

Salient Object Detection: A Survey

Ali Borji, Ming–Ming Cheng, Huaizu Jiang and Jia Li

Abstract—Detecting and segmenting salient objects in natural scenes, also known as salient object detection, has attracted a lot of focused research in computer vision and has resulted in many applications. However, while many such models exist, a deep understanding of achievements and issues is lacking. We aim to provide a comprehensive review of the recent progress in this field. We situate salient object detection among other closely related areas such as generic scene segmentation, object proposal generation, and saliency for fixation prediction. Covering 256 publications we survey i) roots, key concepts, and tasks, ii) core techniques and main modeling trends, and iii) datasets and evaluation metrics in salient object detection. We also discuss open problems such as evaluation metrics and dataset bias in model performance and suggest future research directions.

该文有256篇参考文献

Computational Visual Media 2019

一.显著性检测的追溯、分类、及代表性工作

显著物体/区域检测——人工特征时代与深度学习时代

人工特征

- 局部对比度
- 全局对比度
- 特征空间分布
- 背景低秩性
- 图像聚焦程度
- ……

2015年

深度学习

无需人工设计任何特征，直接依靠神经网络的学习能力

端到端深度学习效果十分强大!

Thanks to 

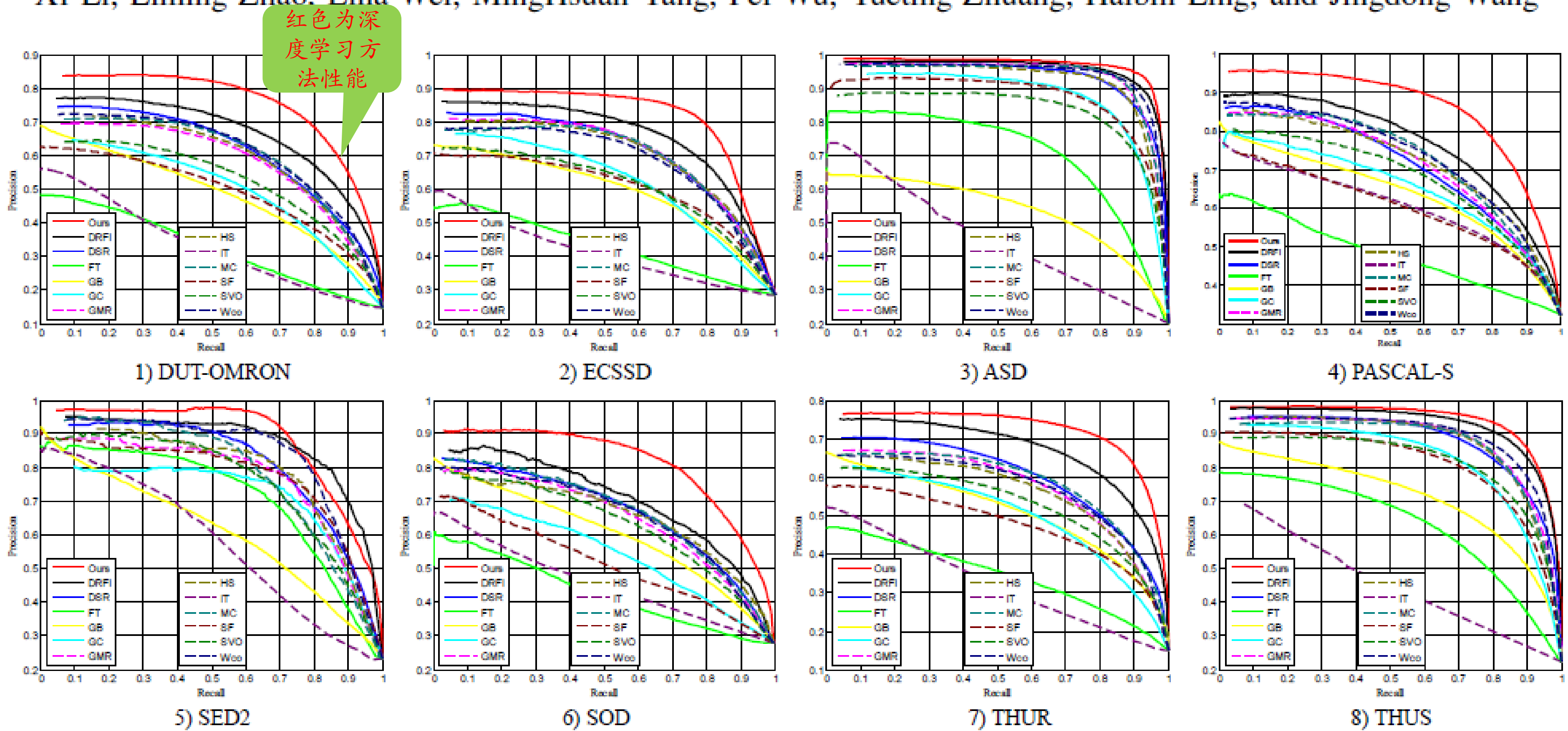
一.显著性检测的追溯、分类、及代表性工作

显著物体/区域检测——人工特征时代与深度学习时代

DeepSaliency: Multi-Task Deep Neural Network Model for Salient Object Detection

TIP 2015

Xi Li, Liming Zhao, Lina Wei, MingHsuan Yang, Fei Wu, Yueting Zhuang, Haibin Ling, and Jingdong Wang

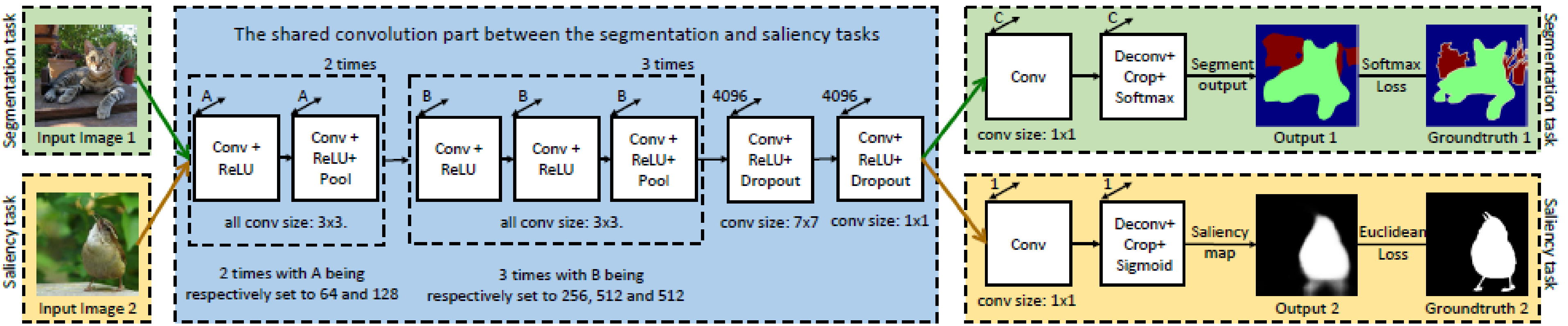


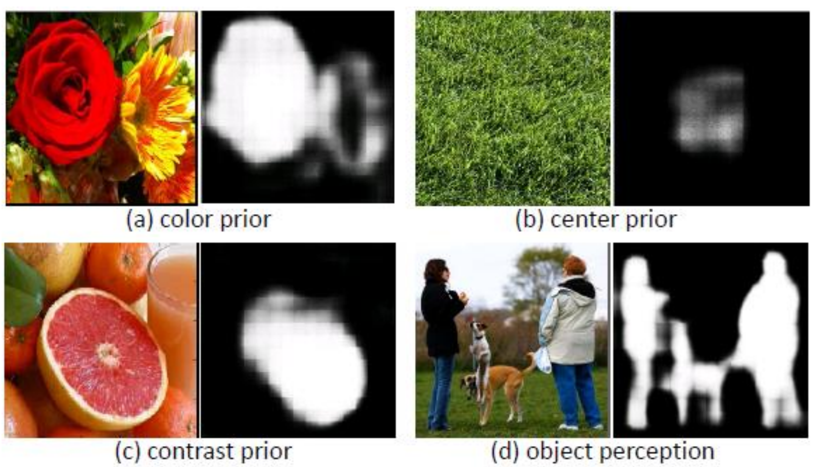
一.显著性检测的追溯、分类、及代表性工作

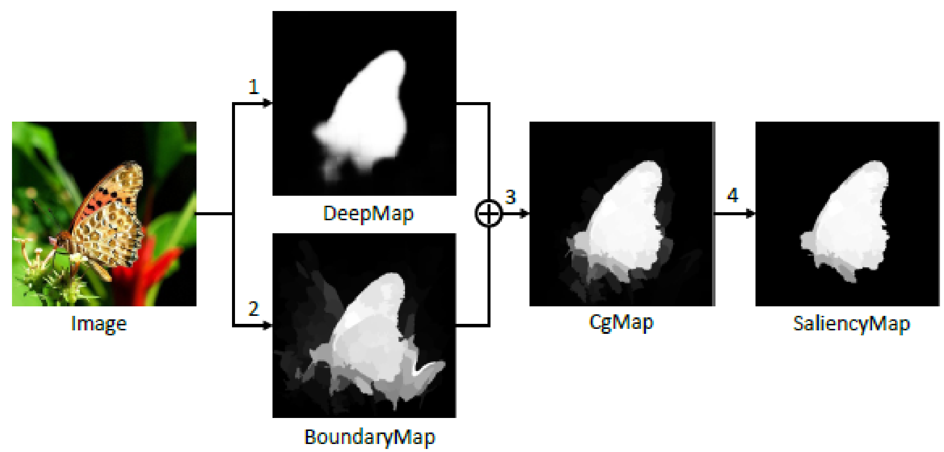
显著物体/区域检测——人工特征时代与深度学习时代

DeepSaliency: Multi-Task Deep Neural Network Model for Salient Object Detection

TIP 2015







一.显著性检测的追溯、分类、及代表性工作

显著物体/区域检测综述（深度学习时代）

Salient Object Detection in the Deep Learning Era: An In-Depth Survey

TPAMI 2021

Wenguan Wang, Qiuxia Lai, Huazhu Fu, Jianbing Shen, Haibin Ling

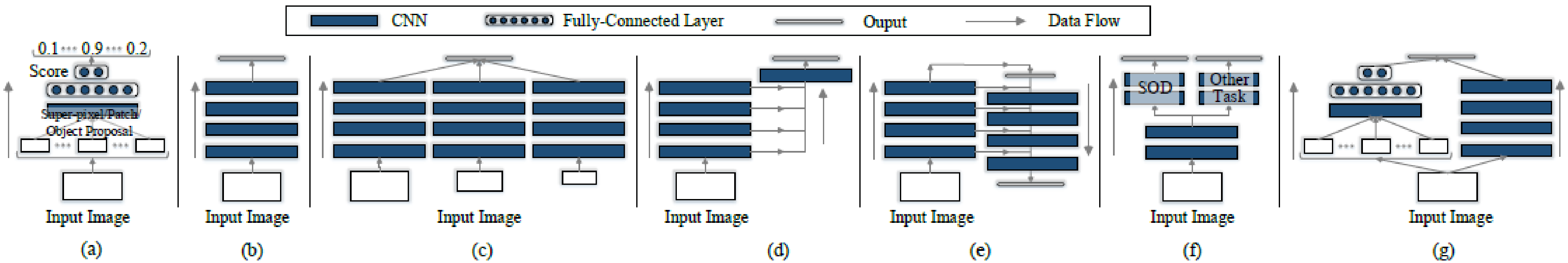
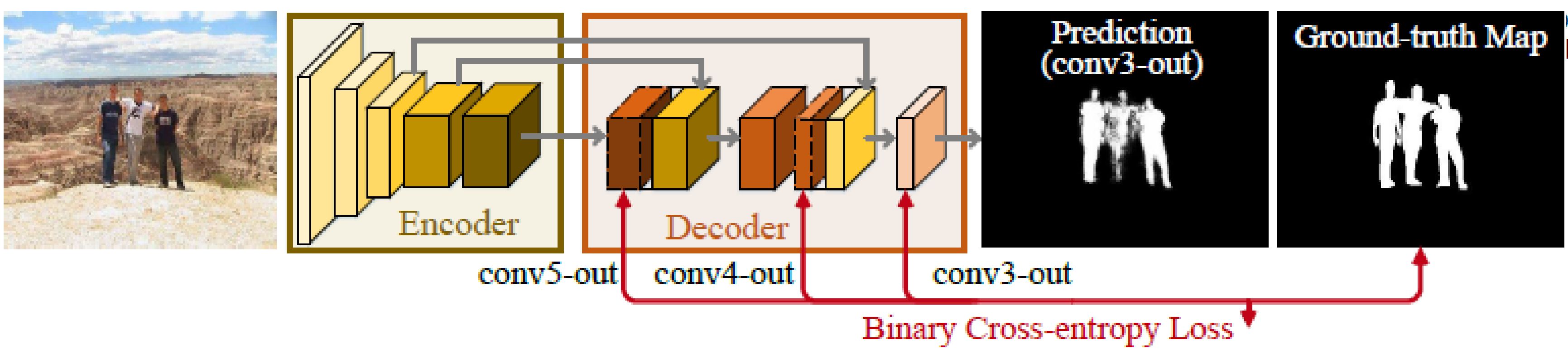


Fig. 2.
multi-s
metho



rk, (c)
based

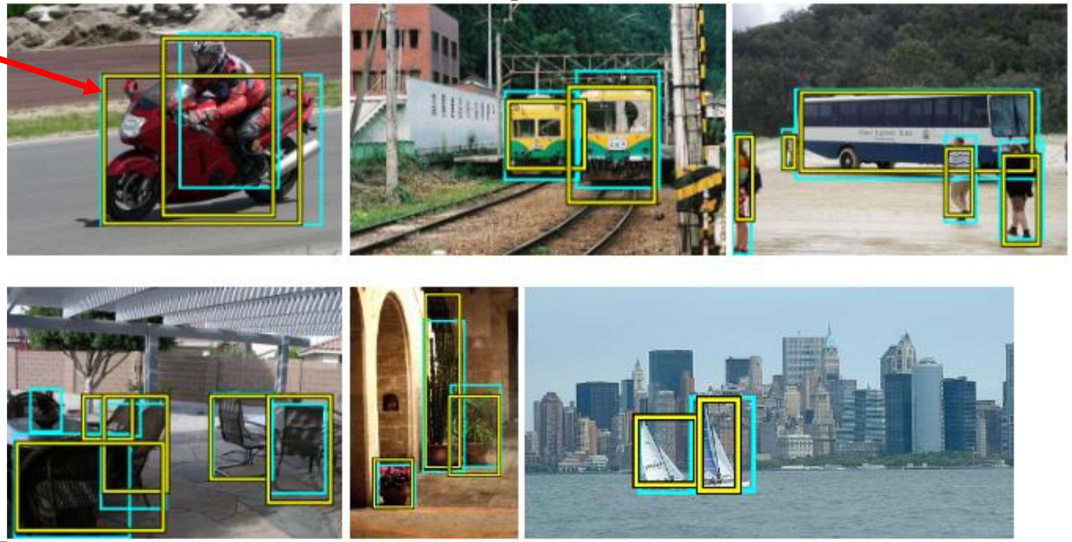
似物性（Objectness）检测

人眼注视预测(Eye fixation prediction), 1998

显著物体/显著区域检测, 2009

似物性（Objectness）检测, 2010

What is an object?



用途:

1.减少搜索空间，提高检测效率。

2.使得应用更复杂的识别算法成为可能，提高精度。

一.显著性检测的追溯、分类、及代表性工作

似物性（Objectness）检测代表性工作

被用于Fast RCNN!

Measuring the objectness of image windows. PAMI2012, Alexe,et.Al.
Selective Search for Object Recognition. IJCV2013, Uijlings et.Al.
BING:Binarized Normed Gradients for Objectness Estimation at 300fp. CVPR2014

似物性（Objectness）检测综述

What makes for effective detection proposals?

Jan Hosang[1], Rodrigo Benenson[1], Piotr Dollár[2], and Bernt Schiele[1]

[1]Max Planck Institute for Informatics
[2] Facebook AI Research (FAIR)

TPAMI 2016

Abstract—Current top performing object detectors employ detection proposals to guide the search for objects, thereby avoiding exhaustive sliding window search across images. Despite the popularity and widespread use of detection proposals, it is unclear which trade-offs are made when using them during object detection. We provide an in-depth analysis of twelve proposal methods along with four baselines regarding proposal repeatability, ground truth annotation recall on PASCAL, ImageNet, and MS COCO, and their impact on DPM, R-CNN, and Fast R-CNN detection performance. Our analysis shows that for object detection improving proposal localisation accuracy is as important as improving recall. We introduce a novel metric, the average recall (AR), which rewards both high recall and good localisation and correlates surprisingly well with detection performance. Our findings show common strengths and weaknesses of existing methods, and provide insights and metrics for selecting and tuning proposal methods.

系统地回顾并评估了近20种似物性检测方法。

内容提纲

一.视觉显著性检测的起源、追溯、分类、

及代表性工作

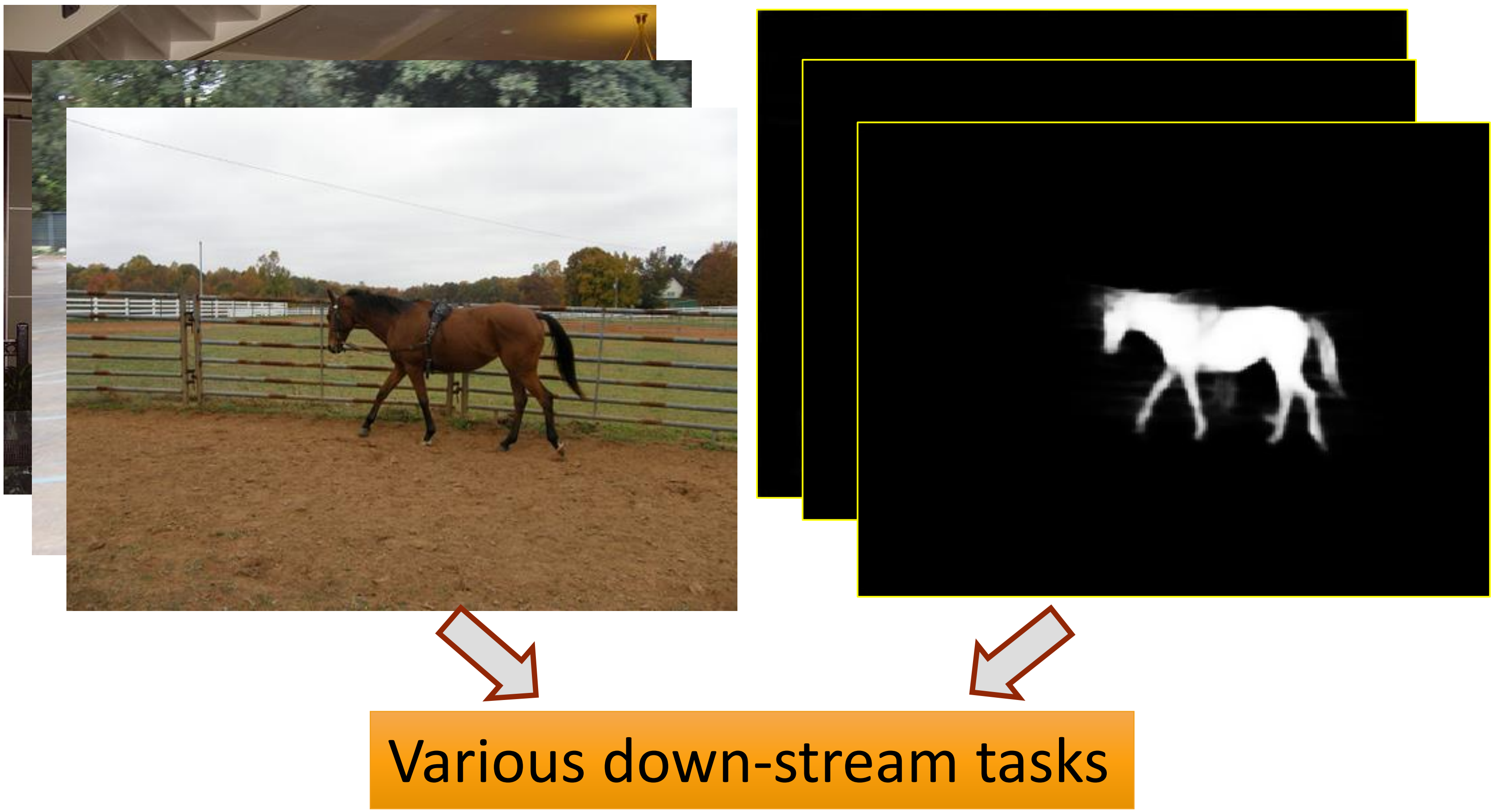
二.视觉显著性检测的应用

三.显著性物体检测的细化分类

四. 总结

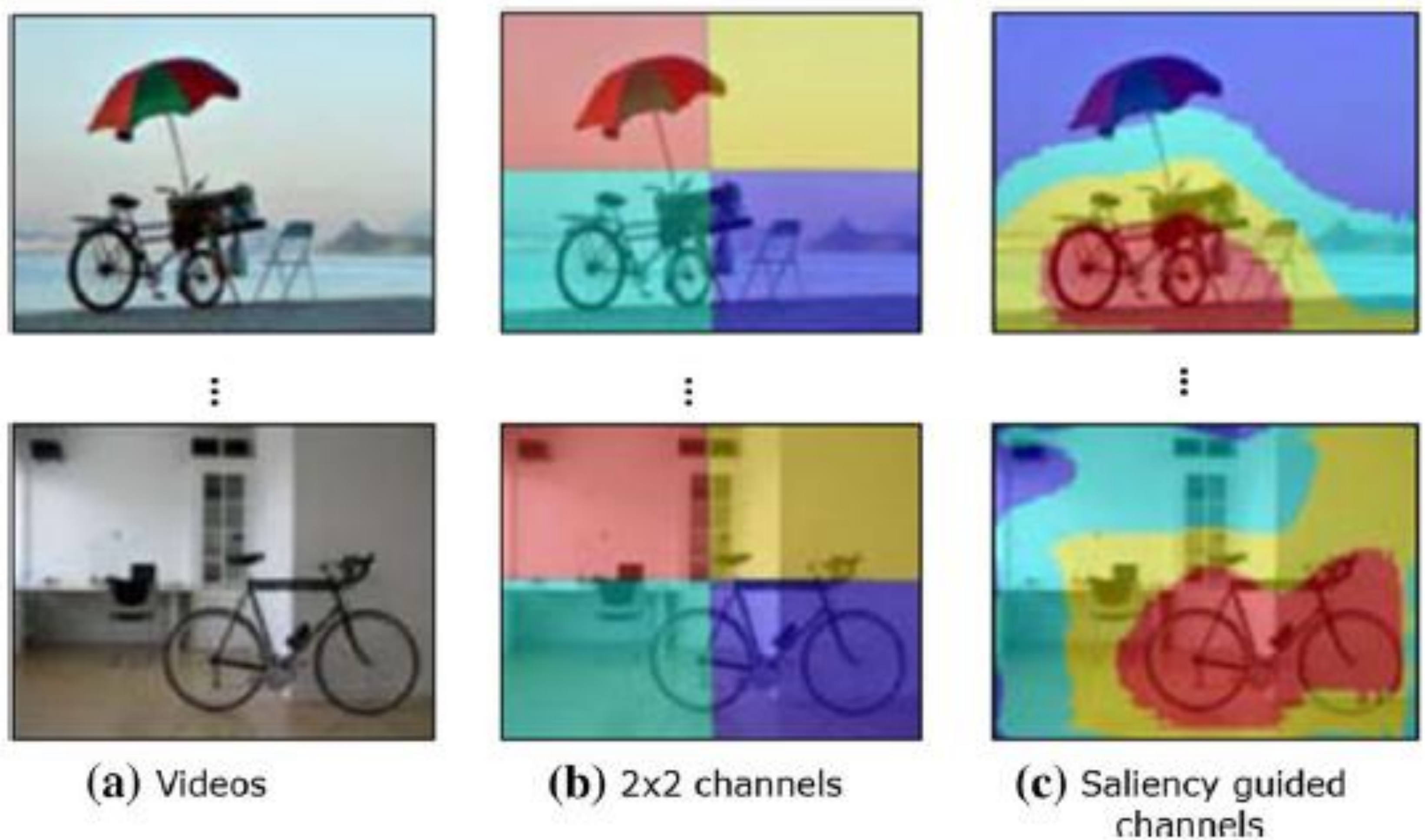
二.视觉显著性检测的应用

- 由于显著性图（saliency map）指示了潜在的感兴趣区域，可使系统能够自动地、智能地处理图像而不需要人的干预。



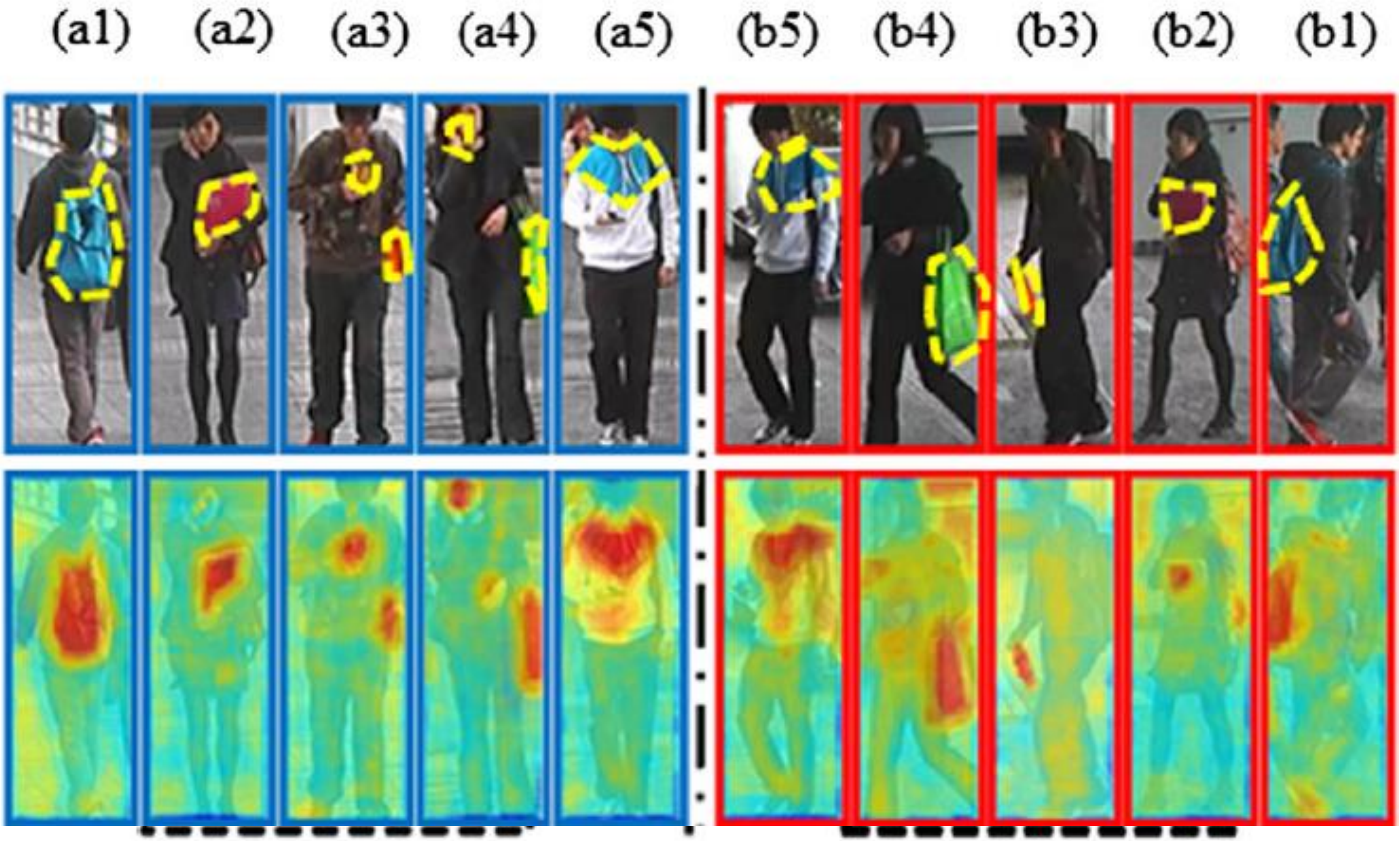
二.视觉显著性检测的应用

基于内容的图像/视频检索



二.视觉显著性检测的应用

行人再识别



二.视觉显著性检测的应用

基于内容的图像编辑

风格化

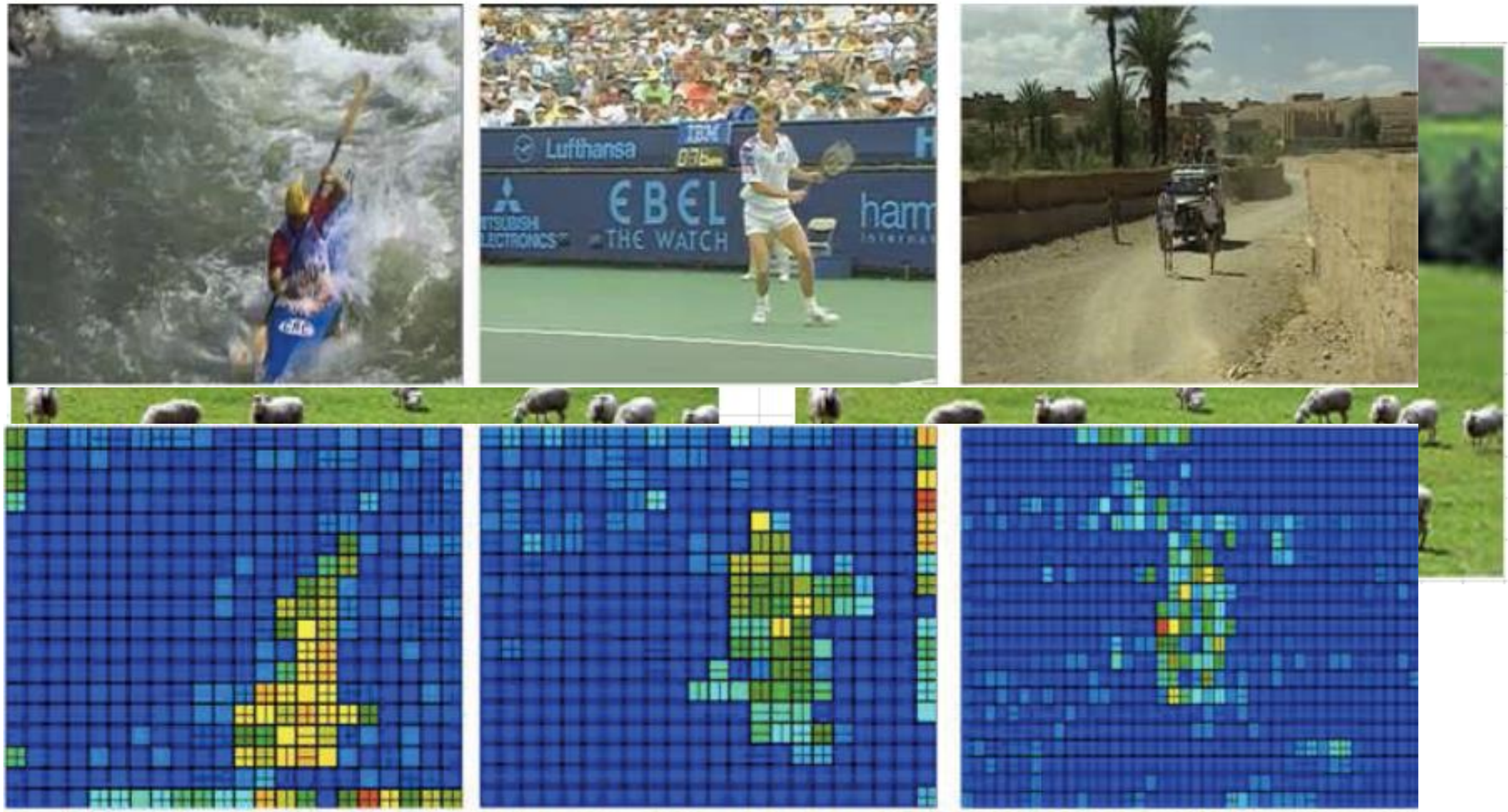
二.视觉显著性检测的应用

基于内容的图像编辑

内容保持的图像缩放和裁剪

二.视觉显著性检测的应用

图像/视频压缩



二.视觉显著性检测的应用

自动图像虚化

图像虚化实例

二.视觉显著性检测的应用

自动智能弹幕

"不挡脸"弹幕

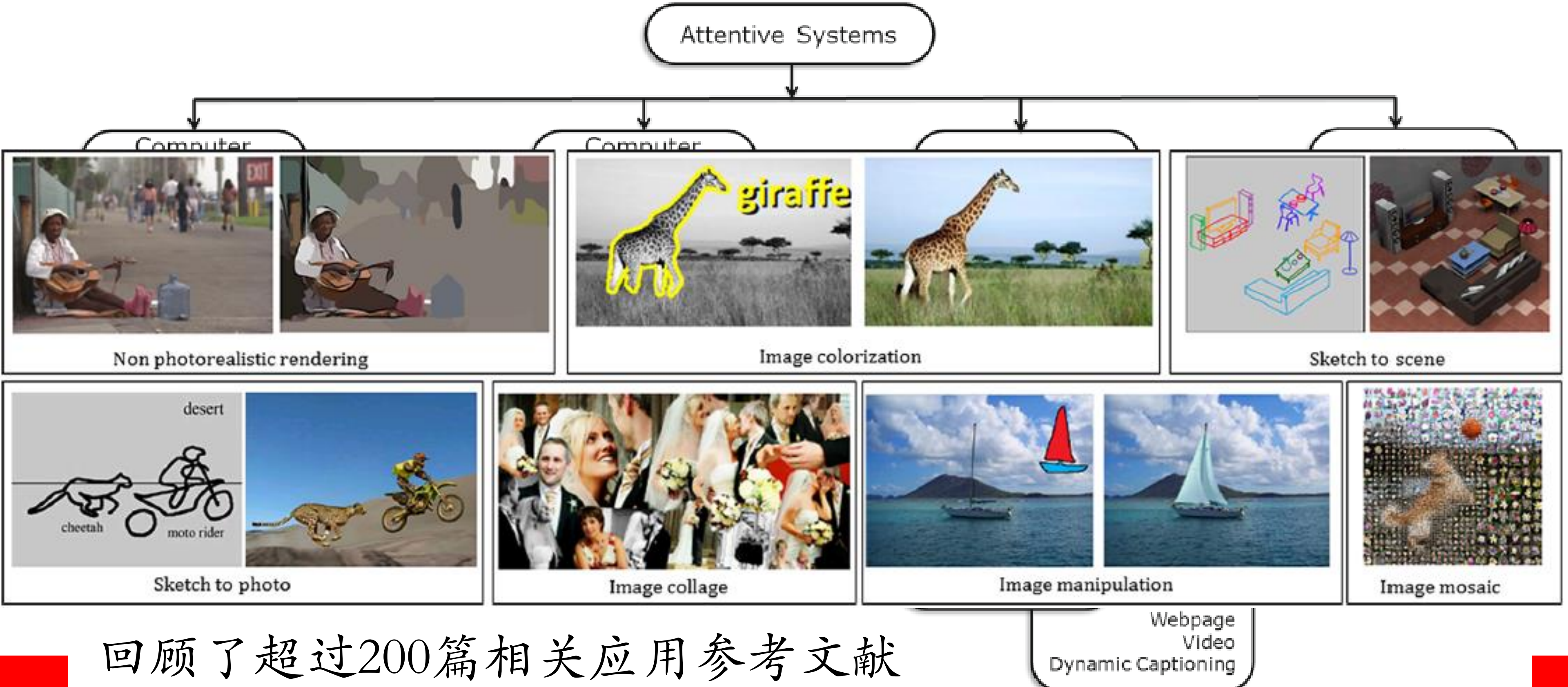
二.视觉显著性检测的应用

显著性检测的相关应用综述

Attentive Systems: A Survey

IJCV 2018

Tam V. Nguyen[1] · Qi Zhao[2] · Shuicheng Yan[3]



回顾了超过200篇相关应用参考文献

内容提纲

一.视觉显著性检测的起源、追溯、分类、及代表性工作

二.视觉显著性检测的应用

三.显著性物体检测的细化分类

四. 总结

三.显著性物体检测的细化分类

视觉显著性检测的三大类

人眼注视预测(Eye fixation prediction), 1998

显著物体/显著区域检测, 2009

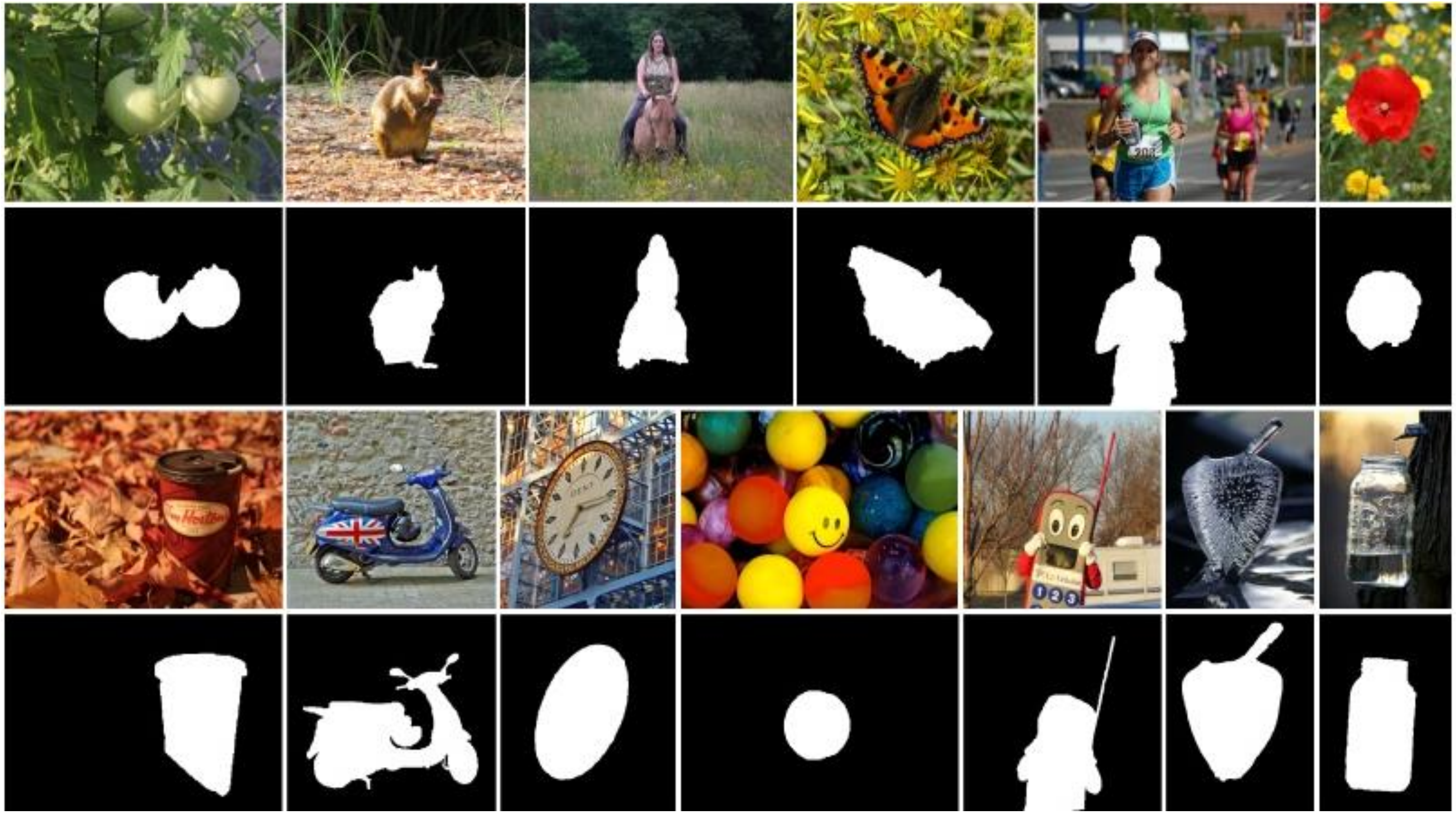
似物性（Objectness）检测, 2010

显著性物体检测的细化分类
……

三.显著性物体检测的细化分类

请大家回顾一下显著物体/显著区域检测任务的定义?

——检测出整个显著物体并且将其边界精确的分割出来~

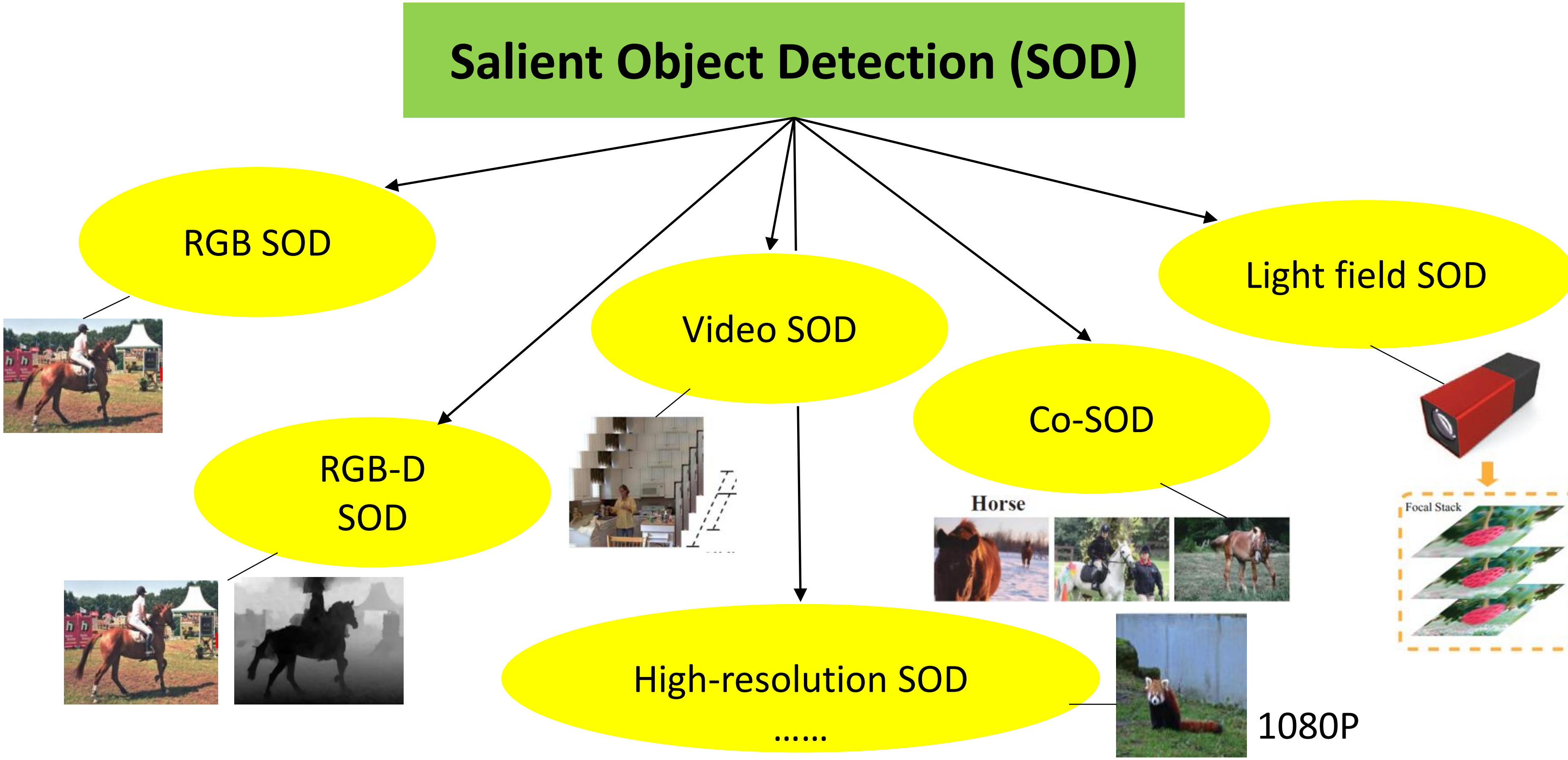


Input Images & Ground Truth (*from ECSSD dataset*)

三.显著性物体检测的细化分类

显著性物体检测的分类

- 根据具体任务和输入数据模态不同，近年来显著性物体检测（Salient Object Detection）可分为以下子领域：



三.显著性物体检测的细化分类

RGB SOD

- 输入图像为单幅彩色图像，也是最常见的SOD任务，RGB SOD的相关方法最多！

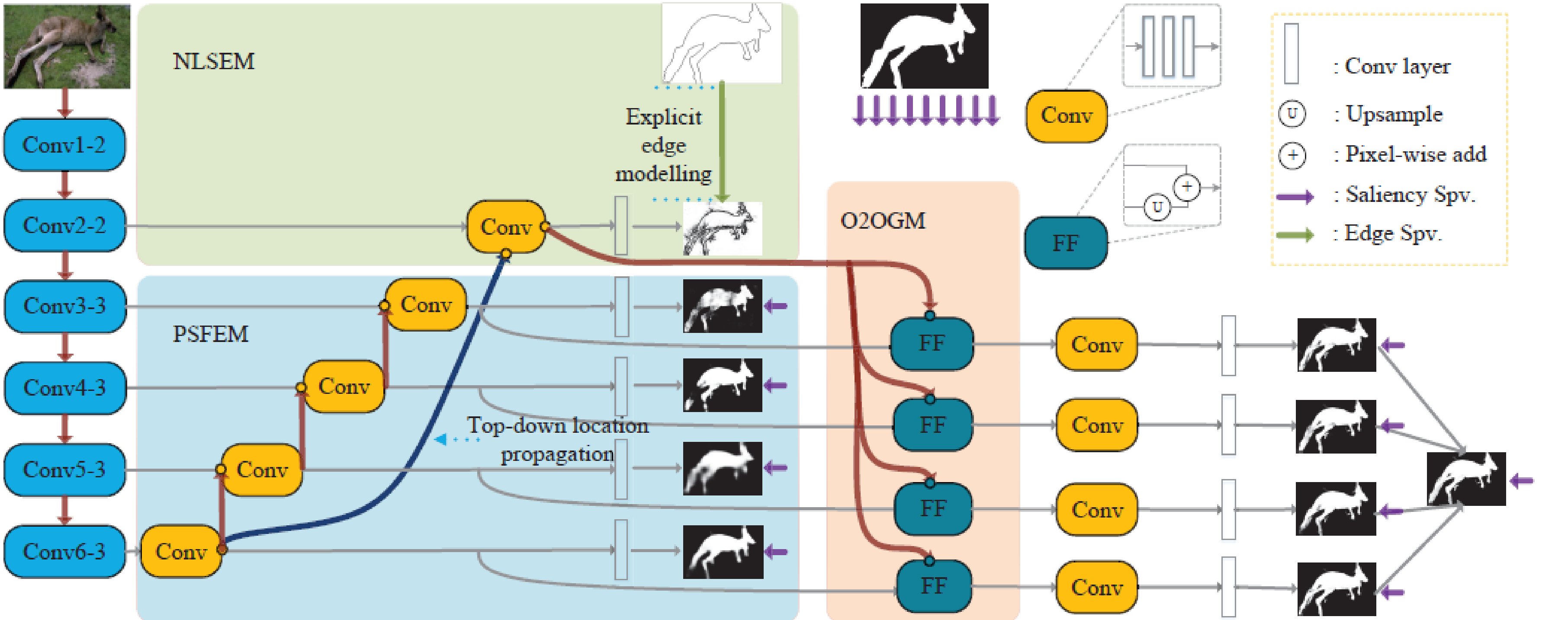


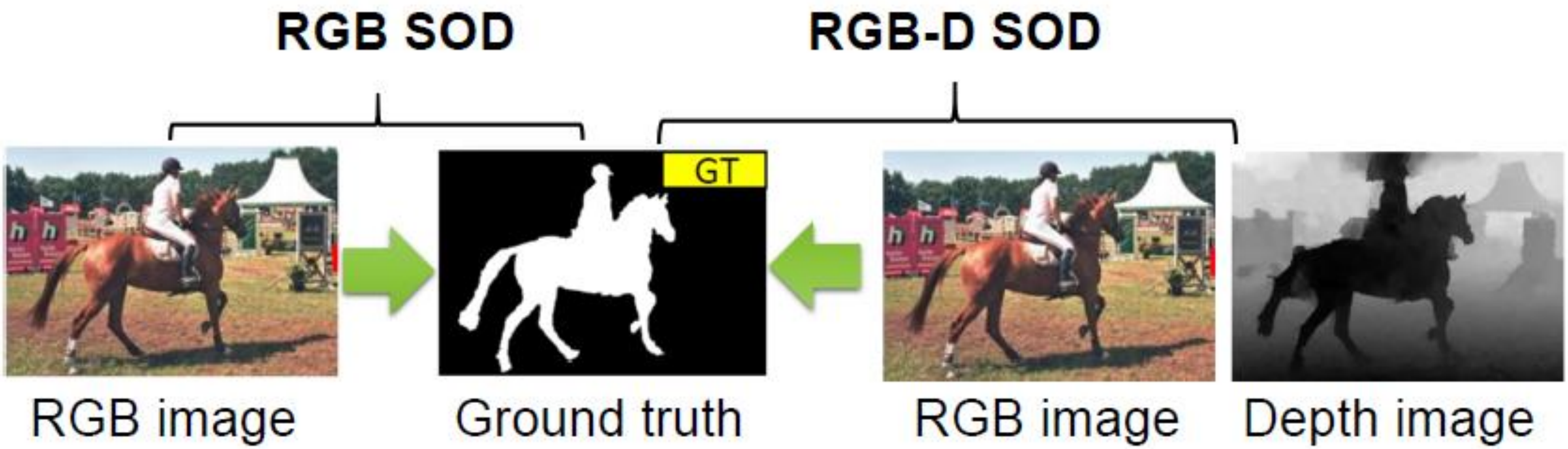
Figure 2. The pipeline of the proposed approach. We use brown thick lines to represent information flows between the scales. PSFEM: progressive salient object features extraction module. NLSEM: non-local salient edge features extraction module. O2OGM : one-to-one guidance module. FF: feature fusion. Spv.: supervision.

EGNet: Edge Guidance Network for Salient Object Detection, ICCV 2019

三.显著性物体检测的细化分类

RGB-D SOD

- 输入图像为单幅彩色图像（RGB）+深度图(Depth)，第一篇用deep learning解决RGB-D SOD的论文出现于2017年！



RGBD Salient Object Detection via Deep Fusion, TIP 2017

三.显著性物体检测的细化分类

RGB-D SOD

- RGB和Depth的三种不同融合策略（Early-fusion，Late-fusion, Middle-fusion）

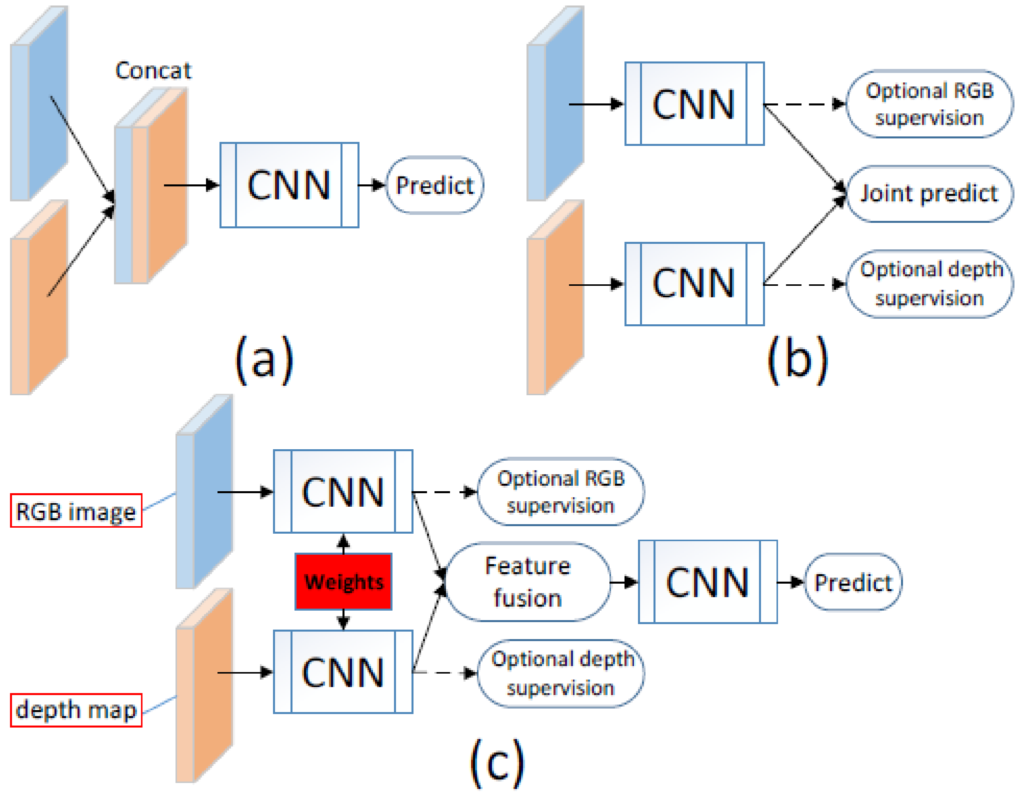


Figure 1: Typical schemes for RGB-D saliency detection. (a) Early-fusion. (b) Late-fusion. (c) Middle-fusion.

三.显著性物体检测的细化分类

RGB-D SOD

- Early-fusion方法举例

Rethinking rgb-d salient object detection: Models, datasets, and large-scale benchmarks， TNNLS 2020

三.显著性物体检测的细化分类

RGB-D SOD

- Late-fusion方法举例

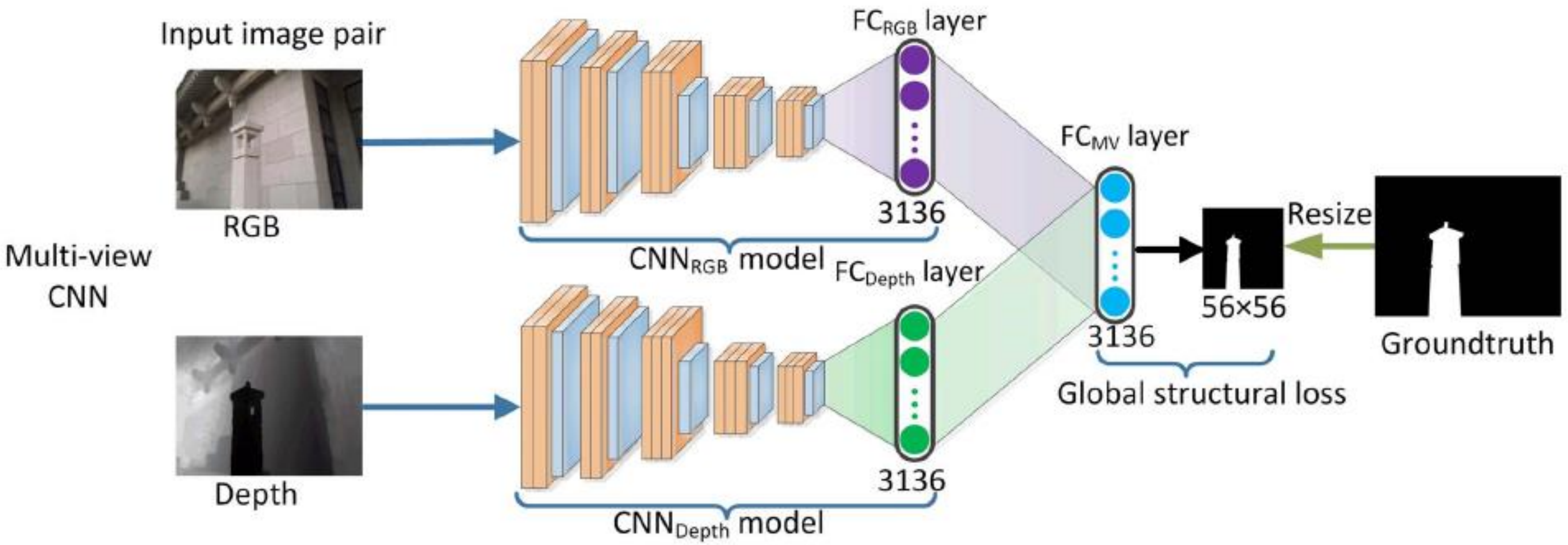


Fig. 3. Architectures of the proposed MV-CNN model. The FC_{RGB} layer (in purple color), which means the fully connected layer of the RGB view branch trained by the CNN_{RGB} model and the FC_{Depth} layer (in green color) which means the fully connected layer of the depth view branch trained by the CNN_{Depth} model, are simultaneously connected with a new fully connected (FC_{MV}) layer (in blue color) with 3136 nodes. Besides, the black arrows indicate they connect the global structural loss between predicted saliency map and supervised ground truth.

CNNs-Based RGB-D Saliency Detection via Cross-View Transfer and Multiview Fusion，TCYB 2017

三.显著性物体检测的细化分类

RGB-D SOD

- Middle-fusion方法举例

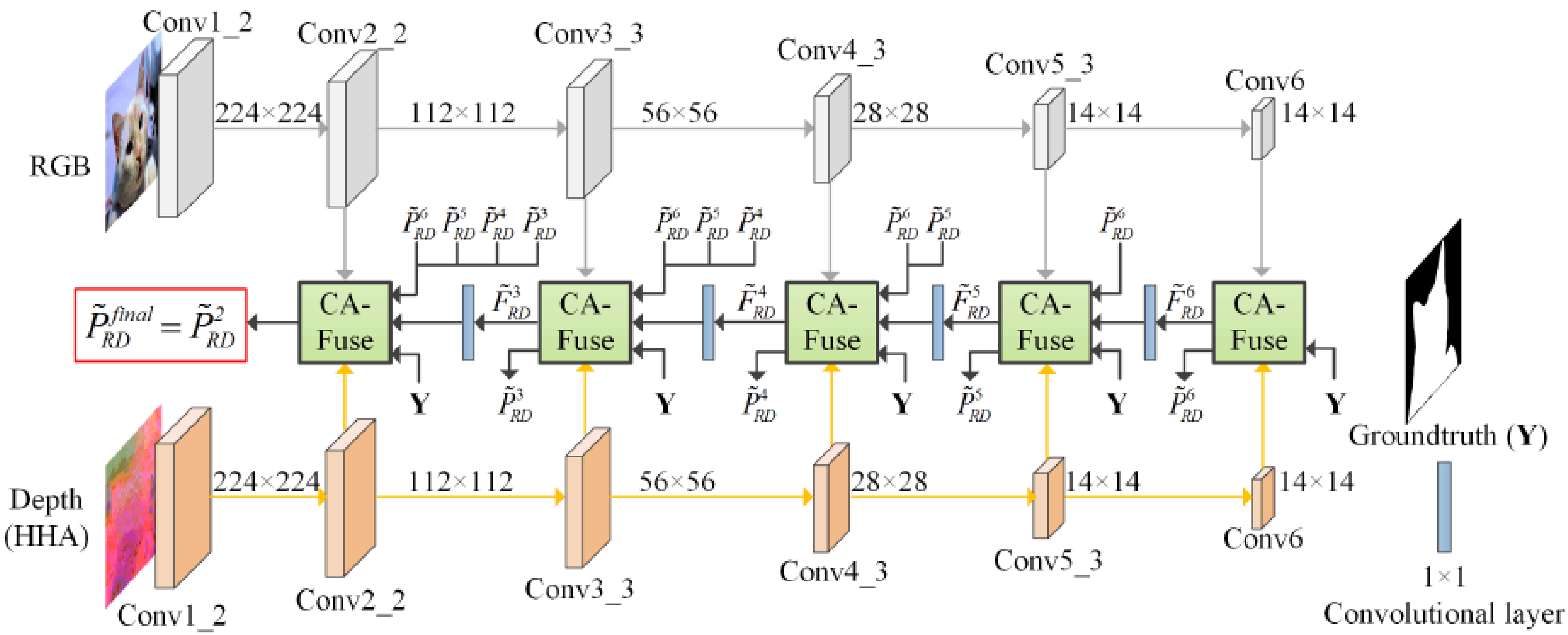


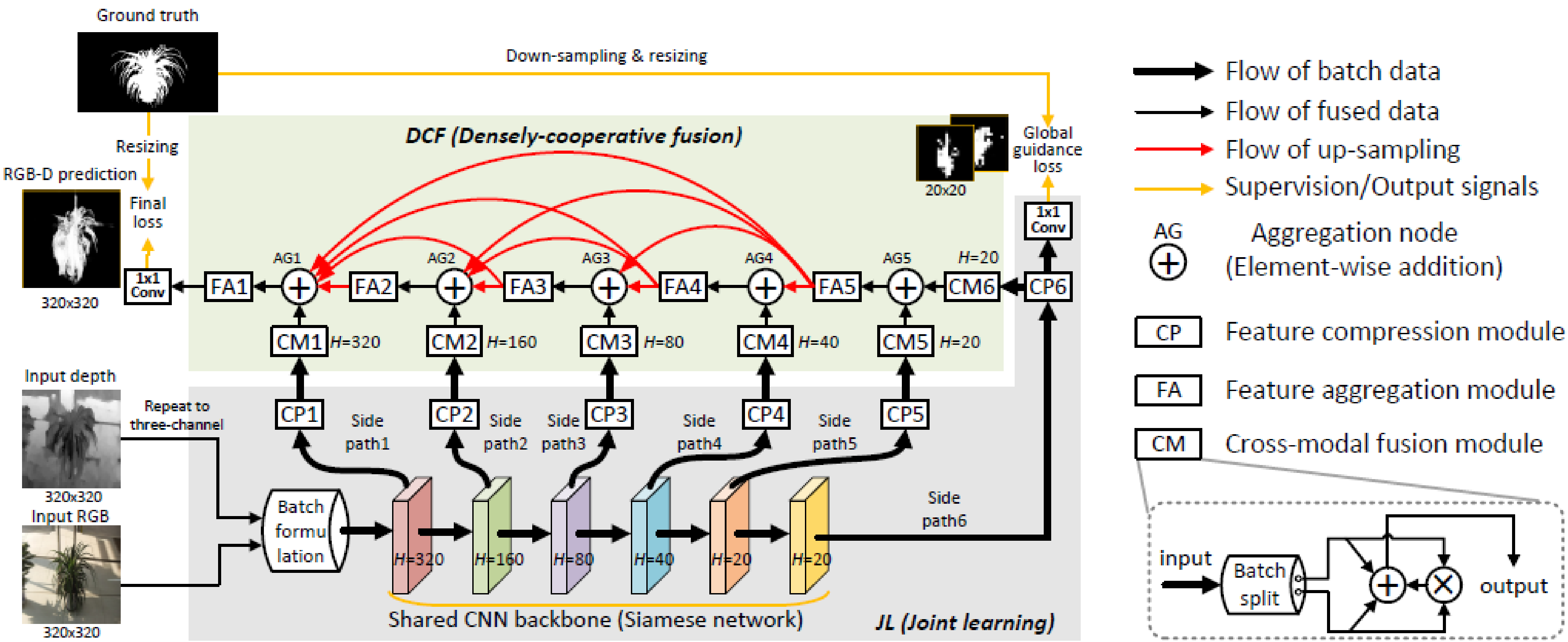
Figure 2: The architecture of the proposed progressively complementarity-aware fusion network for RGB-D salient object detection. Pooling layers are omitted for simplification. The 1×1 convolutional layers between neighboring CA-Fuse blocks are used for feature combination and dimensionality reduction (detailed parameters are shown in Table 1). Follow the practice in [1], we encode the depth image into 3-channel HHA representations.

Progressively Complementarity-aware Fusion Network for RGB-D Salient Object Detection， CVPR 2018

三.显著性物体检测的细化分类

RGB-D SOD

- Middle-fusion方法举例



JL-DCF: Joint Learning and Densely-Cooperative Fusion Framework for RGB-D Salient Object Detection，CVPR 2020

https://github.com/kerenfu/JLDCF/

三.显著性物体检测的细化分类

Video SOD

- 输入为视频序列

三.显著性物体检测的细化分类

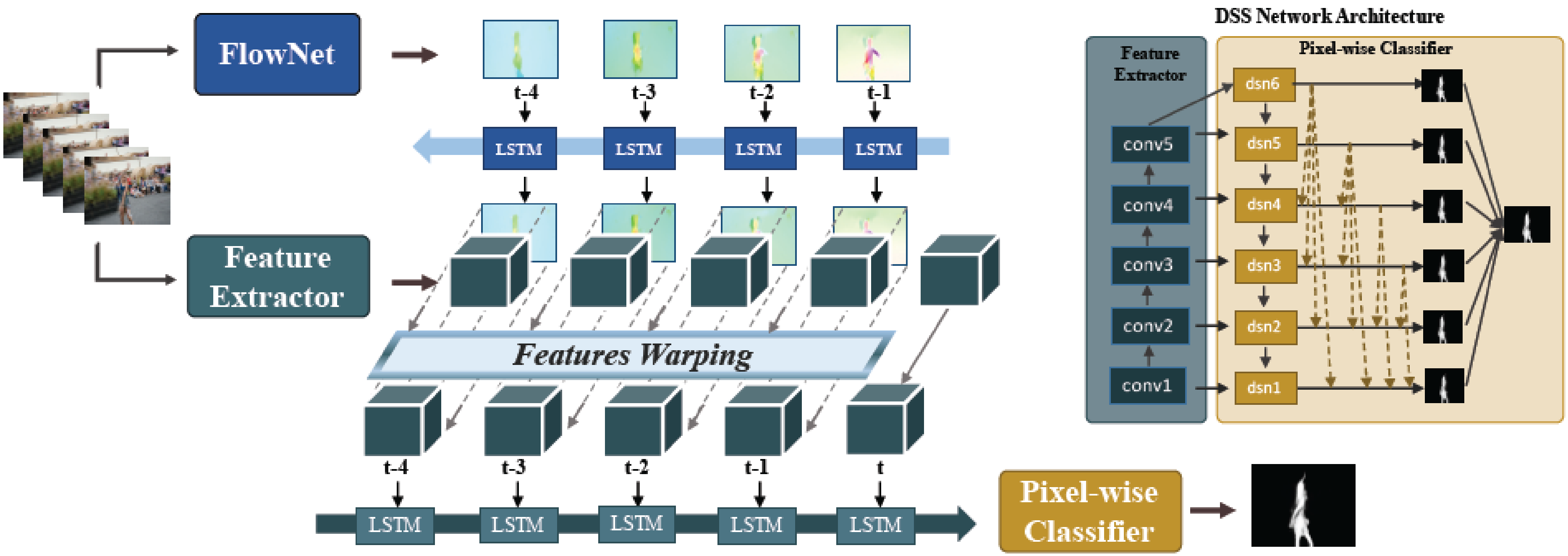
Video SOD

- 输入为视频序列

三.显著性物体检测的细化分类

Video SOD

- VSOD方法举例

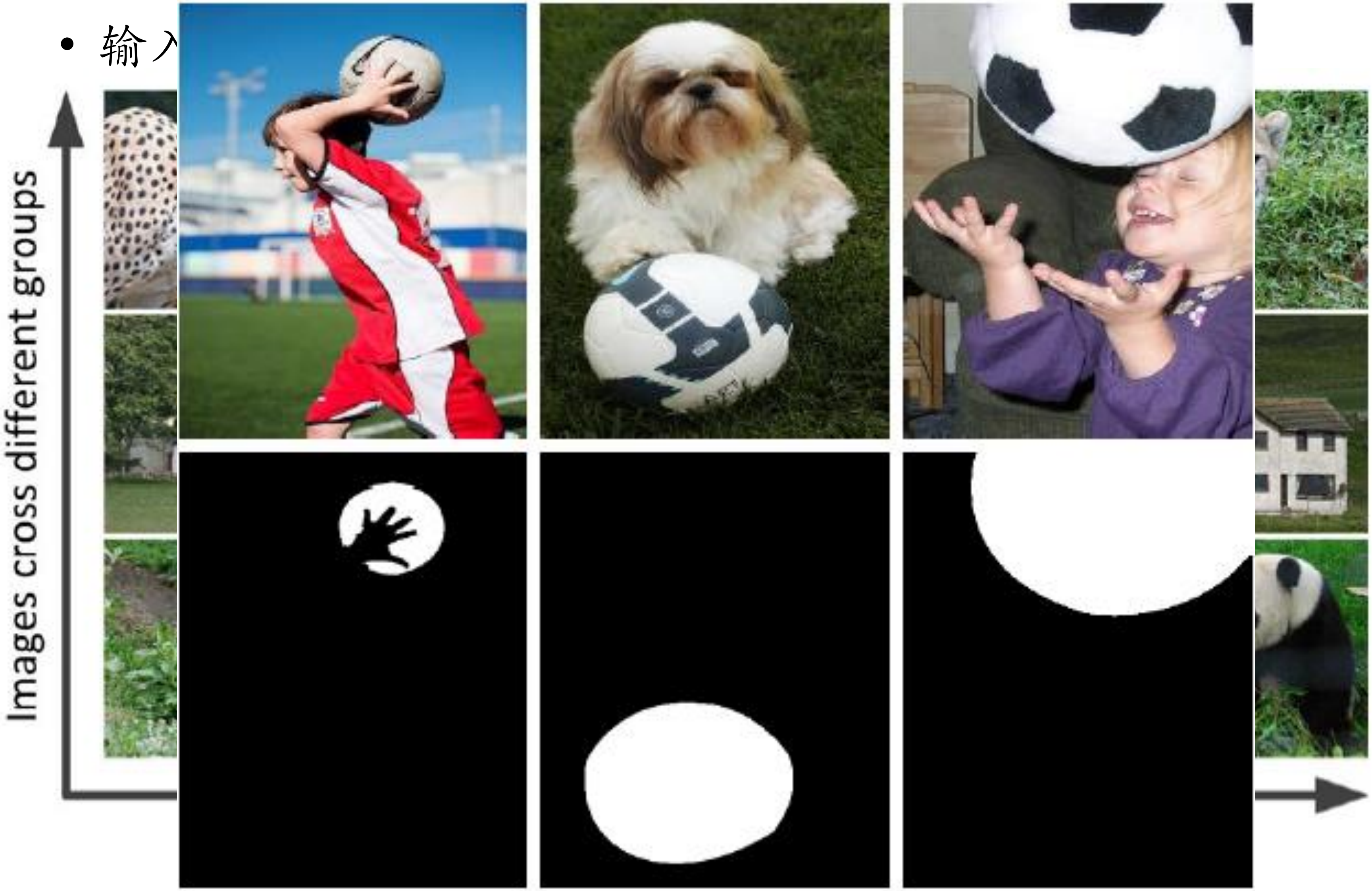


Flow Guided Recurrent Neural Encoder for Video Salient Object Detection， CVPR 2018

三.显著性物体检测的细化分类

Co-salient Object Detection

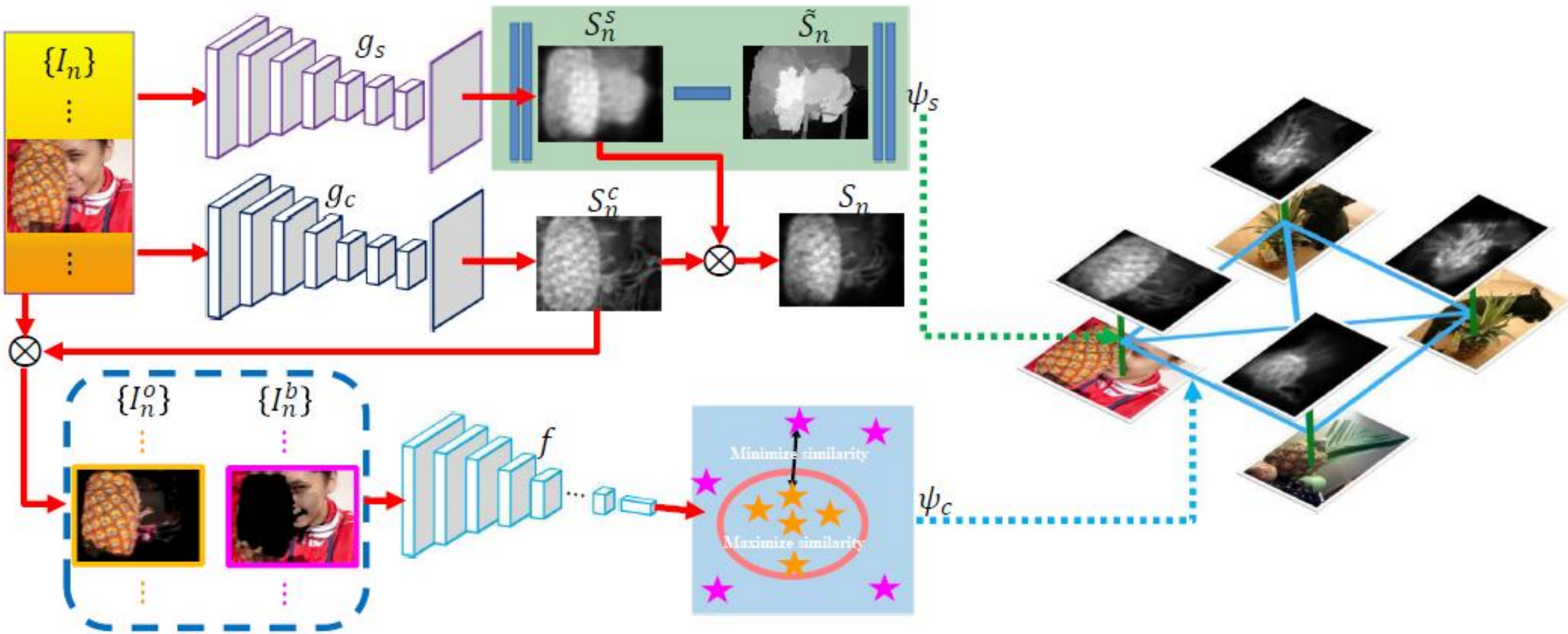
- 输入



三.显著性物体检测的细化分类

Co-salient Object Detection

- Co-SOD举例

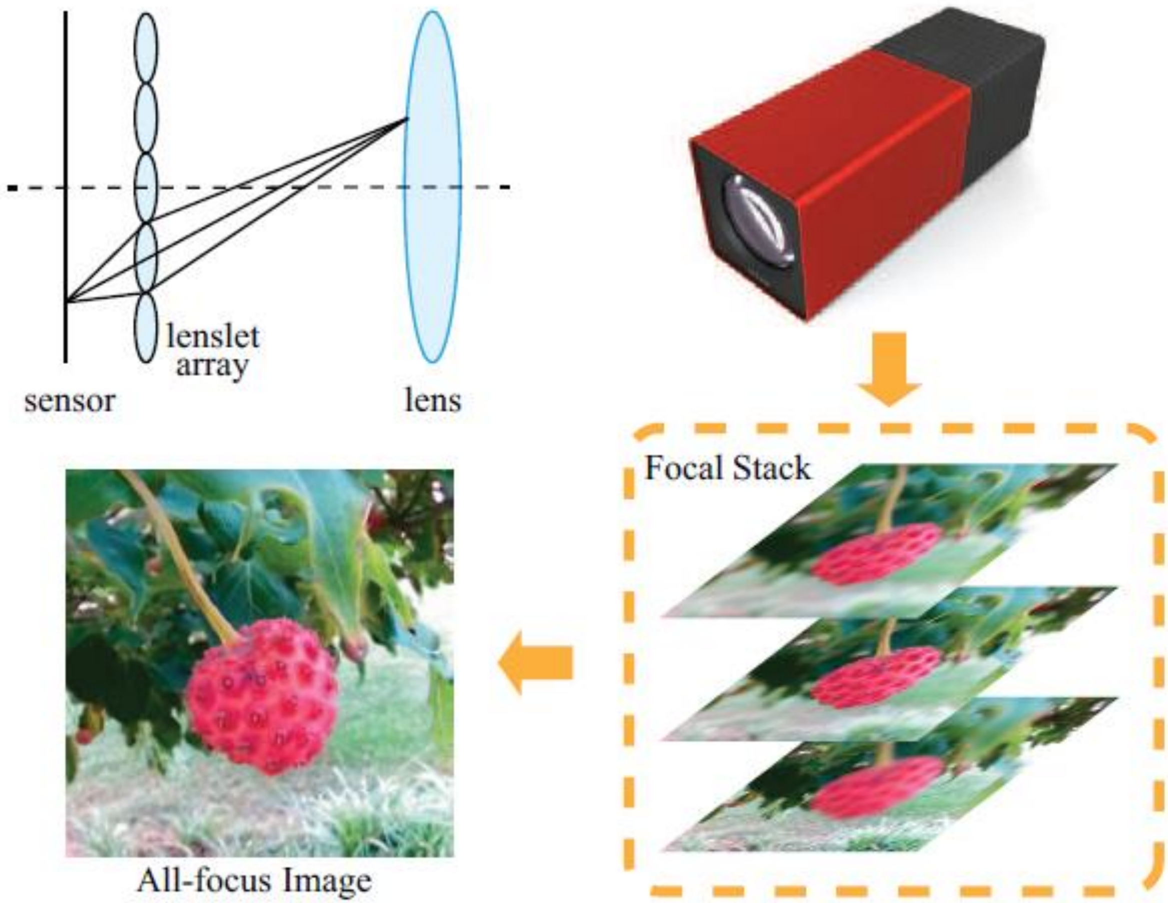


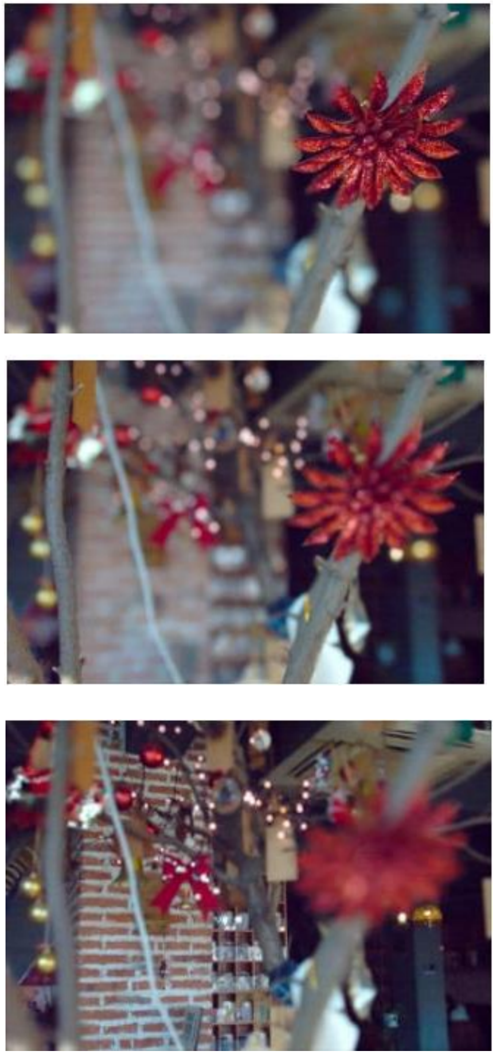
Unsupervised CNN-based Co-Saliency Detection with Graphical Optimization，ECCV 2018

三.显著性物体检测的细化分类

Light field SOD

- 输入为一组光场图像with不同的聚焦程度

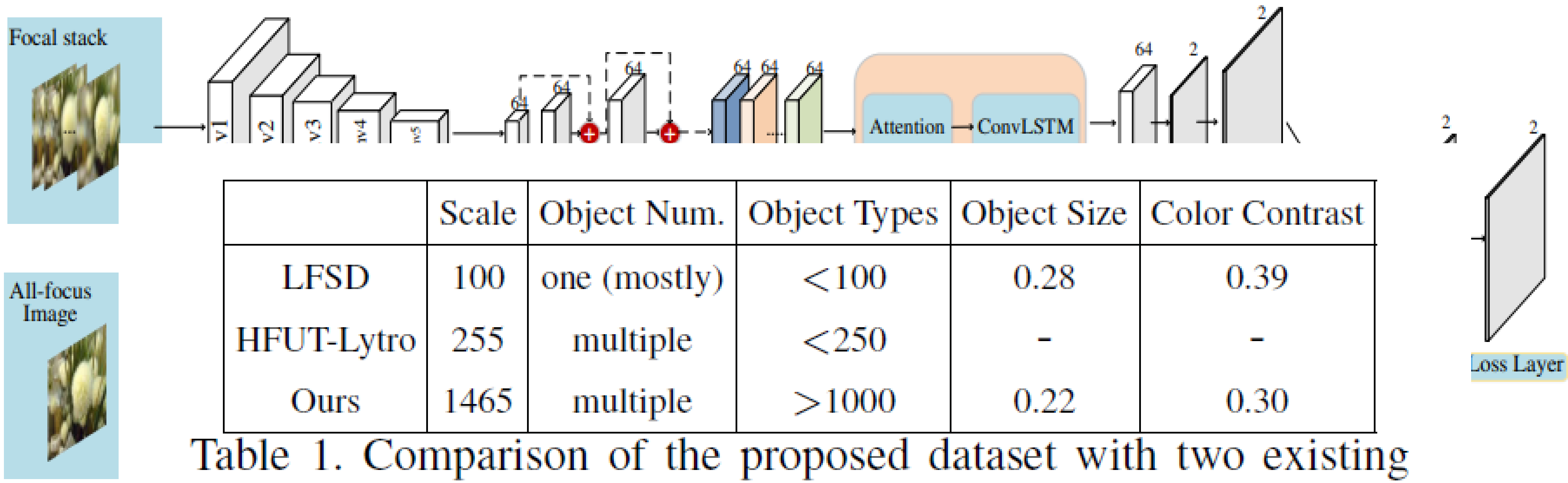




三.显著性物体检测的细化分类

Light field SOD

- Light field SOD举例



	Scale	Object Num.	Object Types	Object Size	Color Contrast
LFSD	100	one (mostly)	<100	0.28	0.39
HFUT-Lytro	255	multiple	<250	-	-
Ours	1465	multiple	>1000	0.22	0.30

Table 1. Comparison of the proposed dataset with two existing datasets in terms of the dataset scale, number of salient objects, type of objects, averaged size of objects and the color contrast.

Deep Learning for Light Field Saliency Detection，ICCV 2019

（提出第一个深度学习方法+当时最大的数据集）

三.显著性物体检测的细化分类

Light field SOD

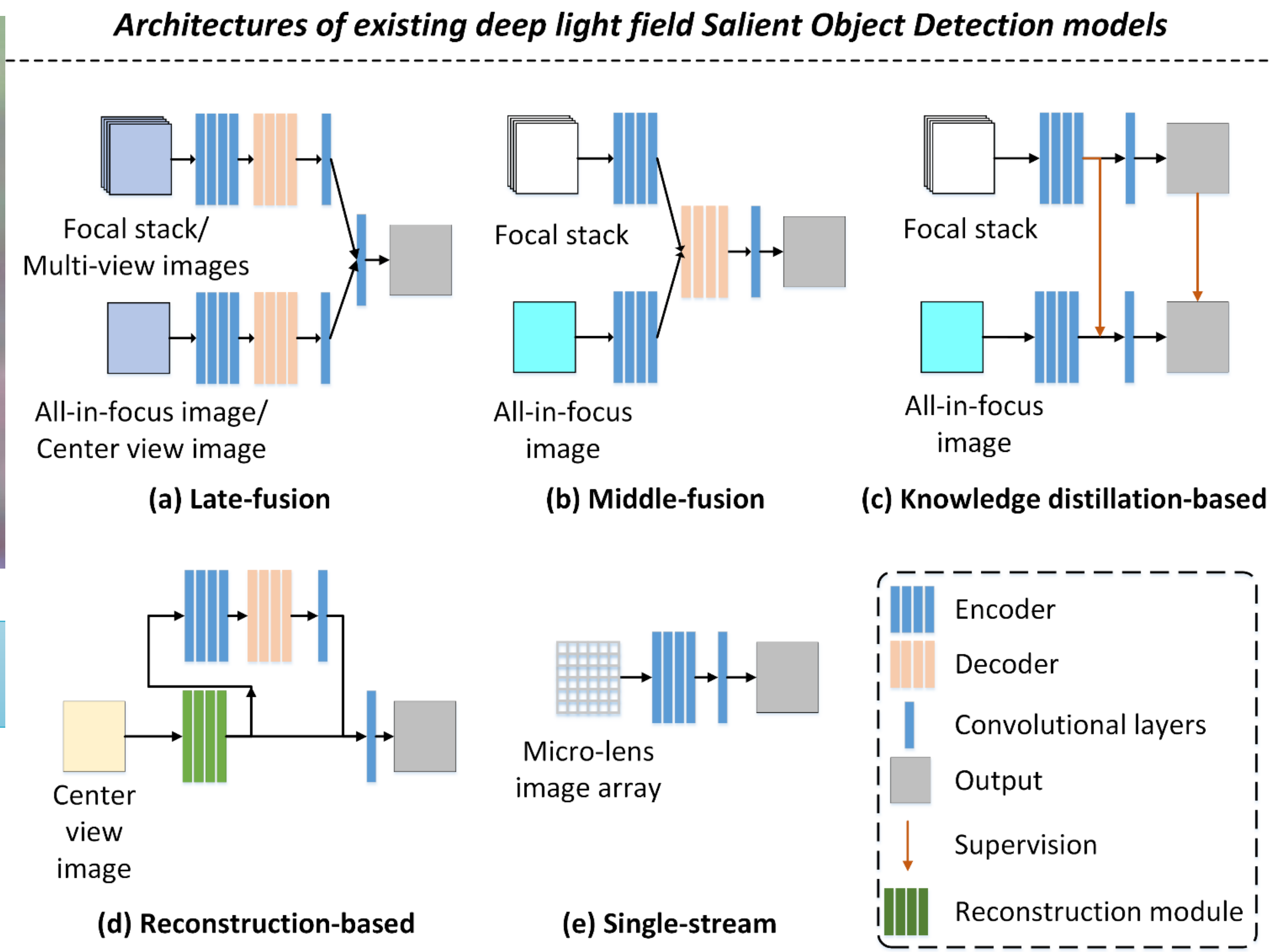
- Light field SOD综述

https://github.com/kerenfu/LFSOD-Survey/

三.显著性物体检测的细化分类

Light field SOD

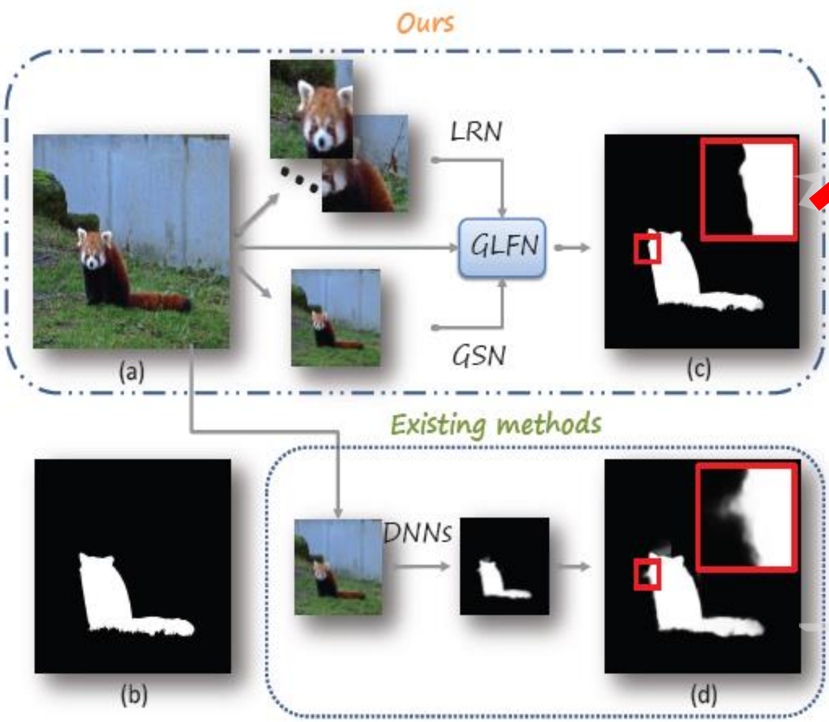
- Light field SOD综述

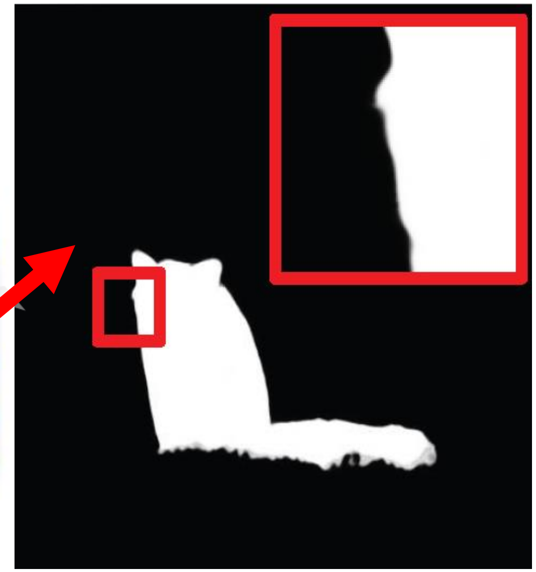


三.显著性物体检测的细化分类

High-resolution SOD

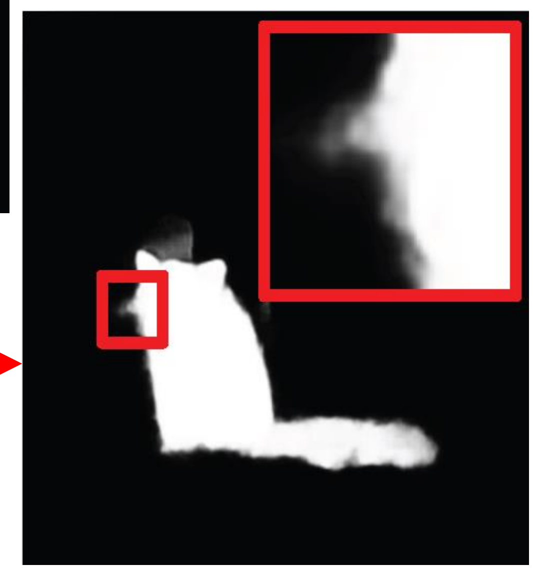
- 输入为高分辨率RGB图像（e.g., 1920×1080）





High-resolution

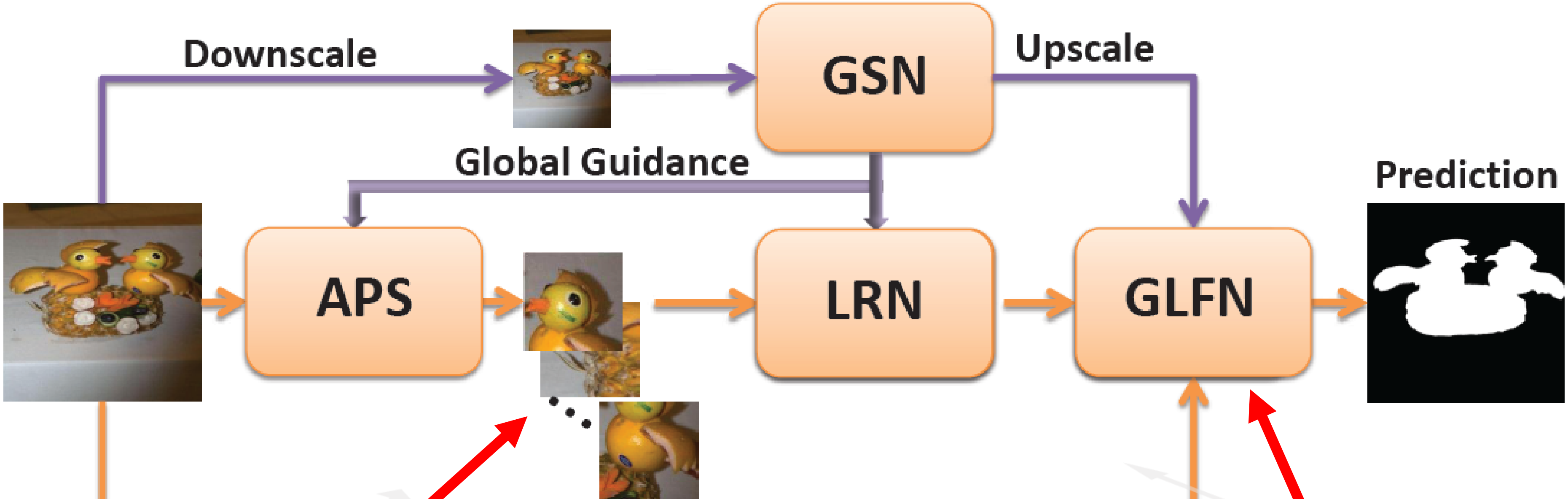
Common RGB SOD (Low-resolution)



Towards High-Resolution Salient Object Detection，ICCV 2019 (首篇,首个数据集)

High-resolution SOD

- High-resolution SOD举例



Uncertain patches

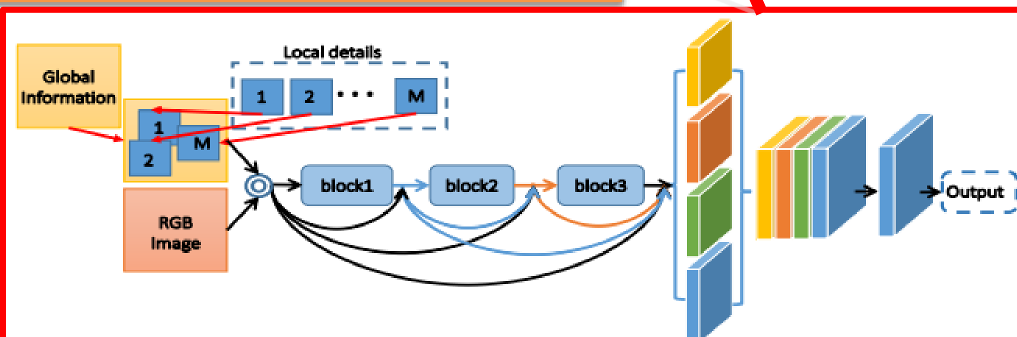
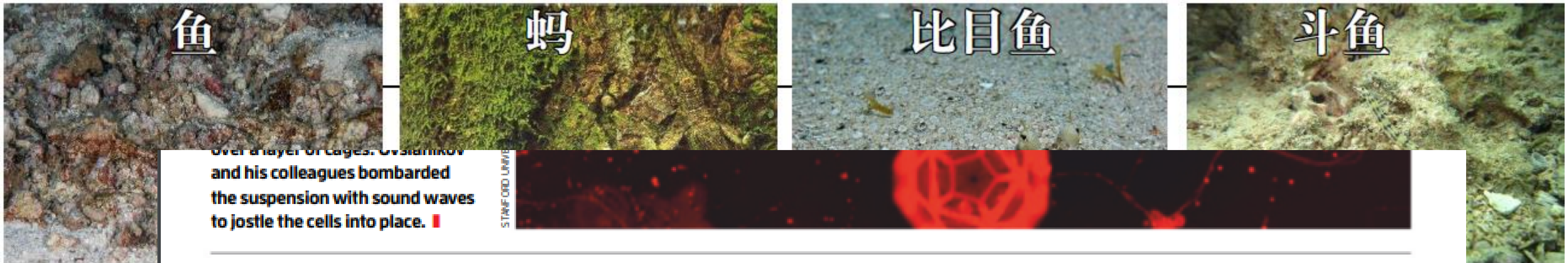
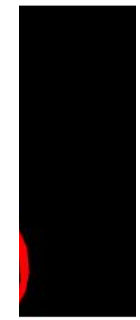


Figure 5. Global-Local Fusion Network.

Towards High-Resolu
ICCV 2019

*. Camouflaged Object Detection-COD（但不属于SOD）





and his colleagues bombarded the suspension with sound waves to jostle the cells into place.

Technology

AI can spot objects even if they are hidden

CAMOUFLAGED objects are difficult to detect, for both humans and artificial intelligence. But now an AI has been trained to parse objects from their backgrounds.

This could have a variety of applications, such as being used for search-and-rescue work, detecting agricultural pests, medical imaging or in military settings.

Detecting camouflaged objects requires visual perception and knowledge. Until now, many AIs have struggled with this task because their algorithms rely on visual cues, such as differences in colour or easily recognisable shapes, to identify objects.

To improve on this, Jianbing Shen at the Inception Institute of Artificial Intelligence in Abu Dhabi in the United Arab Emirates and his colleagues collated a data set of 10,000 photographs to train an AI. The data set includes 5066 images of camouflaged objects, which they have divided into 78 categories, such as "amphibian", "aquatic" and "flying".

The photographs included both naturally camouflaged animals such as fish and insects and examples of artificial camouflage, such as soldiers in uniform. Although databases of camouflaged objects already exist, this data set is the largest, says Shen.

The team manually labelled each image of a camouflaged object to highlight characteristics such as its shape or whether it was partially obstructed by its surrounding environment. They then developed an AI called SINet and trained it on images from the data set.

The researchers compared SINet to 12 existing algorithms built to detect generic objects. They tested all 13 algorithms using three existing data sets of camouflaged objects. SINet did better than the other 12 at isolating camouflaged objects and identifying their correct shape and nature in both the existing and the training data sets.

"Many AIs struggle to detect camouflaged objects because their algorithms rely on visual cues"

"Without any bells and whistles, SINet outperforms various state-of-the-art object detection baselines on all datasets tested, making it a robust, general framework that can help facilitate future research," the researchers write. They are due to present the work at the CVPR 2020 conference in Seattle, Washington, in June.

The researchers hope the data set and algorithm can improve AI's ability to recognise camouflaged objects, says Shen.

Donna Lu

16 May 2020 | New Scientist | 17

*. Camouflaged Object Detection-COD（但不属于SOD）

- COD举例

Camouflaged Object Segmentation with Distraction Mining, CVPR 2021.
Mutual Graph Learning for Camouflaged Object Detection, CVPR 2021.
Simultaneously Localize, Segment and Rank the Camouflaged Objects, CVPR 2021.
Uncertainty-Aware Joint Salient Object and Camouflaged Object Detection, CVPR 2021.

Implicit Motion Handling for Video Camouflaged Object Detection, CVPR 2022.
Detecting Camouflaged Object in Frequency Domain, CVPR 2022.
Segment, Magnify and Reiterate: Detecting Camouflaged Objects the Hard Way, CVPR 2022.
Zoom In and Out: A Mixed-scale Triplet Network for Camouflaged Object Detection, CVPR 2022.
DTA: Physical Camouflage Attacks using Differentiable Transformation Network, CVPR 2022.

Deep Gradient Learning for Efficient Camouflaged Object Detection, Arxiv 2022.
Towards Deeper Understanding of Camouflaged Object Detection, Arxiv 2022
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今日内容

一.视觉显著性检测的起源、追溯、分类、及代表性工作

二.视觉显著性检测的应用

三.显著性物体检测的细化分类

四. 总结

总结

- 视觉显著性检测经过30余年的发展，目前已成为Computer Vision和Pattern Recognition领域的一个独树一帜的方向。
- 显著性检测根据任务不同大分类可分类为3类，且具有繁多的子任务，例如仅显著物体检测就有超过6个的子任务，如此多的“花样”意味着很多的**研究机遇**。
- 在抓住机遇的同时也面临**挑战**。本次报告**回顾的工作、介绍应用和新进展**，也只是显著性检测领域工作的一角，有大量新的**问题和idea**待研究者们探索和发掘。

思考：在同学们自己的科研中有哪些内容可以与视觉显著性检测联系起来?