SEMANTIC SEGMENTATION

SegFix: Model-Agnostic Boundary Refinement for Segmentation

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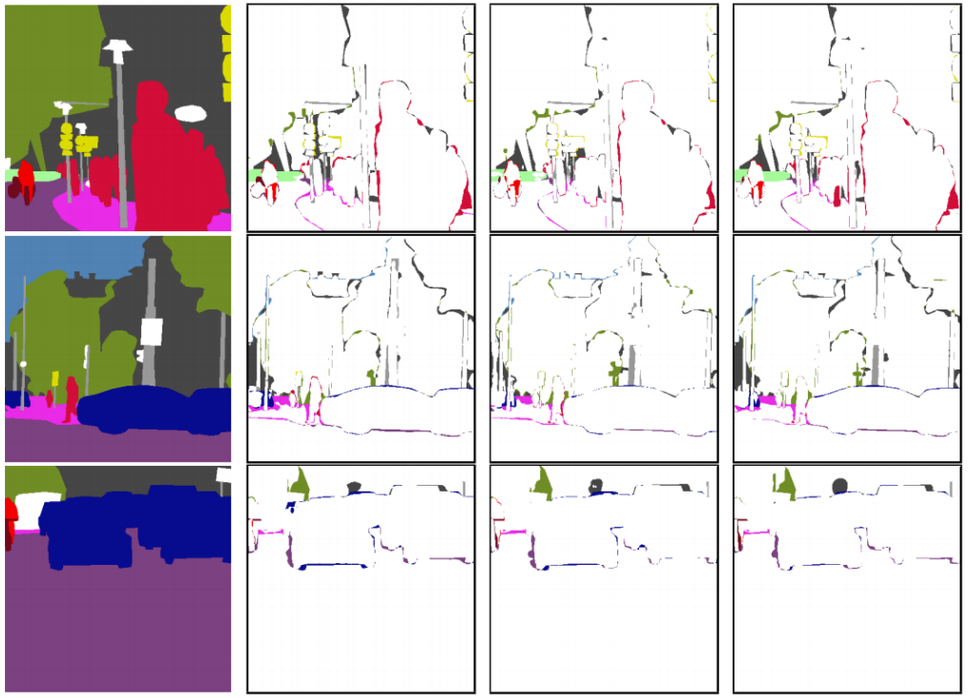
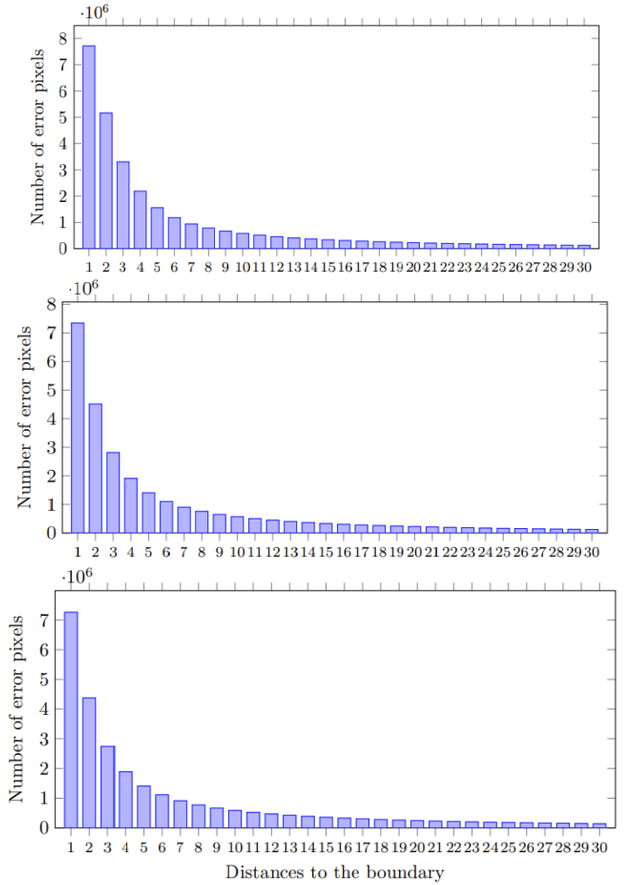
01 SegFix: Model-Agnostic Boundary Refinement for Segmentation

- **ECCV 2020**
- **Motivation**

Most of the existing state-of-the-art segmentation models fail to deal well with the error predictions along the boundary.



DeepLabv3/HRNet/Gated-SCNN



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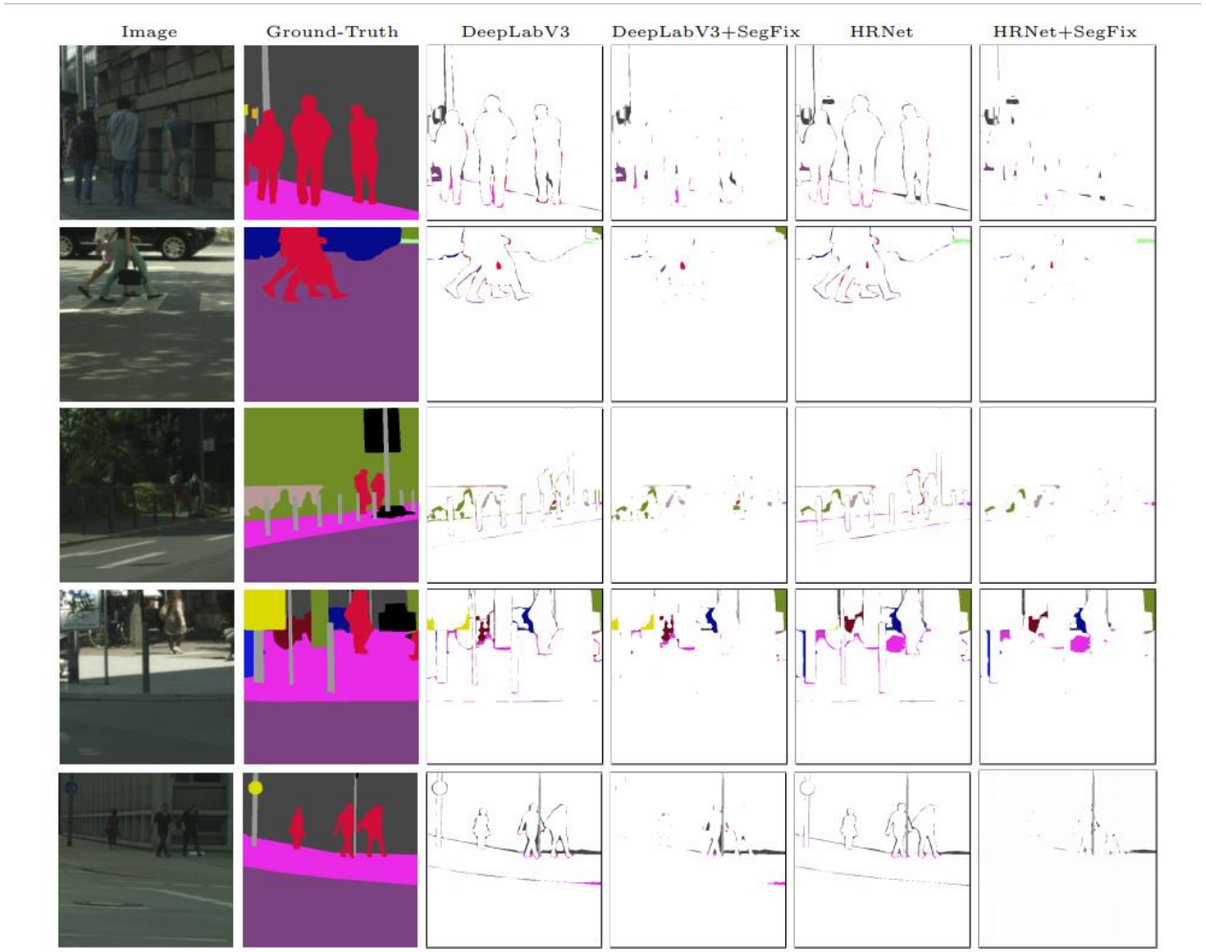
- **Contribution**
  - Propose a novel **model-agnostic** post-processing mechanism, reduce boundary errors by **replacing labels of boundary pixels with the labels of corresponding interior pixels** for a segmentation result.



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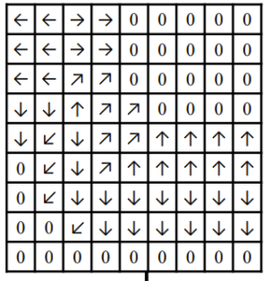
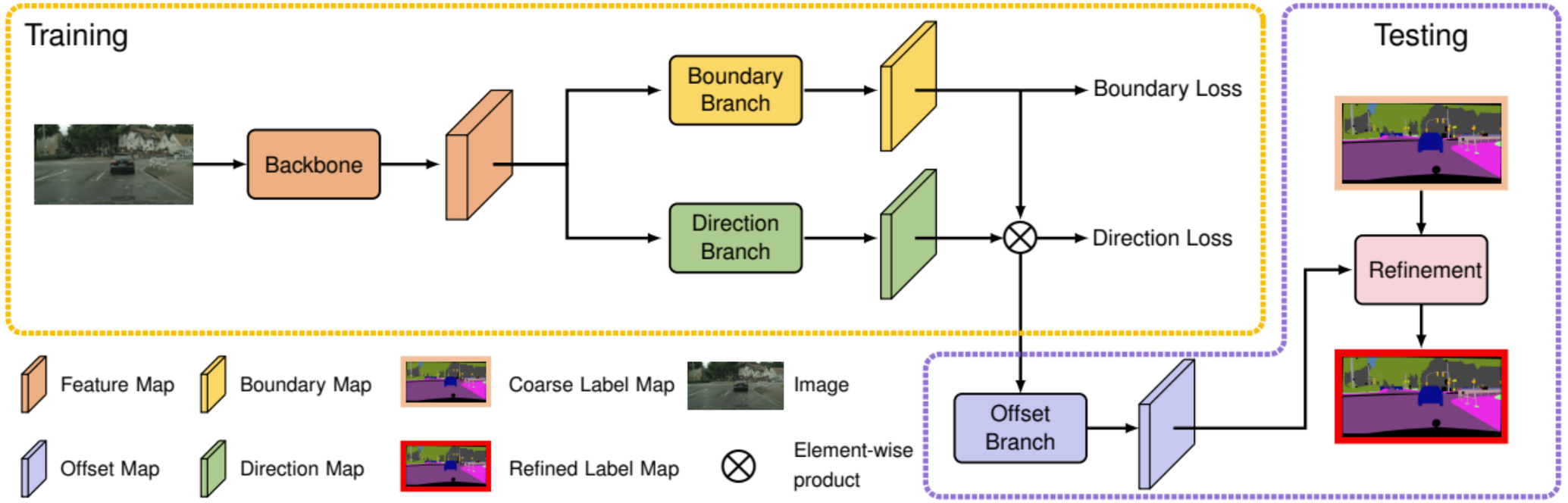
- **Overall network architecture**
  - Localize the pixels along the object boundaries.
  - Learn a direction away from the boundary pixel to an interior pixel.





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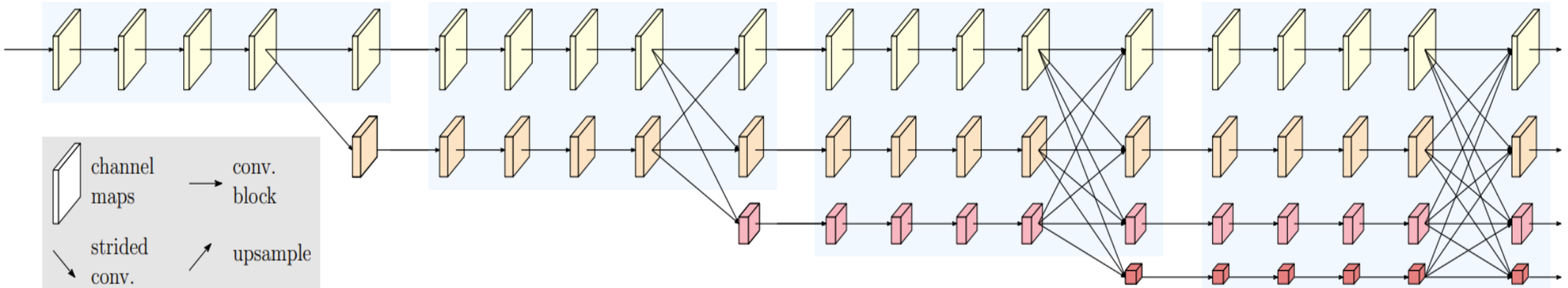
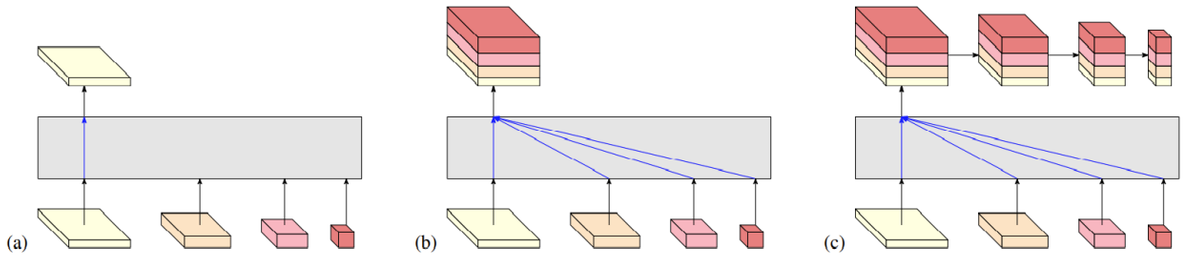
- **Backbone（High-HRNet）**
  - Adopt **h**igh **r**esolution **net**work (HRNet).
  - Modify HRNet through applying a 4×4 deconvolution with stride 2 on the final output feature map of HRNet.

group conv

The resolution is $\frac{H}{s} \times \frac{W}{s} \times D, s = 4$ for HRNet and $s = 2$ for Higher-HRNet





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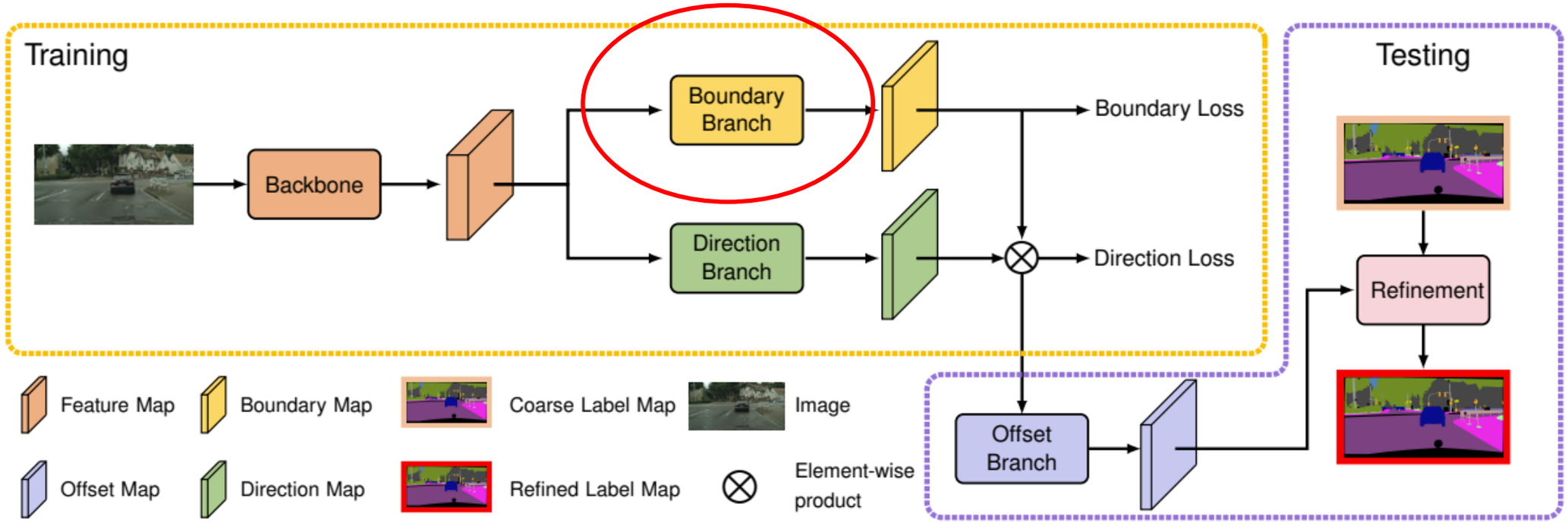
- **Boundary Branch**
  - 1×1 Conv → BN → ReLU
  - Binary cross-entropy loss



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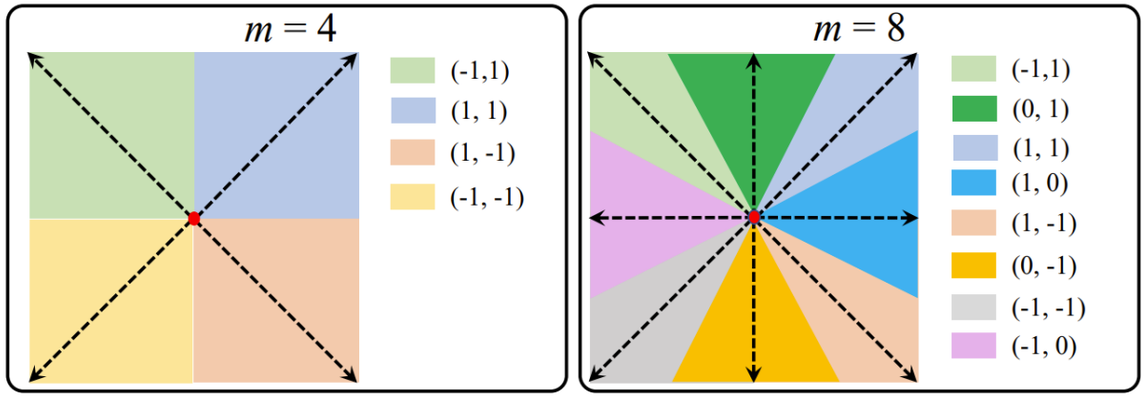
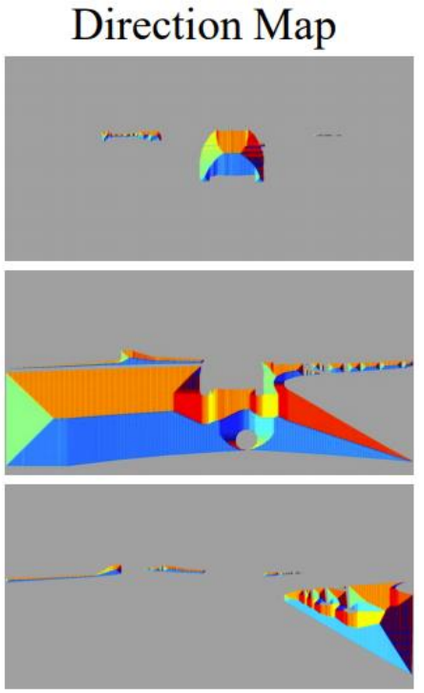
- **Direction branch**
  - Predicts discrete directions by dividing the entire direction range to m partitions as ground-truth. (m = 4 or m = 8)
  - When m = 4, we have $[0^\circ, 90^\circ)$, $[90^\circ, 180^\circ)$, $[180^\circ, 270^\circ)$ and $[270^\circ, 360^\circ)$ correspond to 4 different categories separately. The above 4 direction categories correspond to offsets $(1, 1)$, $(-1, 1)$, $(-1, -1)$ and $(1, -1)$.





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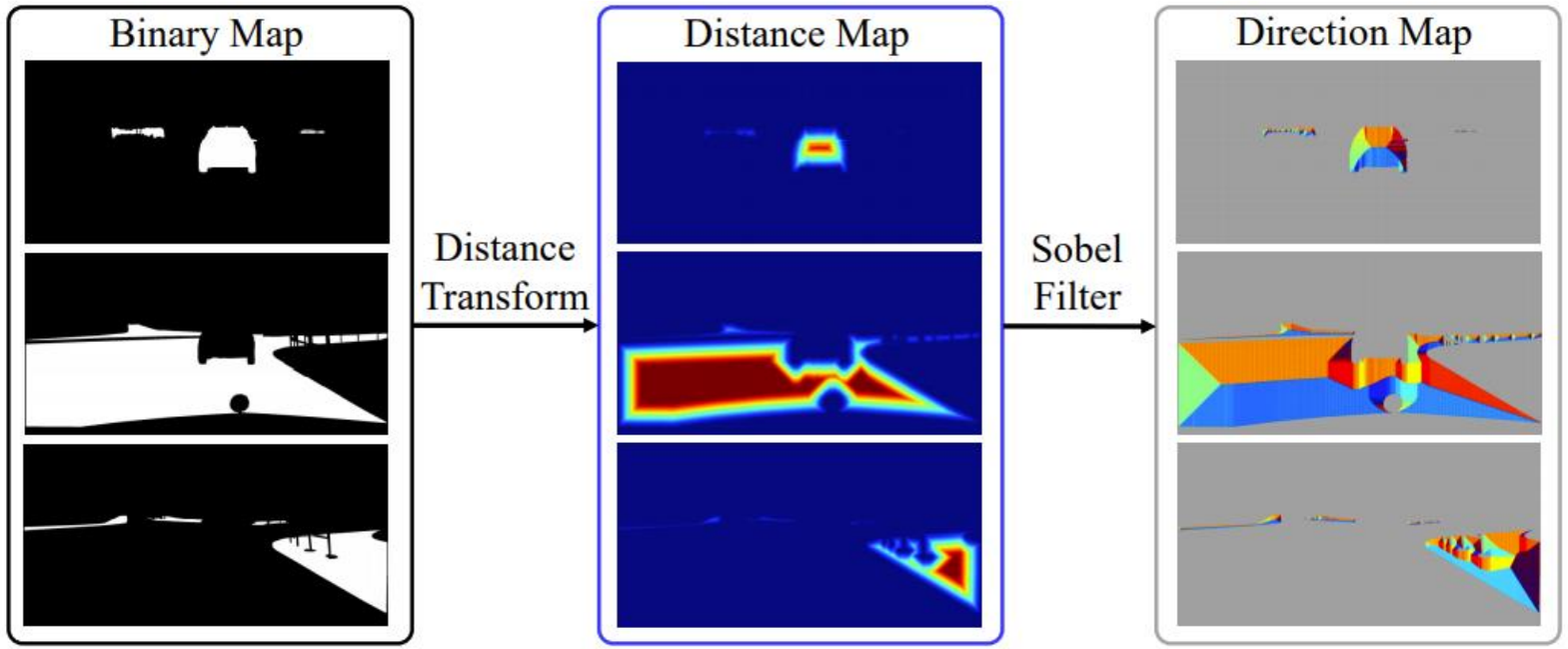
- **Ground-truth generation**
  - Distance map We use `scipy.ndimage.morphology.distance_transform_edt` in implementation.
  - Boundary map
  - Direction map
    - Sobel filter (with kernel size 9×9) on the distance maps to compute the corresponding direction.
    - The Sobel filter based direction is in the range [0◦ , 360◦), each direction points to the interior pixel.



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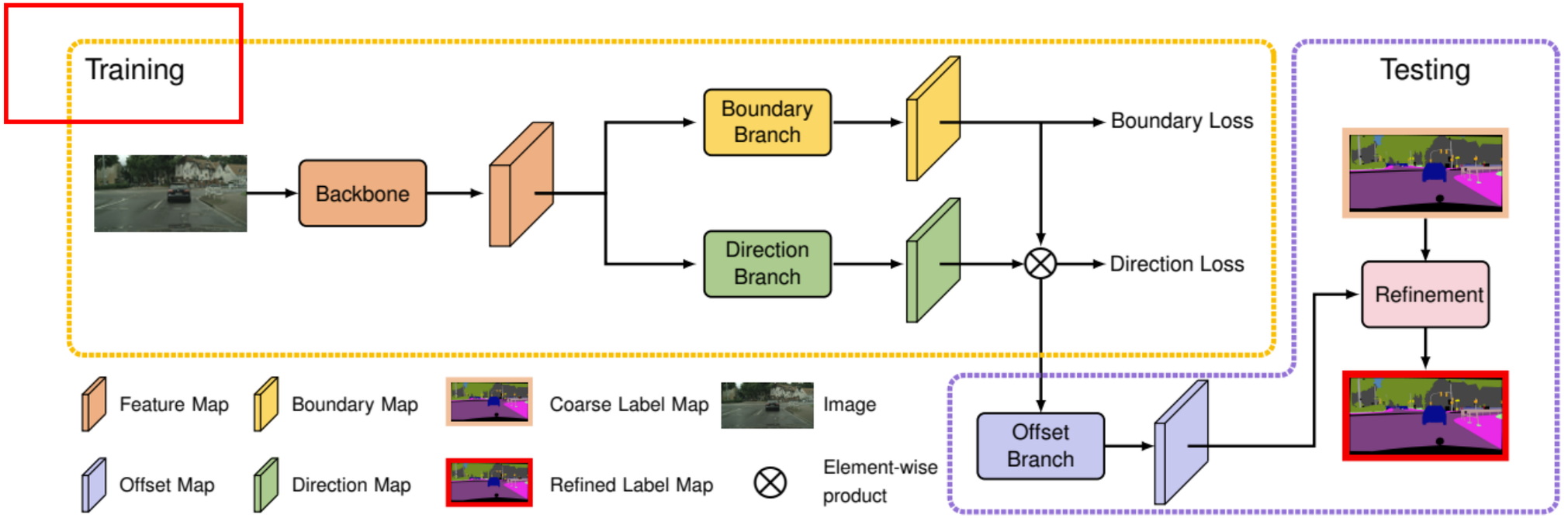
- **Training**
  - The boundary branch to predict a **binary map B.**
  - The direction branch to predict a **direction map D.**



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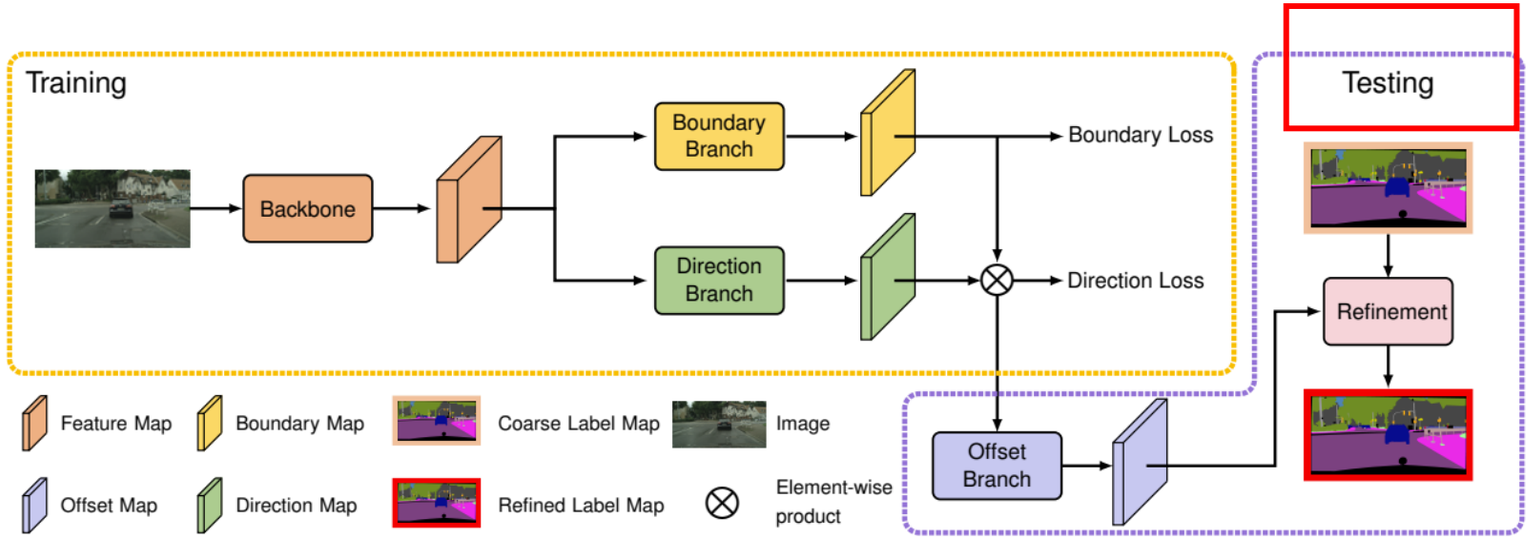
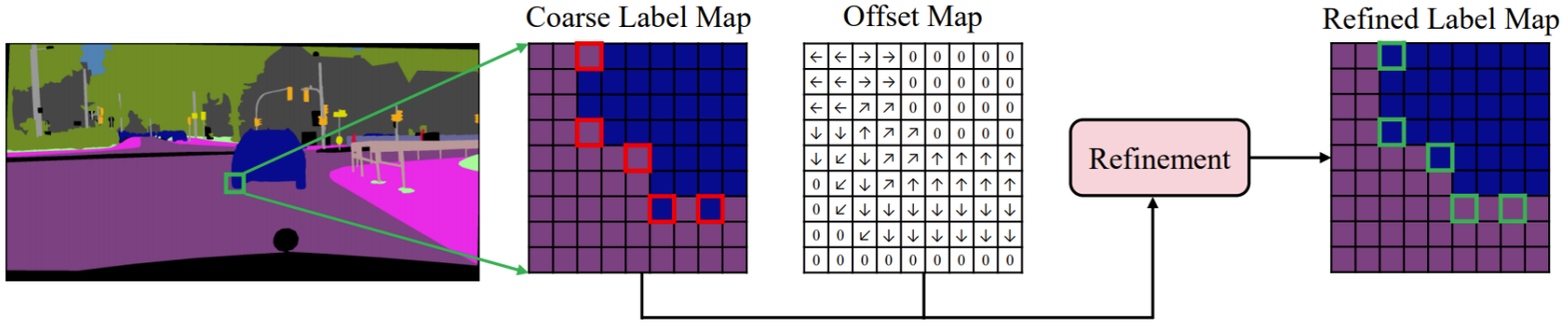
- **Testing**
  - Apply the offset branch to generate a **offset map ΔQ.**
  - Using **ΔQ** to refine the coarse label map.





Two different schemes as following:

(i) re-scaling all the offsets by a factor, e.g., 2.

(ii) applying the offsets until finding an interior pixel

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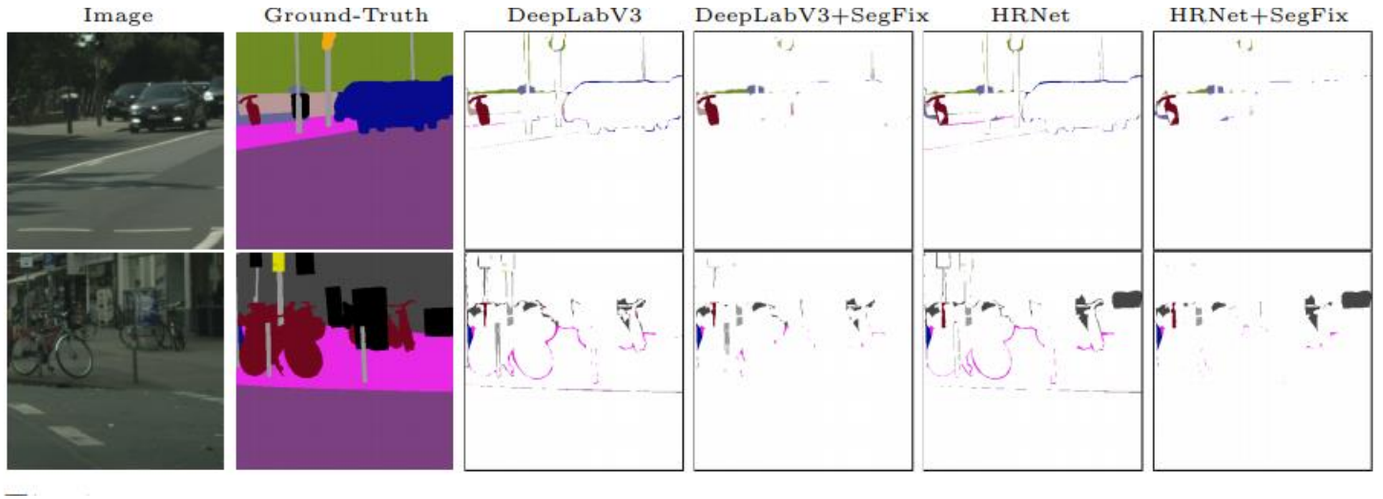
- **Result**

Cityscapes

metric	method	w/o SegFix	w/ SegFix $m = 4$	w/ SegFix $m = 8$
mIoU	DeepLabv3 (Our impl.)	79.5	82.6 (+3.1)	82.4 (+2.9)
	HRNet-W48 (Our impl.)	81.1	84.1 (+3.0)	84.1 (+3.0)
	Gated-SCNN (Our impl.)	81.0	84.2 (+3.2)	84.1 (+3.1)
F-score	DeepLabv3 (Our impl.)	56.6	68.6 (+12.0)	68.4 (+11.8)
	HRNet-W48 (Our impl.)	62.4	73.8 (+11.4)	73.8 (+11.4)
	Gated-SCNN (Our impl.)	61.4	72.3 (+10.9)	72.3 (+10.9)



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- **Ablation Experiments**

	boundary width				# directions		
	$\gamma = 3$	$\gamma = 5$	$\gamma = 10$	$\gamma = \infty$	$m = 4$	$m = 8$	$m = 16$
mIoU△	+0.94	+0.96	+0.95	+0.84	+0.97	+0.96	+0.96
F-score△	+4.1	+4.2	+4.1	+3.6	+4.1	+4.2	+4.2

backbone	#param (M)	runtime (ms)	mask F-score	direction accuracy	mIoU△	F-score△
HRNet-W18	9.6	16	71.44	64.44	+0.8	+3.7
HRNet-W32	29.4	20	72.24	65.10	+0.9	+3.9
Higher-HRNet	47.3	69	73.67	66.87	+1.0	+4.4

	baseline	DenseCRF	SegFix	DenseCRF+SegFix
mIoU	79.5	79.7 (+0.2)	80.5 (+1.0)	80.5 (+1.0)
F-score	56.6	60.9 (+4.3)	61.0 (+4.4)	64.1 (+7.5)