

Pixel-Pair Occlusion Relationship Map (P2ORM): Formulation, Inference & Application

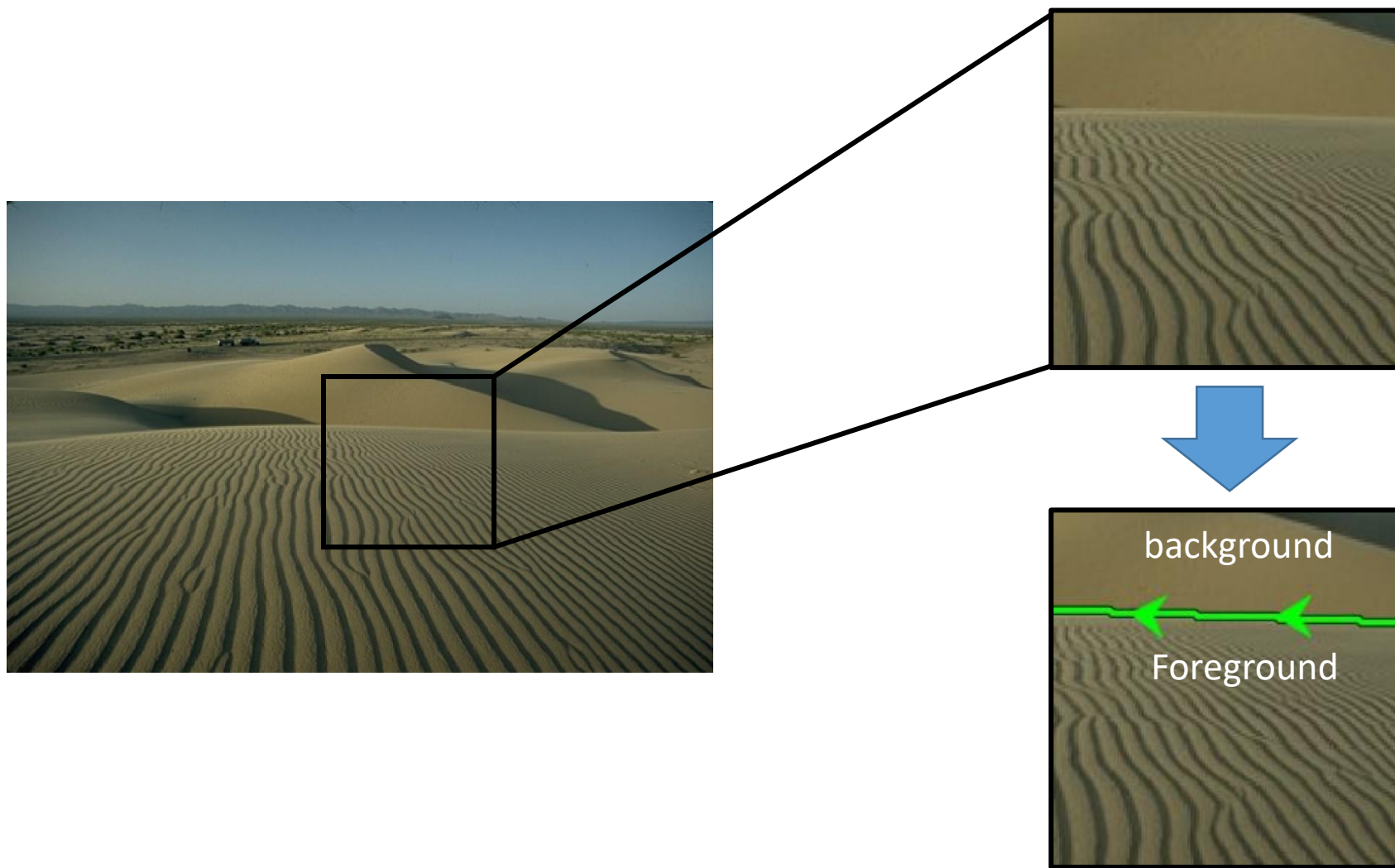
Xuchong Qiu¹, Yang Xiao¹, Chaohui Wang¹, Renaud Marlet^{1,2}

¹LIGM, Ecole des Ponts, Univ Gustave Eiffel, CNRS, ESIEE Paris, France

²valeo.ai, Paris, France

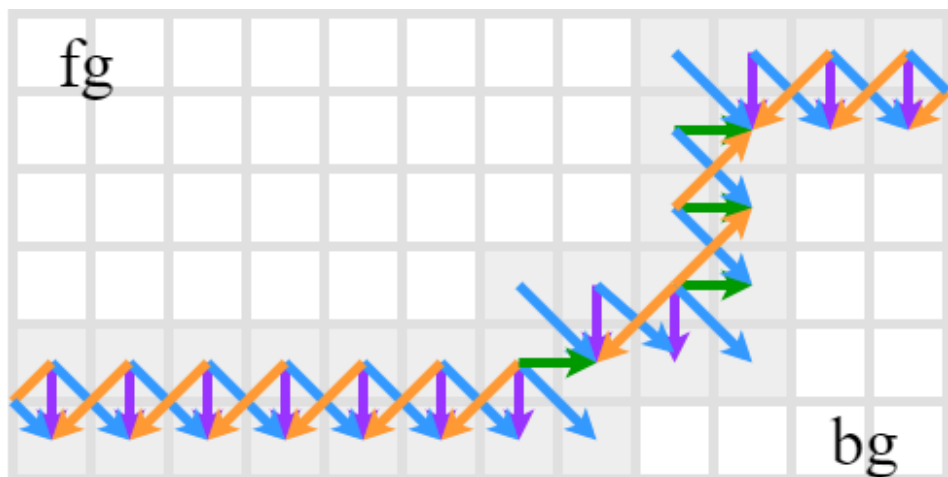


Oriented occlusion boundary

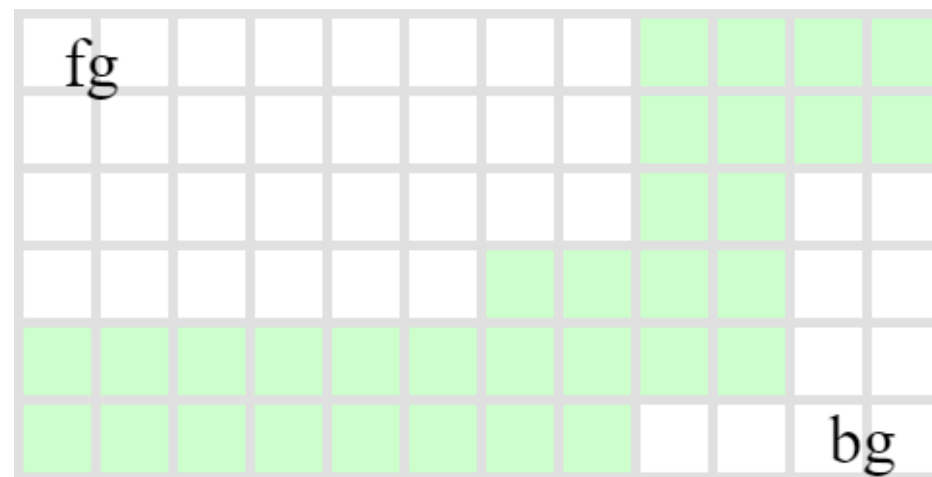


Key Idea: Classifying Pairs of Pixels

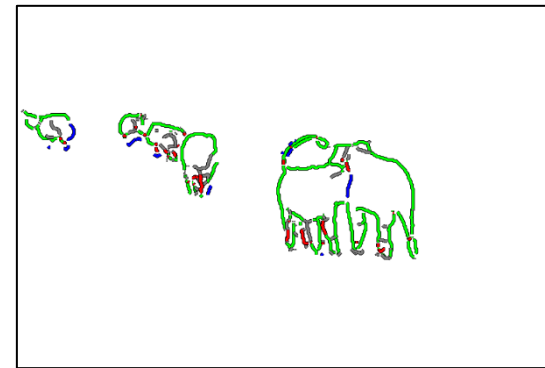
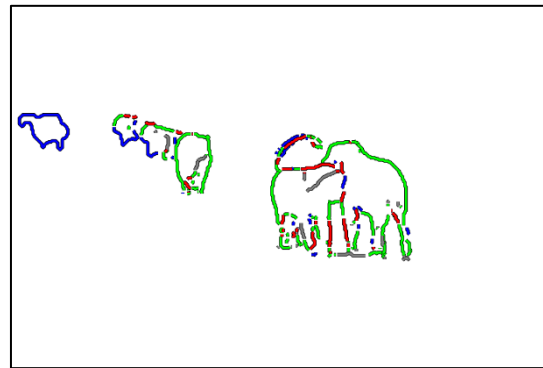
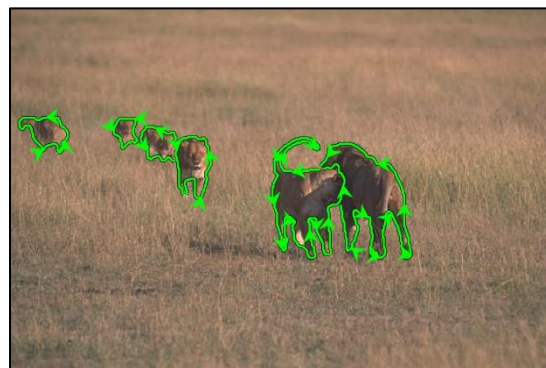
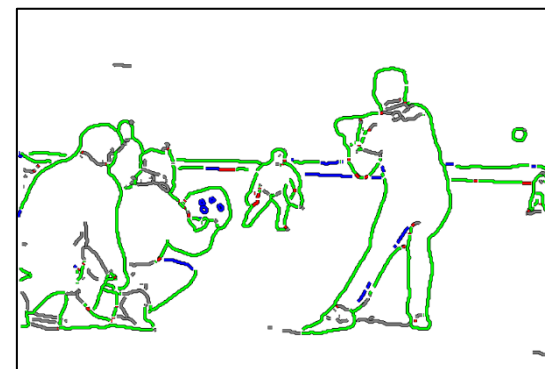
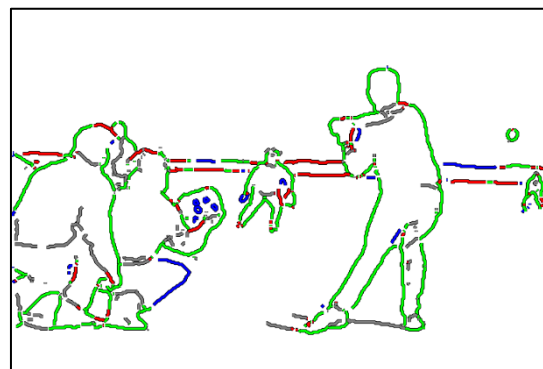
Classifying the occlusion status of neighbor pixel pairs



Pixel-wise occlusion boundary detection



Evaluation on oriented occlusion boundary



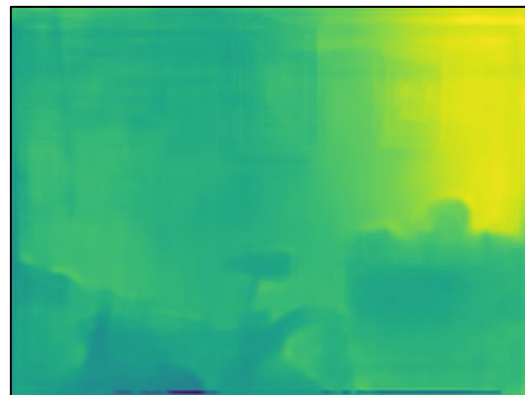
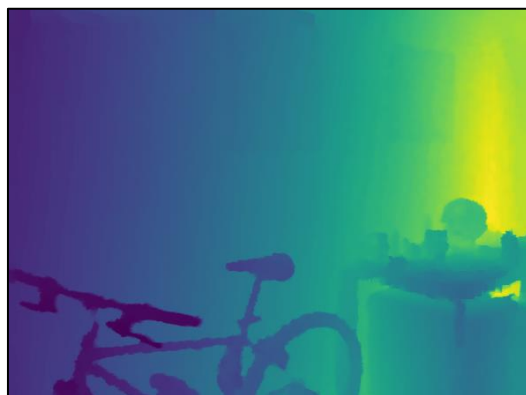
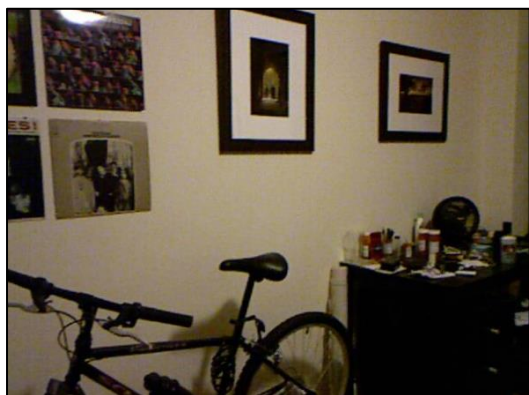
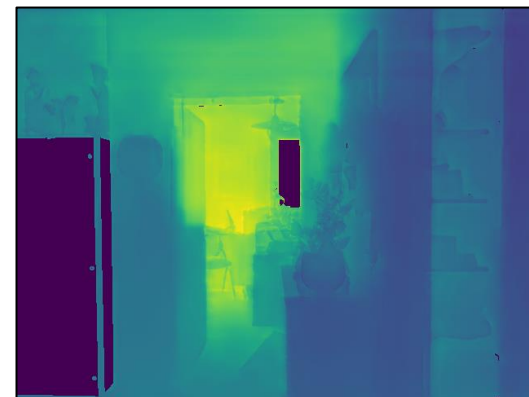
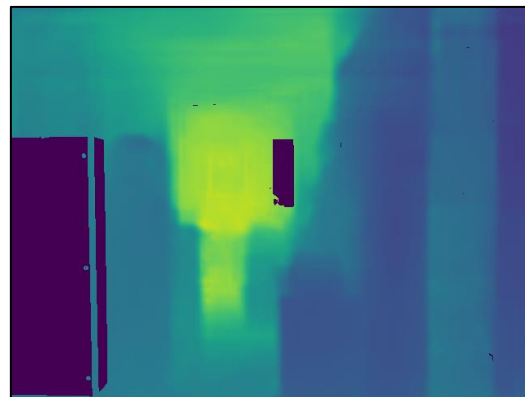
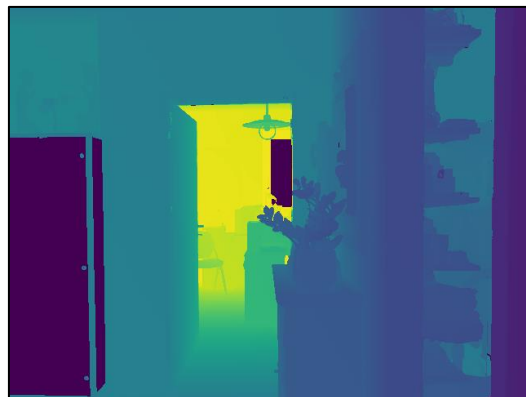
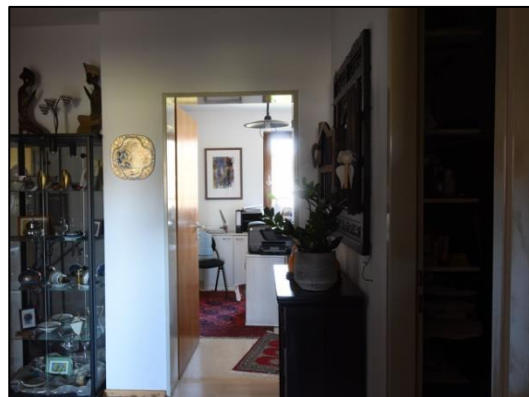
Input image

Ground truth

OFNet prediction [30]

Ours

Evaluation on depth refinement



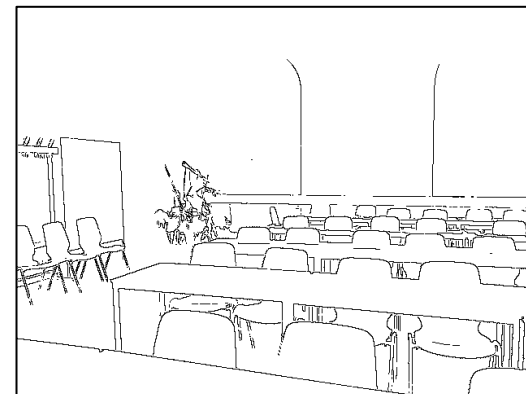
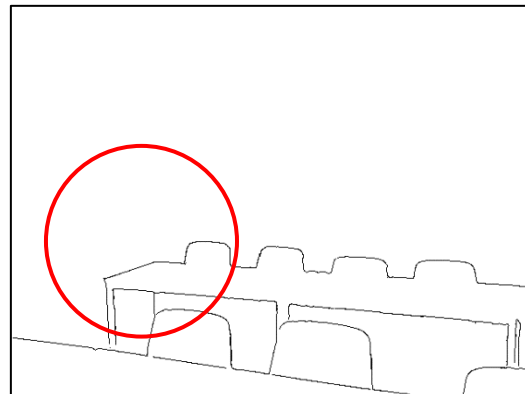
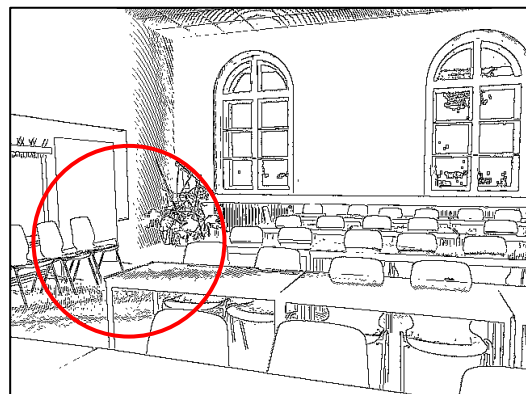
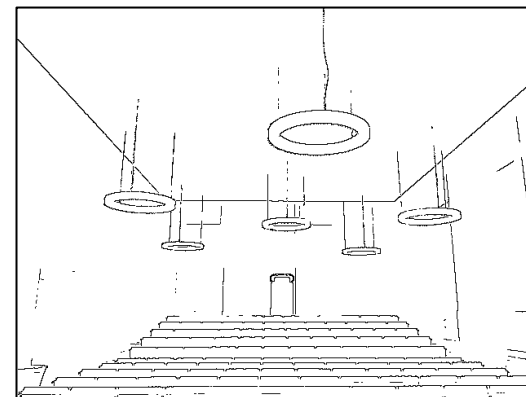
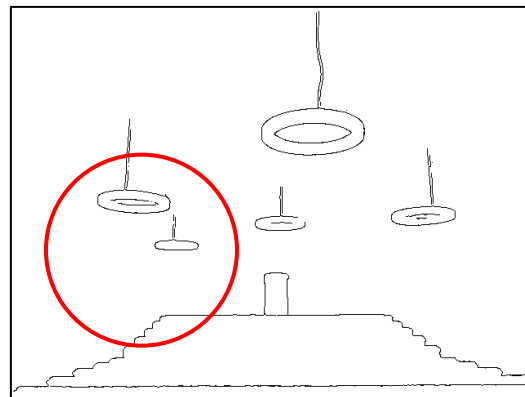
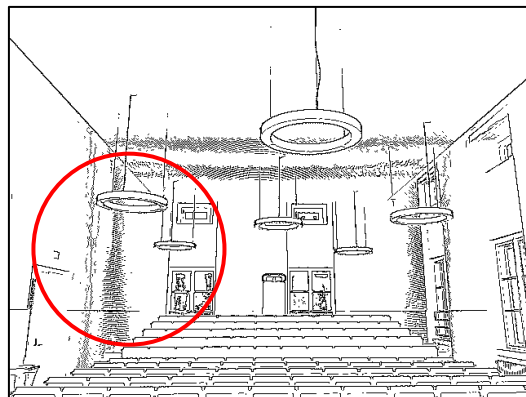
Input image

Ground truth

SharpNet prediction [40]

Our refined depth

Generated occlusion boundary



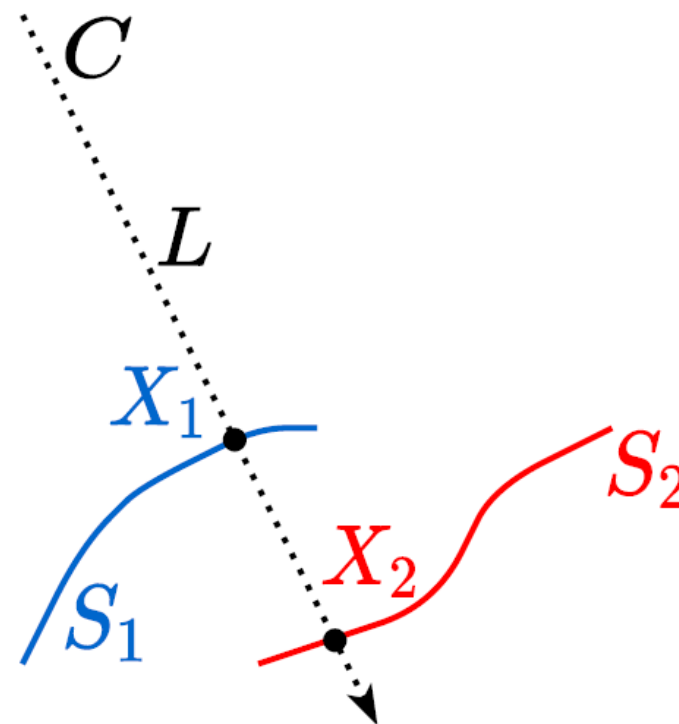
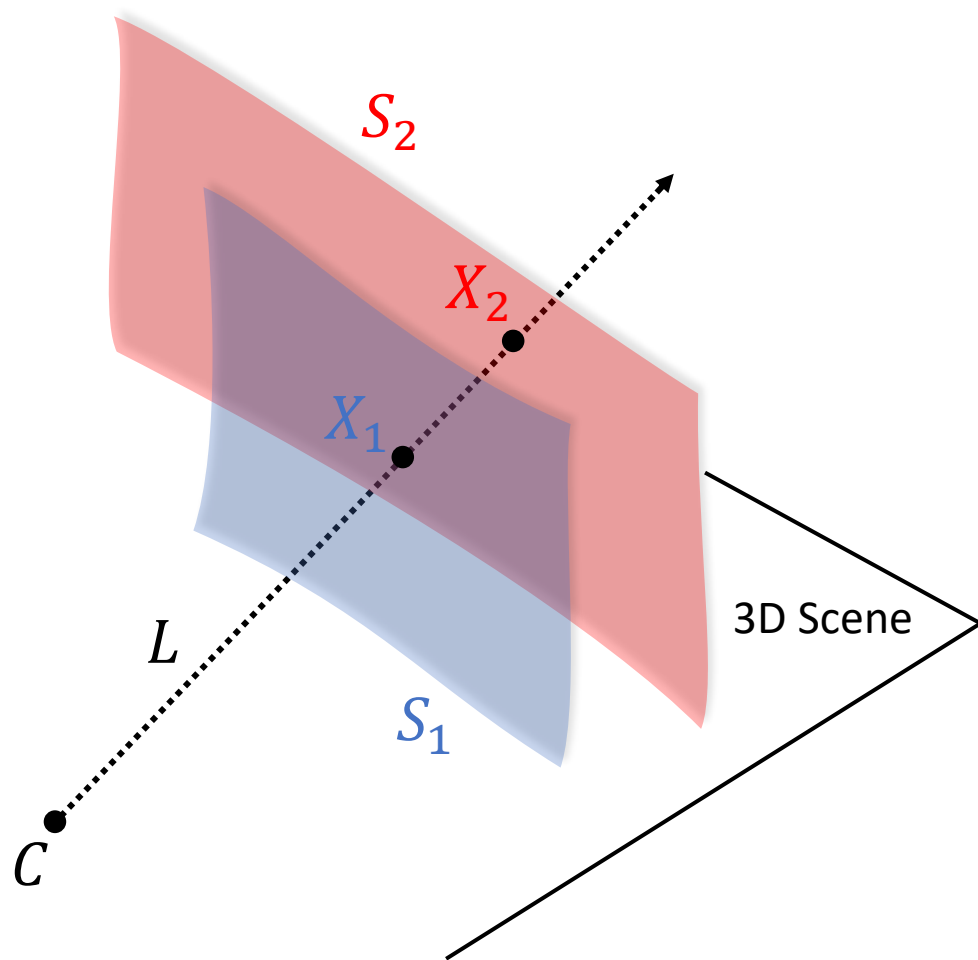
Image

Thresholding depth difference

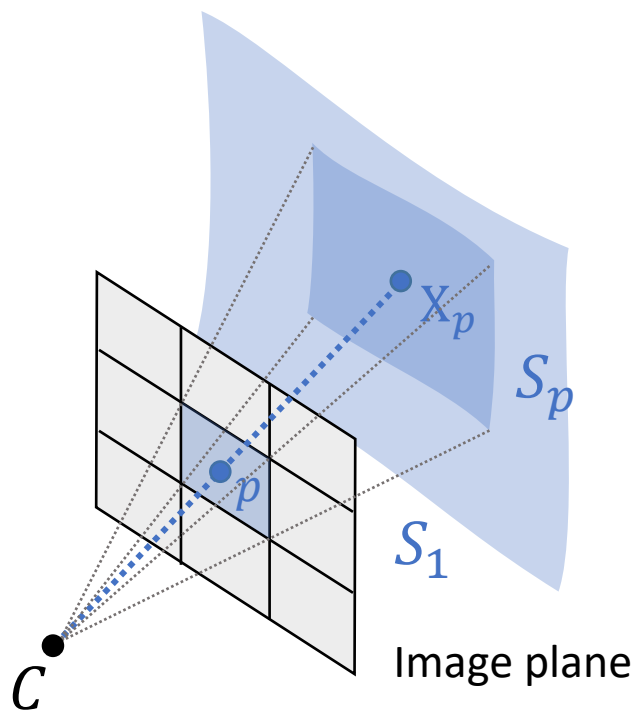
Edge detection on depth

Ours

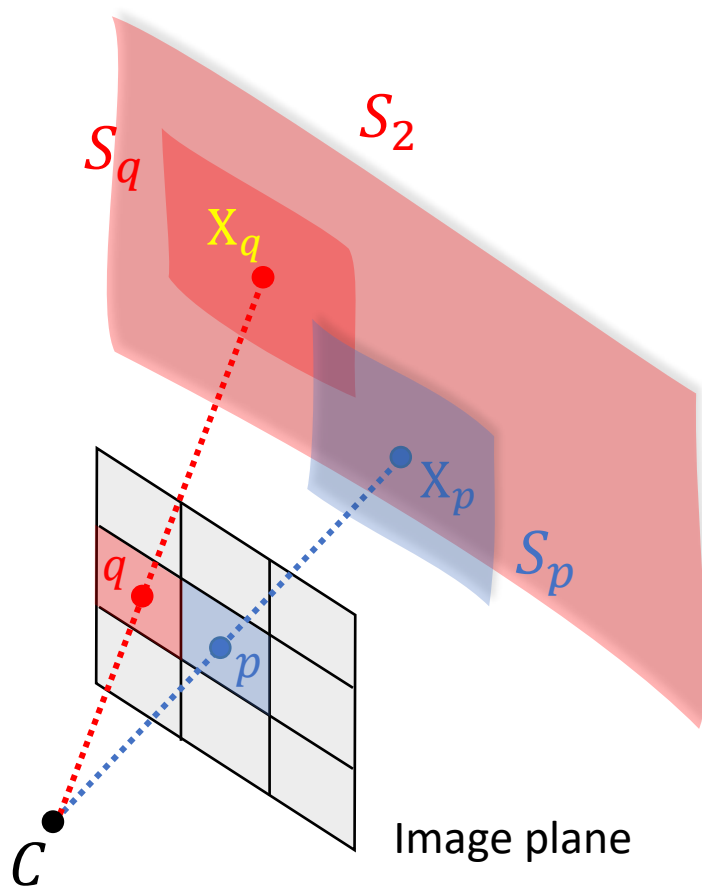
Geometric occlusion in a single image



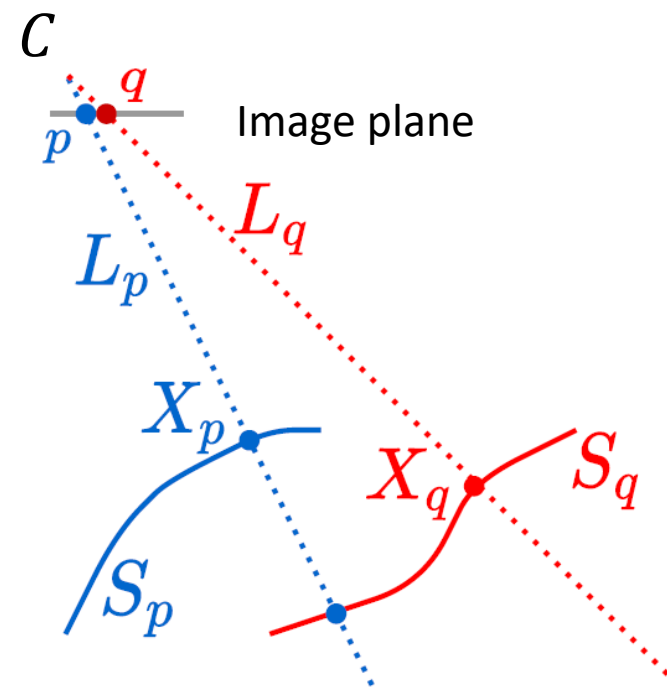
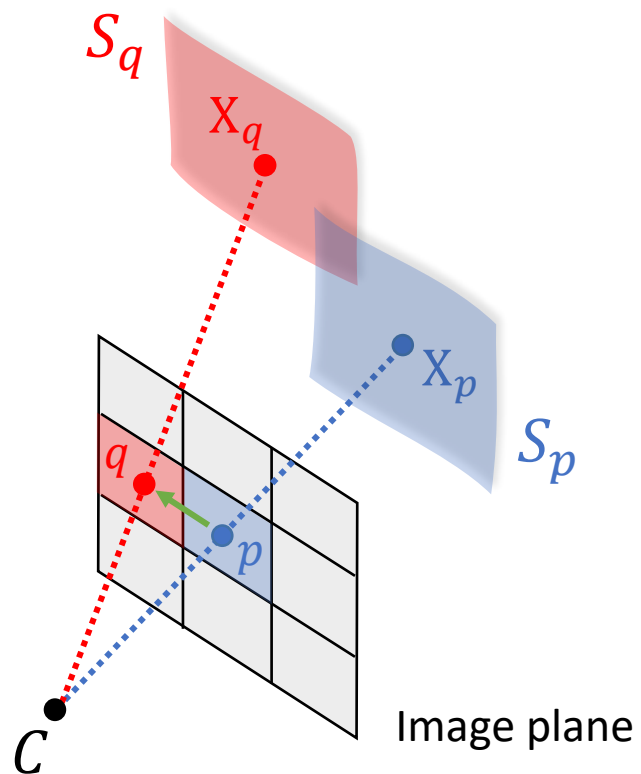
Geometric occlusion in a single image



Geometric occlusion in a single image

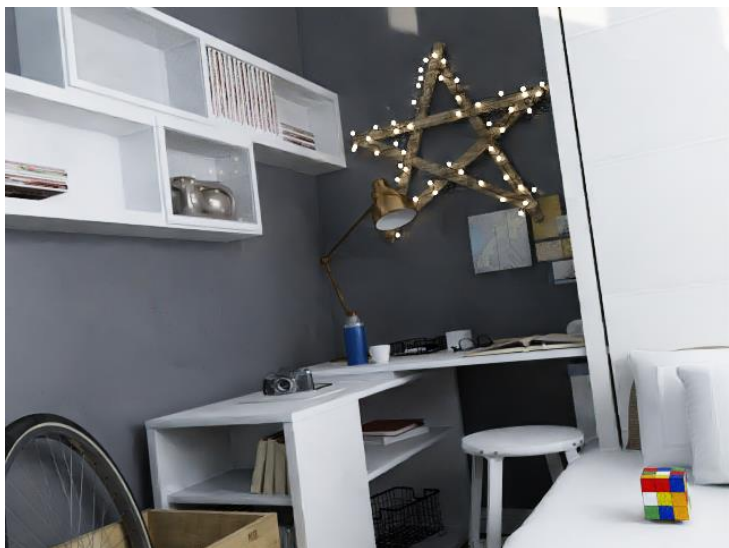


Geometric occlusion in a single image

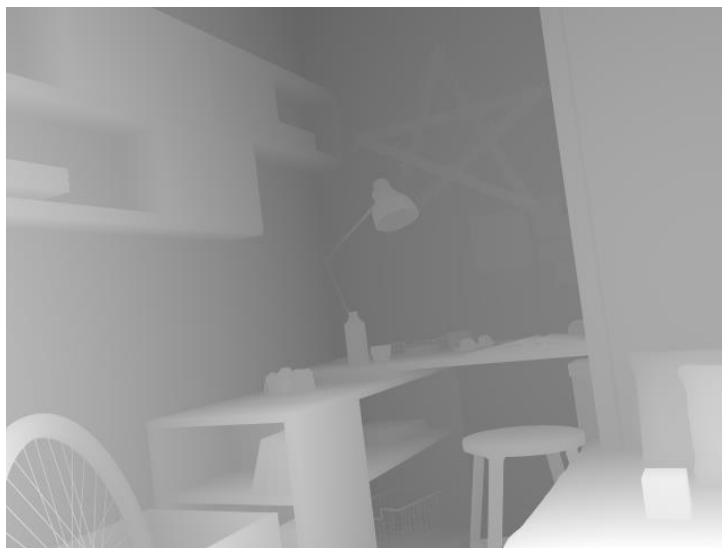


What we have

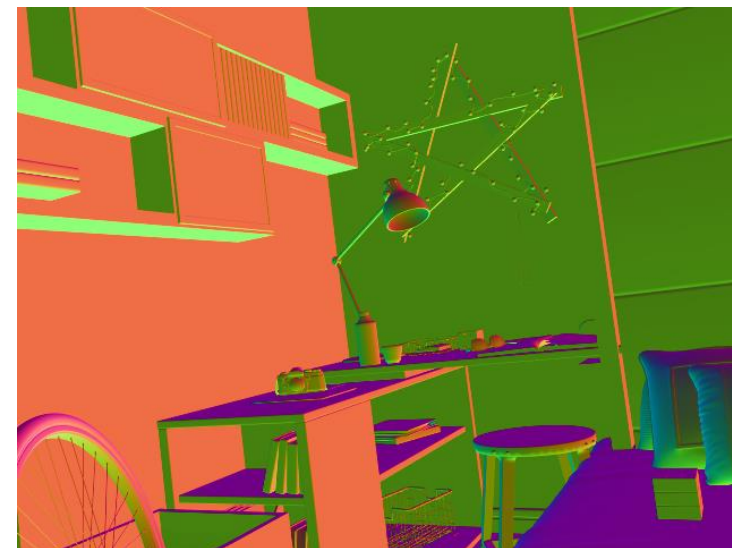
- A typical RGBD dataset



RGB image

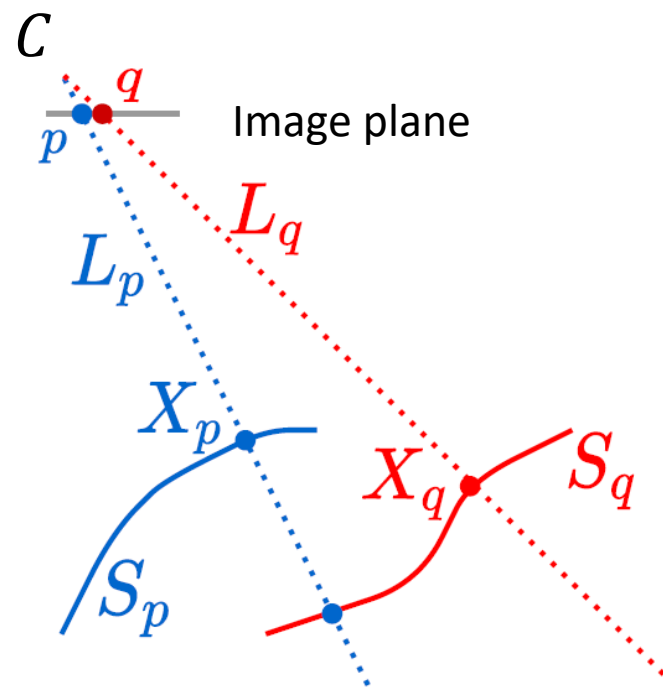
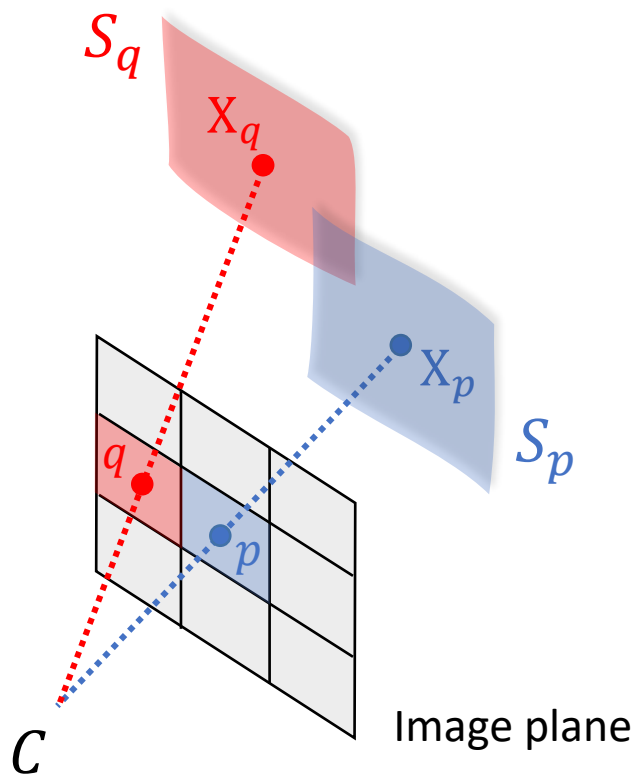


Depth map

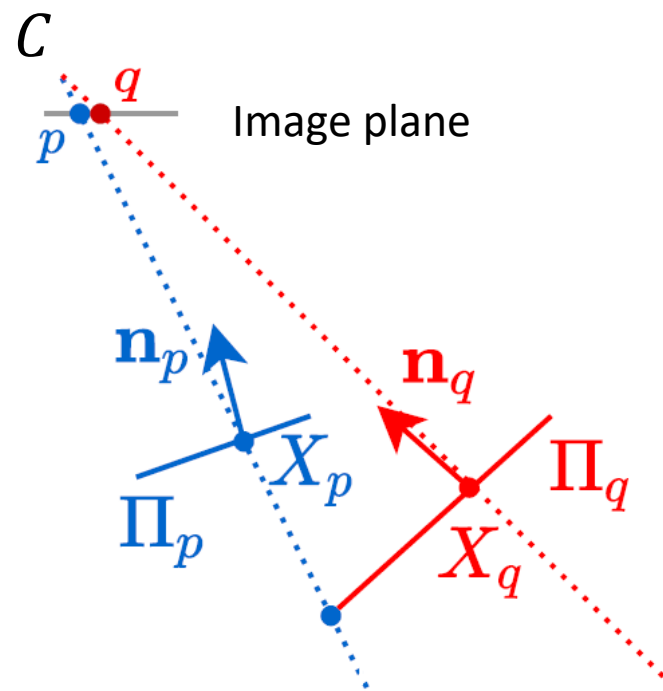
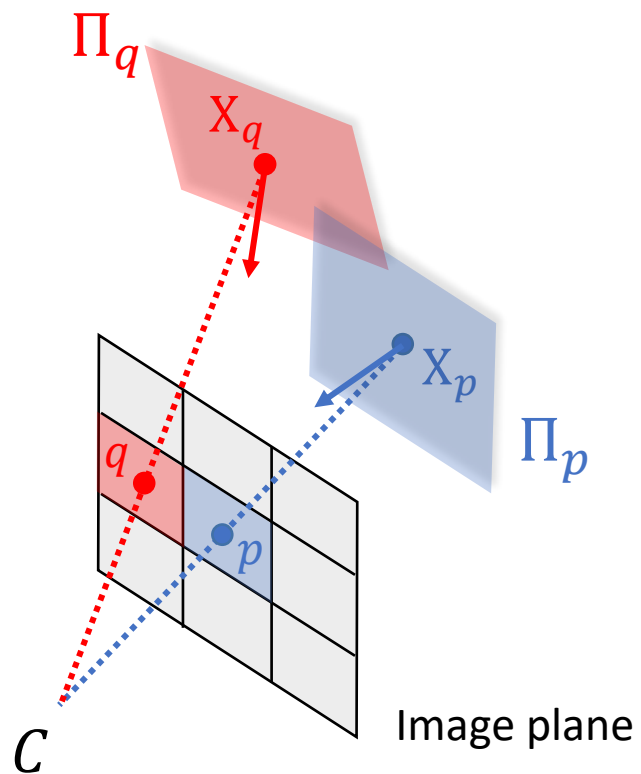


Surface normal map

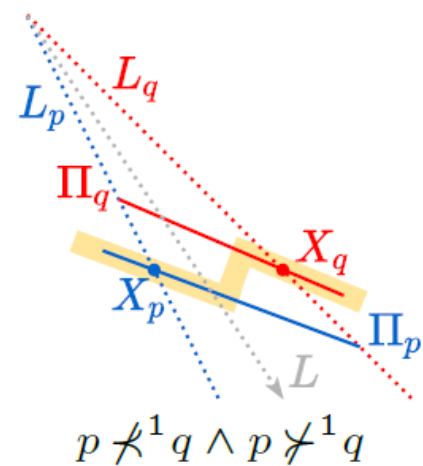
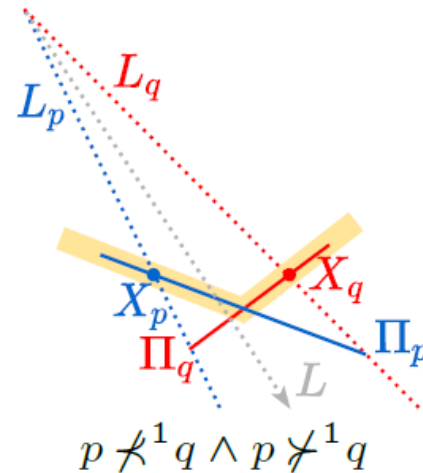
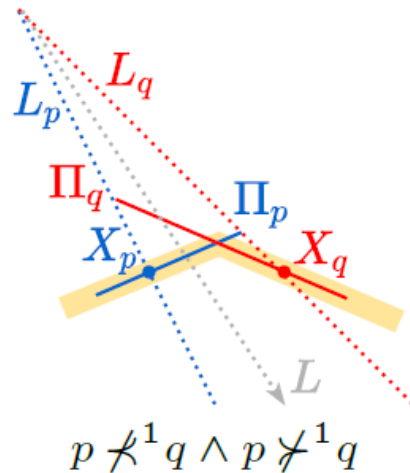
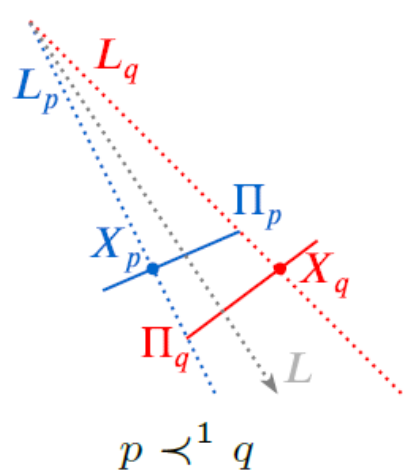
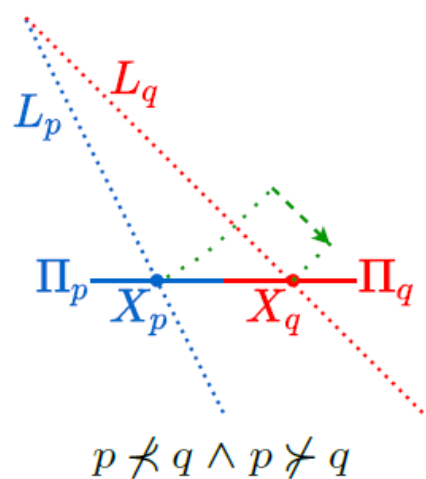
Ground truth generation



Ground truth generation



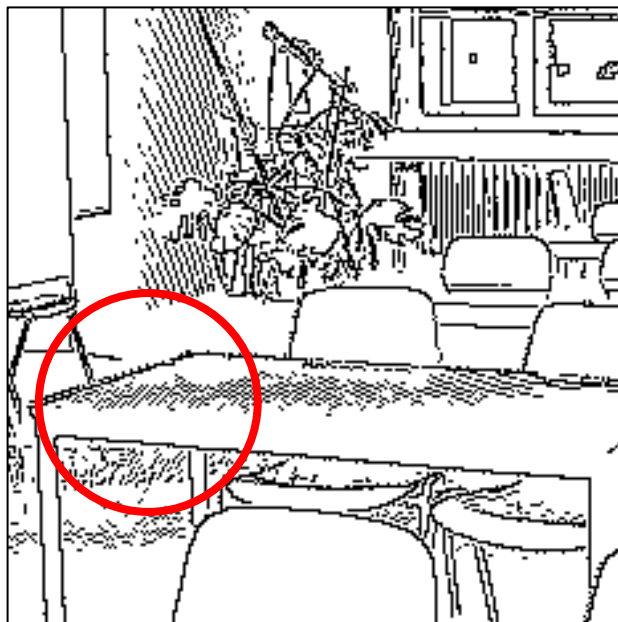
Ground truth generation



Ground truth generation



Image



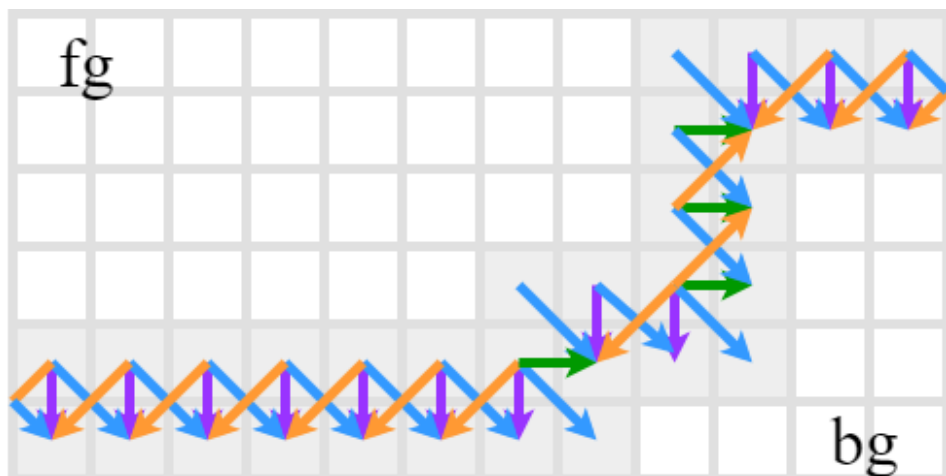
Thresholding depth difference



Ours

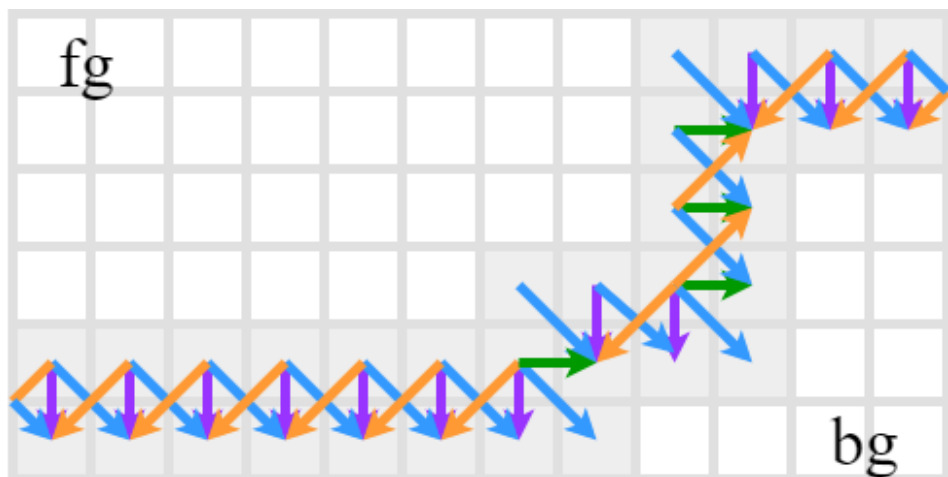
Pixel-Pair Occlusion Relationship Map

Pixel-Pair Occlusion Relationship Map (P2ORM)

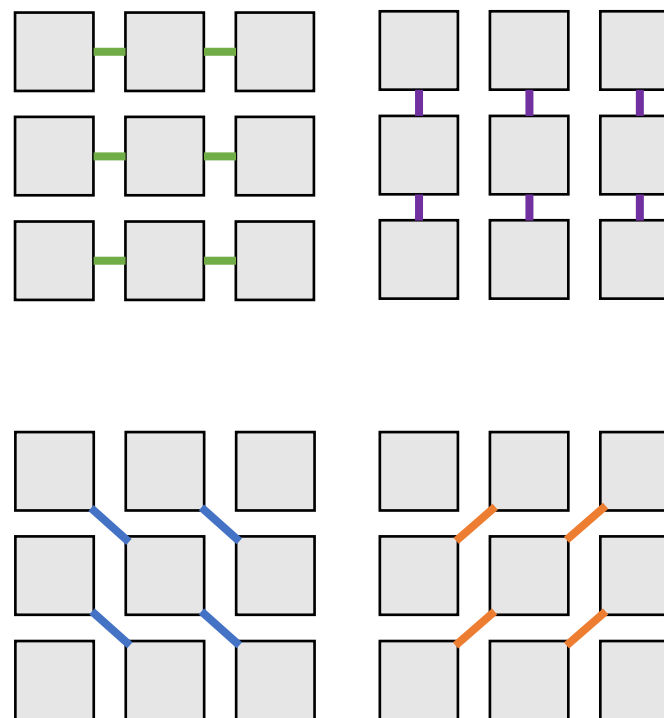


Pixel-Pair Occlusion Relationship Map

Pixel-Pair Occlusion Relationship Map (P2ORM)

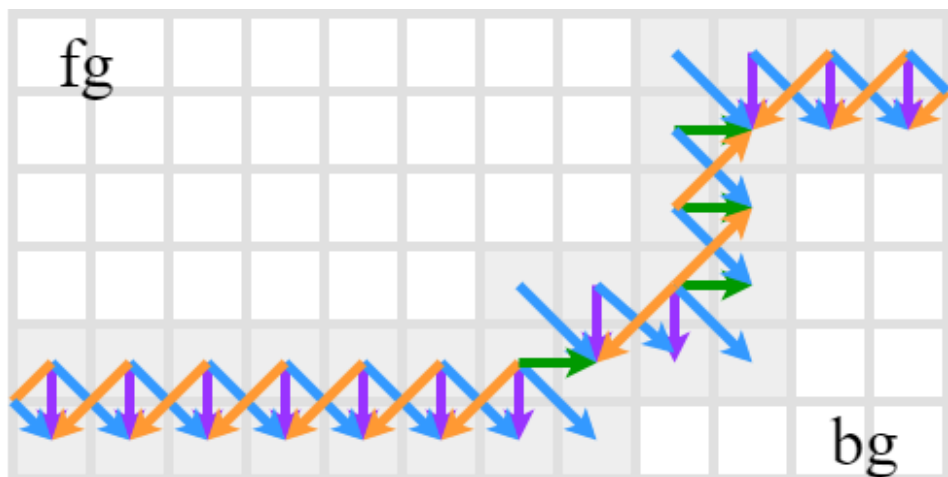


Four inclinations in 8-connectivity

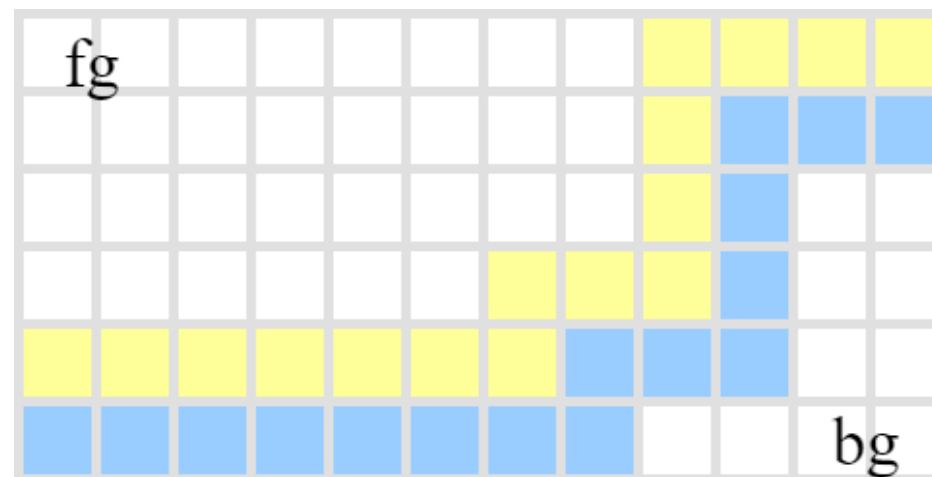


P2ORM and Figure/Ground notion

Pixel-Pair Occlusion Relationship Map (P2ORM)

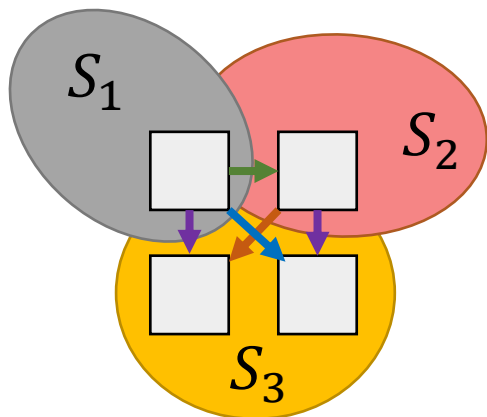


Figure/Ground notion



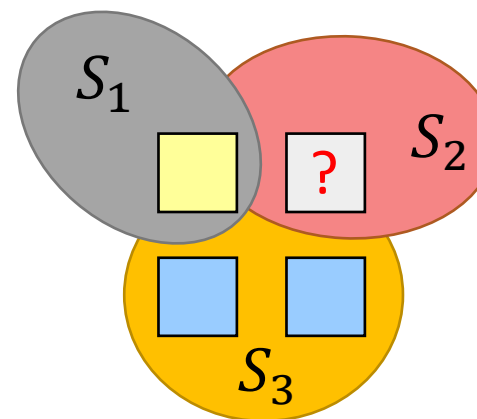
P2ORM and Figure/Ground notion

Pixel-Pair Occlusion Relationship Map (P2ORM)



S_1 occludes S_2, S_3
 S_2 occludes S_3

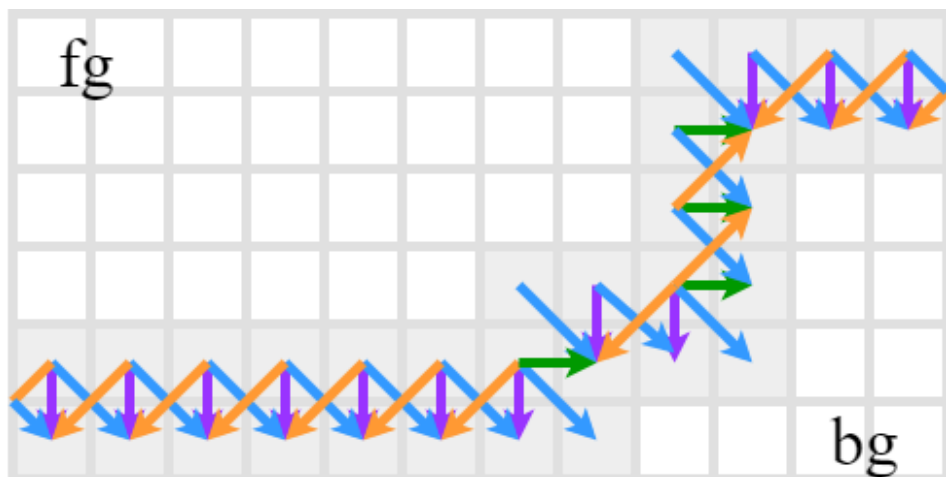
Figure/Ground notion



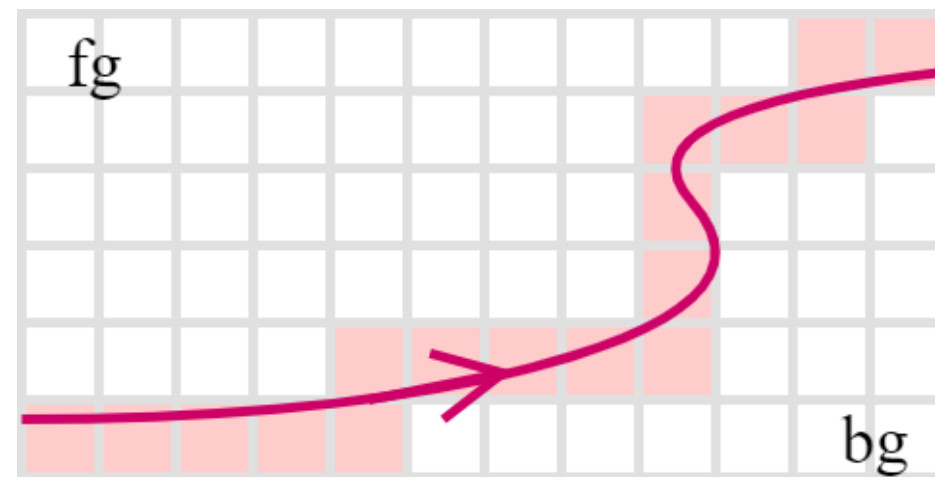
S_1 occludes S_2, S_3
 S_2 occludes S_3

P2ORM and oriented occlusion boundary notion

Pixel-Pair Occlusion Relationship Map (P2ORM)



Oriented occlusion boundary notion

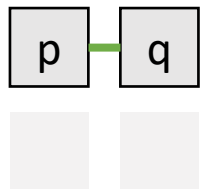


Modelling P2ORM

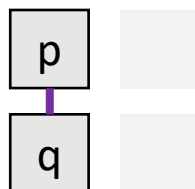
- Pixel-pair occlusion status label

$$\omega_{p,q} = r = \begin{cases} 1 & p \text{ occludes } q \\ 0 & \text{no occlusion between } p, q \\ -1 & p \text{ is occluded by } q \end{cases}$$

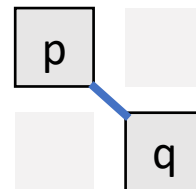
- Four inclinations for pixel-pairs



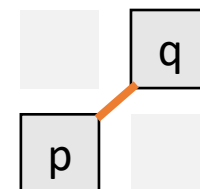
Horizontal



Vertical



Diagonal

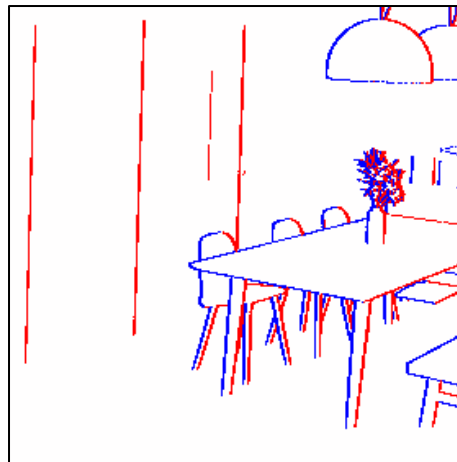


Antidiagonal

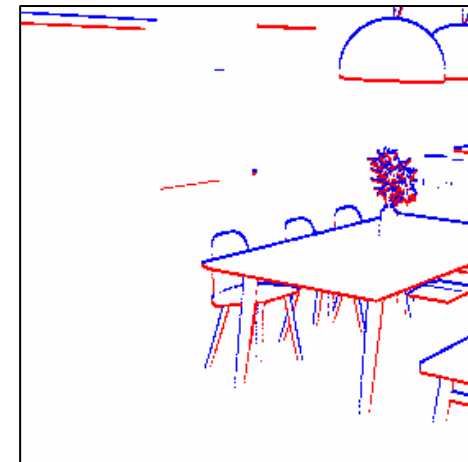
Modelling P2ORM



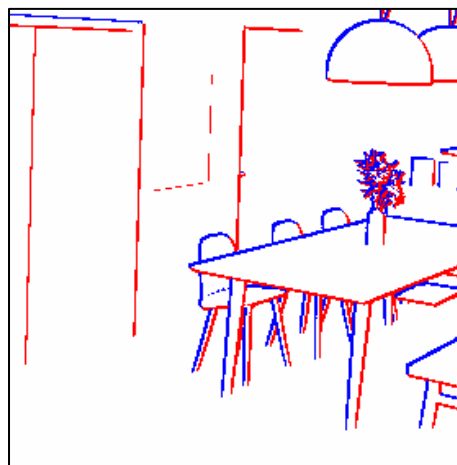
Horizontal



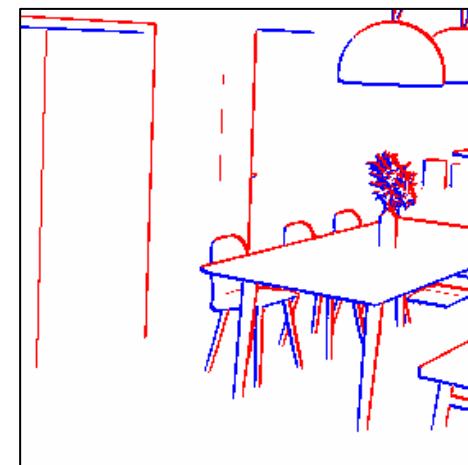
Vertical



Diagonal



Antidiagonal



p occludes q

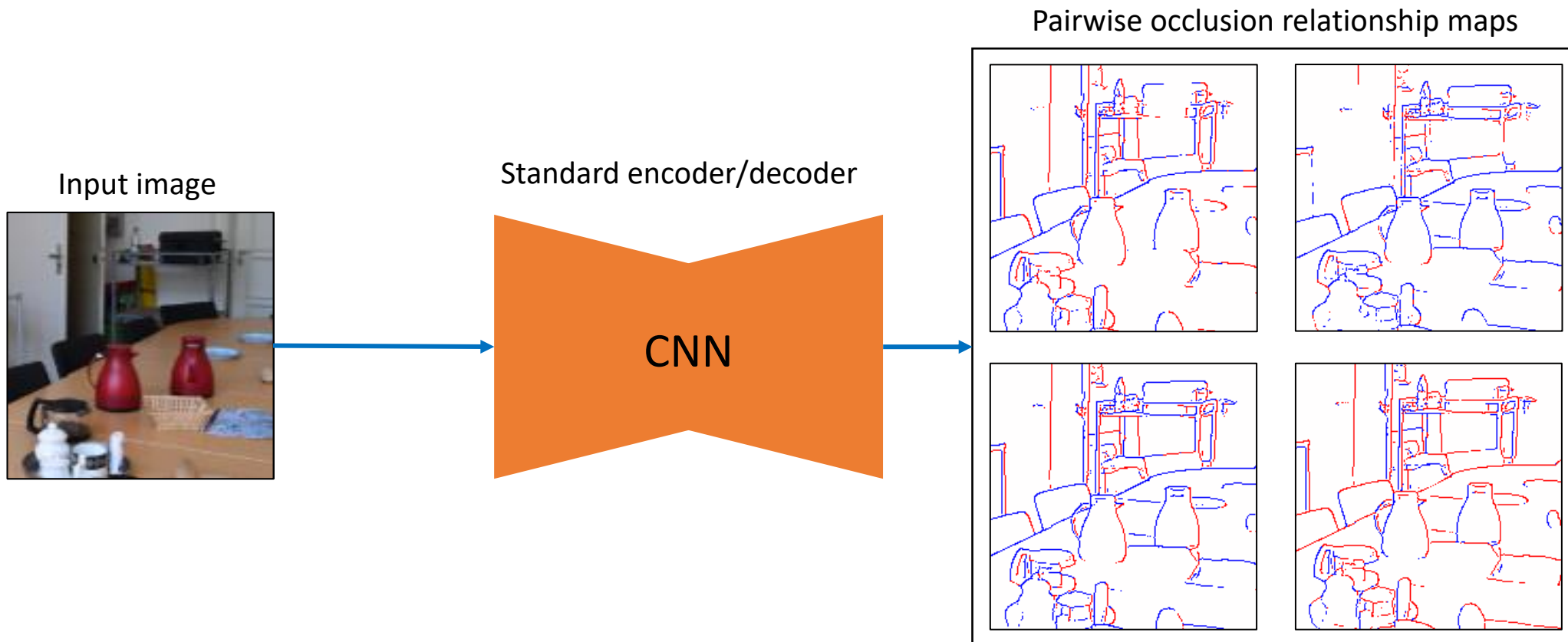


q occludes p



no occlusion

Estimating P2ORM: A segmentation task

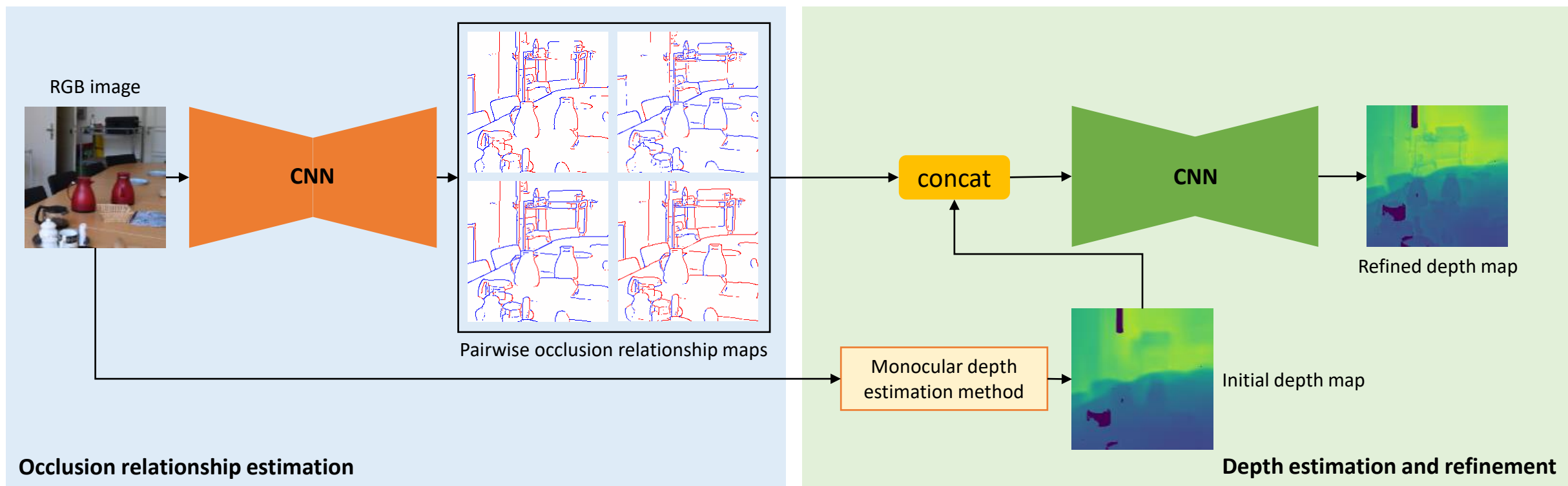


Evaluation on oriented occlusion boundary

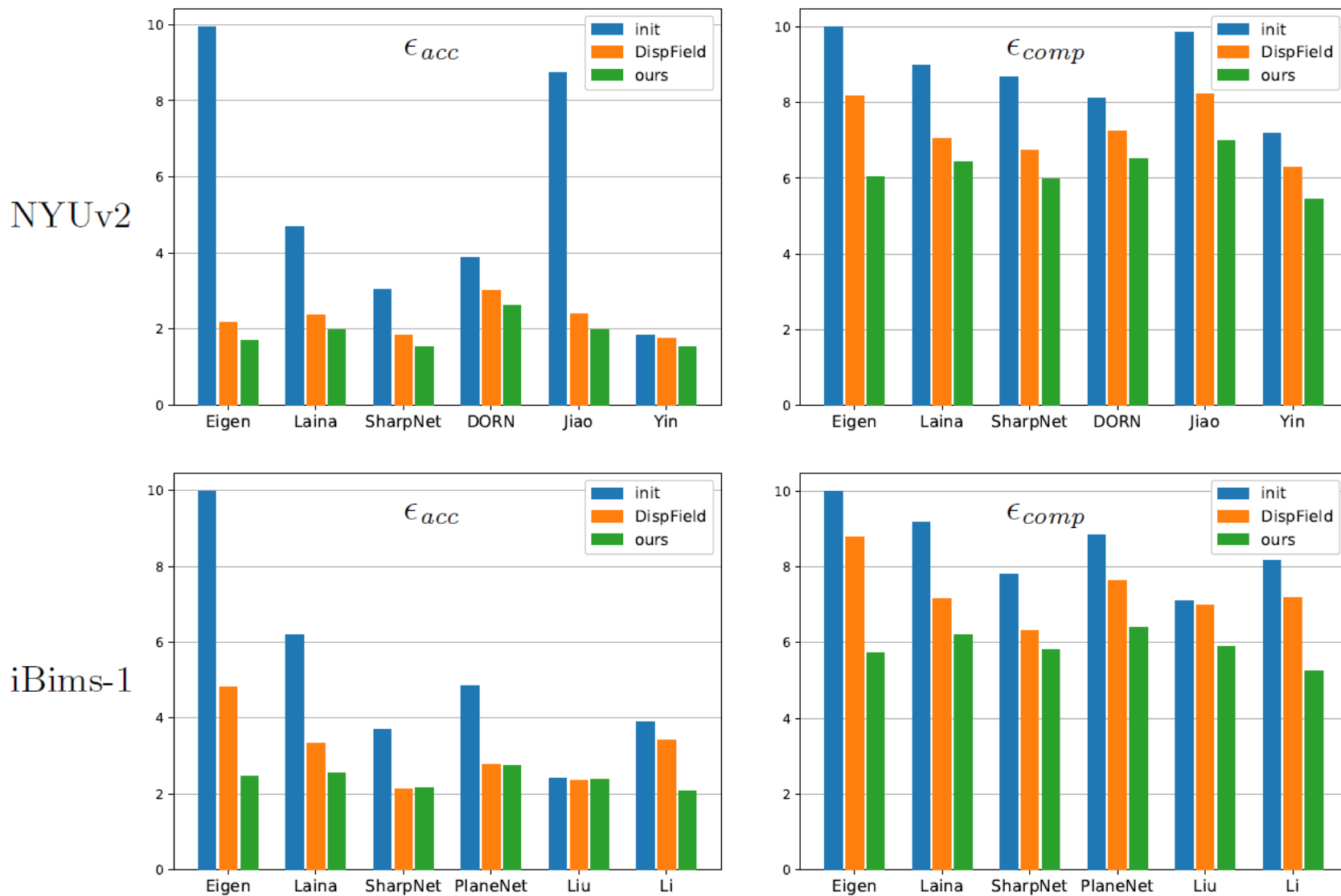
Table 2. Oriented occlusion boundary estimation. *Our re-implementation.

Method Metric	BSDS ownership			NYUv2-OR			iBims-1-OR		
	ODS	OIS	AP	ODS	OIS	AP	ODS	OIS	AP
SRF-OCC [49]	.419	.448	.337	-	-	-	-	-	-
DOC-DMLFOV [53]	.463	.491	.369	-	-	-	-	-	-
DOC-HED [53]	.522	.545	.428	-	-	-	-	-	-
DOOBNet [51]	.555	.570	.440	-	-	-	-	-	-
OFNet [30]	.583	.607	.501	-	-	-	-	-	-
DOOBNet*	.529	.543	.433	.343	.370	.263	.421	.440	.312
OFNet*	.553	.577	.520	.402	.431	.342	.488	.513	.432
baseline	.571	.605	.524	.396	.428	.343	.482	.507	.431
ours (4-connectivity)	.590	.612	.512	.500	.522	.477	.575	.599	.508
ours (8-connectivity)	.607	.632	.598	.520	.540	.497	.581	.603	.525

P2ORM: Application in depth refinement



Evaluation on depth refinement





Thank You

Project webpage: <http://imagine.enpc.fr/~qiux/P2ORM/>

Email: xuchong.qiu@enpc.fr

