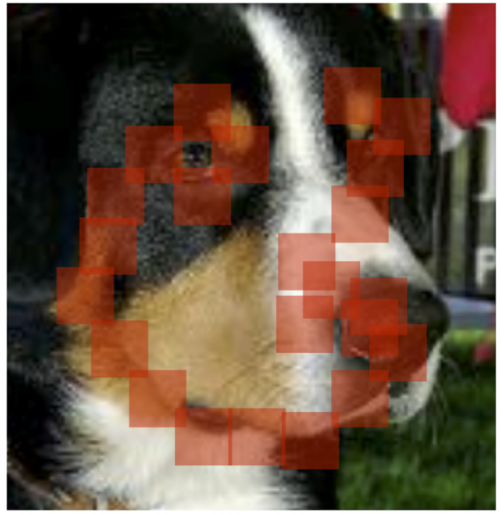
Learning what and where to attend

Drew Linsley, Dan Shiebler, Sven Eberhardt, Thomas Serre

ICLR 2019

Human clicks



Presented by
Fiona Muntwyler

Visible to DCN

7 seconds to recognize

1. Problem description and motivation
2. Related work
3. ClickMe.ai
4. Network architecture
5. Evaluation
6. Discussion
7. Conclusion

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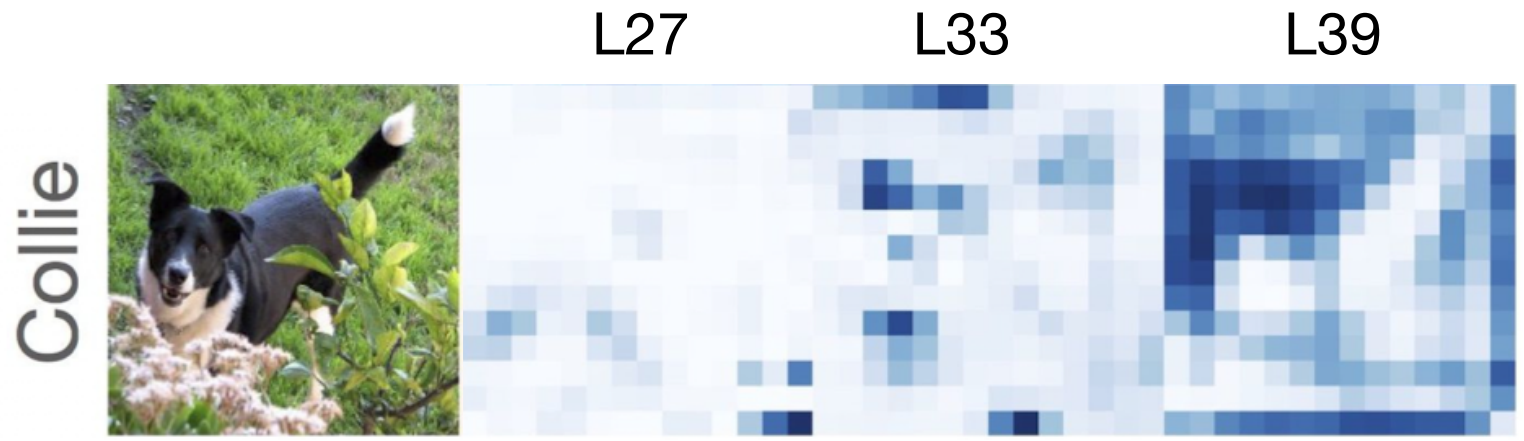
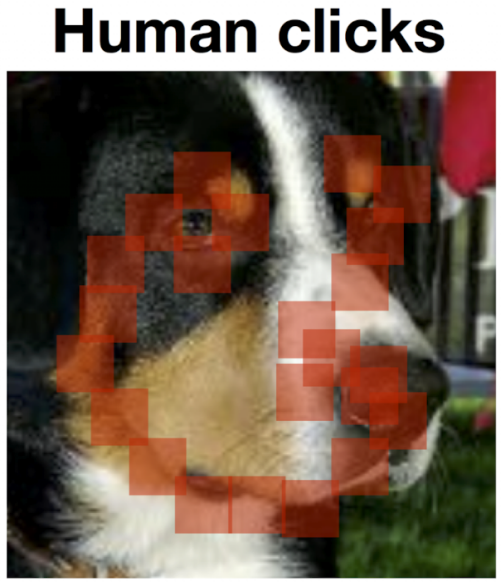
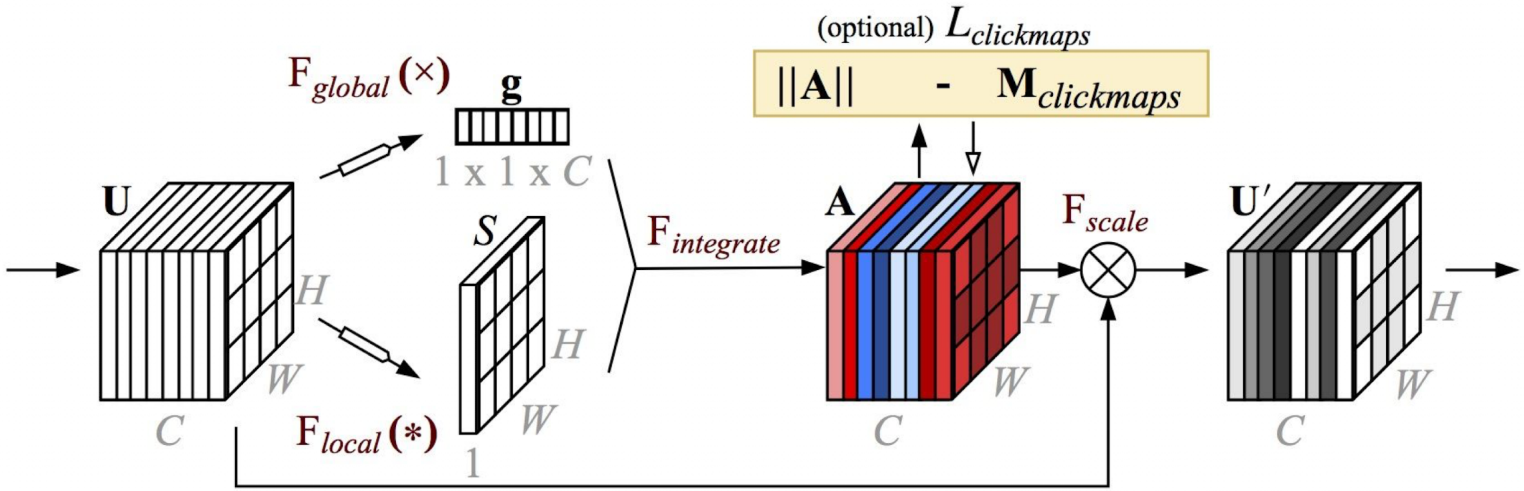

L27
L33
L39
Collie

Contributions





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LEARNING WHAT AND WHERE TO ATTEND

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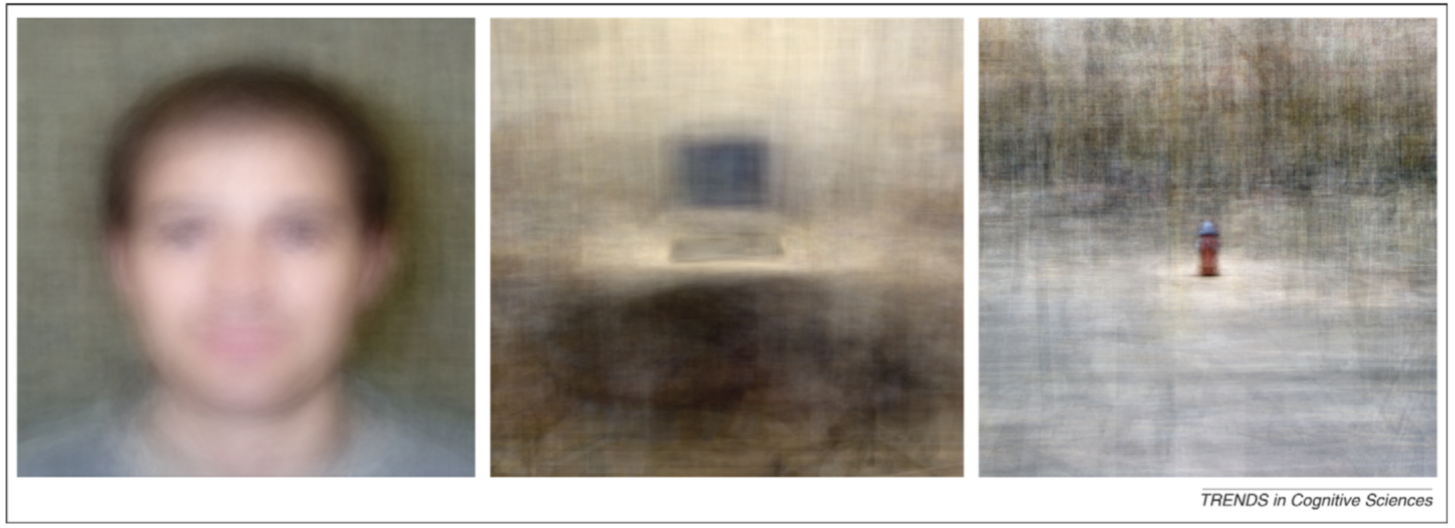
Attention models in human vision

- Local features

Source: https://www.directindustry.de/prod/vag-group/product-26045-1884491.html

- Global features



Source: Oliva and Torralba, 2007

Humans-in-the-loop computer vision and attention datasets

- Online games
- Attention dataset: Salicon

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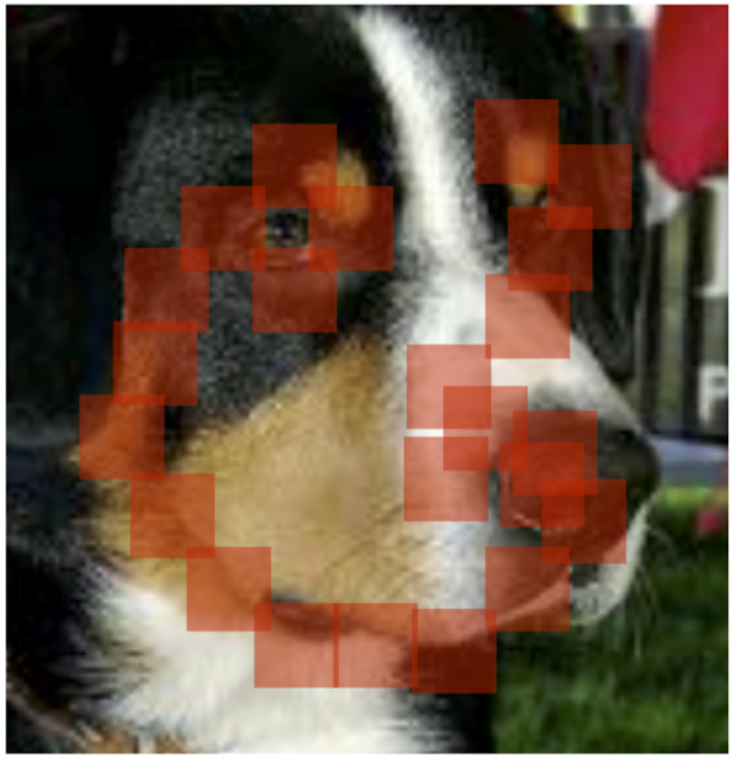
ClickMe.ai

Human clicks



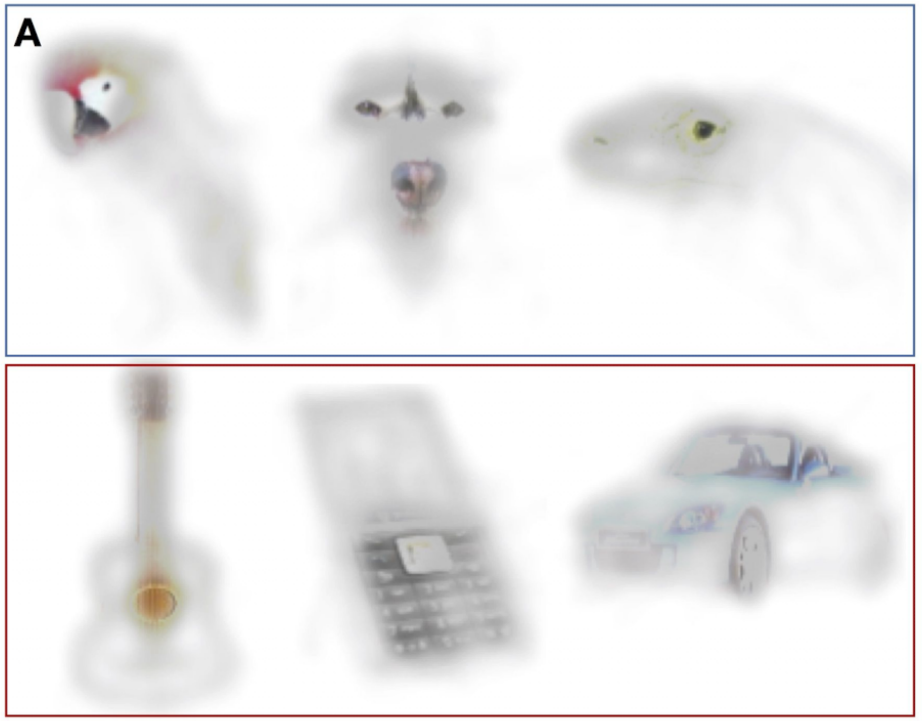
Visible to DCN

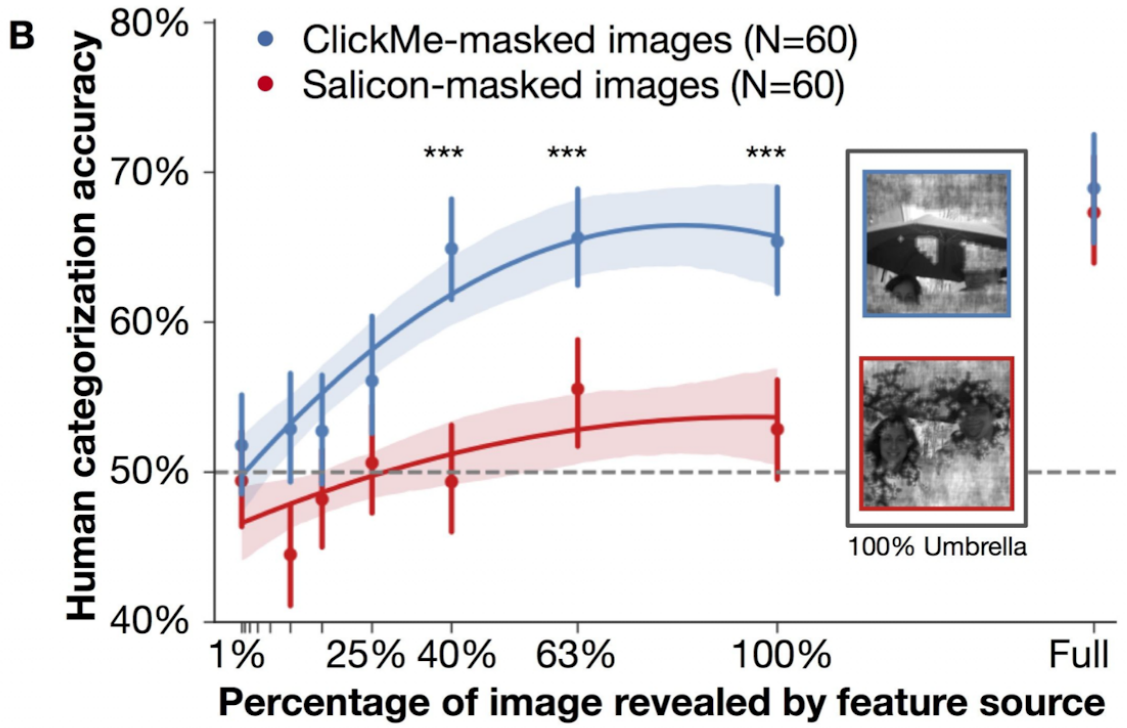
7 seconds to recognize

ClickMe.ai

- 1235 participants
- Each participant played on average 380 images
- Dataset: ILSVRC12 (10,000,000 labelled images)
- 472,946 ClickMe maps on 196,499 unique images
- Maps highly correlated with Clicktionary maps

ClickMe.ai


A


B
ClickMe-masked images (N=60)
Salicon-masked images (N=60)
Human categorization accuracy
80%
70%
60%
50%
40%
***
***
***
100% Umbrella
1%
25%
40%
63%
100%
Full
Percentage of image revealed by feature source

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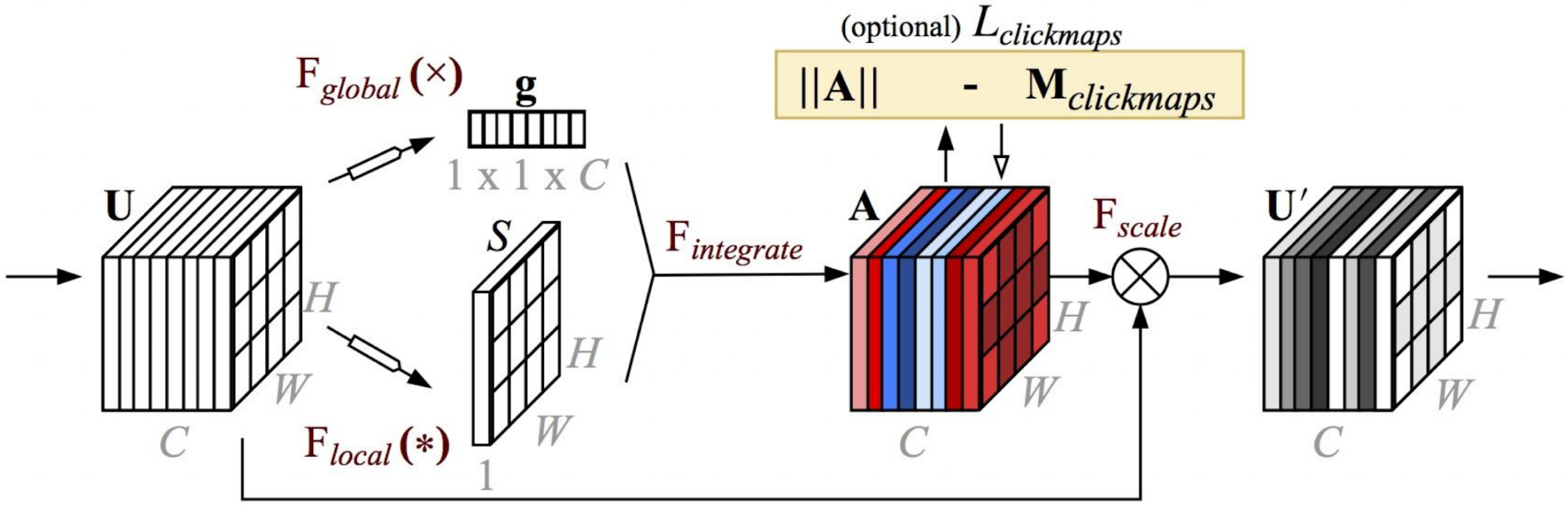
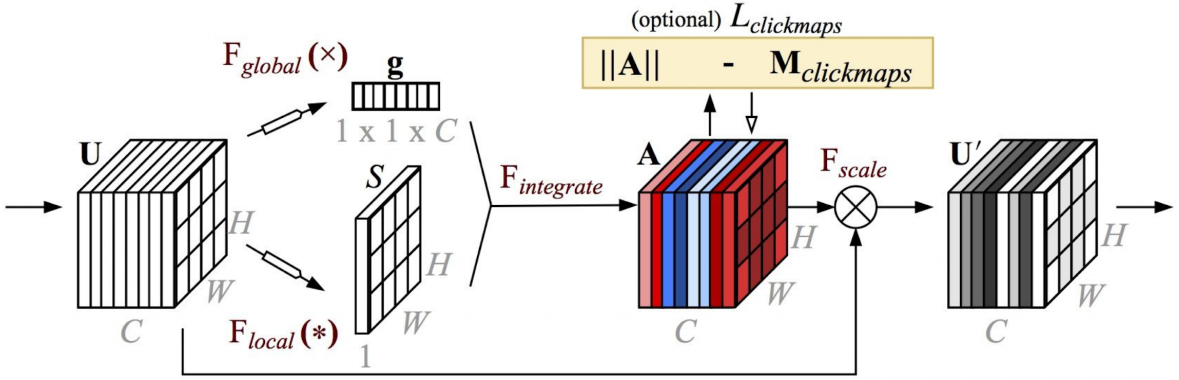
Global-and-local attention (GALA) block



$\mathbf{U}, \mathbf{A} \in \mathbb{R}^{H \times W \times C}$ $\quad \mathbf{g} \in \mathbb{R}^{1 \times 1 \times C}$

$S \in \mathbb{R}^{H \times W \times 1}$

Global attention g



$$\mathbf{p_k} = \frac{1}{WH} \sum_{x=1}^{W} \sum_{y=1}^{H} \mathbf{u}_{kxy}$$

$$\mathbf{g} = W_{\text{expand}} \left(\delta \left(W_{\text{shrink}} (\mathbf{p}) \right) \right)$$

$$\mathbf{U} = \left[\mathbf{u}_k \right]_{k=1 \ldots C} \in \mathbb{R}^{H \times W \times C}$$

$$\mathbf{p} = \left(p_k \right)_{k=1 \ldots C} \in \mathbb{R}^{1 \times 1 \times C}$$

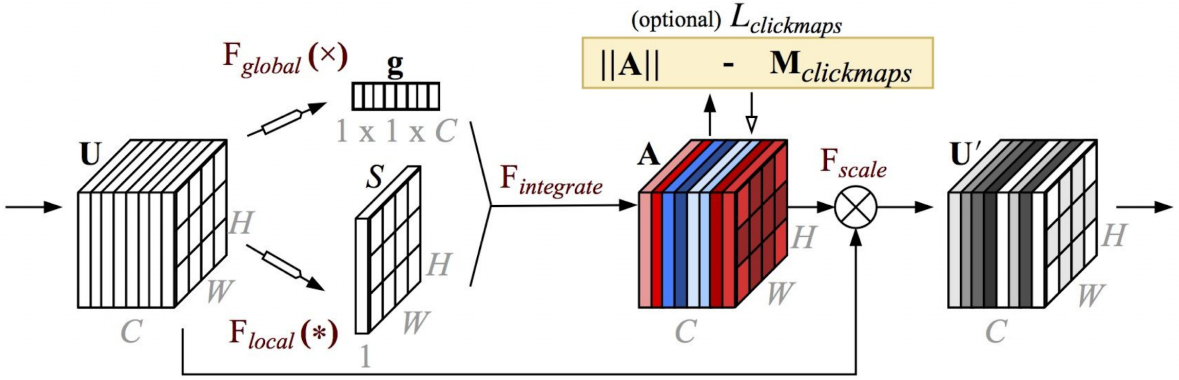
$$\mathbf{g} \in \mathbb{R}^{1 \times 1 \times C}$$

$$W_{\text{shrink}} \in \mathbb{R}^{\frac{c}{r} \times C}$$

$$W_{\text{expand}} \in \mathbb{R}^{C \times \frac{c}{r}}$$

$$r = 4$$

Local attention S



$$S = \mathbf{V}_{\text{collapse}} * \left(\delta \left(\mathbf{V}_{\text{shrink}} * \mathbf{U} \right) \right) \in \mathbb{R}^{H \times W \times 1}$$

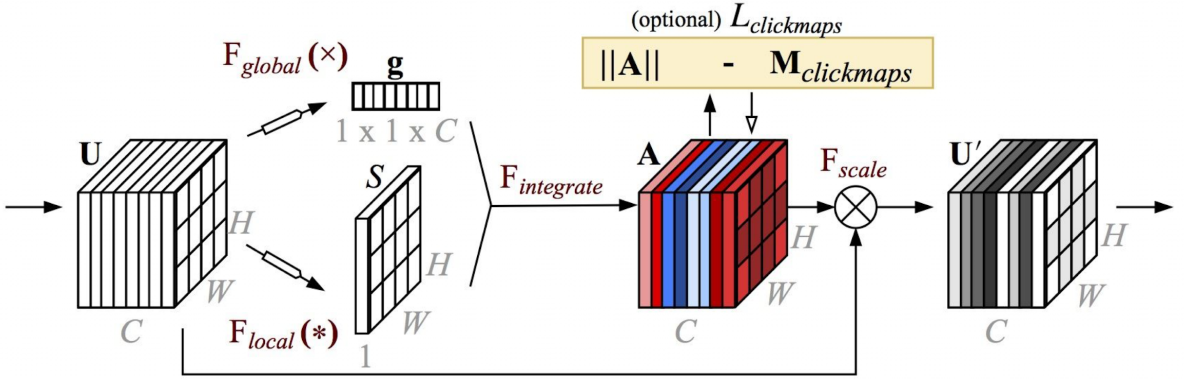
$$\mathbf{U} \in \mathbb{R}^{H \times W \times C}$$

$$S \in \mathbb{R}^{H \times W \times 1}$$

$$\mathbf{V}_{\text{shrink}} \in \mathbb{R}^{1 \times 1 \times C \times \frac{c}{r}}$$

$$\mathbf{V}_{\text{collapse}} \in \mathbb{R}^{1 \times 1 \times \frac{c}{r} \times 1}$$

Total attention A



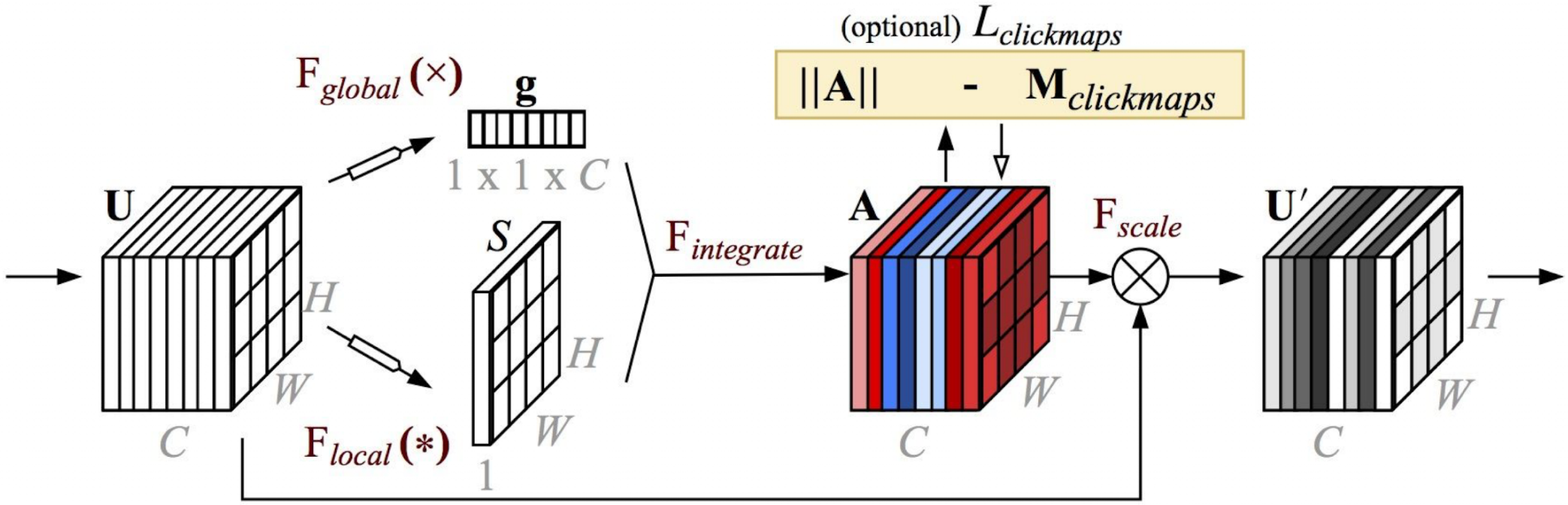
$$\mathbf{A}_{h,w,c} = \zeta\left(a_c\left(\boldsymbol{G}^*_{h,w,c} + \boldsymbol{S}^*_{h,w,c}\right) + m_c\left(\boldsymbol{G}^*_{h,w,c} \cdot \boldsymbol{S}^*_{h,w,c}\right)\right)$$

$$\mathbf{g} \in \mathbb{R}^{1\times1\times C}$$
$$S \in \mathbb{R}^{H\times W\times 1}$$
$$\boldsymbol{G}^*, \boldsymbol{S}^* \in \mathbb{R}^{H\times W\times C}$$

$$\mathbf{U}' = \mathrm{F}_{\mathsf{scale}}(\mathbf{U}, \mathbf{A}) = \mathbf{U} \odot \mathbf{A}$$

$$\left(m_c\right)_{c\in1..C}$$
$$\left(a_c\right)_{c\in1\ldots C}$$

Global-and-local attention (GALA) block



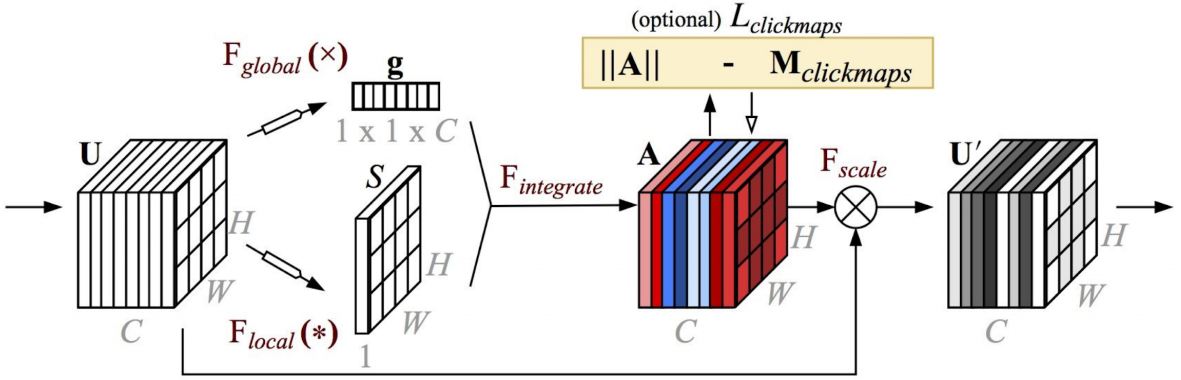
$\mathbf{U}, \mathbf{A} \in \mathbb{R}^{H \times W \times C}$ $\quad \mathbf{g} \in \mathbb{R}^{1 \times 1 \times C}$

$S \in \mathbb{R}^{H \times W \times 1}$

Network architecture

- ResNet-50
- Apply GALA module to final activity in a dense path of a residual module at 6 mid- to high-level feature layers (layers 24, 27, 30, 33, 36, 39)
  - 14x14

ClickMe Supervision



$$\mathscr{L}_T(\mathbf{X}, y) = \mathscr{L}_C(M(\mathbf{X}), y) + \mathscr{L}_{clickmaps}(\mathbf{X})$$

$$\mathscr{L}_{clickmaps}(\mathbf{X}) = \lambda \sum_{l \in \mathbf{L}} \left\| \frac{R^l(\mathbf{X})}{\| R^l(\mathbf{X}) \|_2} - \frac{\mathbf{A}^l(\mathbf{X})}{\| \mathbf{A}^l(\mathbf{X}) \|_2} \right\|_2$$

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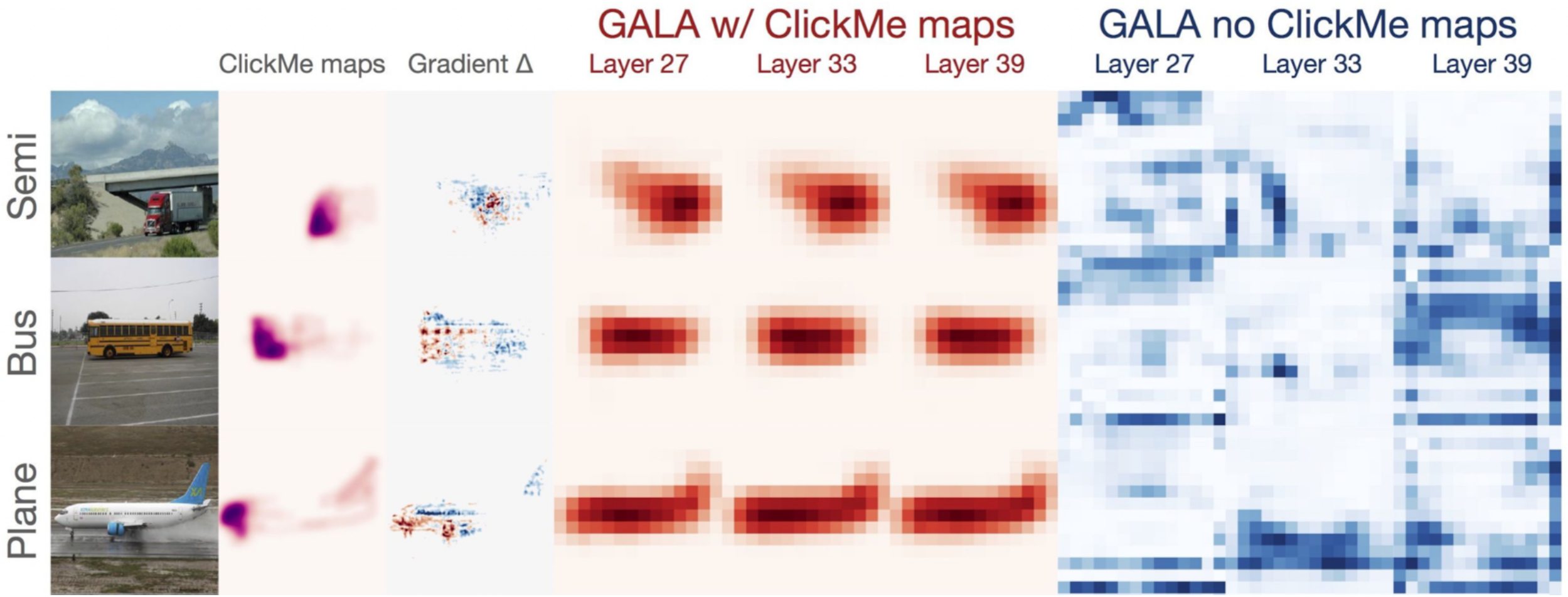
Evaluation

- Object classification accuracy
- Similarity between ClickMe maps and model attention maps
- Analysis over different values of λ -> $\lambda = 6$
- Model interpretability

Results

	top-1 err	top-5 err	maps
SE-ResNet-50	66.17	42.48	64.36**
ResNet-50	63.68	40.65	43.61
GALA-ResNet-50 no ClickMe	53.90	31.04	64.21**
GALA-ResNet-50 w/ ClickMe	**49.29**	**27.73**	**88.56****

	Reference		Ours	
	top-1 err.	top-5 err.	top-1 err.	top-5 err.
ResNet-50 (He et al., 2016)	24.70	7.80	23.88	6.86
SE-ResNet-50 (Hu et al., 2017)	23.29	6.62	23.26	6.55
GALA-ResNet-50 no ClickMe	-	-	**22.73**	**6.35**


GALA w/ ClickMe maps
GALA no ClickMe maps
ClickMe maps
Gradient Δ
Layer 27
Layer 33
Layer 39
Layer 27
Layer 33
Layer 39
Semi
Bus
Plane

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Discussion and Limitations

- ClickMe supervised GALA training
  - Improved performance when **data is limited**
  - Selects features similar to features that humans deem important -> possible application in areas where **interpretability** is important, e.g. in medicine
- For large datasets no improvement

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Conclusion

- **ClickMe dataset**
- **GALA module:** attention inspired by human attention
- **GALA + ClickMe:** Leverage human supervision to co-train an attention network

- Authors exaggerate how well their method performs
- A lot of results not presented in main part, but only in appendix
- Global attention in humans interesting insight

Source: http://www.home-designing.com/workstation-setup-ideas-photos

Source: https://whc.unesco.org/en/list/1505/

Thank you for your attention!

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