Deep Outdoor Illumination Estimation

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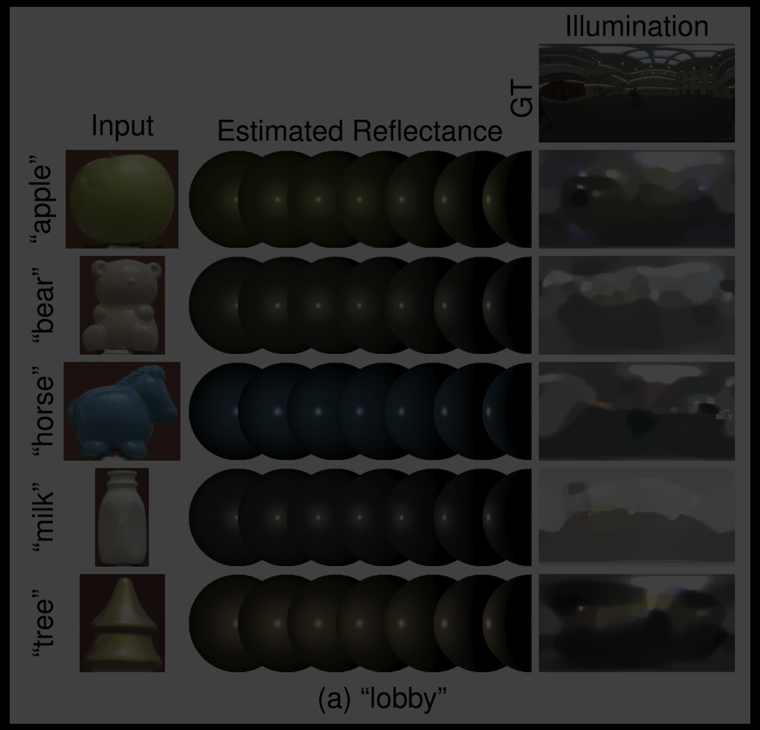
Capturing lighting conditions

[Debevec 1998]

Illumination capture and estimation

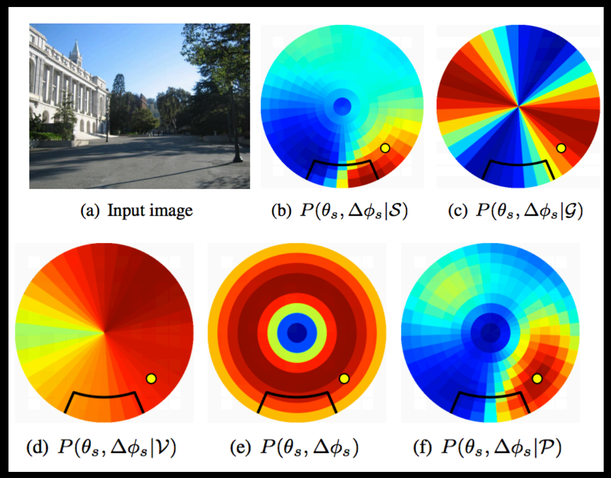
1. Specialized equipment

[Stumpfel et al. ’04]



2. Known object in scene

[Lombardi et al. ’15]



3. Handcrafted features

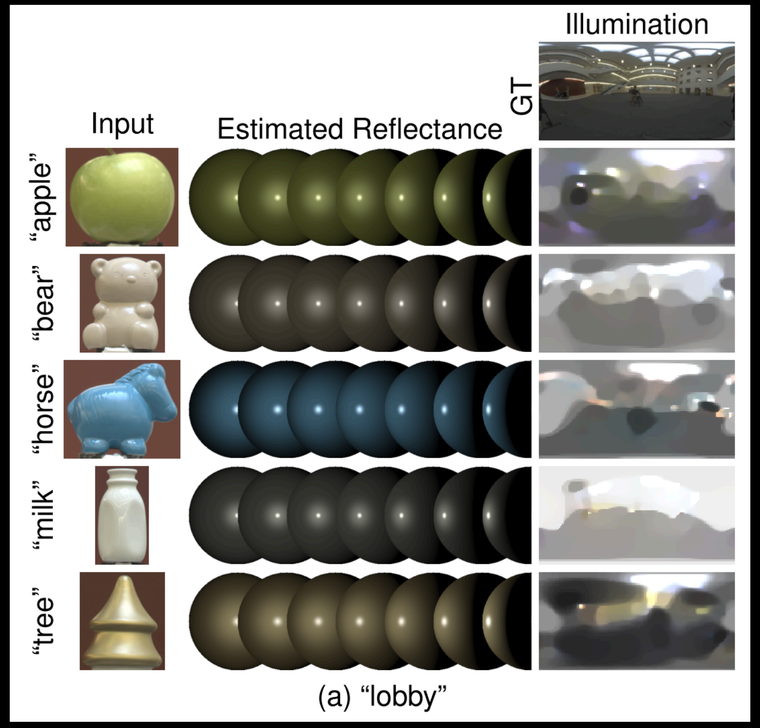
[Lalonde et al ‘12]

Our work

~~1. Specialized equipment~~

[Stumpfel et al. ’04]

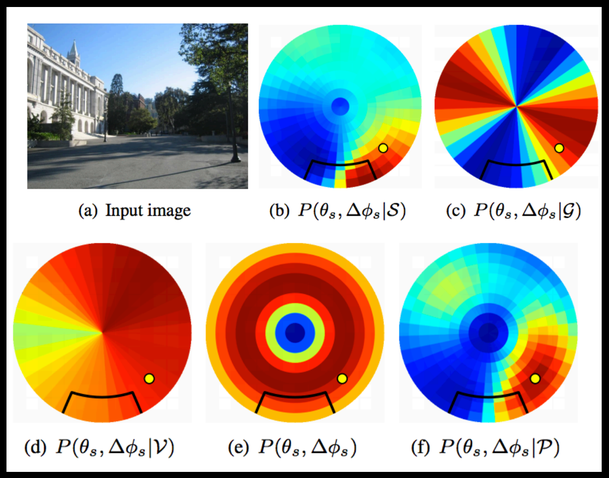
Conventional camera



~~2. Known object in scene~~

[Lombardi et al. ’15]

Generic scene



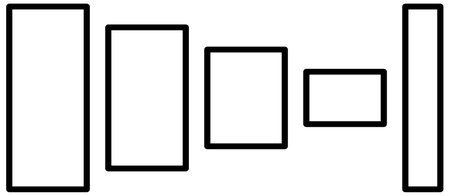
~~3. Handcrafted features~~

[Lalonde et al ‘12]

Learned features

Input

CNN

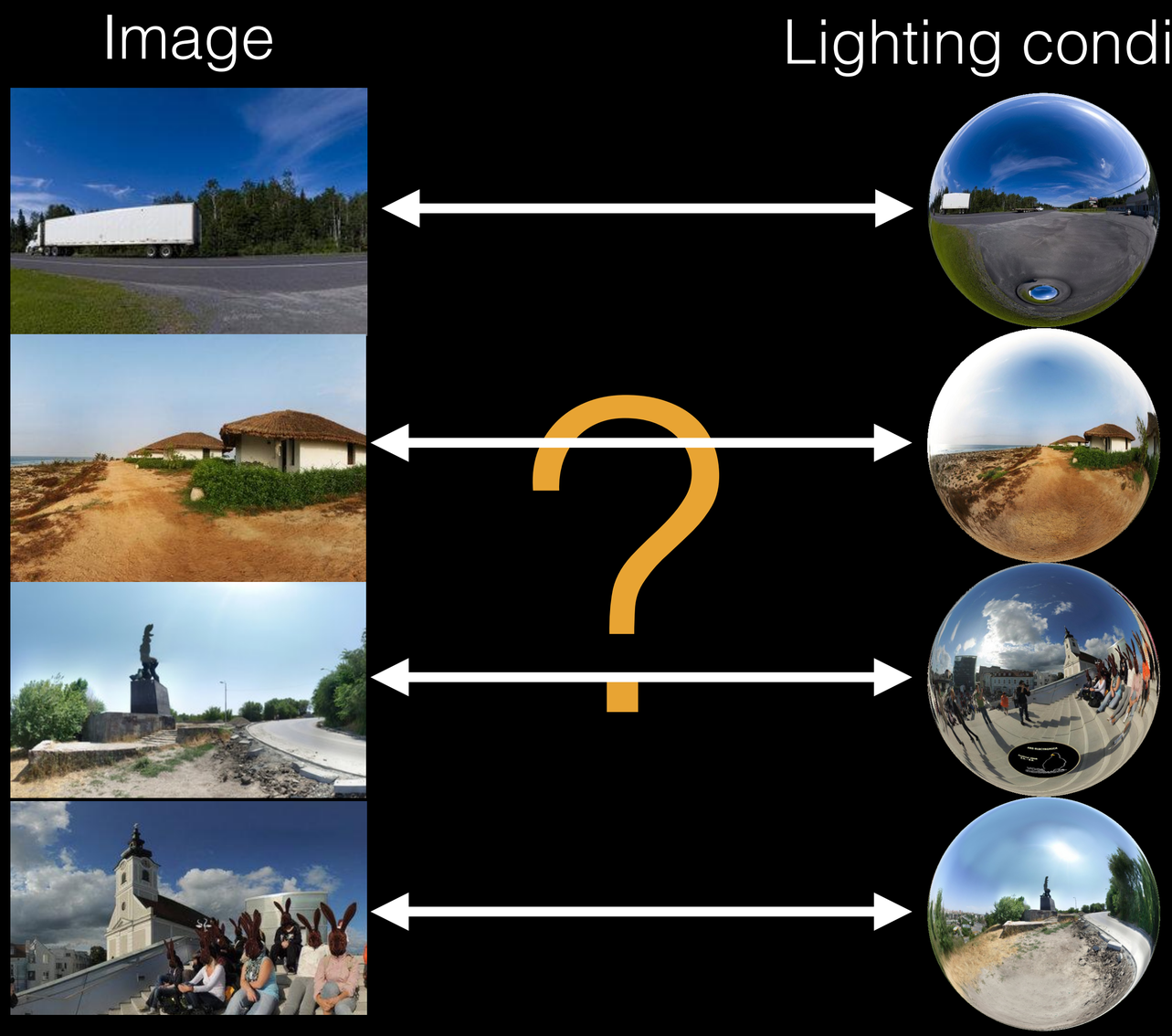


Light

Output

How do we train such an approach?

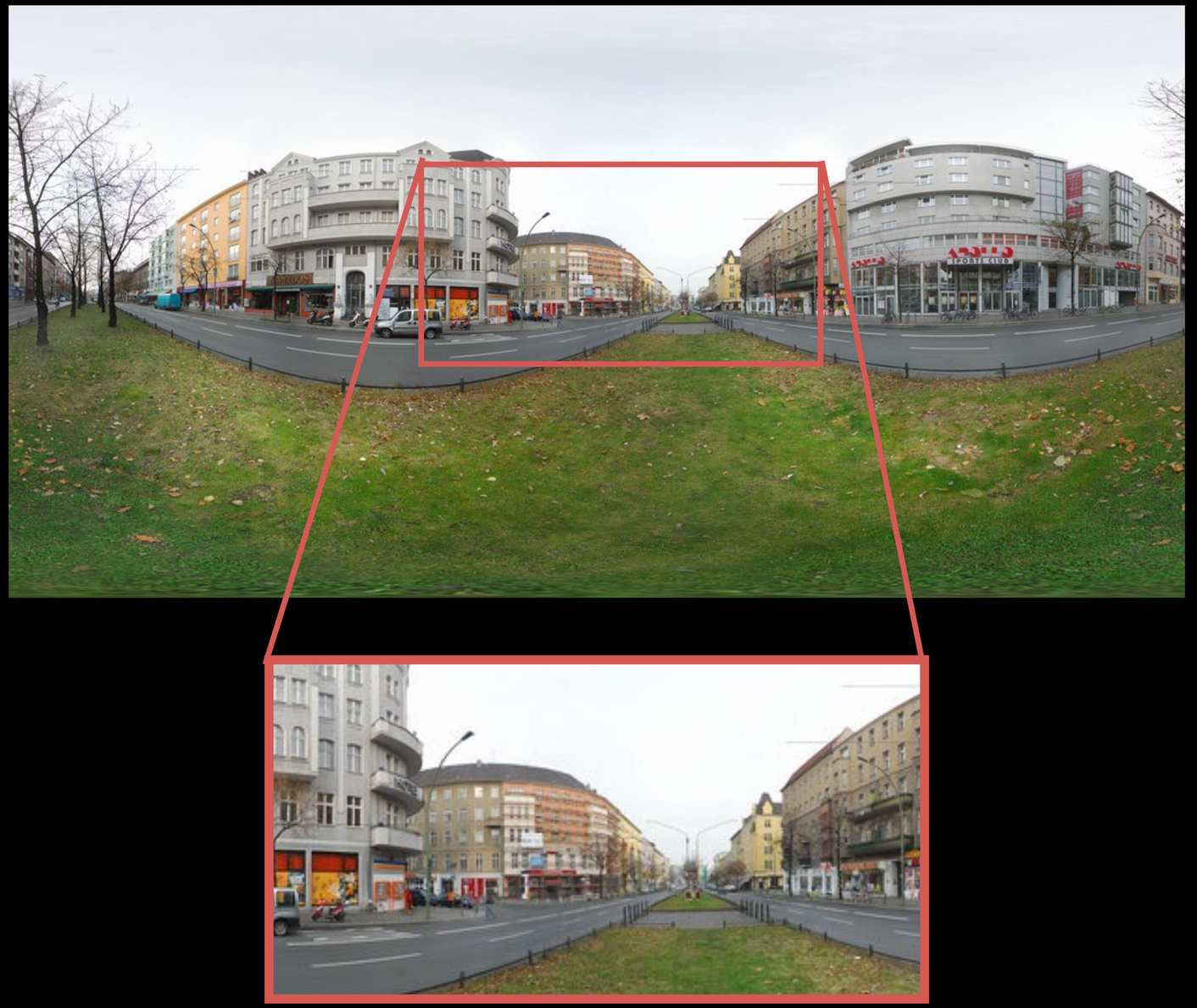
How to train?



SUN360 dataset

[Xiao et al. CVPR'12]

- 45,000 outdoor panoramas
- Vast diversity of illumination conditions



CNN

Problem: SUN360 is Low Dynamic Range

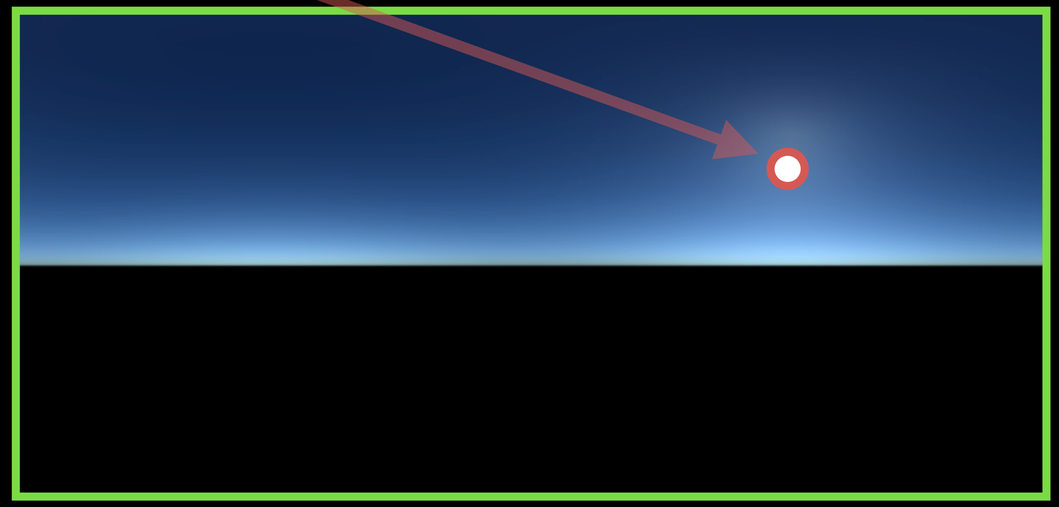
LDR lighting

HDR lighting

Hošek-Wilkie Sky Model

$$f_h^c(\mathbf{l};\mathbf{q}_h) = \omega\left[f_{sun}^c(\mathbf{l}_{\text{sun}},t) + f_{sky}^c(\mathbf{l}_{\text{sun}},t)\right]$$

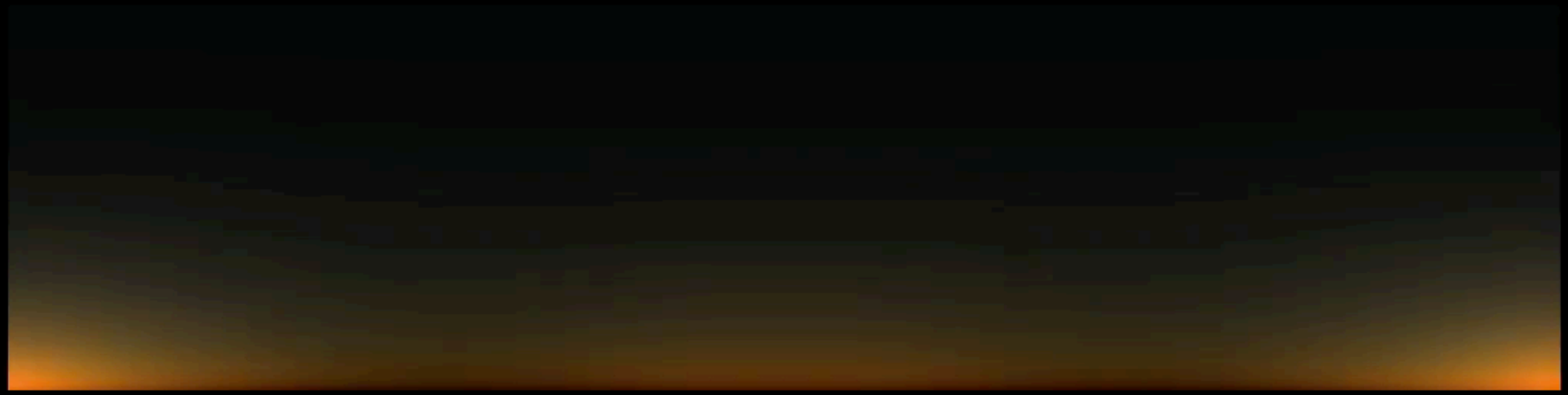
$\approx$



Hošek-Wilkie Sky Model

$$f_h^c(\mathbf{l}; \mathbf{q}_h) = \omega \left[f_{sun}^c(\mathbf{l}_{\text{sun}}, t) + f_{sky}^c(\mathbf{l}_{\text{sun}}, t) \right]$$

$$\mathbf{q}_h = [t, \mathbf{l}_{\text{sun}}]$$



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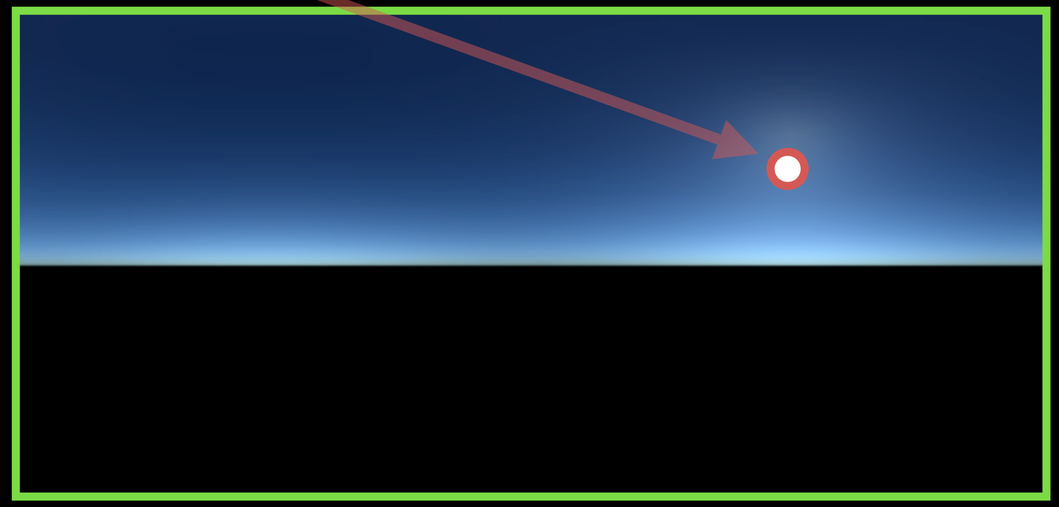
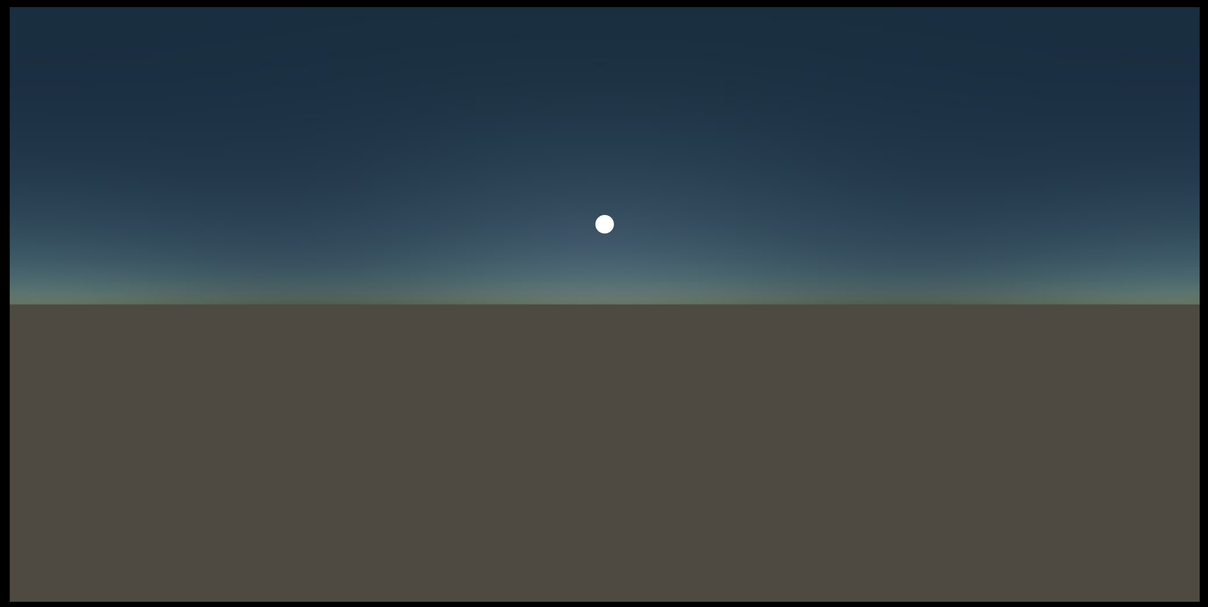
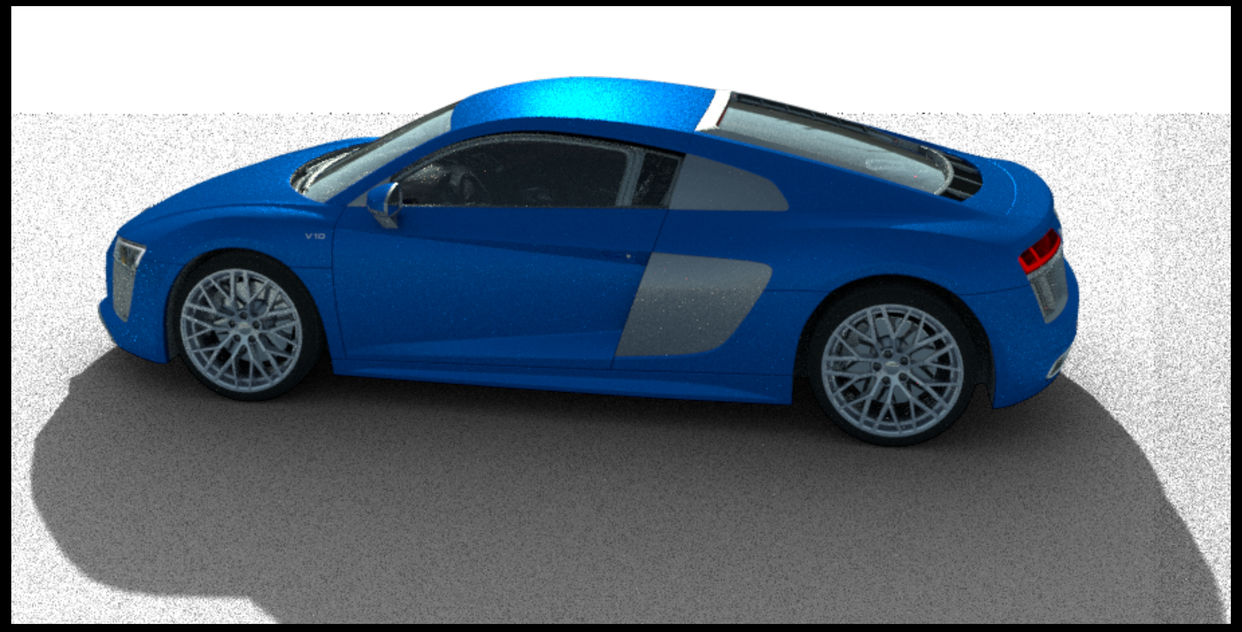
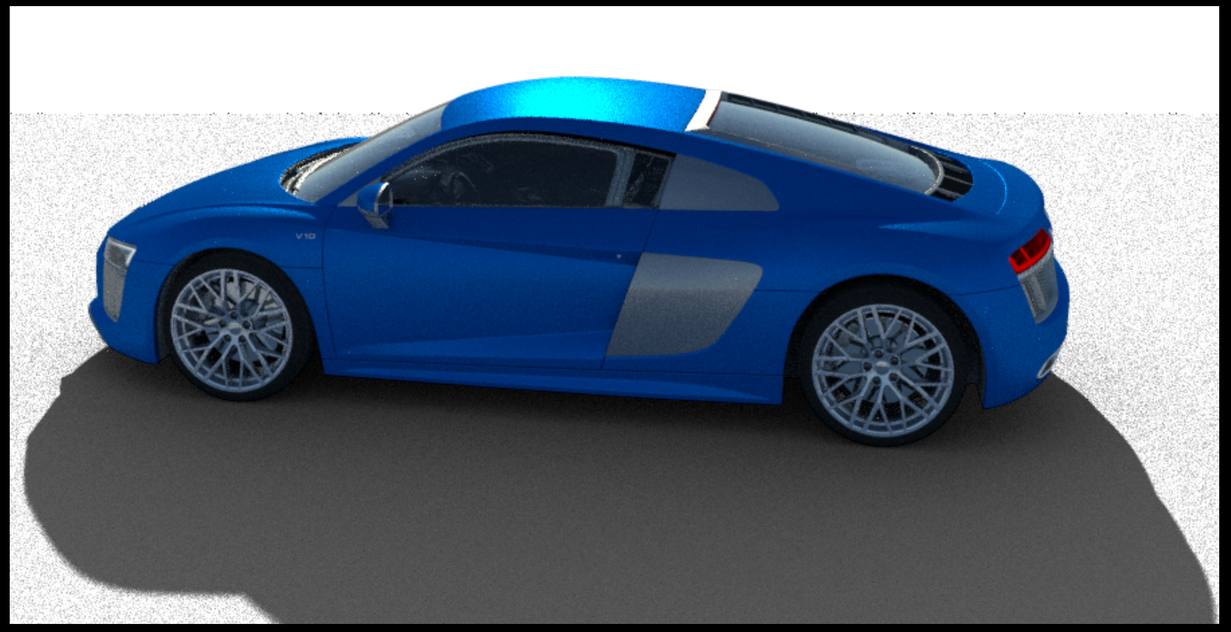


Full panorama: millions of pixels

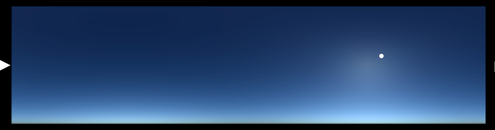
Sky model: 4 parameters







Framing the problem as one of end-to-end learning



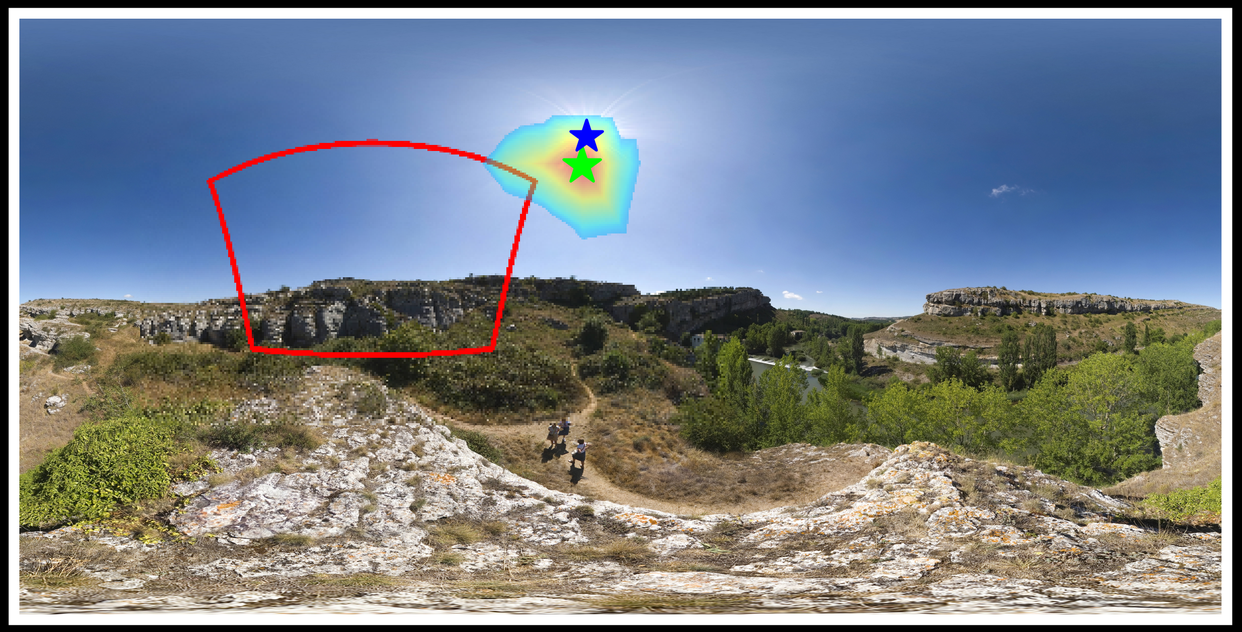
CNN

$$\mathbf{q}_h = [\, t,\ \mathbf{l}_{\text{sun}} \,]$$

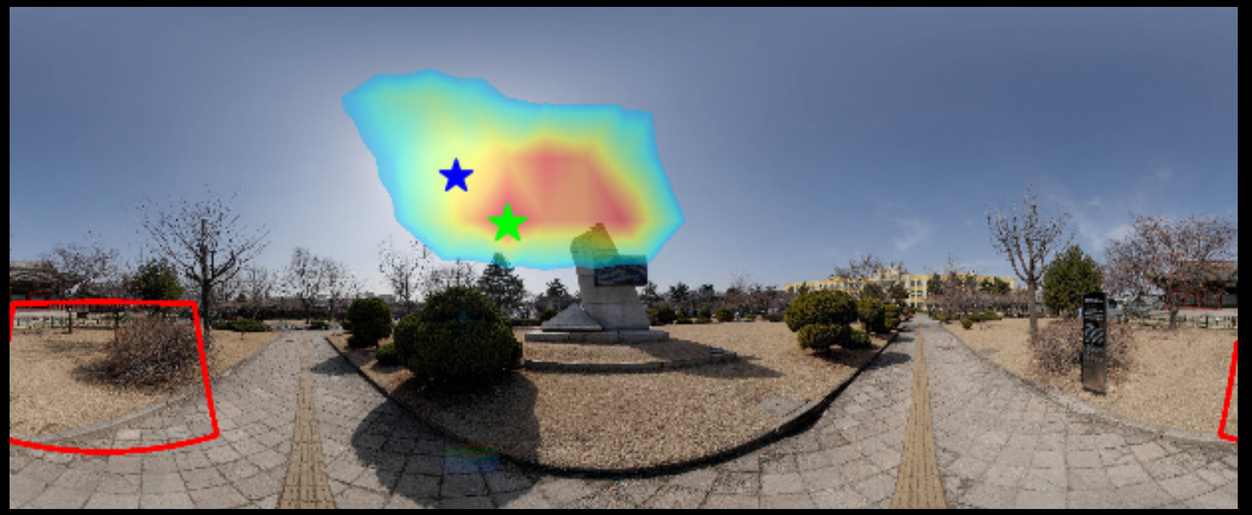
CNN Architecture and Training

Layer	Stride	Resolution
Input		320×240
conv7-64	2	160×120
conv5-128	2	80×60
conv3-256	2	40×30
conv3-256	1	40×30
conv3-256	2	20×15
conv3-256	1	20×15
conv3-256	2	10×8
FC-2048		
FC-160 LogSoftMax		FC-5 Linear
Output: sun position distribution		Output: turbidity and scale factor

Sun position results

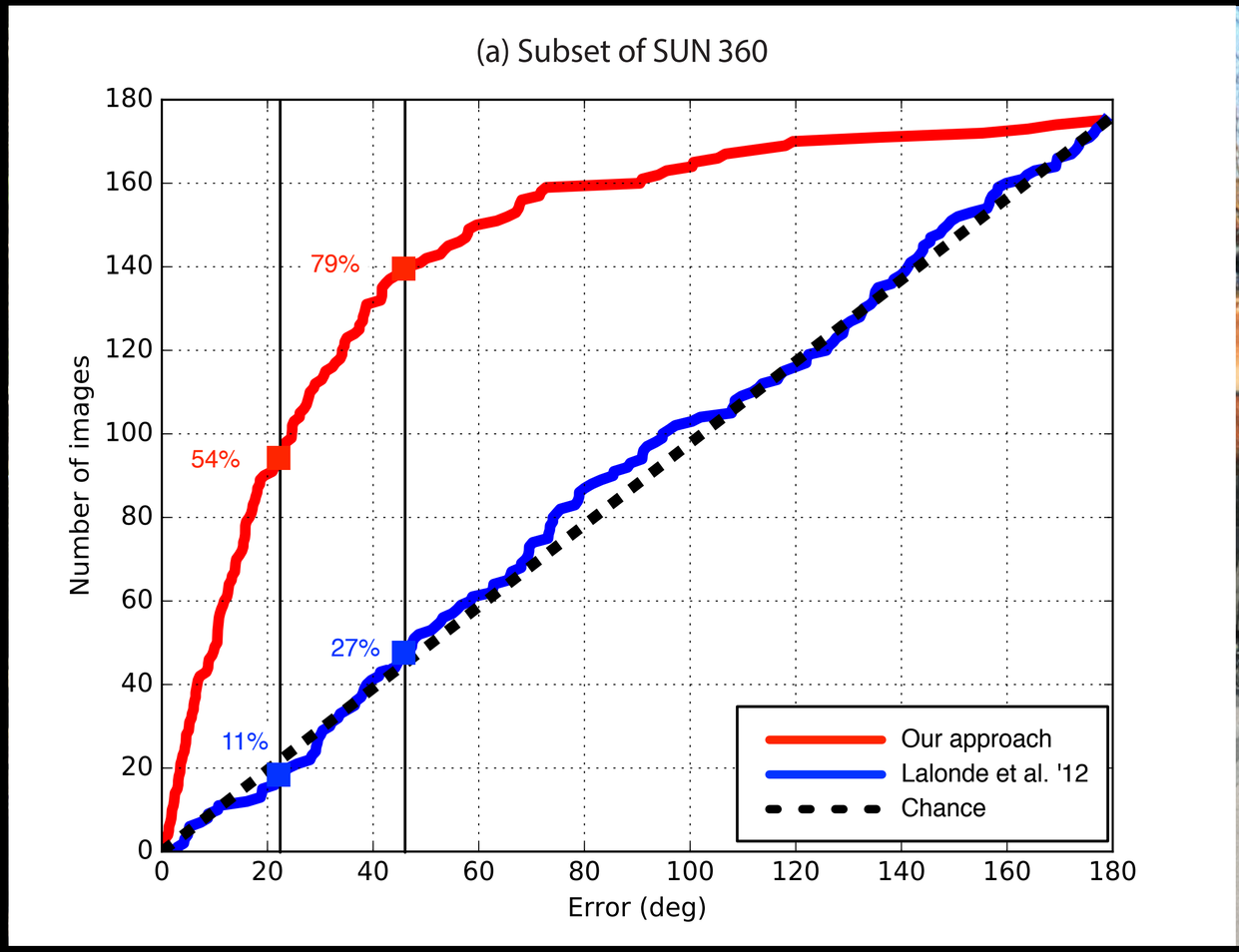


Sun position result



Quantitative results — sun azimuth estimation

Lalonde et al, 2012



SUN360 subset

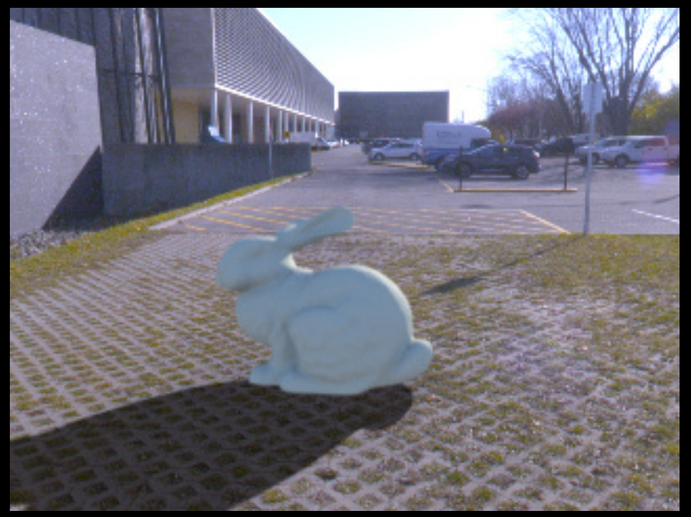
Virtual object insertion

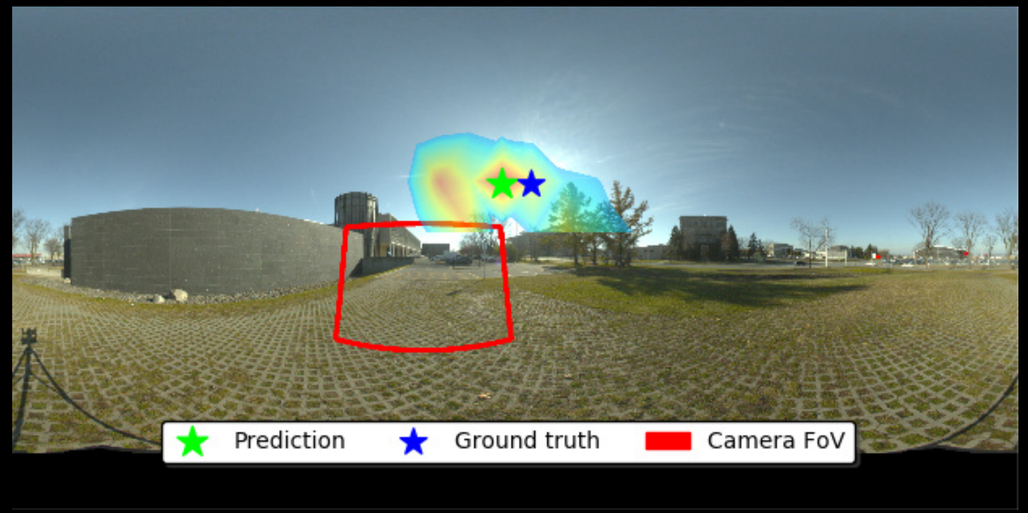
Insertion results on an HDR validation set

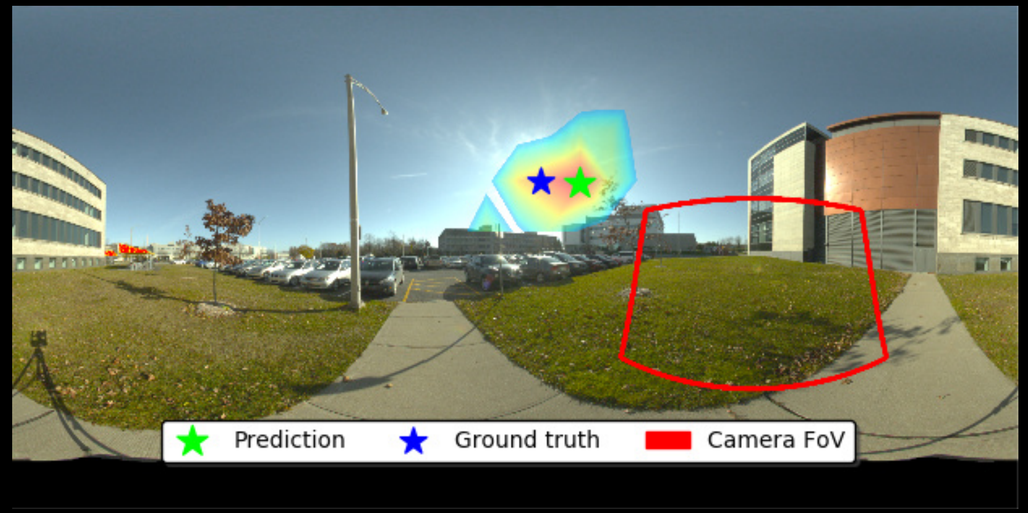
Network Output

Ground truth

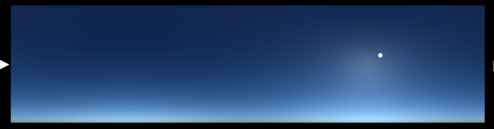
Sun position estimation







Recovering camera parameters



CNN

$$\mathbf{q}_h = [\, t,\ \mathbf{l}_{\text{sun}}\ , \theta_{\text{cam}}\ , \alpha_{\text{cam}}\ ]$$

Camera pitch

Camera Field of View

Camera parameters estimation

Camera pitch: (est.) -2°
(real) -1°
Field of View: (est.) 51°
(real) 59°

Camera pitch: (est.) -16°
(real) -16°
Field of View: (est.) 46°
(real) 45°

Conclusion

SUN360 dataset

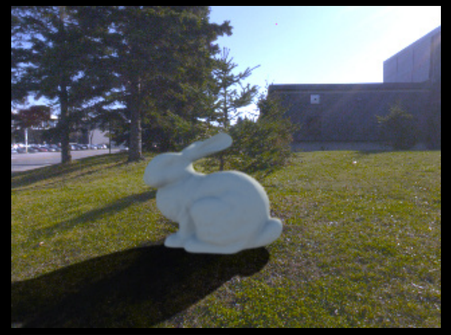
...

CNN

model parameters
Sun position
Atmospheric turbidity
Exposure
Camera pitch and FoV



http://jflalonde.ca/projects/deepOutdoorLight/





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