

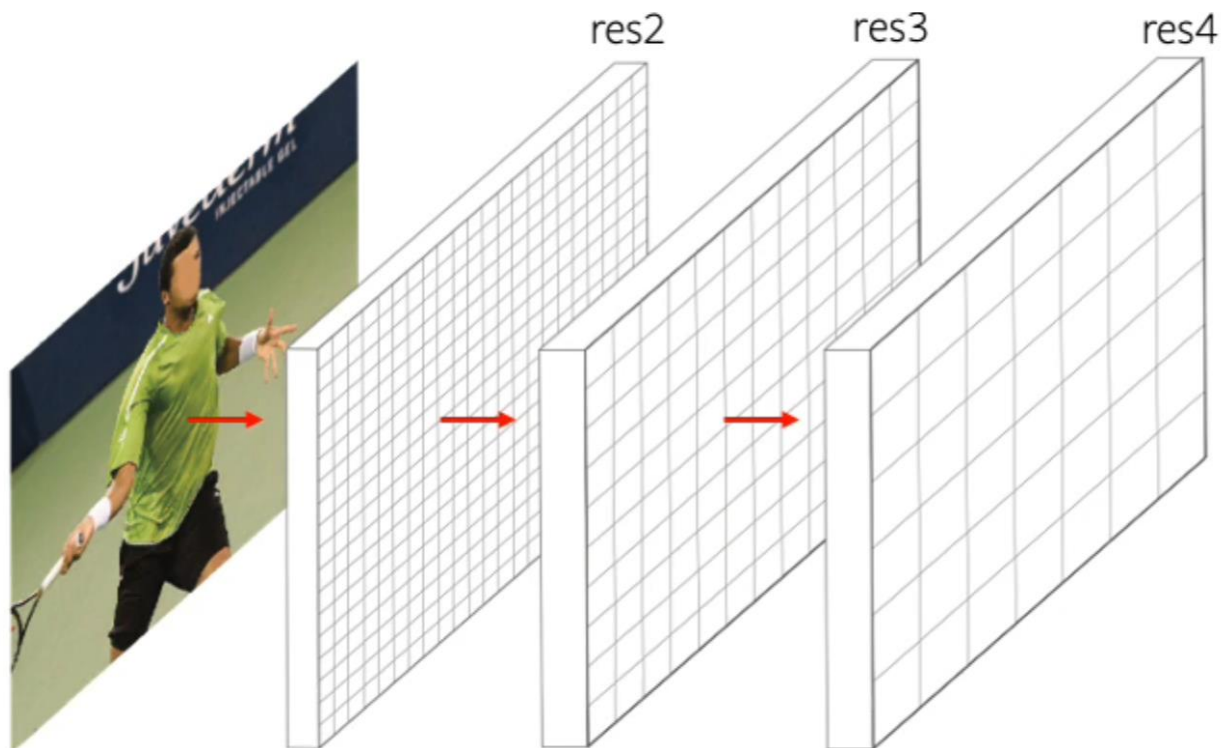
PointRend

Image Segmentation as
Rendering

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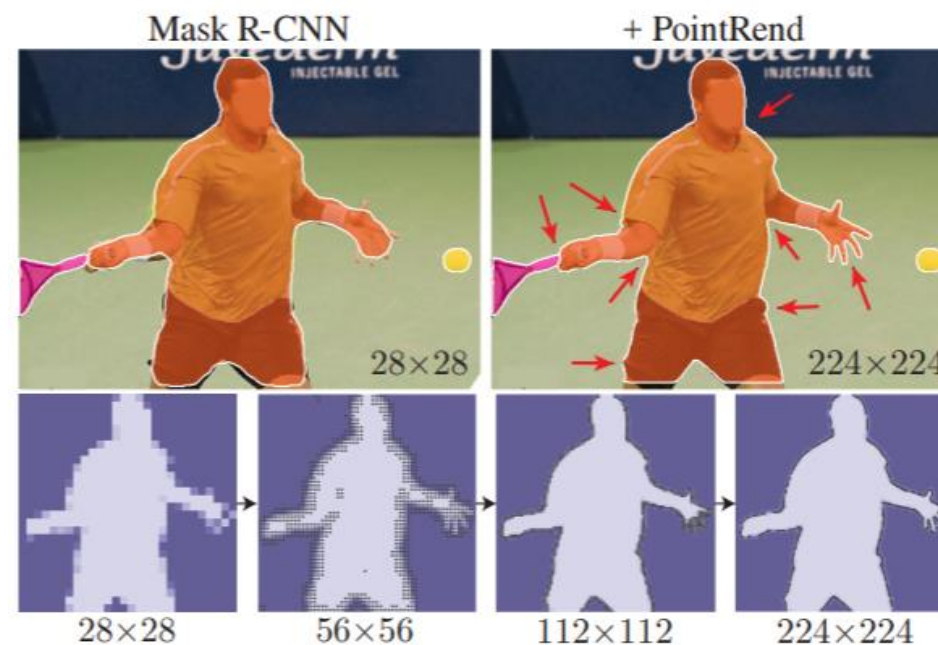
Submitted on Jan 11, 2022

Authors: Facebook AI Research (FAIR)

Alexander Kirillov, Yuxin Wu, Kaiming He Ross Girshick

Typical Problems in Image Segmentation

- CNNs for image segmentation typically operate on regular 3 channel grids.
 - Not computationally ideal for image segmentation.
 - Label maps predicted by these networks are mostly smooth.
 - Unnecessarily oversample the smooth areas while simultaneously under-sampling object boundaries.
- The result is excess computation in smooth regions and blurry contours.
- Often predict labels on a low-resolution regular grid.



PointRend

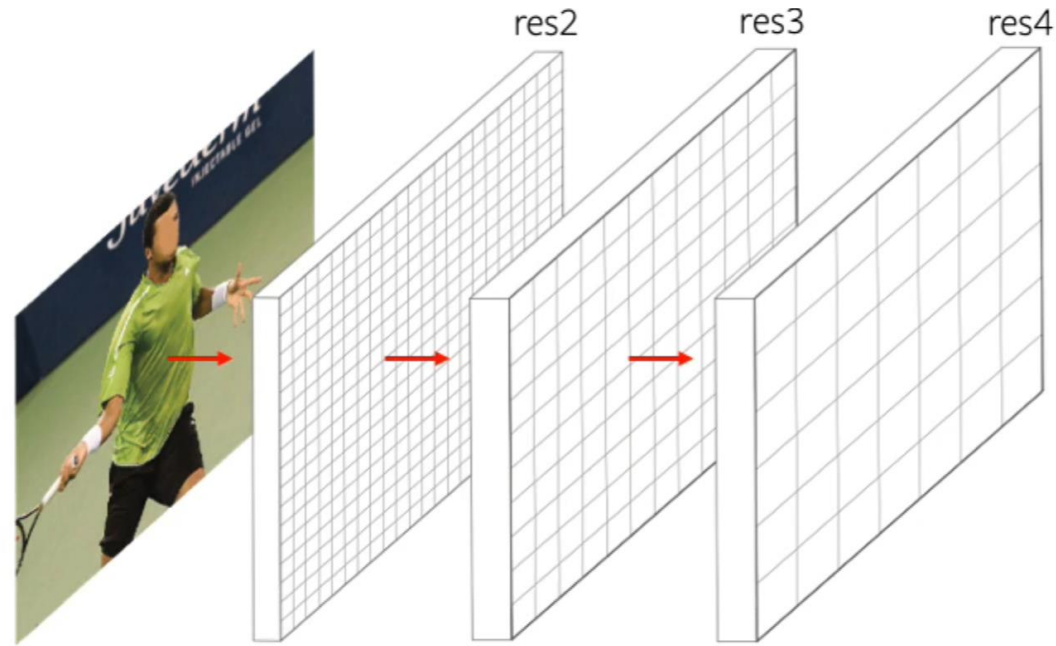
Propose “Point based Rendering” as a methodology for image segmentation using point representations.

To Efficiently “render” high quality label map

Benefits over other architectures:

1. Training and Inference is less computationally intensive
2. Generate higher quality, higher resolution label maps (masks)

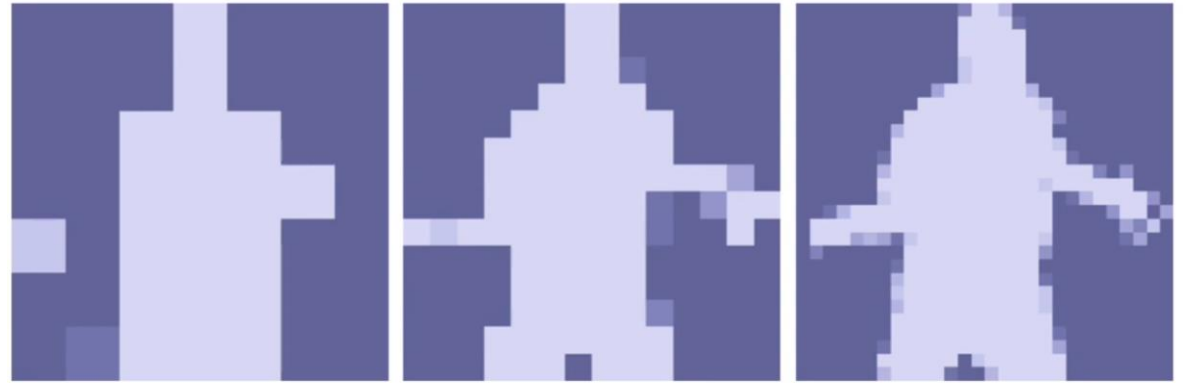
CNN/FCN is the main tool for 2D image recognition



- Operates with **feature map on regular grids**



Output resolution is tradeoff between computational cost and level of detail



7x7

14x14

28x28



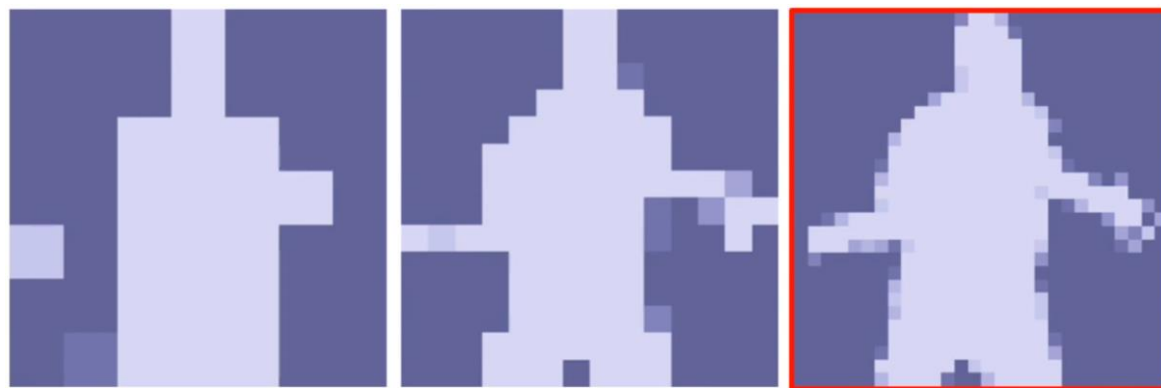
56x56

112x112

224x224



Mask R-CNN efficiently predicts
low-resolution masks



7x7

14x14

28x28



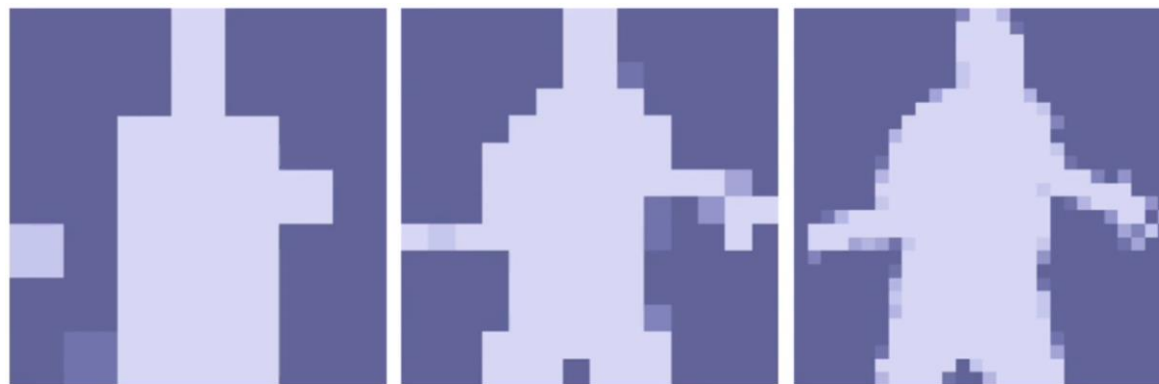
56x56

112x112

224x224



Note that different areas require different levels of detail



7x7

14x14

28x28



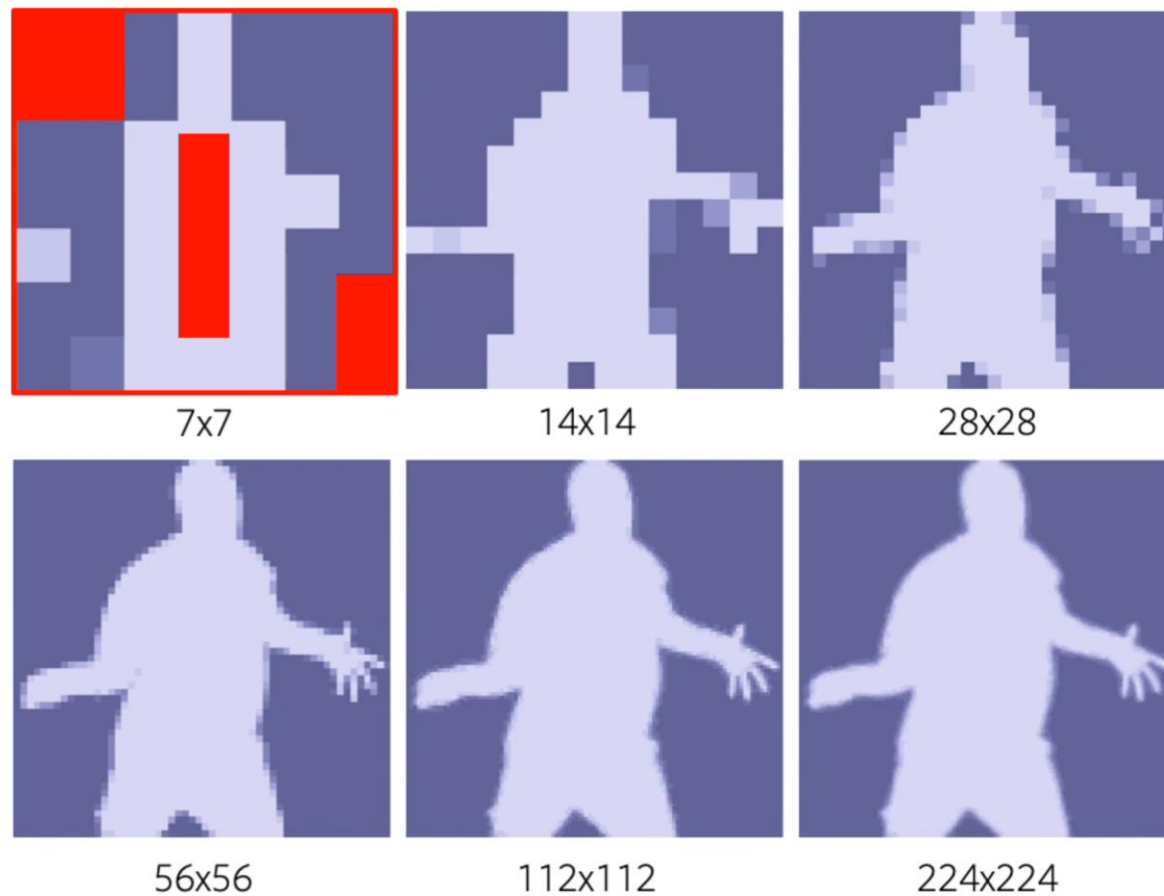
56x56

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224x224

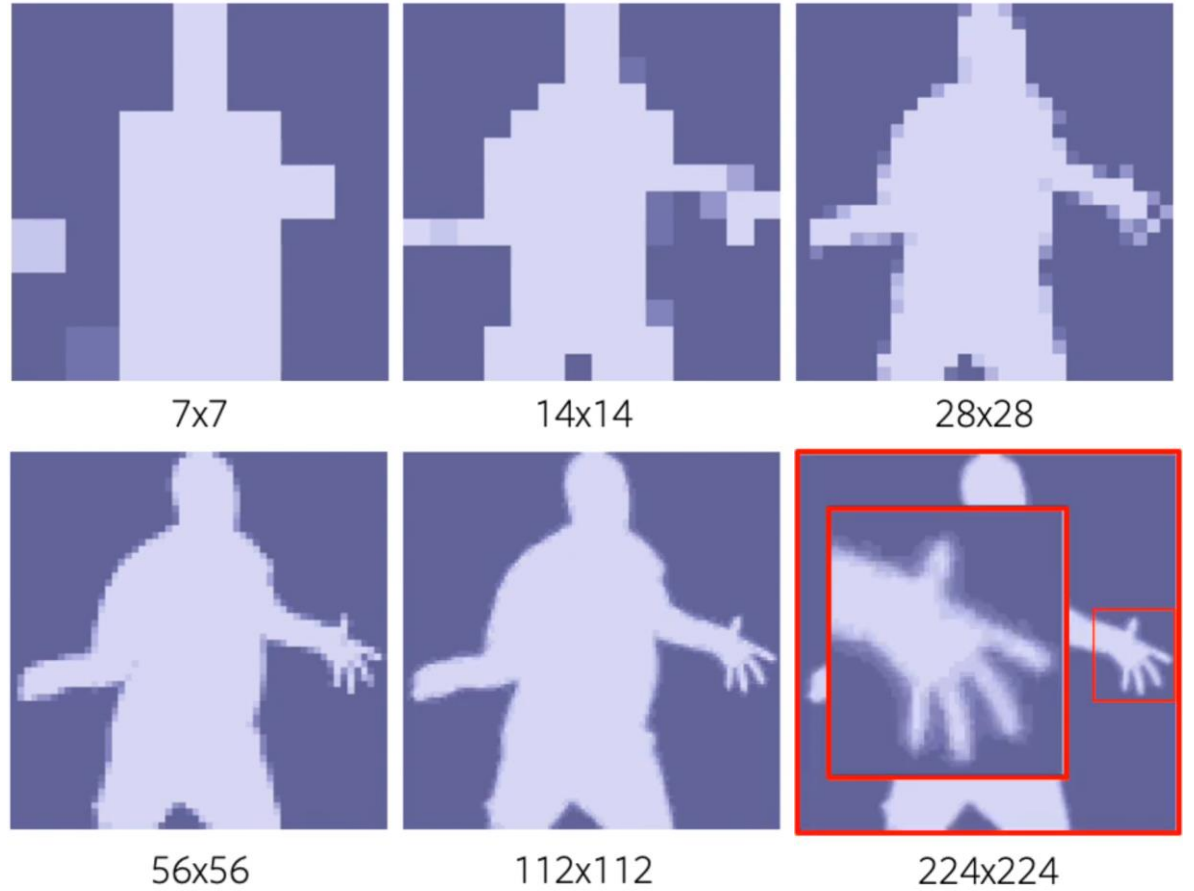


Some are perfectly segmented with
low resolution prediction



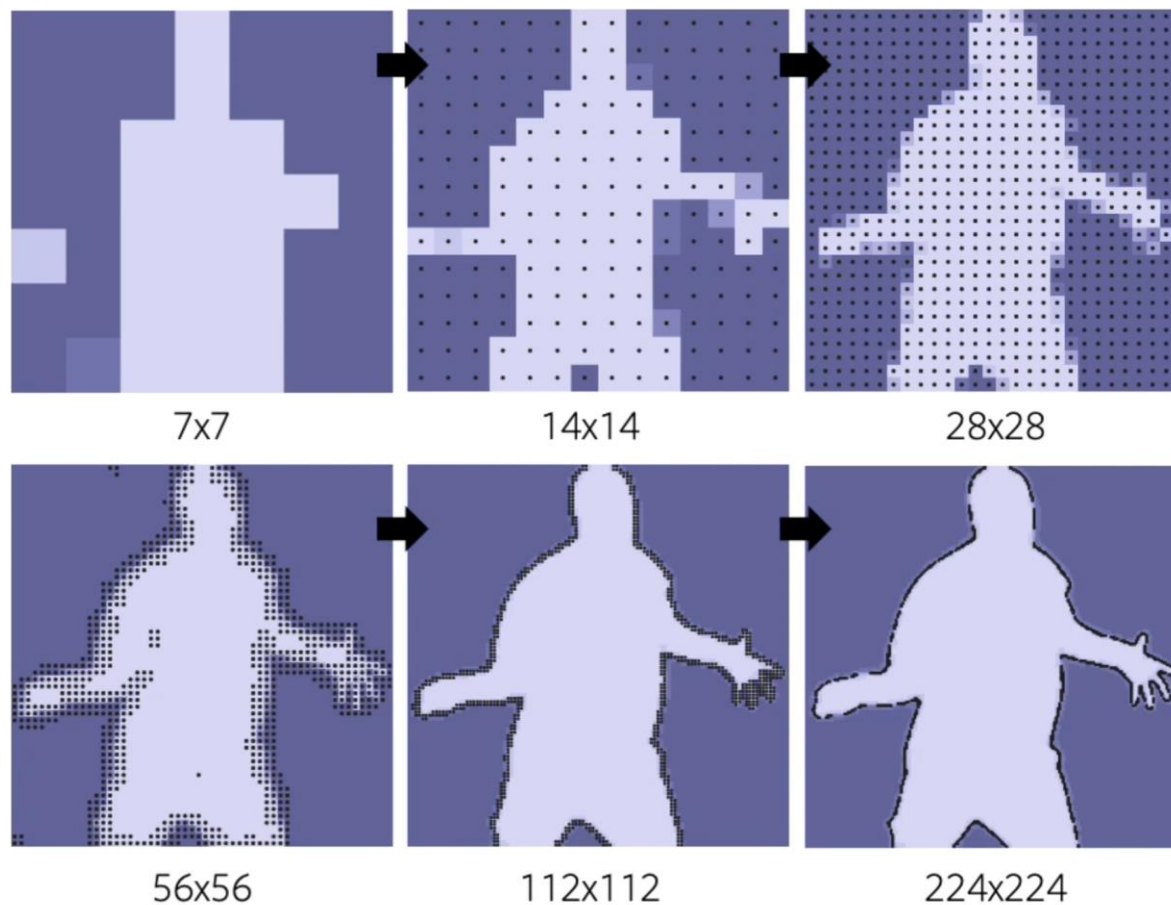


Whereas high-frequency regions require prediction in a very high resolution

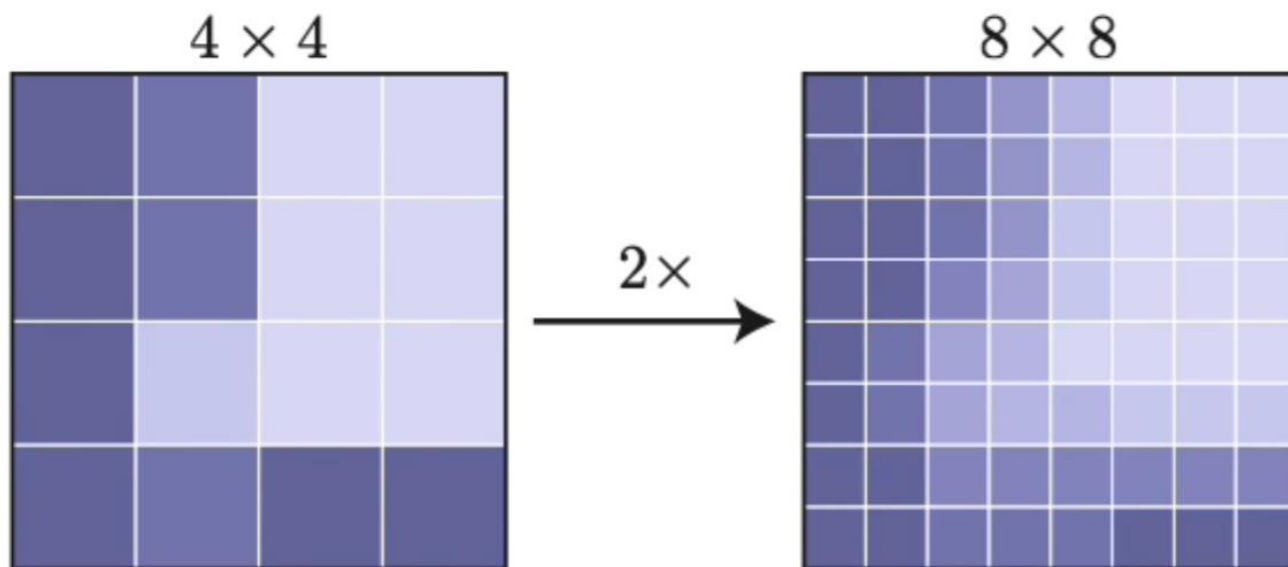




PointRend gradually increases resolution by making predictions for the most uncertain points

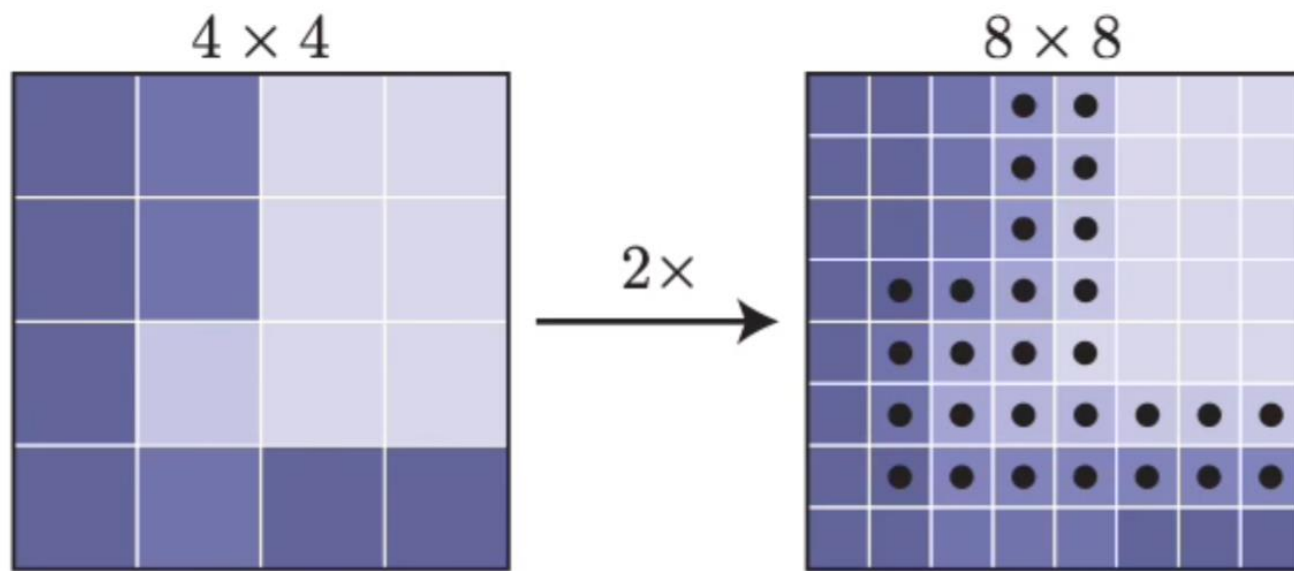


Point-based inference via subdivision



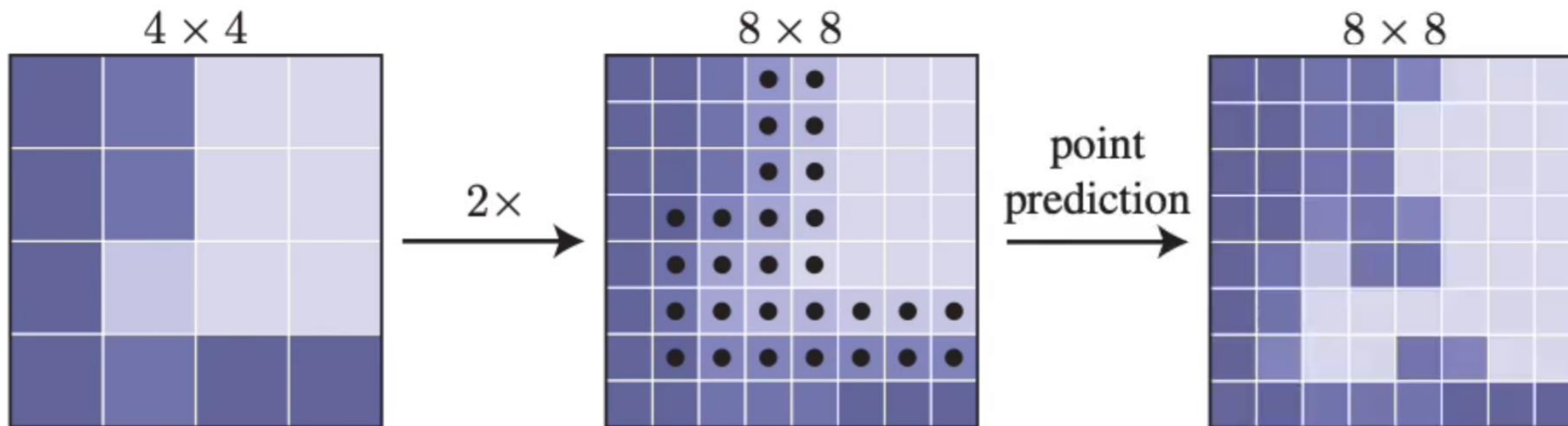
Lower resolutions prediction is
unsampled with bilinear interpolation

Point-based inference via subdivision



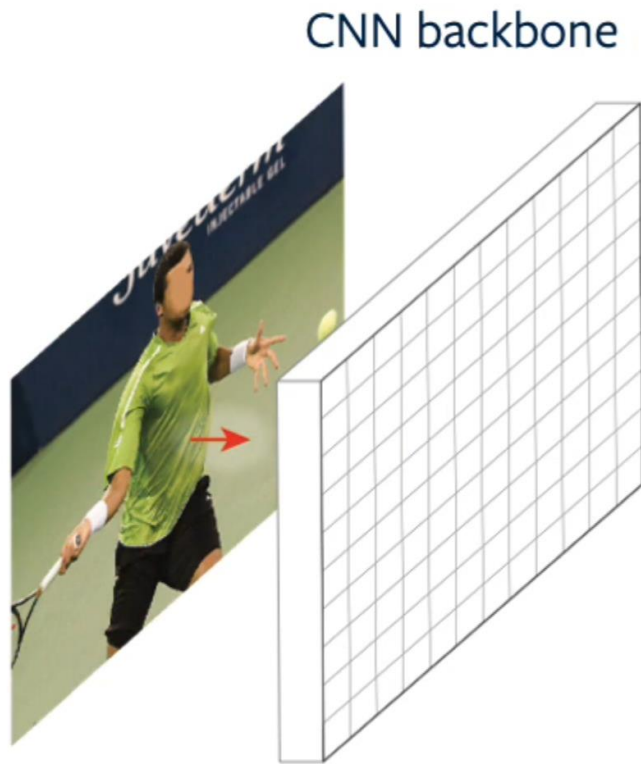
The subset of most uncertain
points is selected

Point-based inference via subdivision



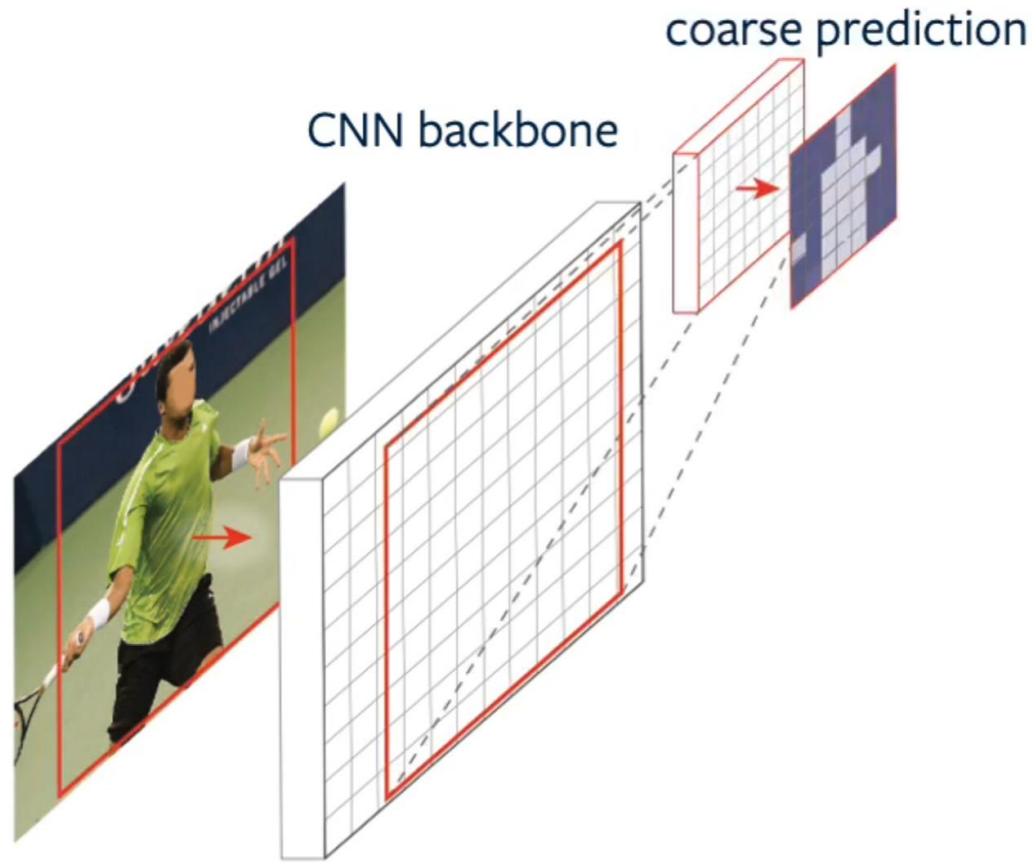
Prediction for each selected points is refined using a lightweight MLP

PointRender architecture for instance segmentation



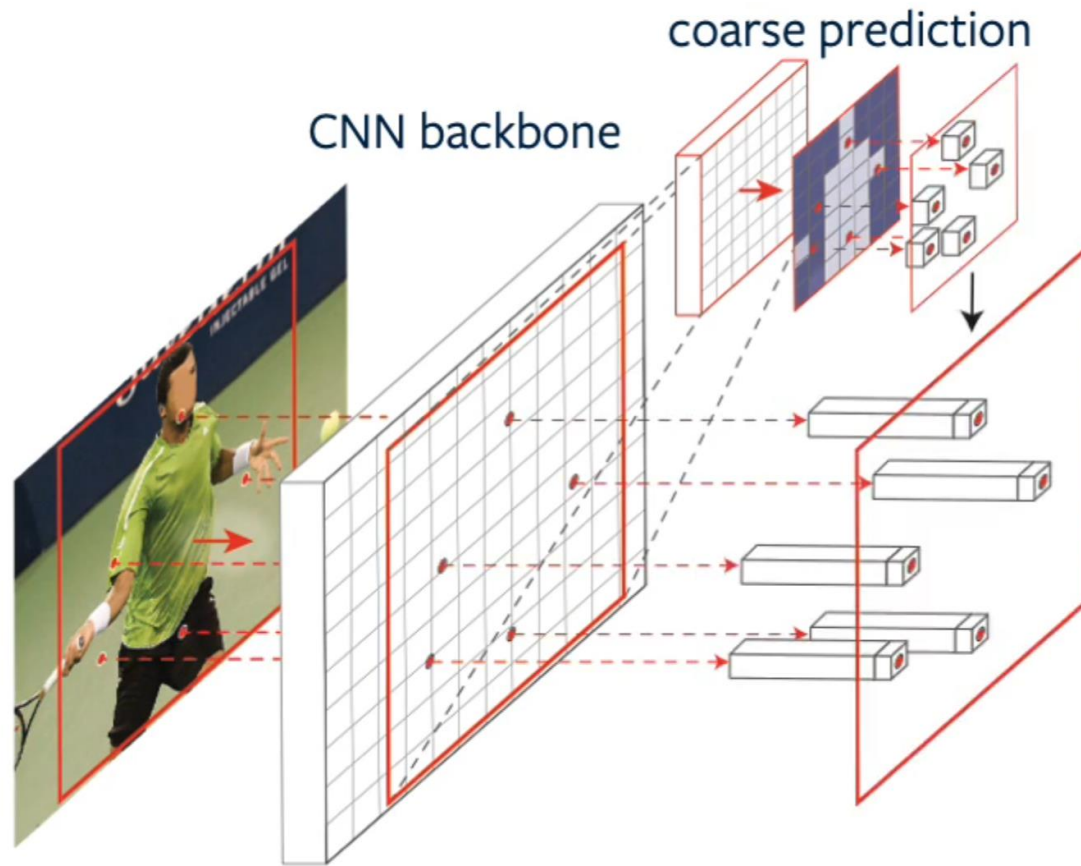
Backbone computes features
that represent the whole image

PointRender architecture for instance segmentation



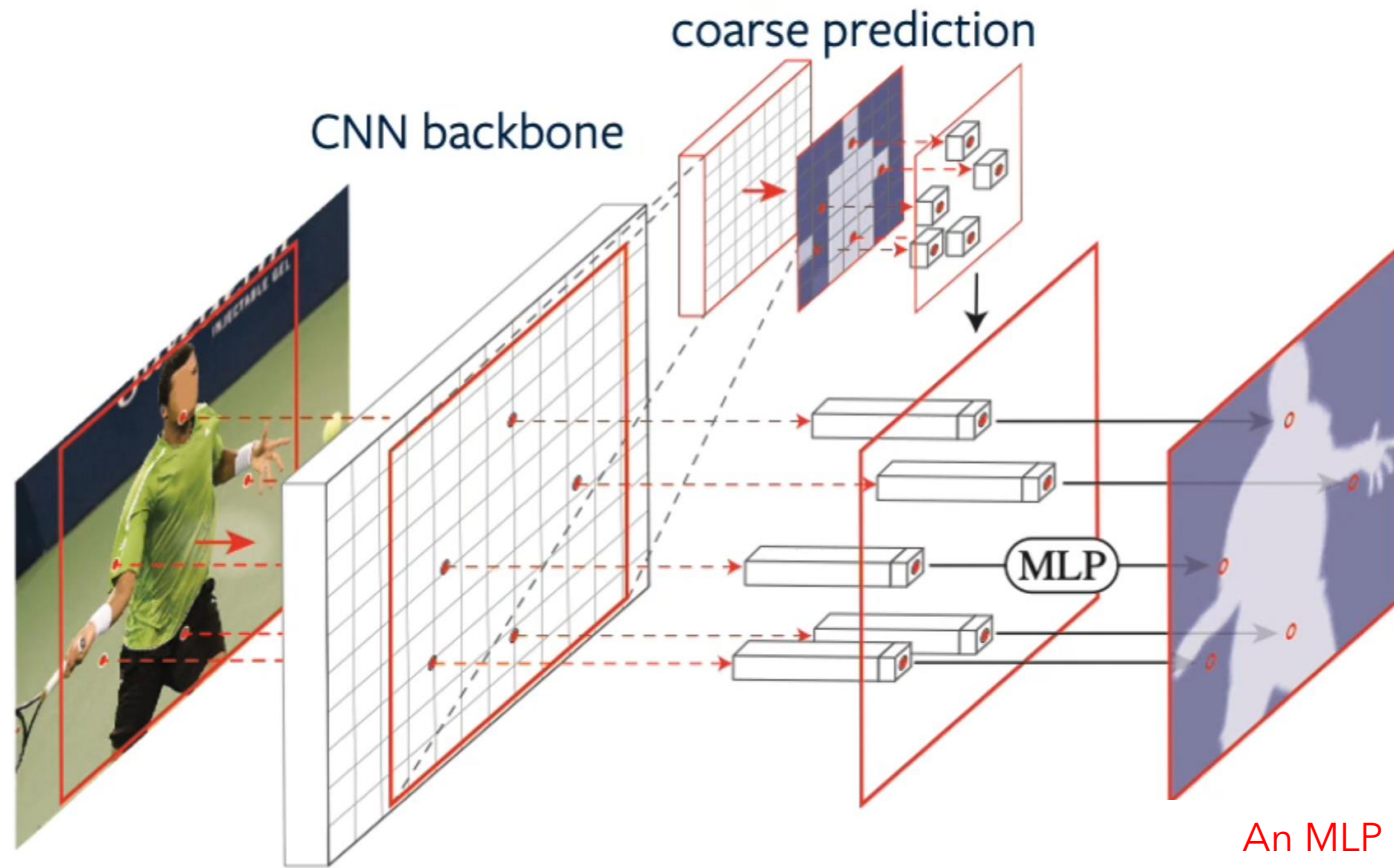
For each bounding box
a small head yields
low-resolution mask prediction

PointRend architecture for instance segmentation



For a subset of points we extract features from the coarse prediction and the backbone features using bilinear interpolation

PointRend architecture for instance segmentation

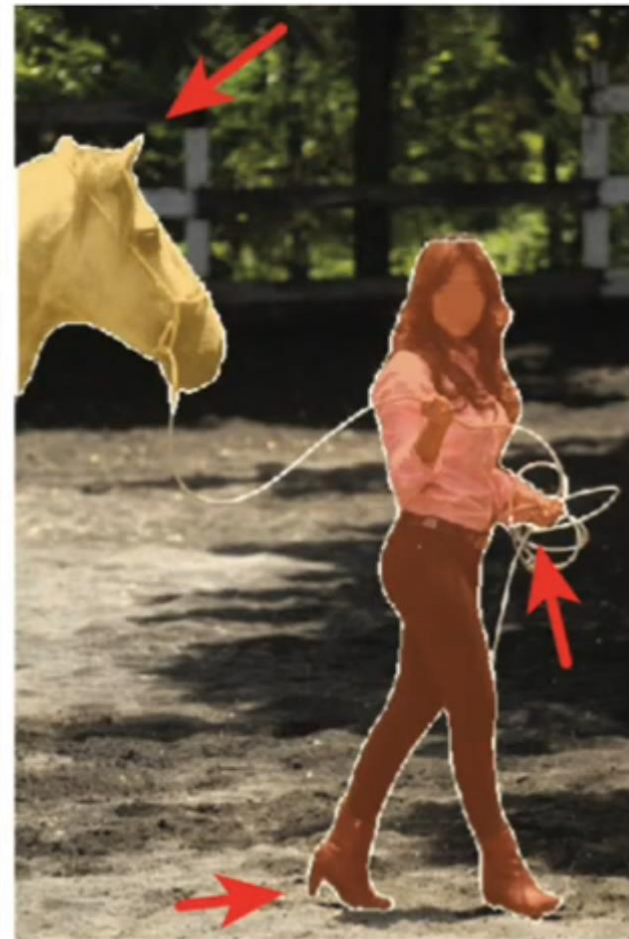
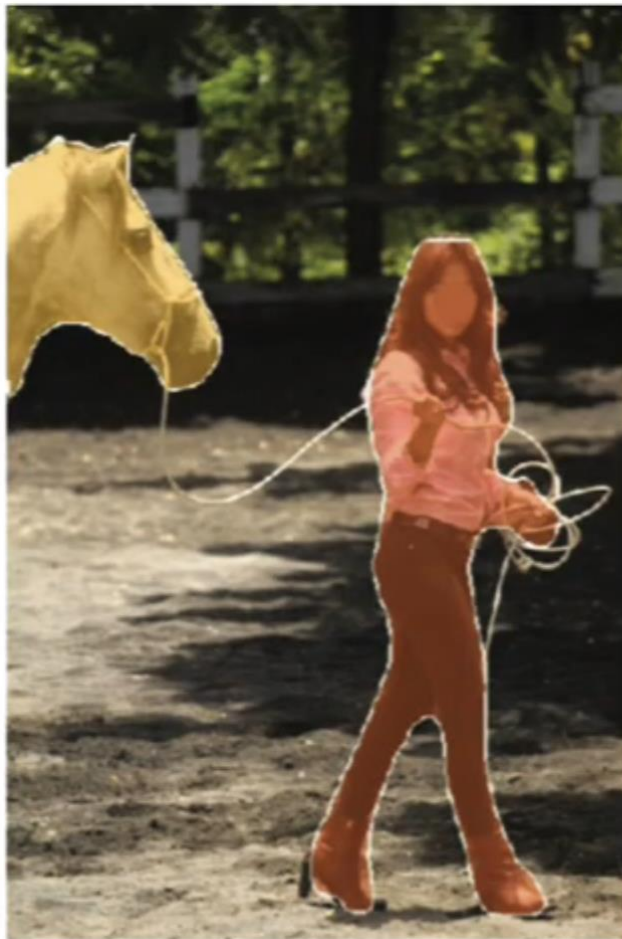


An MLP is used to make prediction for each point independently

Mask R-CNN with standard head vs. Mask R-CNN with PointRend



+ PointRend



+ PointRend

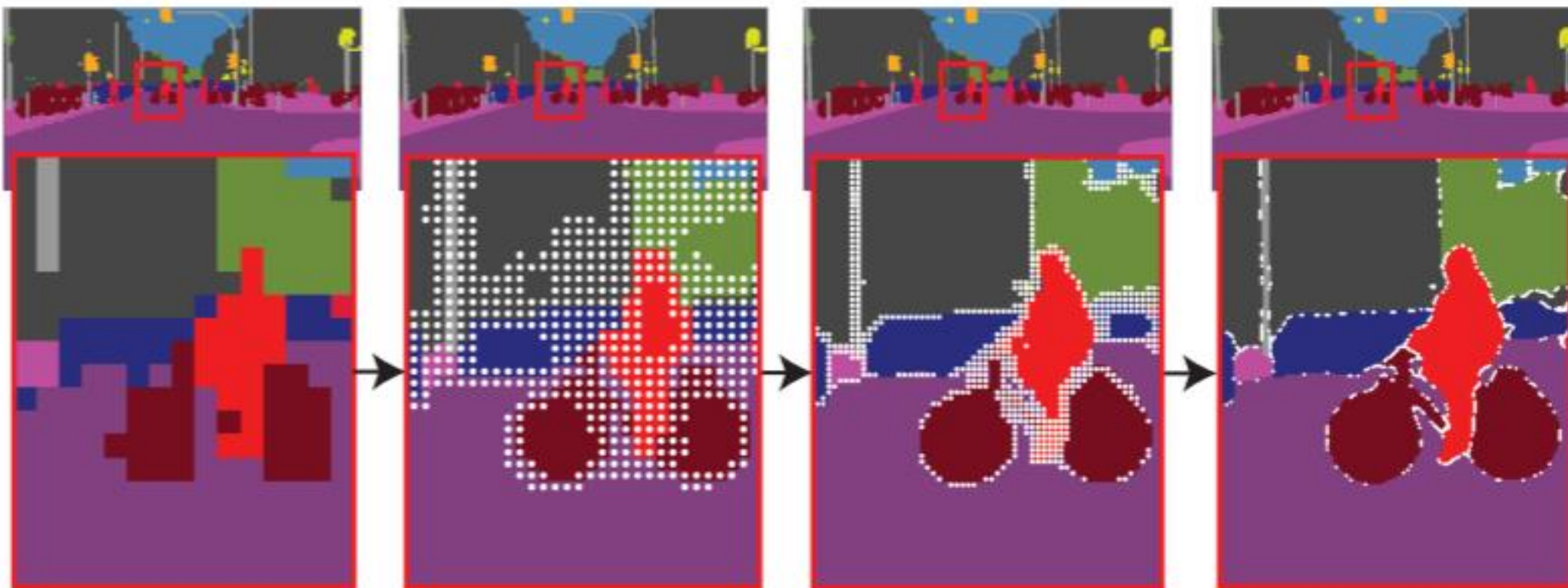
Quantitative comparison: instance segmentation

mask head	output resolution	COCO		Cityscapes AP
		AP	AP*	
4× conv	28×28	35.2	37.6	33.0
PointRend	224×224	36.3 (+1.1)	39.7 (+2.1)	35.8 (+2.8)

Mask R-CNN with standard head (4x Conv) vs. Mask R-CNN with PointRend

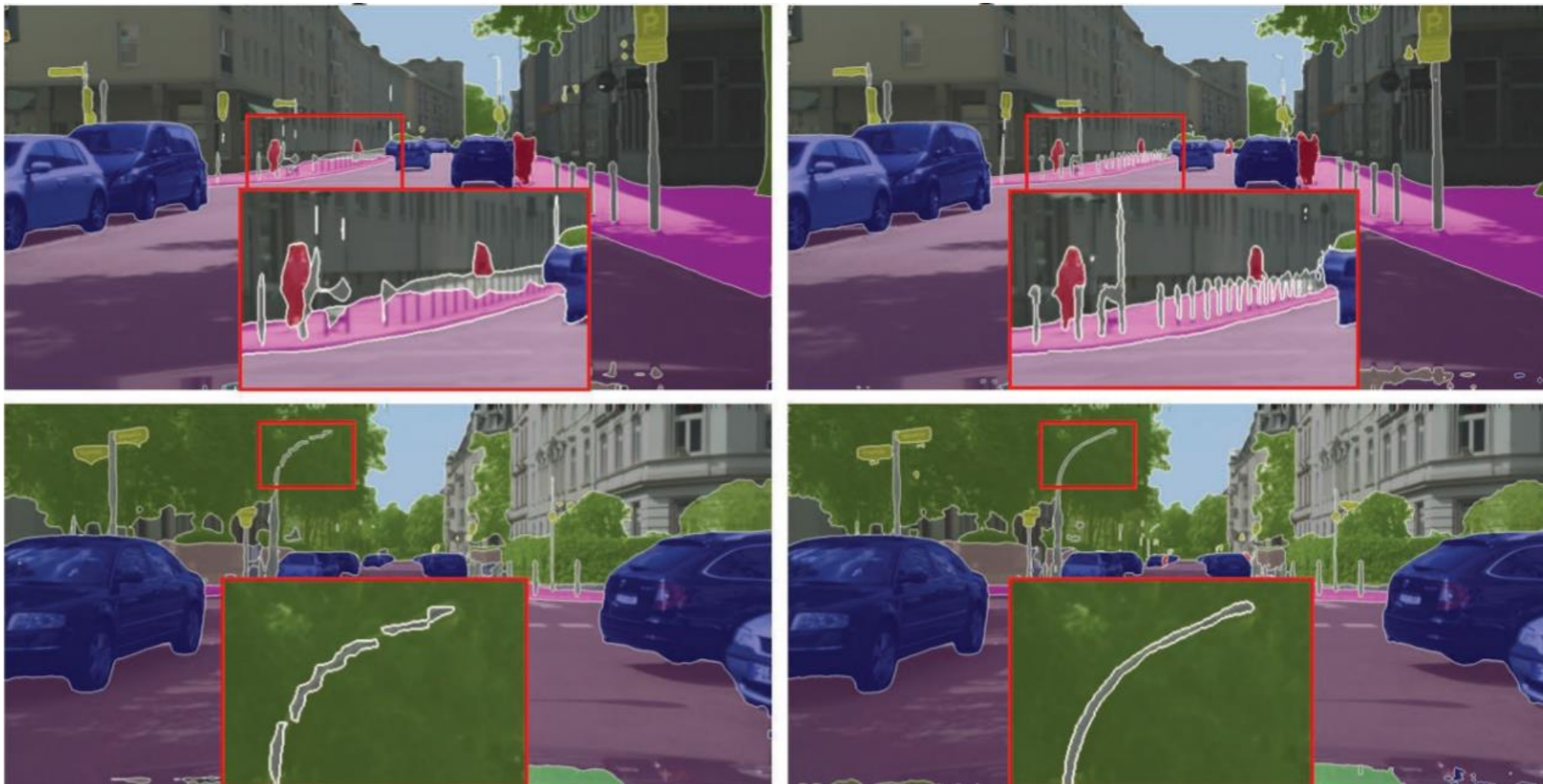
AP* is COCO mask AP for a COCO-trained model
evaluated against the higher quality LVIS annotation

PointRender for semantic segmentation



PointRender can be applied on top of
any modern semantic segmentation model

PointRend for semantic segmentation



+ PointRend

Quantitative comparison: semantic segmentation

method	output resolution	mIoU
DeeplabV3-OS-16	64×128	77.2
DeeplabV3-OS-8	128×256	77.8 (+0.6)
DeeplabV3-OS-16 + PointRend	1024×2048	78.4 (+1.2)

DeeplabV3 vs. DeeplabV3 with PointRend

method	output resolution	mIoU
SemanticFPN P_2 - P_5	256×512	77.7
SemanticFPN P_2 - P_5 + PointRend	1024×2048	78.6 (+0.9)
SemanticFPN P_3 - P_5	128×256	77.4
SemanticFPN P_3 - P_5 + PointRend	1024×2048	78.5 (+1.1)

SemanticFPN vs SemanticFPN with PointRend

Conclusion

- High resolution output with little to no computational overhead
Higher resolution, more accurate masks
with fewer model params, less compute time.
- “plug & play” on top of any FCN-based model for segmentation
- Significant quantitative and qualitative improvement

Thank You.

[Paper Review] PointRend: Image Segmentation as Rendering

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