MULTI-LOSS CONVOLUTIONAL NETWORKS FOR GLAND ANALYSIS IN MICROSCOPY

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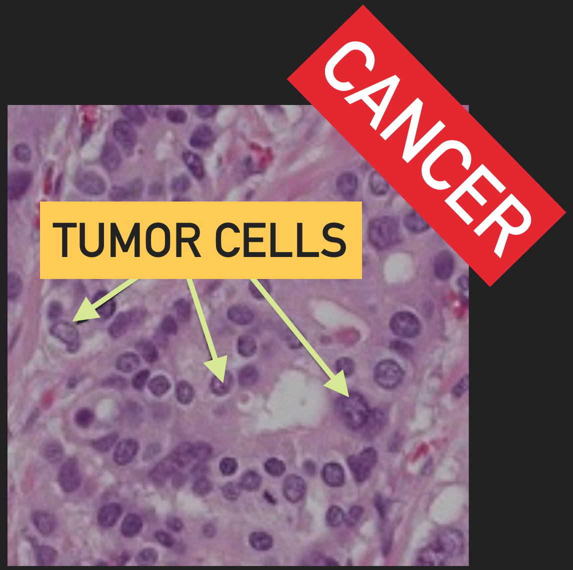
ISBI 2016, SPECIAL SESSION IN DEEP LEARNING FOR MEDICAL IMAGING

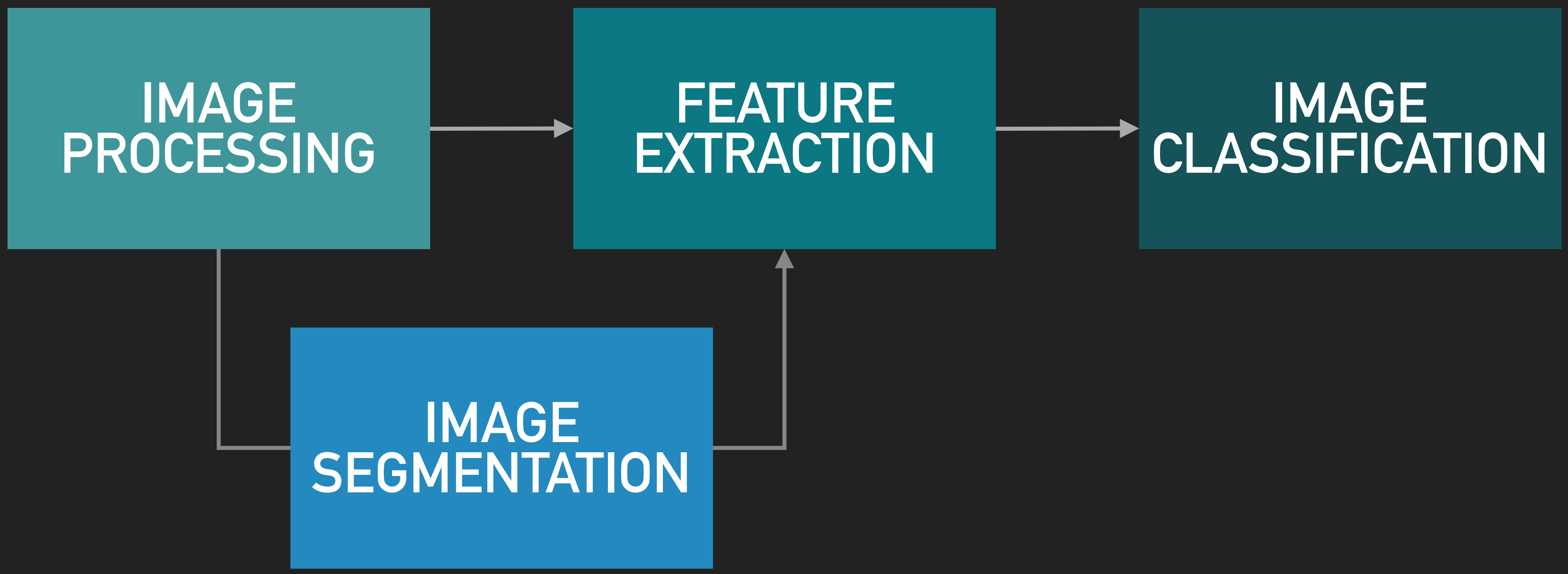
CANCER DIAGNOSIS

- Pathologists' diagnosis involves simultaneous feature identification and tumor classification.



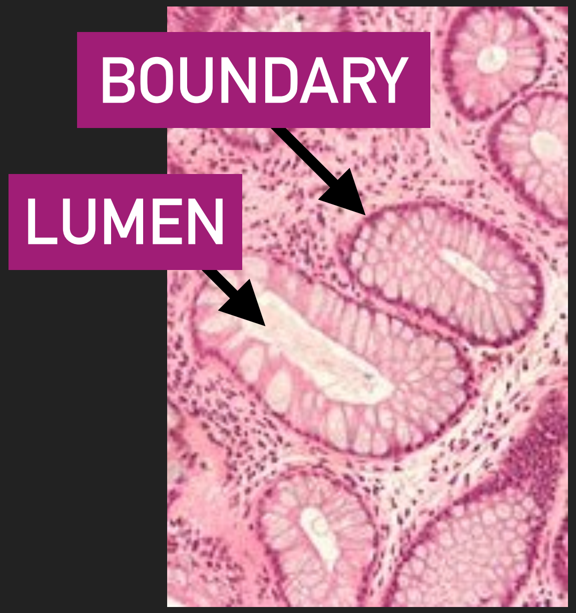
AUTOMATIC CANCER DIAGNOSIS

- Automatic cancer diagnosis often involves independent segmentation and classification steps.



EXAMPLE: GLAND ANALYSIS FOR CANCER DIAGNOSIS

- Glands are reliable bio-markers for different types of adenocarcinoma: colon, breast, prostate, etc.



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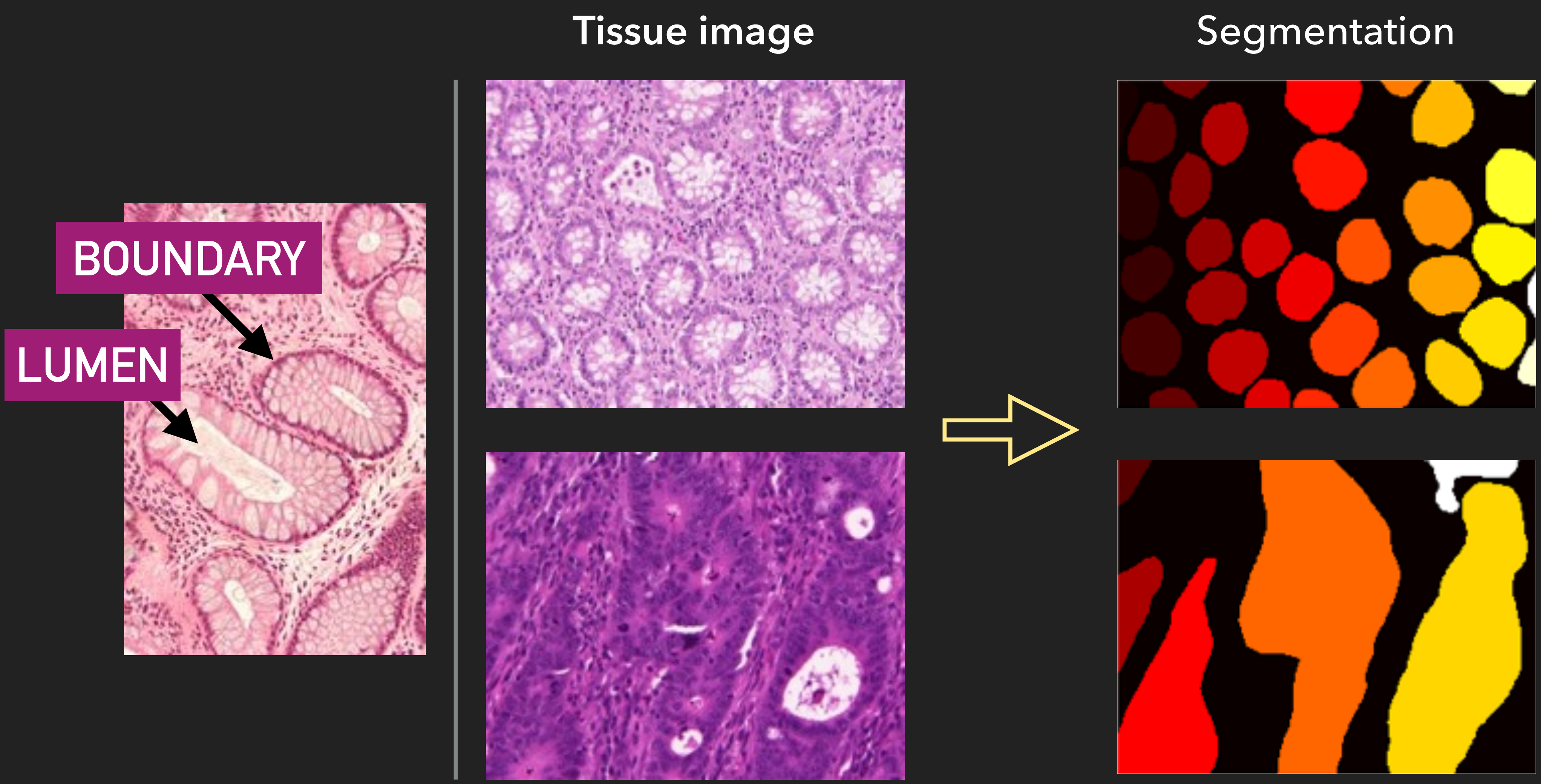

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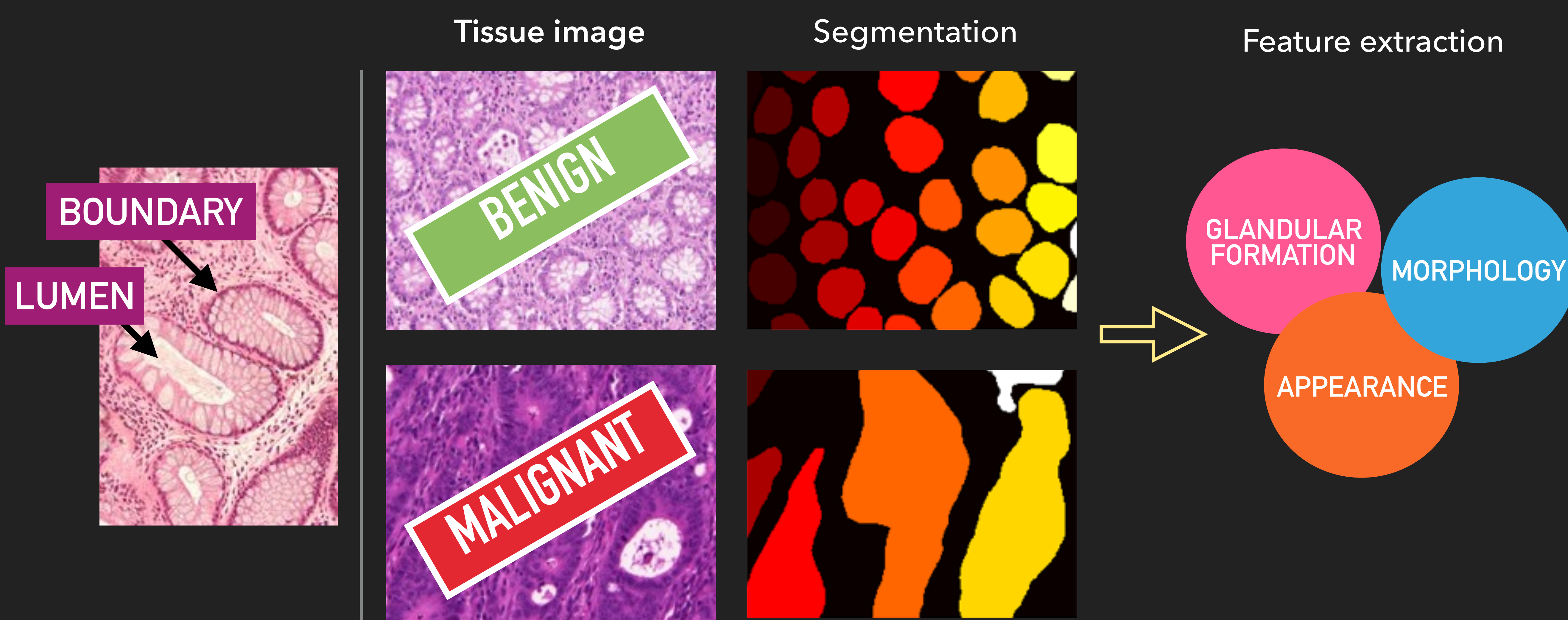
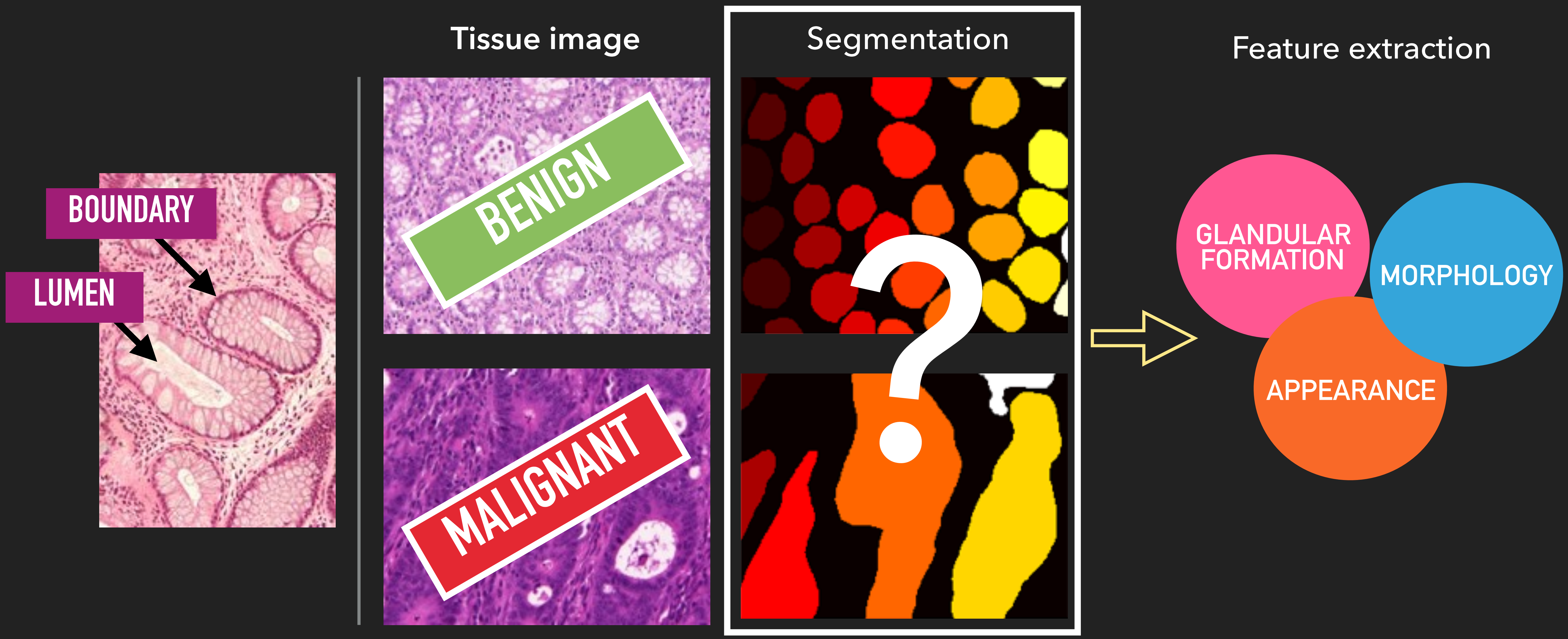


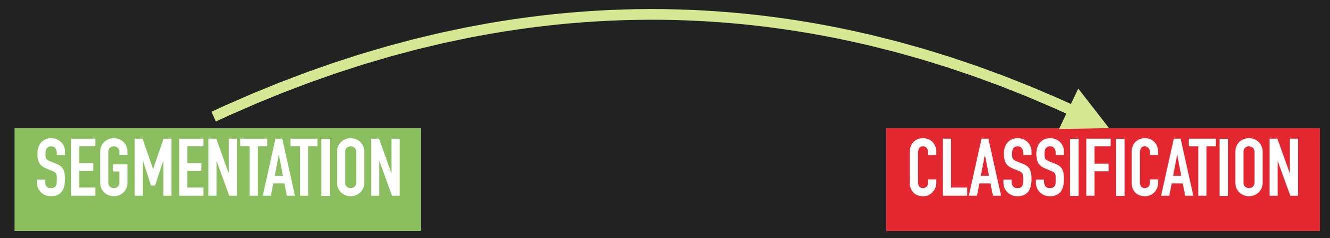
GLAND ANALYSIS FOR CANCER DIAGNOSIS

- Should the class information influence the segmentation ?



JOINT CLASSIFICATION–SEGMENTATION

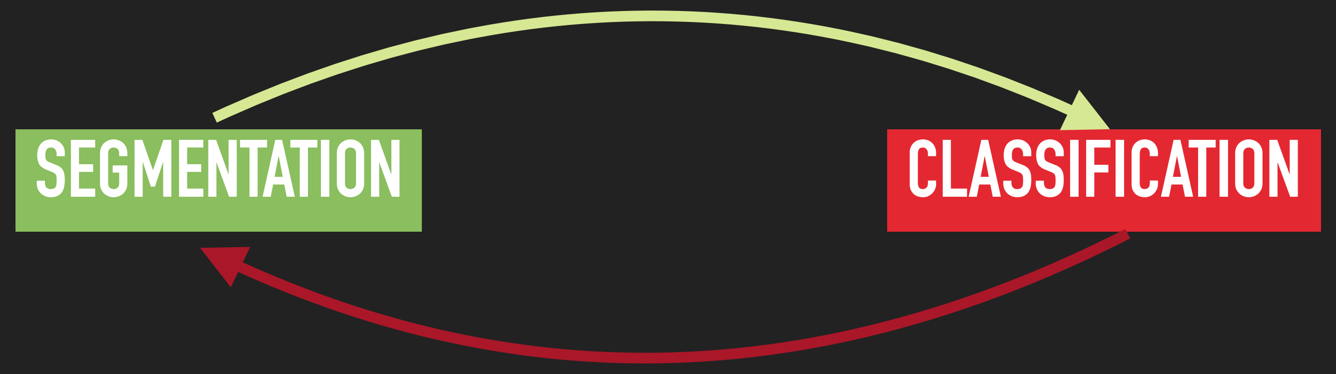
- Classification requires segmentation-based features …



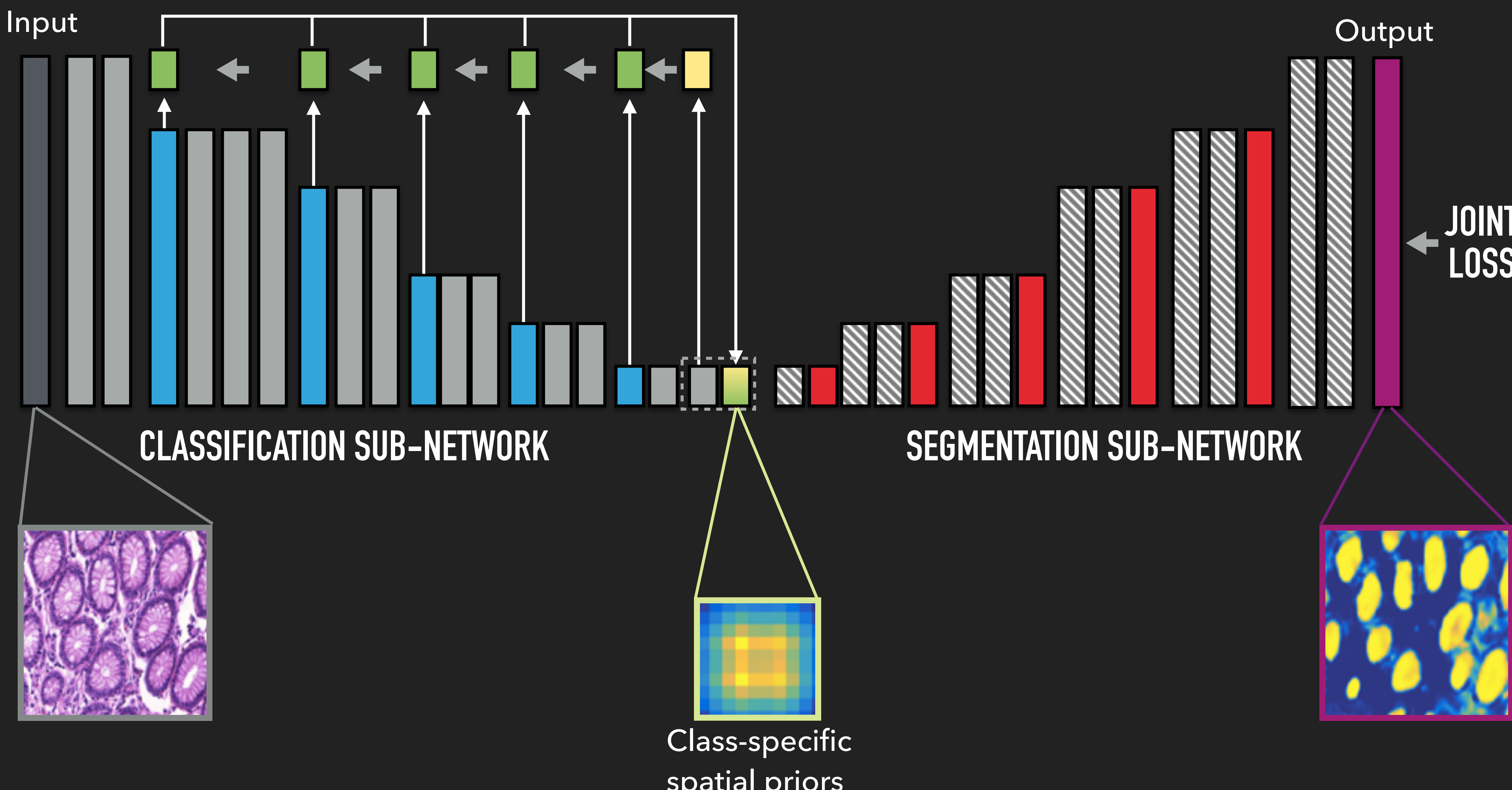
- but generally, segmentation techniques does not involve knowledge of the class …

JOINT CLASSIFICATION-SEGMENTATION

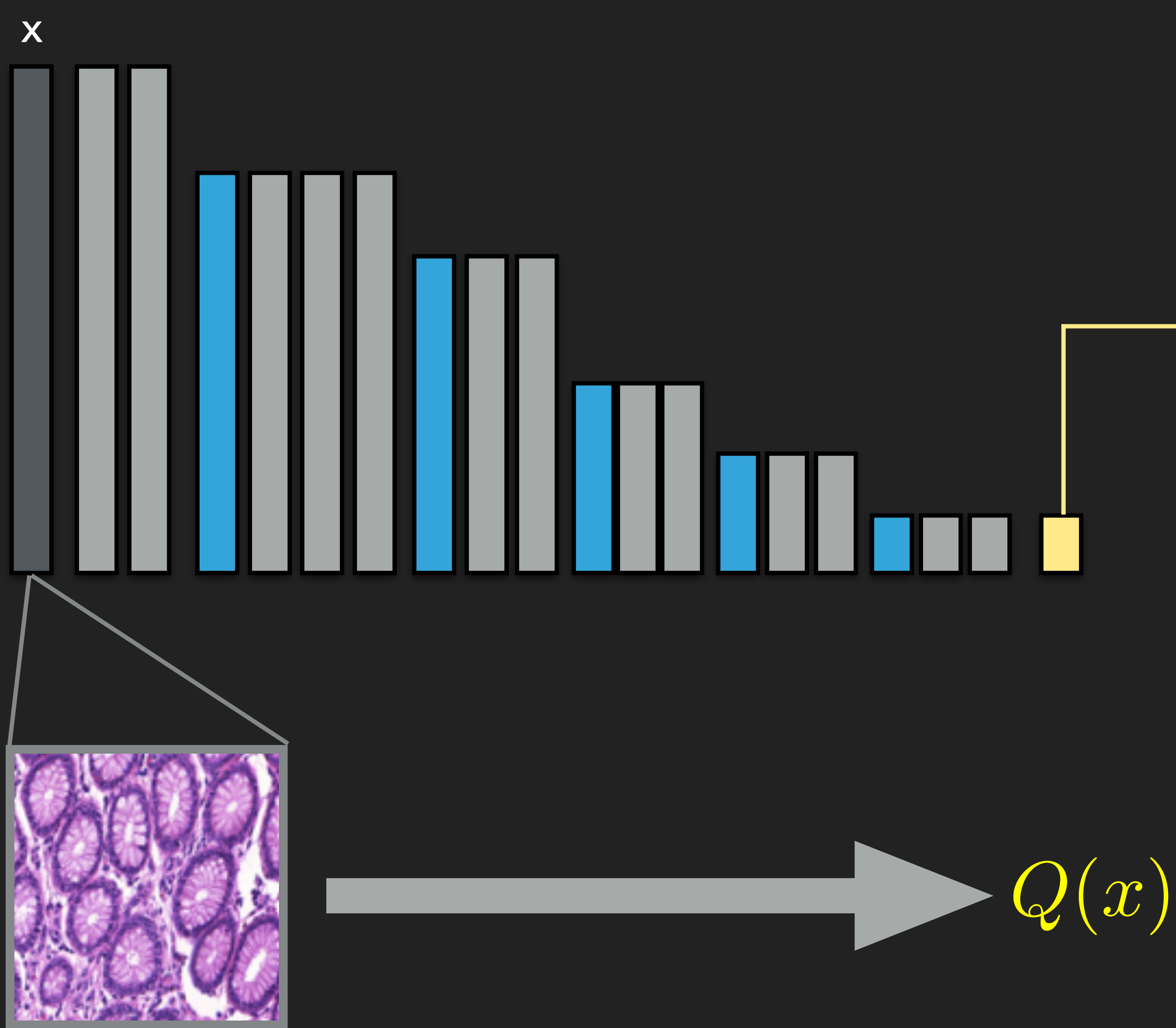
- We pose the problem of automatic tissue diagnosis as the joint task of segmentation and classification.
- Goal: train an end-to-end system to jointly optimize the classification and segmentation predictions.
- Using a deep learning model.



HYBRID CLASSIFICATION-SEGMENTATION NETWORK



CLASSIFICATION SUB-NETWORK

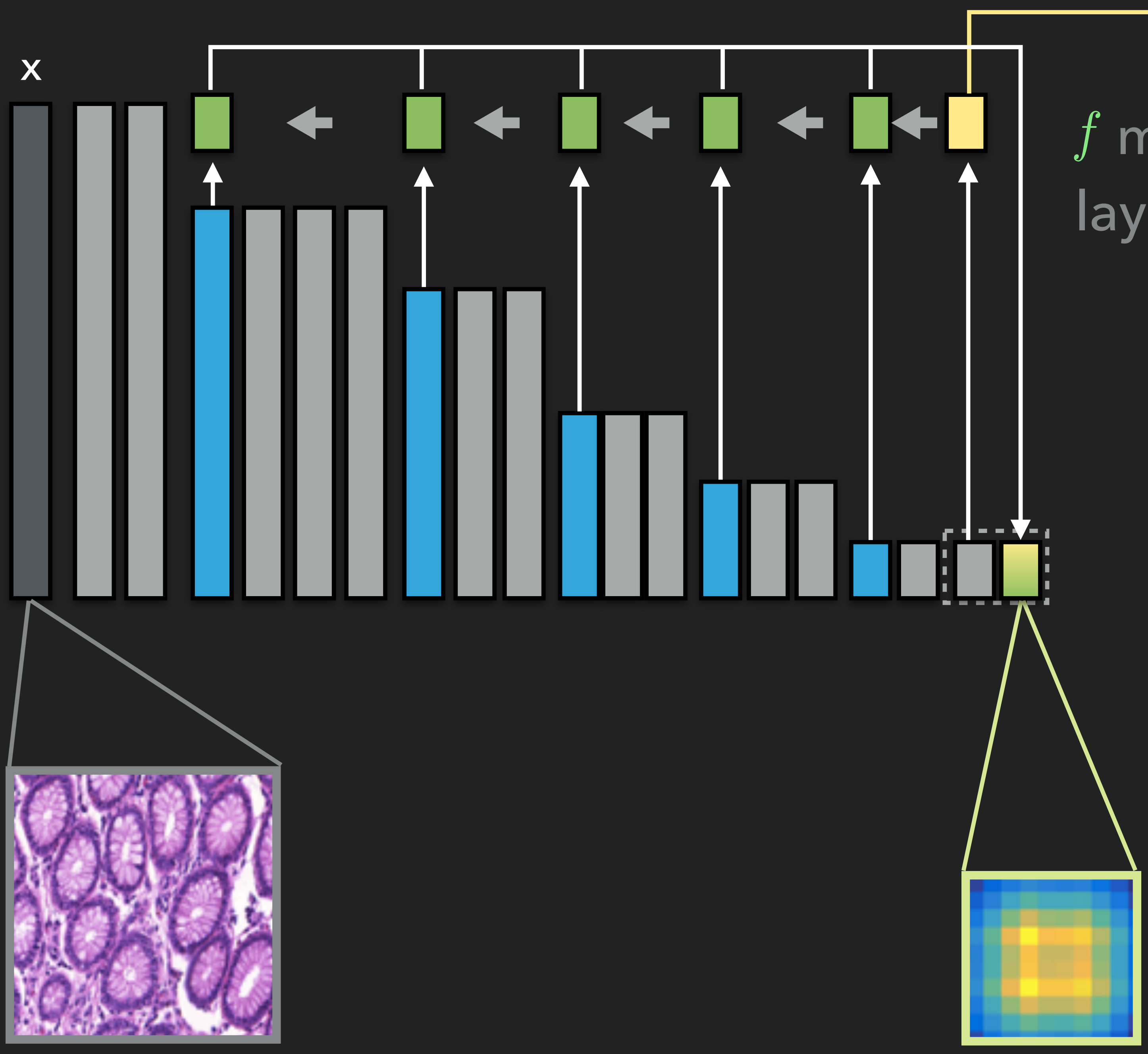


CLASSIFICATION LOSS

$$\mathcal{L}_C = -\log(Q_y(x))$$

$$Q_y(x) = \frac{\exp(z^y(x))}{\sum_{l=1}^{Y} \exp(z^l(x))}$$

CLASS-SPECIFIC SPATIAL PRIORS



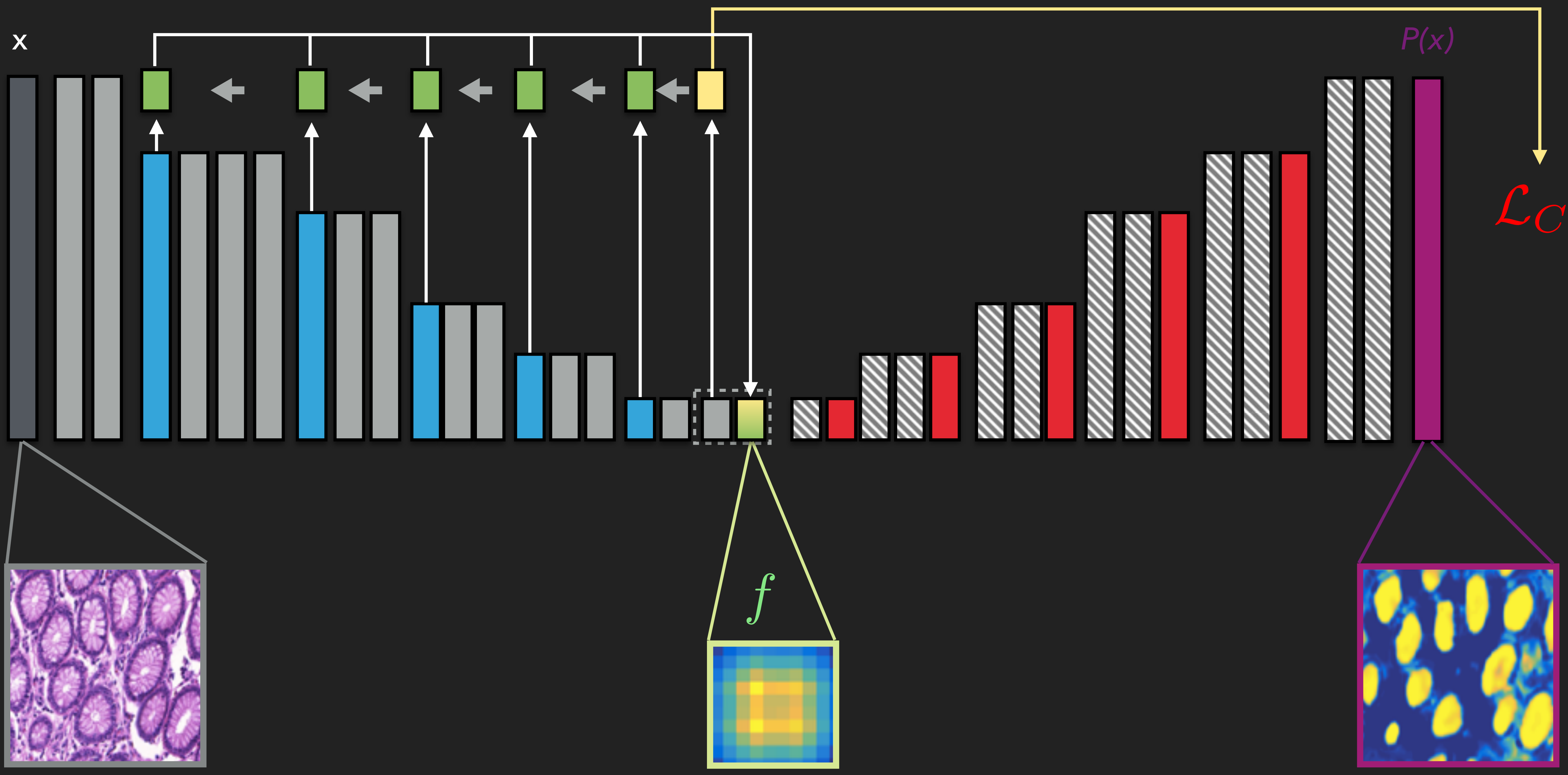
f measures the contribution of each layer to the final classification score:

$\mathcal{L}_C$

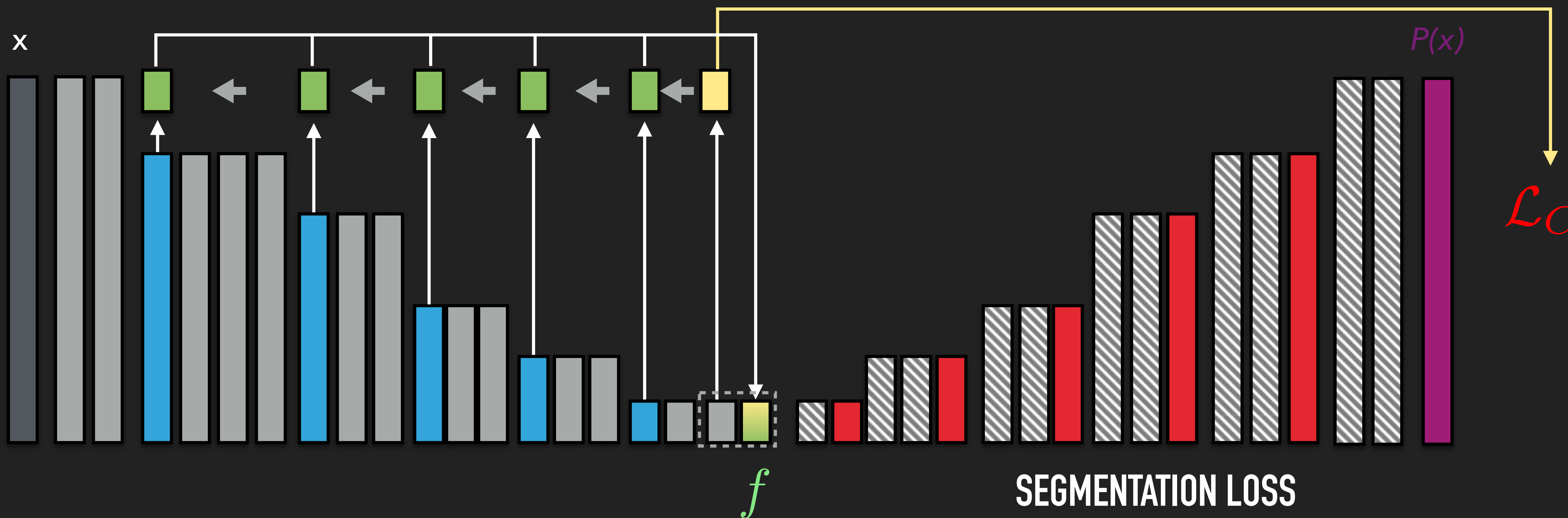
$$f_k^y = \frac{\partial Q_y(x)}{\partial z_k(x)}$$

Simonyan et al. ICLR Workshop, 2014.

FULLY CONVOLUTIONAL SEGMENTATION NETWORK



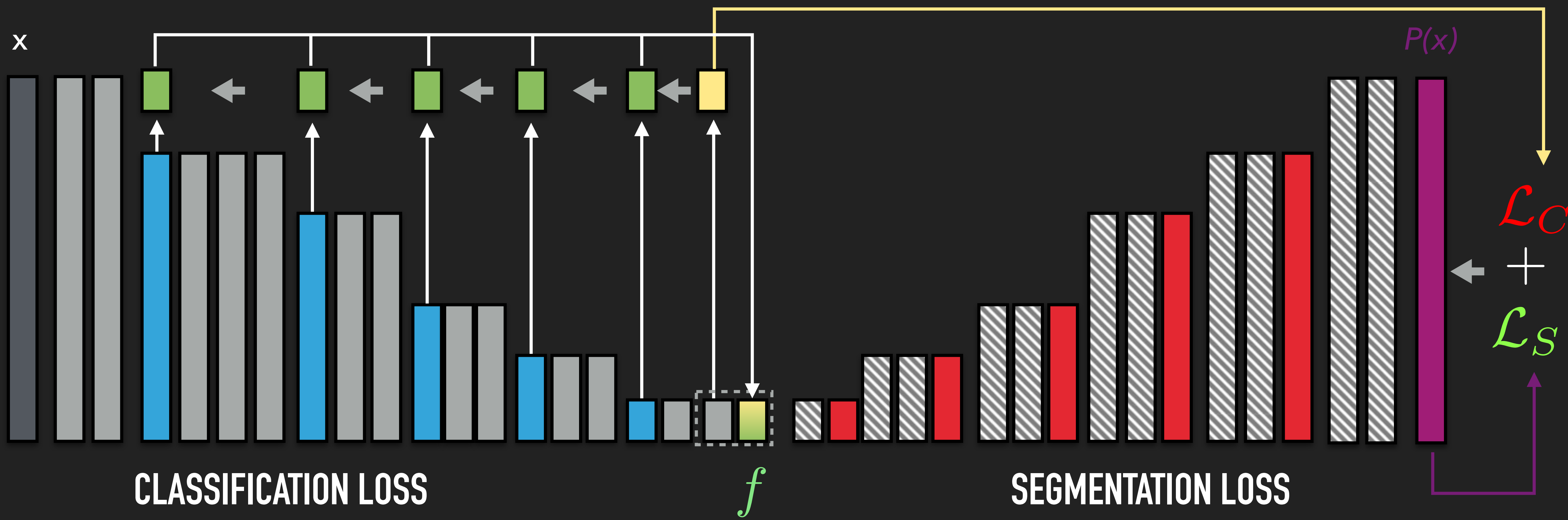
WEIGHTED SEGMENTATION LOSS



SEGMENTATION LOSS

$$\mathcal{L}_S = -\sum_{j=1}^{\Omega} S_j f_j^g (\log P_g(x_j)) + (1 - S_j) f_j^b \log(P_b(x_j))$$

MULTI-LOSS NETWORK



$$\mathcal{L}_C = -\log(Q_y(x))$$

$$\mathcal{L}_S = -\sum_{j=1}^{\Omega} S_j f_j^g (\log P_g(x_j)) + (1 - S_j) f_j^b \log(P_b(x_j))$$

Proposed Loss = $\mathcal{L}_C + \mathcal{L}_S$

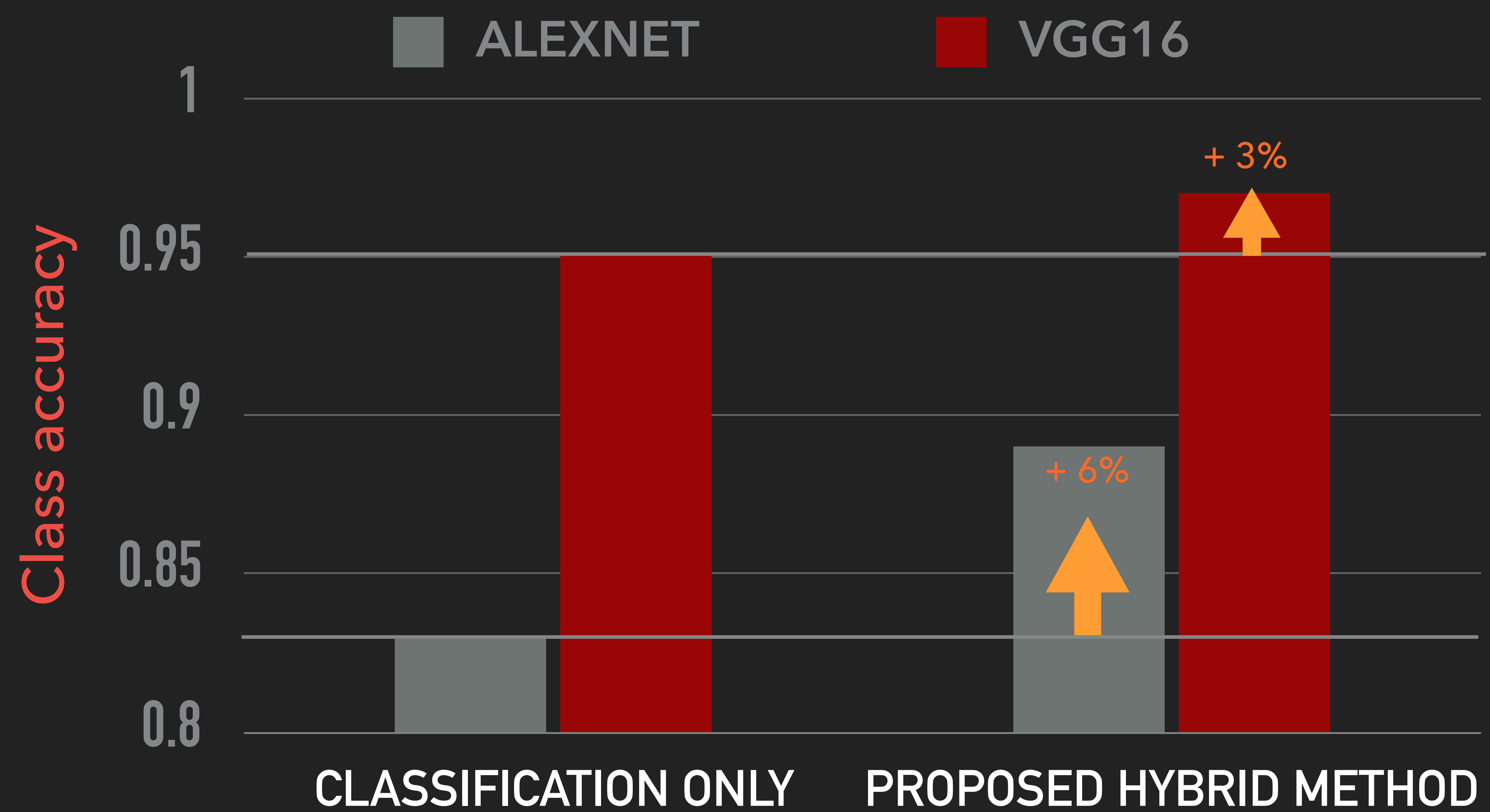
EXPERIMENTS

- Dataset:
  - GLaS gland segmentation challenge, MICCAI 2015 [1].
  - 85 training images: 37 Benign, 48 Malignant.
  - 80 test images: 37 Benign, 43 Malignant.
- Model training:
  - Sequential training: 1) Classifier 2) Segmentation 3) Joint fine-tuning.
  - Stochastic Gradient Descent optimization.
  - Implemented in Caffe [2].

[1] Sirinukunwattana et al. arXiv:1603.00275 (2016).
[2] Jia et al. arXiv:1408.5093 (2014).

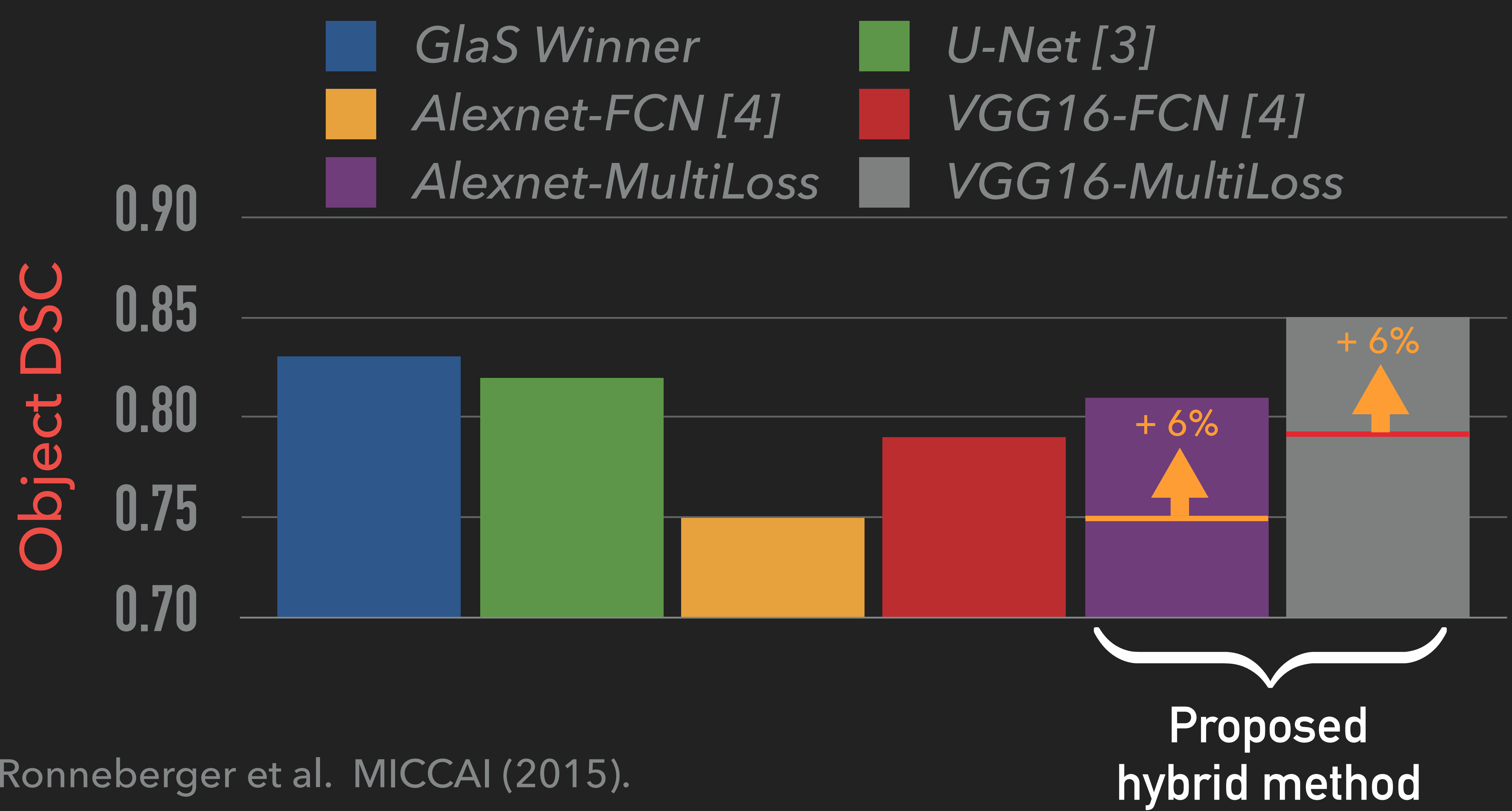
CLASSIFICATION ACCURACY

Our hybrid classification-segmentation approach increases the classification accuracy up to 6%



SEGMENTATION RESULTS

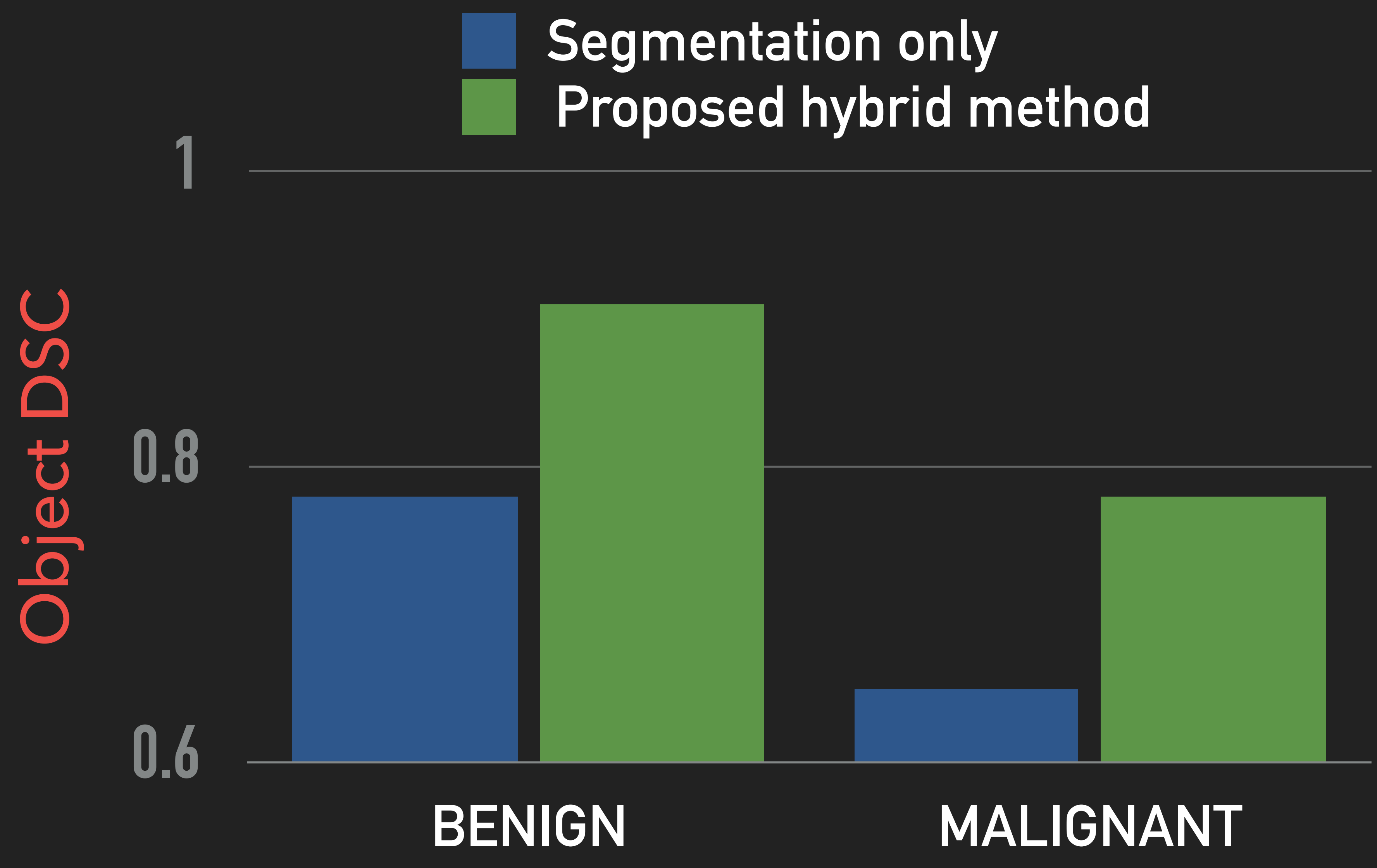
Using class-specific priors increases the segmentation Dice by 6%.



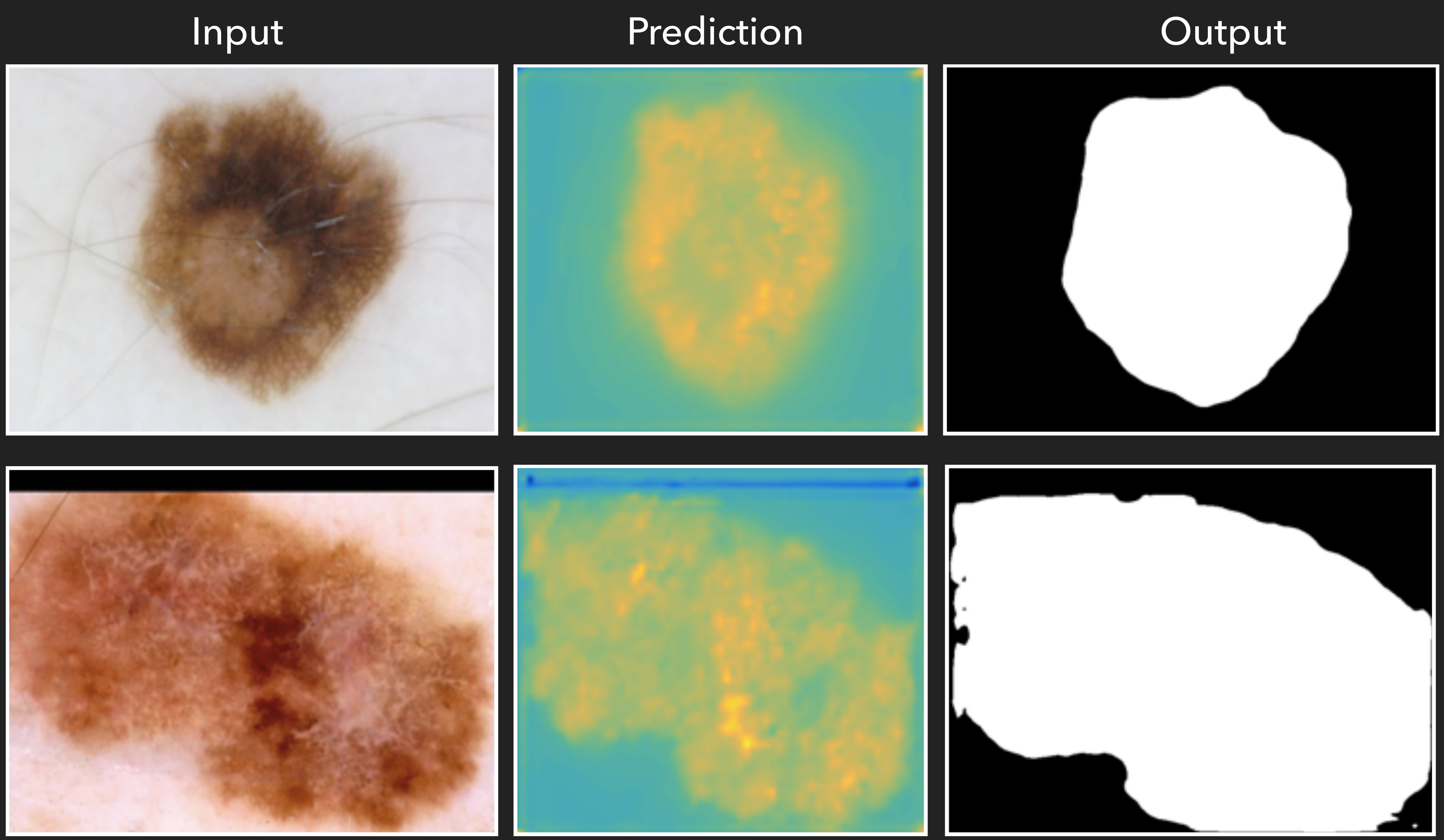
[3] Ronneberger et al. MICCAI (2015).
[4] Long et al. CVPR (2015).

SEGMENTATION RESULTS

For malignant glands, using our hybrid network (using VGG16) increased the segmentation Dice by 13%.



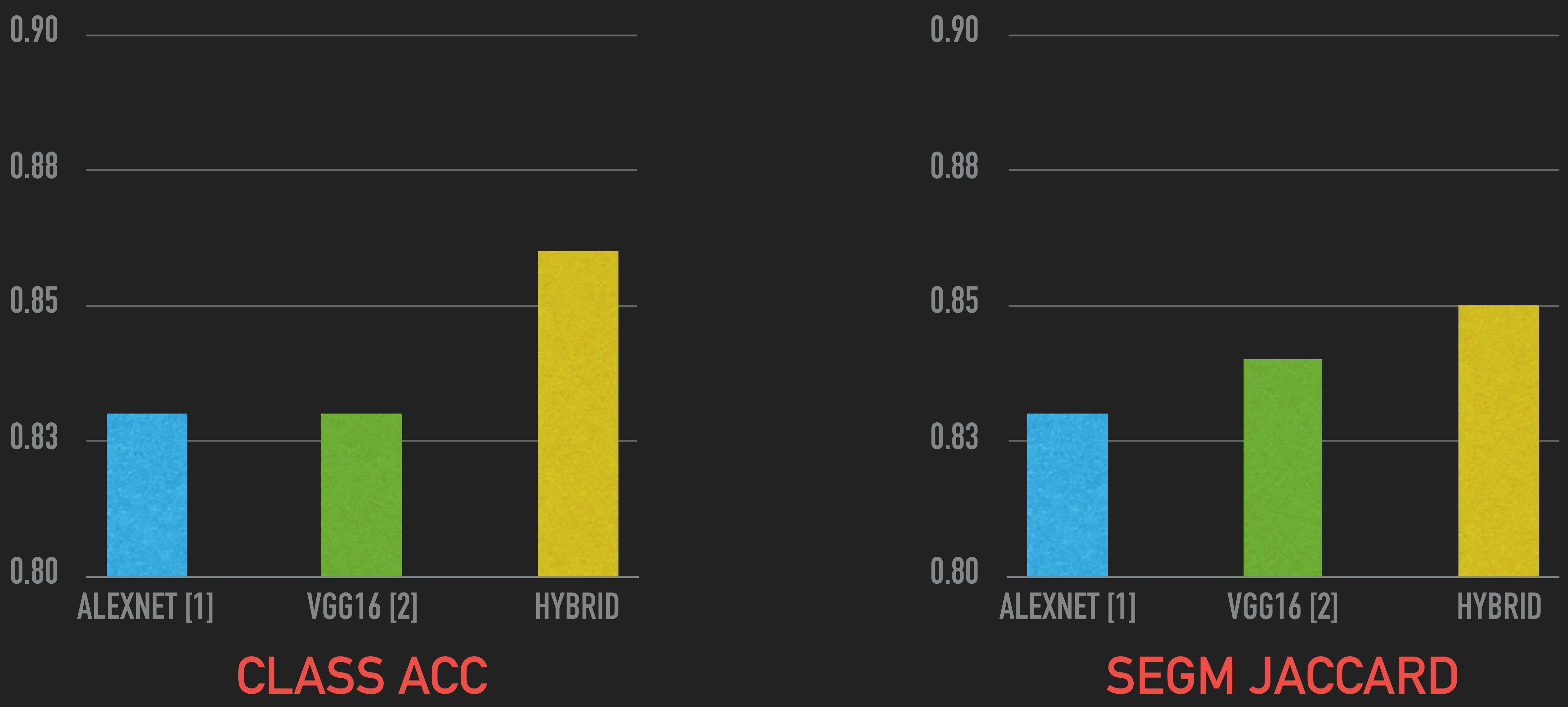
ISBI 2016 SKIN LESION SEGMENTATION CHALLENGE



ISBI 2016 SKIN LESION SEGMENTATION CHALLENGE

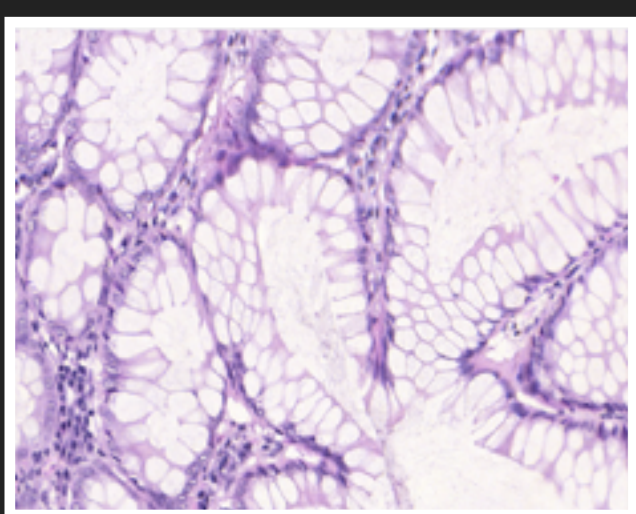
Using segmentation priors increased the classification accuracy by 3%.

Using class-specific priors increases the segmentation Jaccard by 2%.

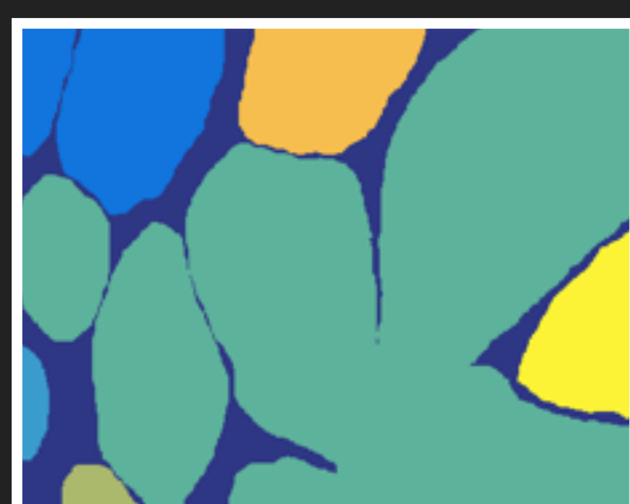


- We proposed a novel multi-loss network for simultaneous image segmentation and classification.
- We showed that:
  1. classification can facilitate the segmentation by introducing class-specific spatial priors.
  2. segmentation can benefit classification by providing region-specific features.

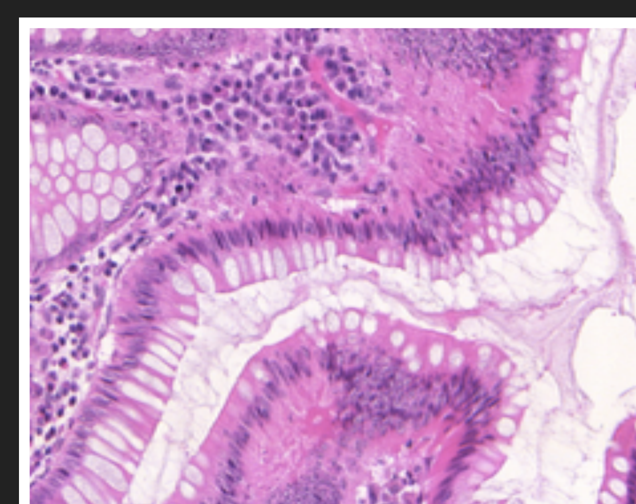
Benign Glands



Segmentation



Malignant Glands



Segmentation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