Leveraging Uncertainty for Deep Interpretable Classification and Weakly-Supervised Segmentation of Histology Images

#4

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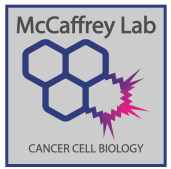
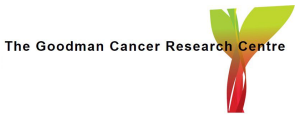
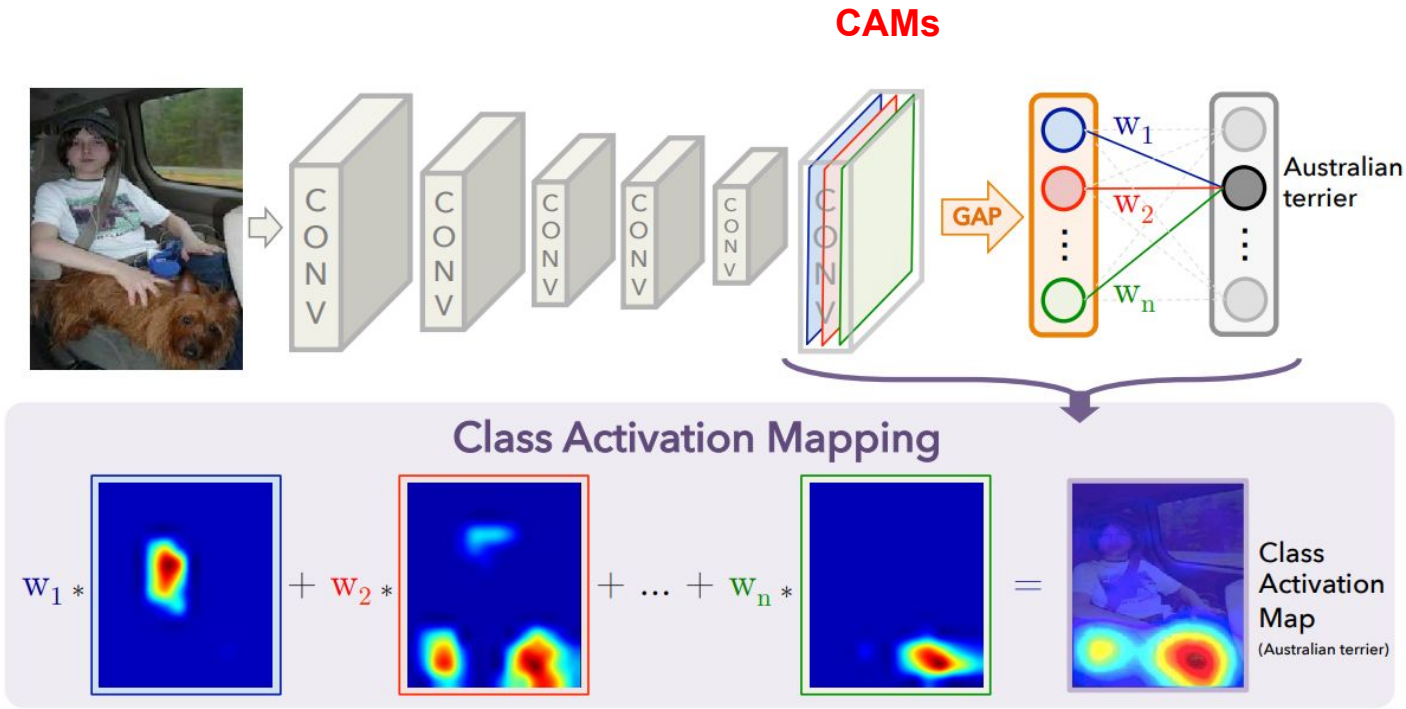
MIDL 2022 - Short





Classifier, ROI localization, and interpretability via global labels

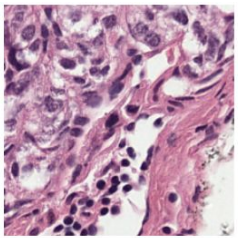


CAMs' challenges in histology images

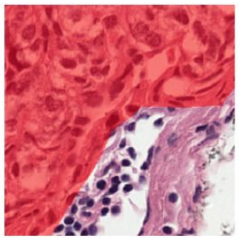
- Non-salient object → visual similarity between foreground/background

↓

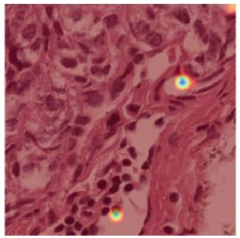
High false positives/negatives



Input



Ground truth

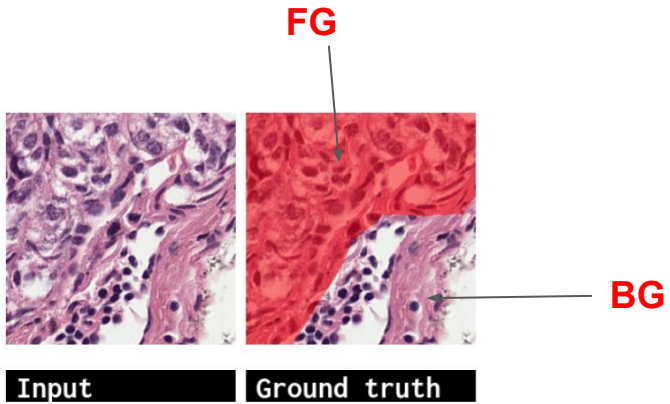


CAM

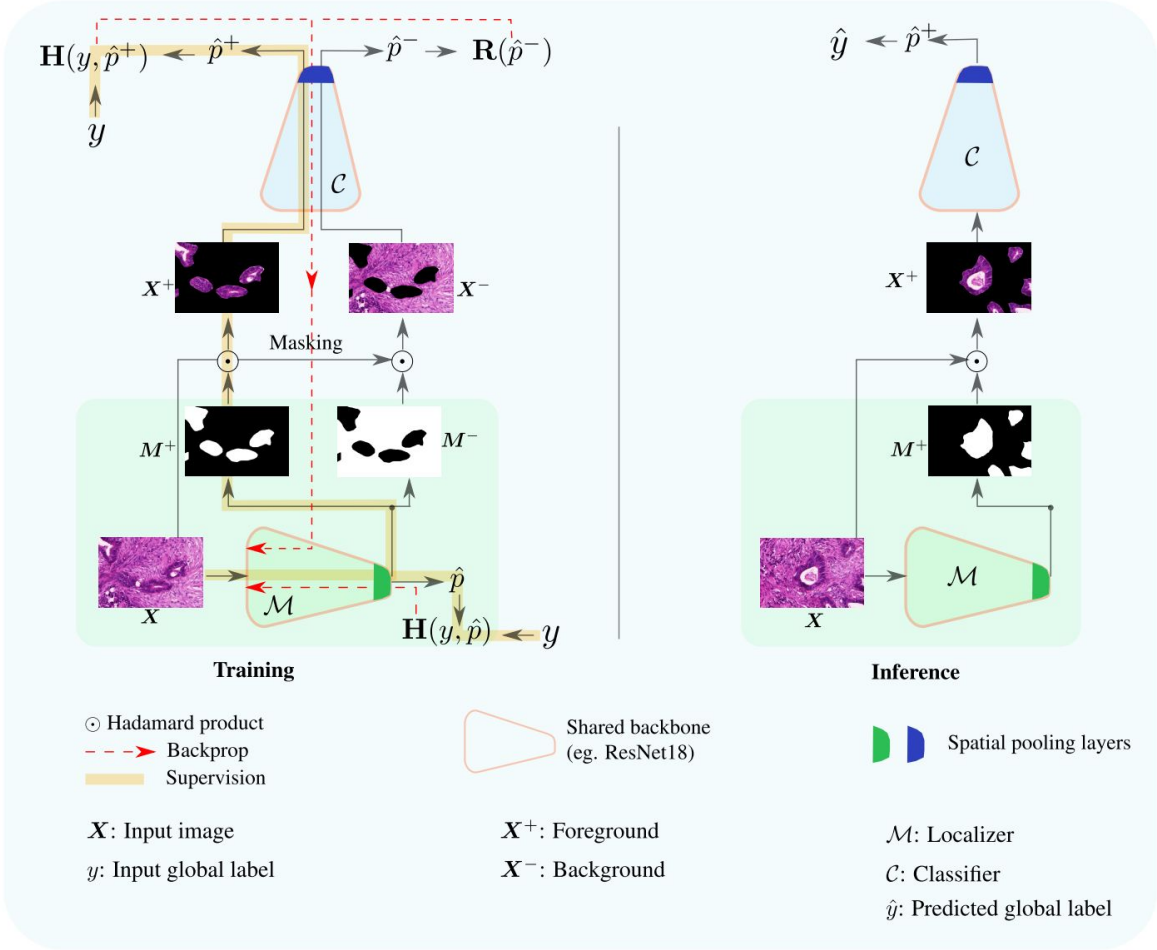
Deep Weakly-Supervised Learning Methods for Classification and Localization in Histology Images: A Comparative Study. 2022. arxiv.org/abs/1909.03354

Our work: Constrain CAMs

- Explicit modeling foreground/background map
- Constrain the presence of both FG / BG using size constraints
- Ensure that each map is consistent using classifier response.



Our architecture



Training loss

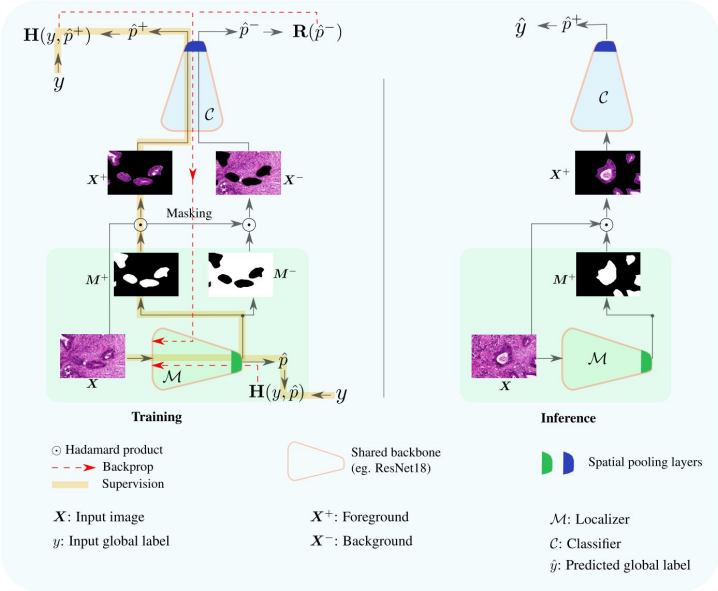
ASC: Absolute Size Constraint

$$\min_{\boldsymbol{\theta}_C} \quad \mathbf{H}(p, \hat{p}^+) + \lambda\, \mathbf{R}(\hat{p}^-) - \frac{1}{t}\left[\log \boldsymbol{s}^+ + \log \boldsymbol{s}^-\right],$$

Maximize classifier Response over FG

The BG has no discriminative regions left

Ensure both FG/BG are present: max size.



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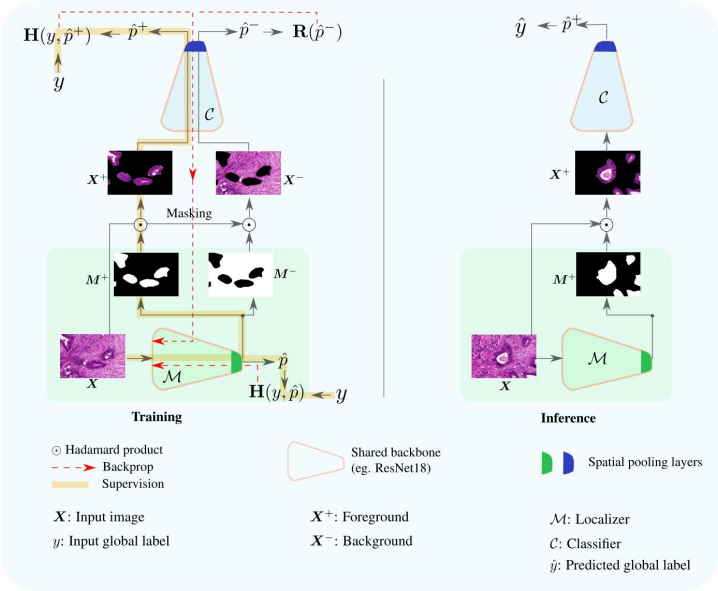

$$\mathbf{R}(\hat{p}^-) = -\mathbf{H}(\hat{p}^-); \quad \text{or} \quad \mathbf{R}(\hat{p}^-) = \mathbf{H}(q, \hat{p}^-),$$

Explicit Entropy Maximization (EEM)

Surrogate for explicit Entropy Maximization (SEM). q: uniform dist.

Training loss

ASC: Absolute Size Constraint

$$\min_{\boldsymbol{\theta}_C} \quad \mathbf{H}(p, \hat{p}^+) + \lambda\, \mathbf{R}(\hat{p}^-) - \frac{1}{t}\left[\log \boldsymbol{s}^+ + \log \boldsymbol{s}^-\right],$$

Maximize classifier Response over FG

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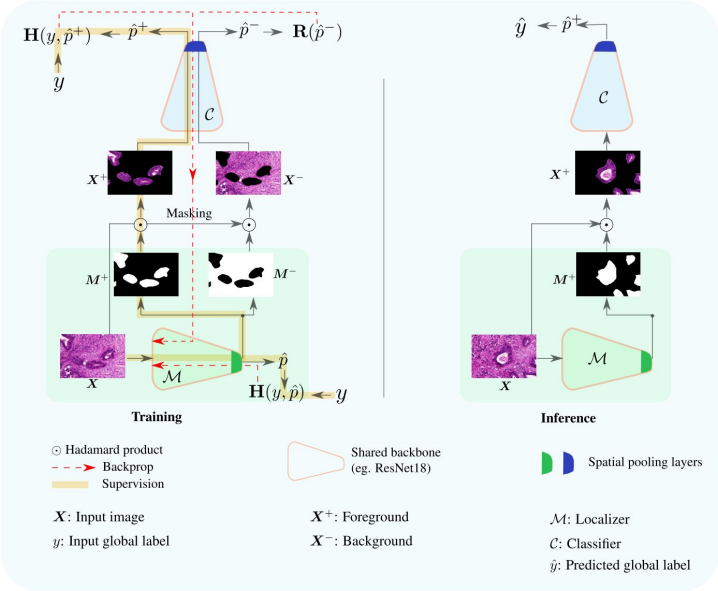
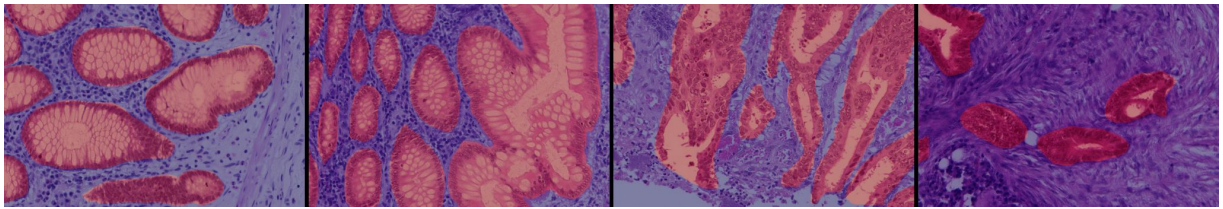


$$\boldsymbol{s}^+ = \sum_{z\in\Omega} \boldsymbol{M}^+(z)\,, \quad \boldsymbol{s}^- = \sum_{z\in\Omega} \boldsymbol{M}^-(z)$$

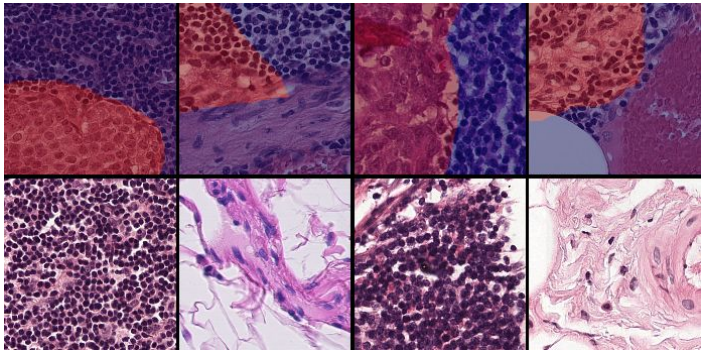
Sizes

Experiments

- Task: classify and localize ROI
- 2 public datsets: GlaS, Camelyon16 patches.



GlaS: colon cancer diagnosis



Camelyon16 patches: breast cancer

Results

Method	Image level Cl. error (%)	Pixel level $F1^+$ (%)	Pixel level $F1^-$ (%)
All-ones (Lower-bound)	−−	66.01	00.00
PN [39]	−−	65.52	24.08
ERASE [80]	7.50	65.60	25.01
CAM-Max [52]	1.25	66.00	26.32
CAM-LSE [57, 74]	1.25	66.05	27.93
Grad-CAM [64]	**0.00**	66.30	21.30
CAM-Avg [88]	**0.00**	66.90	17.88
Wildcat [20]	1.25	67.21	22.96
Deep MIL [33]	**2.50**	68.52	41.34
Ours (EEM)	**0.00**	**72.11**	69.07
Ours (SEM)	**0.00**	71.94	**69.23**
U-Net [60] (Upper-bound)	−−	90.19	88.52

GlaS

Method	Image level Cl. error (%)	Pixel level $F1^+$ (%)	Pixel level $F1^-$ (%)
All-ones (Lower-bound)	−−	59.44	00.00
PN [39]	−−	31.15	37.36
ERASE [80]	8.61	31.30	42.48
CAM-Max [52]	10.06	48.28	81.92
CAM-LSE [57, 74]	1.51	64.31	63.78
Grad-CAM [64]	2.40	62.78	79.05
CAM-Avg [88]	2.40	62.75	79.05
Wildcat [20]	**1.48**	62.73	72.59
Deep MIL [33]	1.93	59.01	36.94
Ours (EEM)	6.26	67.98	**88.80**
Ours (SEM)	6.95	**68.26**	88.55
U-Net [60] (Upper-bound)	−−	71.11	89.68

Camelyon16

Visual results

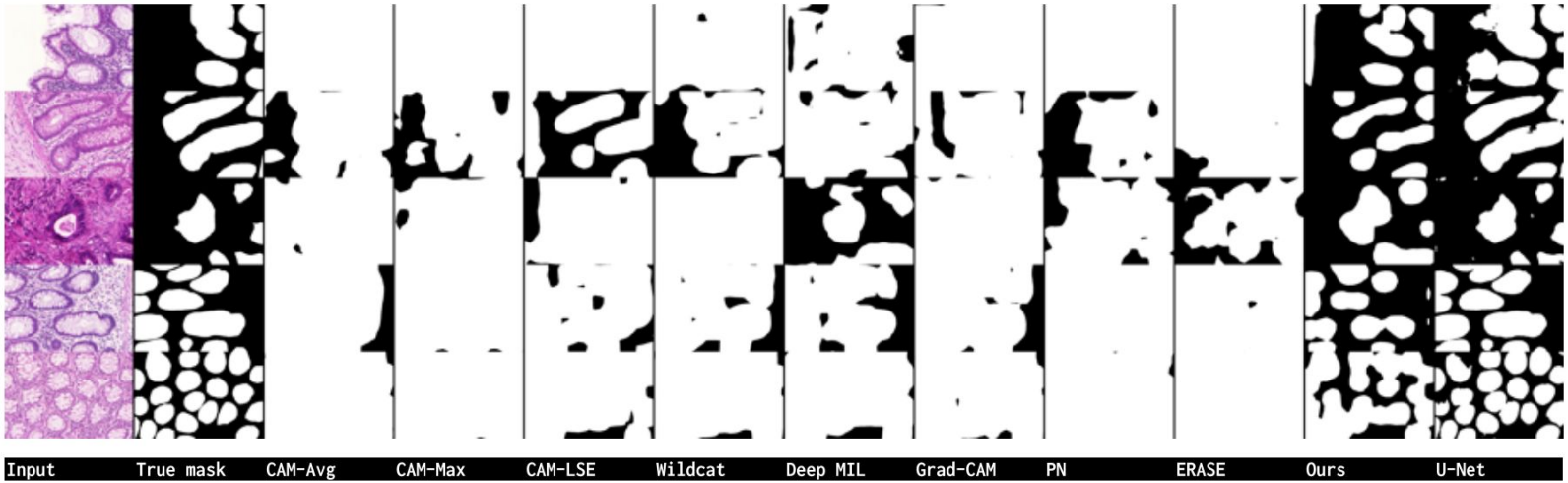


Figure 2: **GlaS dataset**: Qualitative results of the predicted binary mask for each method on several GlaS test images. Our method, referred to as *Ours*, is the SEM version with the ASC regularization term. (Best visualized in color.)

Visual results

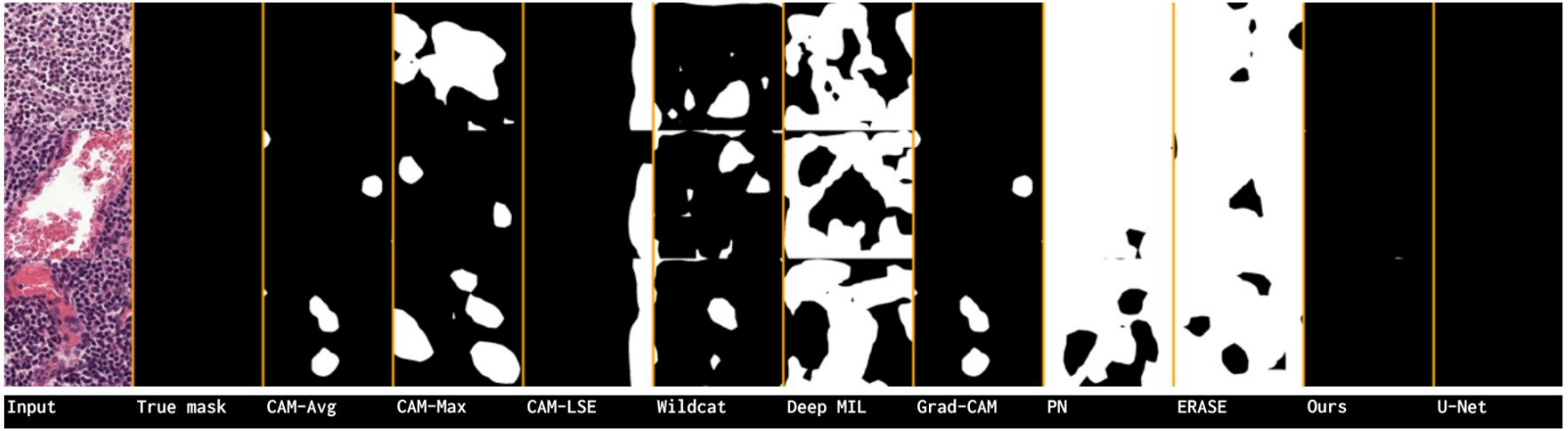


Figure 3: **Camelyon16-P512 benchmark**: Examples of mask predictions over **normal** samples from the testing set. White pixels indicate metastatic regions, while black pixels indicate normal tissue. This illustrates false positives. Note that normal samples do not contain any metastatic regions. Ours is SEM version with the ASC regularization. (Best visualized in color.)

Results

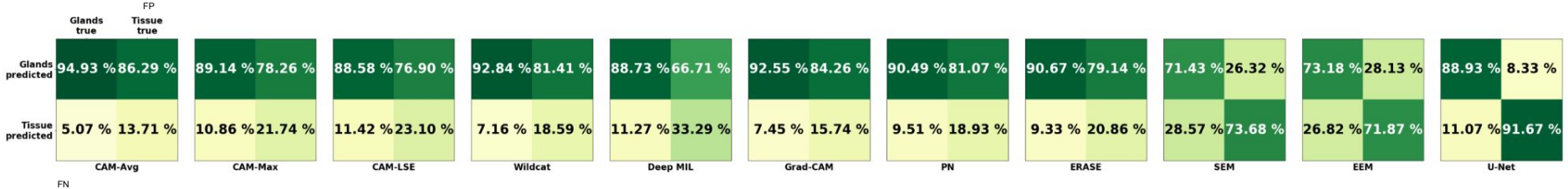


Figure 5: **GlaS dataset**: Confusion matrix over entire pixels of test set. (Best visualized in color.)

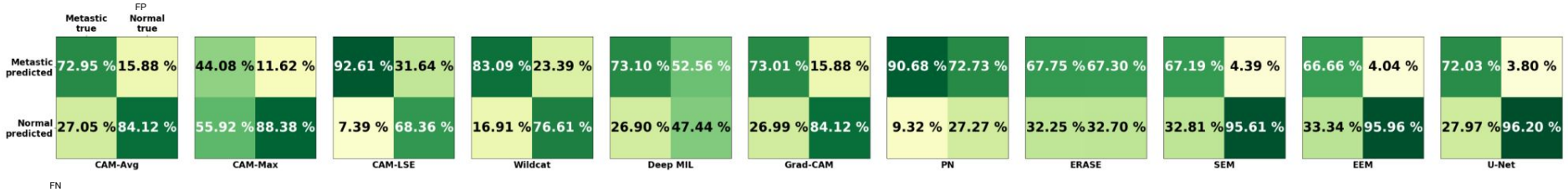
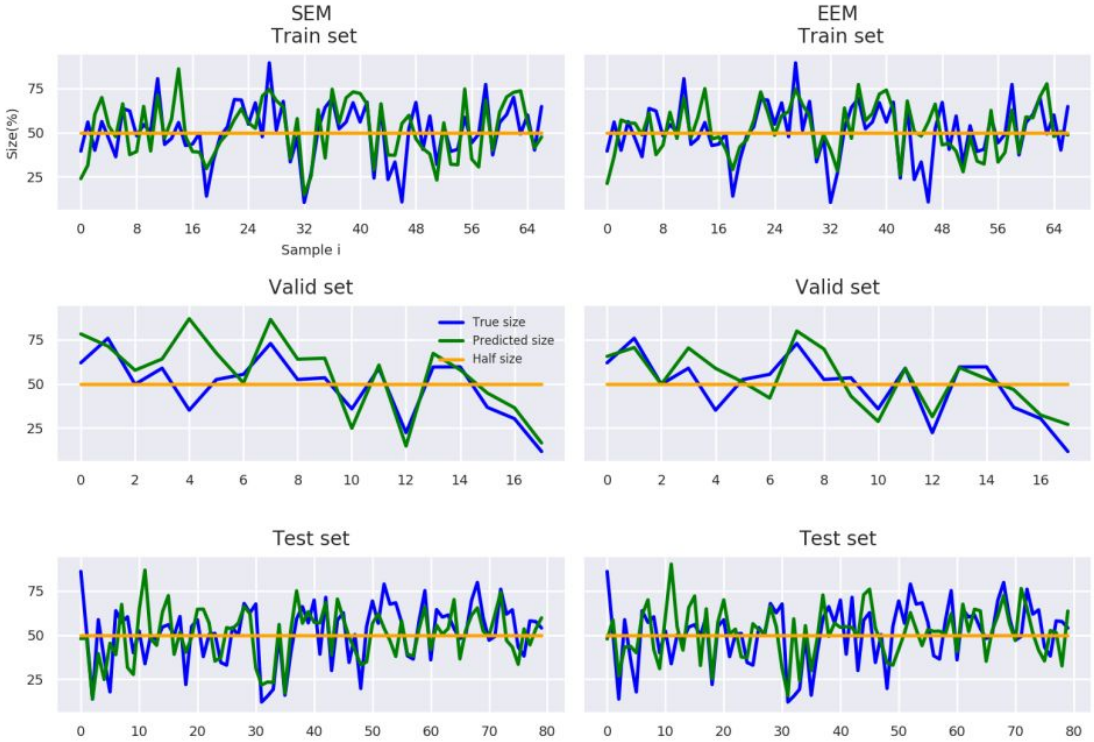


Figure 6: **Camelyon16-P512 dataset**: Confusion matrix over entire pixels of test set. (Best visualized in color.)

Size constraint



GlaS

Ablation

Method	Image level Cl. error (%)	Pixel level $F1^+$ (%)	Pixel level $F1^-$ (%)
Wildcat [20]	1.25	67.21	22.96
FG only	1.25	71.54	49.23
FG + BG (EEM)	1.25	72.54	61.82
FG + BG (EEM) + ASC	0.00	72.11	69.07
FG + BG (SEM)	1.25	**72.96**	61.95
FG + BG (SEM) + ASC	0.00	71.94	**69.23**

Thanks! Questions?

Please visit us at #4 – Short

Code: https://github.com/sbelharbi/deep-wsl-histo-min-max-uncertainty