Deep Learning for Saliency Prediction in Images

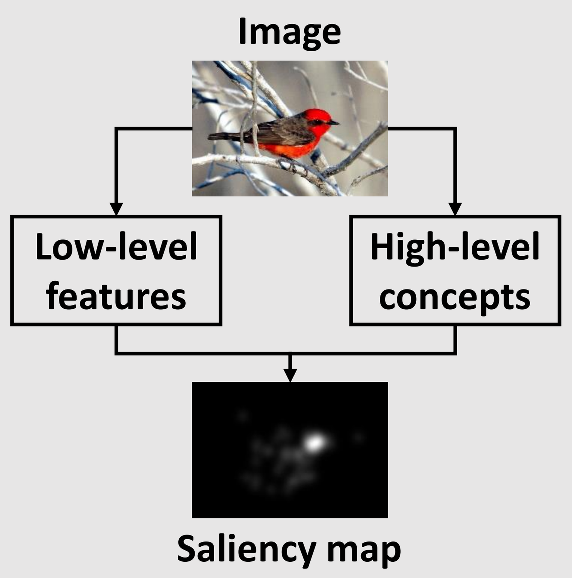
Marcella Cornia, University of Modena and Reggio Emilia
Tutor: Prof. Rita Cucchiara

Problem statement

Classical algorithms for saliency prediction focused on identifying the fixation points that human viewer would focus on at first glance.

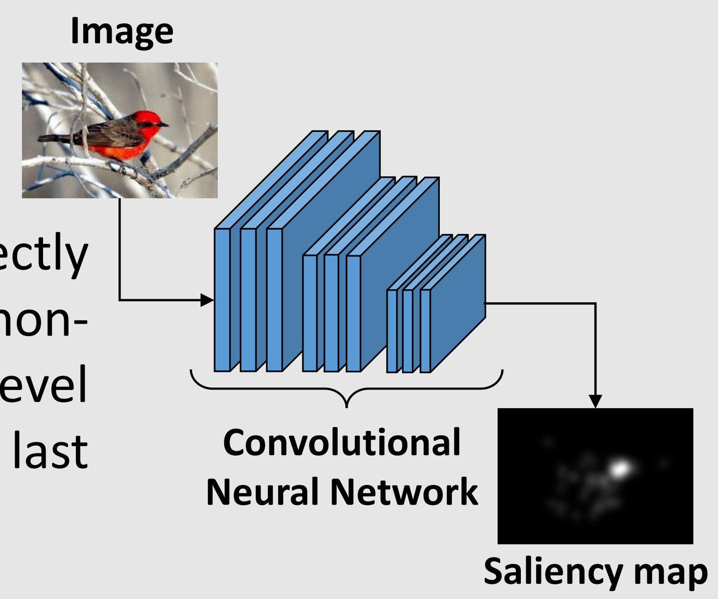
CONVENTIONAL SALIENCY

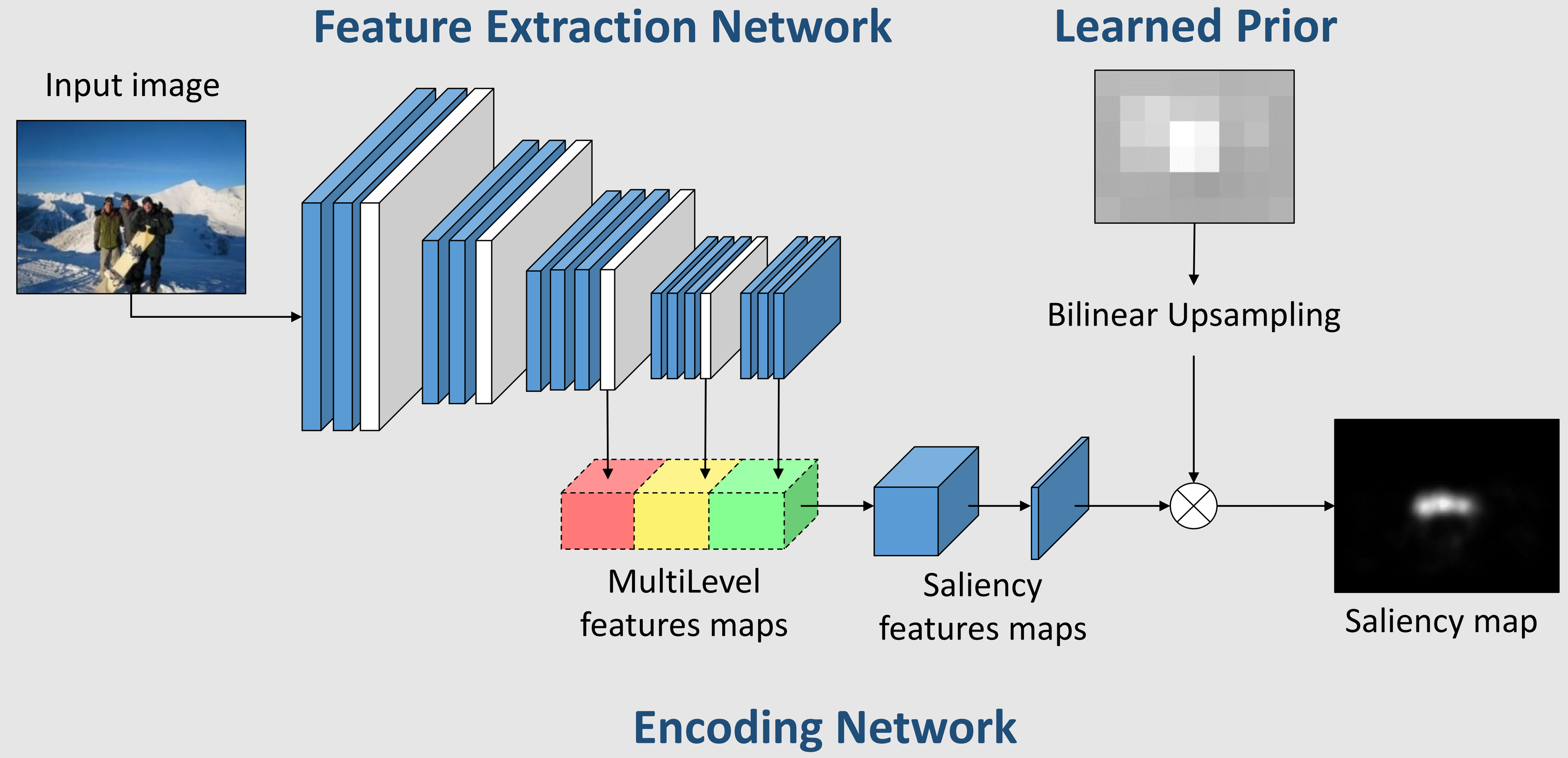
- Extraction of hand-crafted and multi-scale features:
  - Lower-level features
  - Higher-level concepts
    - faces, people, text, horizon, etc.
- Difficult to combine all these factors.



DEEP SALIENCY

- Fully Convolutional networks directly predict saliency maps given by a non-linear combination of high level feature maps extracted from the last convolutional layer.





Feature Extraction and Encoding Network

- Fully Convolutional net with 13 layers, inspired by VGG-16.
- To limit rescaling, the last pooling stage is removed and the stride of the last but one pooling layer is decreased.
- We take feature maps at three different locations of the FCN, and concatenate them to form a tensor with 1280 channels.
- A 3 x 3 convolutional layer learns 64 saliency-specific feature maps, then a 1 x 1 convolution learns to weight each map to produce a temporary saliency prediction.

Learned Prior

- We let the network learn its own custom prior.
- A coarse mask, which has a much smaller size of the saliency map, is learned
- Then it is upsampled and applied to the predicted saliency map with pixel-wise multiplication.

Loss Function

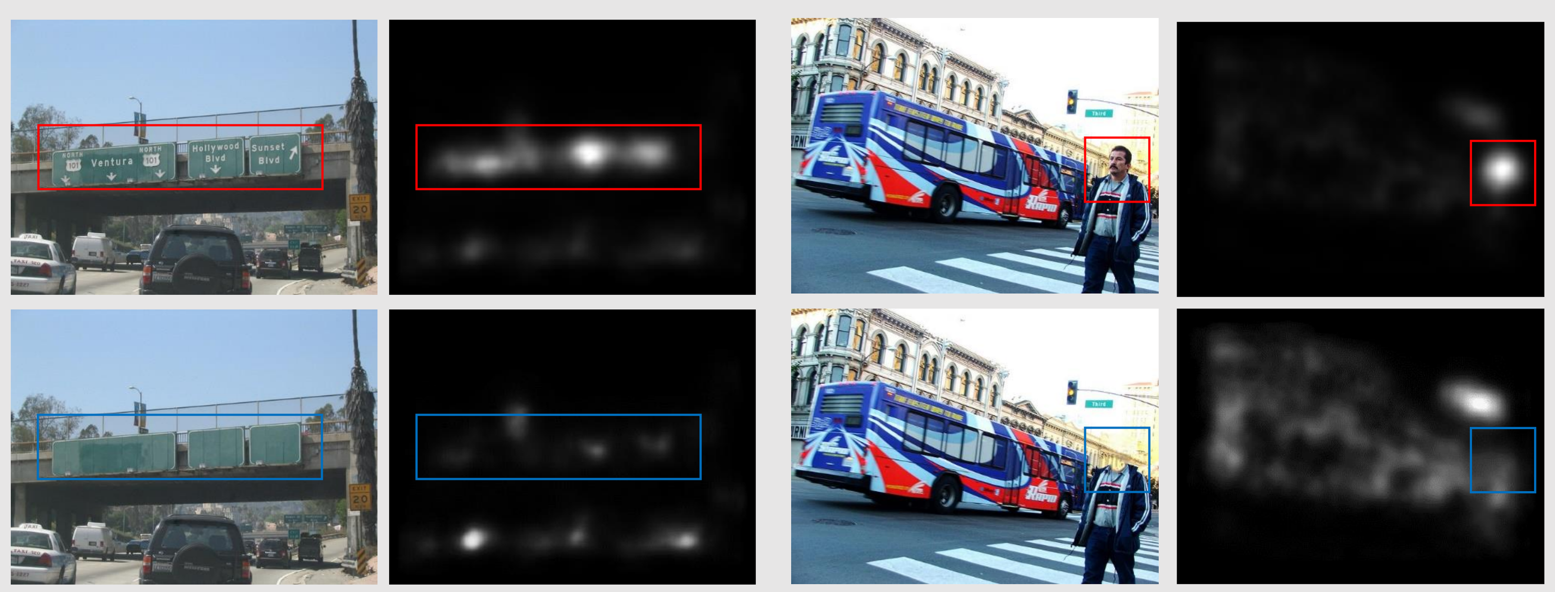
Three objectives:

- Predictions should be pixel-wise similar to ground truth.
- Predicted maps should be invariant to their maximum.
- The loss should give the same importance to high and low GT values.

$$L(\mathbf{w}) = \frac{1}{N}\sum_{i=1}^{N}\left\|\frac{\frac{\phi(\mathbf{x}_i)}{\max\phi(\mathbf{x}_i)} - \mathbf{y}_i}{\alpha - \mathbf{y}_i}\right\|^2 + \lambda\|\mathbf{1} - U\|^2$$

y_i are ground truth values and $\phi(x_i)$ are predicted values.

L_2 regularization term added to penalize the deviation of the prior mask U form its initial value.



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[3] Zhang, Jianming, and Stan Sclaroff. "Saliency detection: A boolean map approach." *ICCV*, 2013.
[4] Harel, Jonathan, Christof Koch, and Pietro Perona. "Graph-based visual saliency." *ANIPS*, 2006.
[5] Itti, Laurent, Christof Koch, and Ernst Niebur. "A model of saliency-based visual attention for rapid scene analysis." *IEEE TPAMI*, 1998.
[6] Kruthiventi, et al. "DeepFix: A Fully Convolutional Neural Network for predicting Human Eye Fixations." *arXiv:1510.02927*, 2015.
[7] Huang, Xun, et al. "SALICON: Reducing the Semantic Gap in Saliency Prediction by Adapting Deep Neural Networks." *ICCV*, 2015.
[8] Kümmerer, et al. "Deep Gaze I: Boosting saliency prediction with feature maps trained on ImageNet." *arXiv:1411.1045*, 2014.
[9] Liu, Nian, et al. "Predicting eye fixations using convolutional neural networks." *CVPR*, 2015.

Experimental results

- We evaluate our model on the SALICON dataset and on the MIT300 benchmark.
- Our solution outperforms all competitors on SALICON dataset, even the most recent approach published in CVPR 2016, by a big margin on all considered metrics.

RESULTS ON SALICON DATASET

	CC	sAUC	AUC
Our method	**0.74**	**0.77**	**0.87**
Deep Convnet (CVPR16) [1]	0.62	0.72	0.86
Shallow Convnet (CVPR16) [1]	0.60	0.67	0.84
WHU IIP (LSUN Challenge 2015)	0.46	0.61	0.79
Rare 2012 Improved [2]	0.51	0.66	0.81
Xidian (LSUN Challenge 2015)	0.48	0.68	0.81
Baseline: BMS [3]	0.43	0.70	0.79
Baseline: GBVS [4]	0.42	0.63	0.79
Baseline: Itti [5]	0.20	0.61	0.67

RESULTS ON MIT300 DATASET

	Sim	CC	sAUC	AUC	NSS	EMD
Infinite humans	1.00	1.00	0.80	0.91	3.18	0.00
DeepFix [6]	0.67	0.78	0.71	0.87	2.26	2.04
SALICON [7]	0.60	0.74	0.74	0.87	2.12	2.62
Our method	**0.60**	**0.69**	**0.71**	**0.85**	**2.07**	**2.53**
Deep Convnet(CVPR16) [1]	0.52	0.58	0.69	0.83	1.51	3.31
BMS [3]	0.51	0.55	0.65	0.83	1.41	3.35
Deep Gaze 2 [8]	0.46	0.51	0.76	0.87	1.29	4.00
Mr-CNN [9]	0.48	0.48	0.69	0.79	1.37	3.71
Shallow Convnet (CVPR16) [1]	0.46	0.53	0.64	0.80	1.47	3.99
GBVS [4]	0.48	0.48	0.63	0.81	1.24	3.51
Rare 2012 Improved [2]	0.46	0.42	0.67	0.77	1.34	3.74