A Computational Model for Saliency Detection based on Probability Distributions

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IVS intelligent vision systems

Motivation

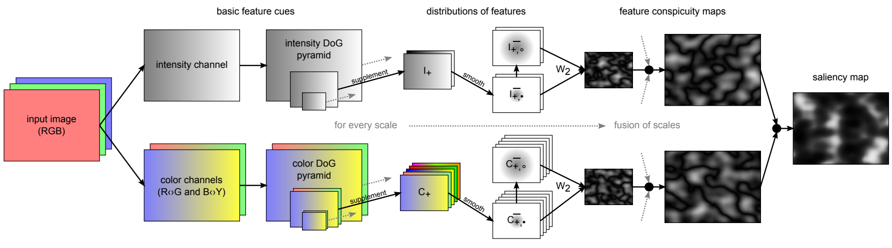
Task: detect salient objects

We present a computational attention system that quickly detects salient objects in web images. It can deal with real-world images and different object sizes. Details in [1].

Approach:
- Use standard structure of visual attention systems [2]: separate feature channels, different scales, center-surround
- Represent feature statistics by multivariate normal distributions
- Compare distributions with the Wasserstein metric based on Euclidean norm.

Obtains good results on psychophysical data and outperforms 9 state-of-the-art saliency systems on the MSRA benchmark [3,4].

CoDi-Saliency Model



CoDi-Saliency: Continuous Distribution Saliency
- use two basic feature channels: *intensity and color (red-green + blue-yellow opponents)*
- compute basic features on 12 scales
- compute center-surround contrast of basic feature distributions based on W_2
- first fuse information from scales, then combine channels into a single saliency map

Method

Compute basic feature cues for intensity: and color:

$$I(x,y) = \left(\frac{R+G+B}{3}\right)_{(x,y)} \qquad C(x,y) = \begin{pmatrix} c_1 \\ c_2 \end{pmatrix} = \begin{pmatrix} R-G \\ B-\frac{R+G}{2} \end{pmatrix}_{(x,y)}$$

Collect feature statistics by multivariate normal distributions represented by ML-estimates:

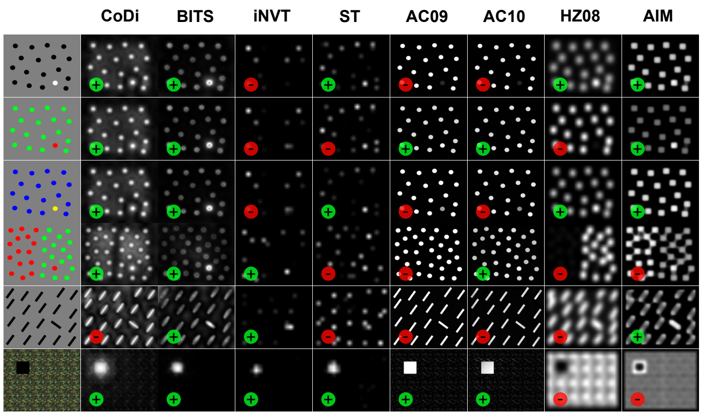
$$\hat{\mu}_{\mathrm{I}} = \bar{i} \qquad \hat{\mu}_{\mathrm{C}} = \begin{pmatrix} \bar{c}_1 \\ \bar{c}_2 \end{pmatrix}$$

$$\hat{\sigma}_{\mathrm{I}} = \overline{i^2} - \bar{i}^2 \qquad \hat{\Sigma}_{\mathrm{C}} = \begin{pmatrix} \overline{c_1^2} - \bar{c}_1^2 & \overline{c_1 c_2} - \bar{c}_1\bar{c}_2 \\ \overline{c_1 c_2} - \bar{c}_1\bar{c}_2 & \overline{c_2^2} - \bar{c}_2^2 \end{pmatrix}$$

Sophisticated optimizations enable efficient computing. See [1] for details. Saliency is computed as difference between center and surround distributions by the Wasserstein distance W_2 based on the Euclidean norm:

$$W_2(P_\bullet, P_\odot) = \sqrt{\|\mu_\bullet - \mu_\odot\|_2^2 + tr(\Sigma_\bullet) + tr(\Sigma_\odot) - 2tr\left(\sqrt{\sqrt{\Sigma_\bullet}\Sigma_\odot\sqrt{\Sigma_\bullet}}\right)}$$

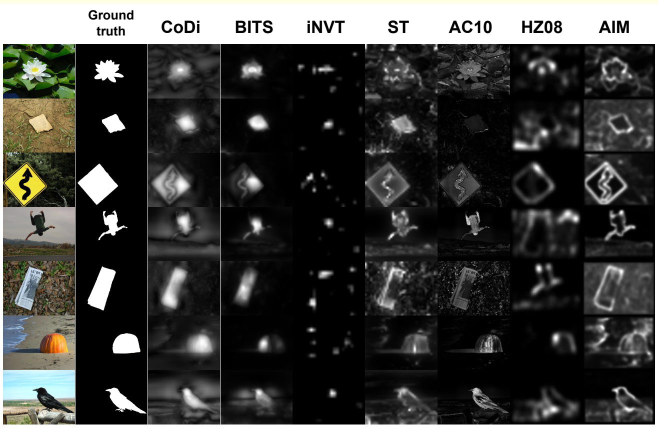
Results on Psychophysical Data



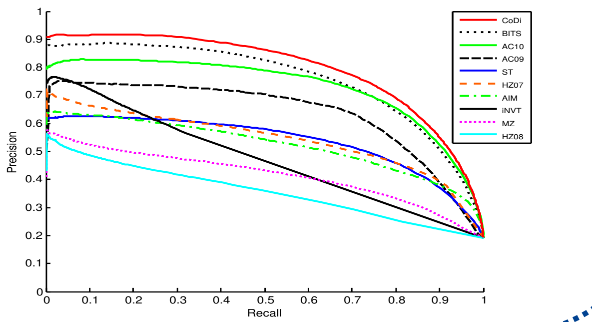
Outlier detected with 1st FOA — Outlier not detected with 1st FOA

BITS (Bonn Information-Theoretic Saliency): Klein/Frintrop
iNVT (Neuromorphic Vision Toolkit): Itti et al.
ST (Saliency Toolbox): Walther et al.
AC09/AC10: Achanta et al.
HZ08: Hou/Zhang
AIM (Attention based on Information Maximation): Bruce/Tsotsos

Results on MSRA Dataset [3]



We use the Achanta benchmark [3] which contains 1000 web images with salient objects and the corresponding ground truth (user-drawn binary maps). It is a subset of the MSRA salient object database [2].



References:
[1] Klein, Frintrop: Salient Pattern Detection using W_2 on Multivariate Normal Distributions, DAGM 2012
[2] Frintrop: Computational Visual Attention, in Computer Analysis of Human Behavior, Springer, 2011
[3] Liu et al.: Learning to detect a salient object, Trans. on PAMI, 2009
[4] Achanta et al.: Frequency-tuned salient region detection, CVPR 2009