



Scene Understanding — Lighting

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light estimation

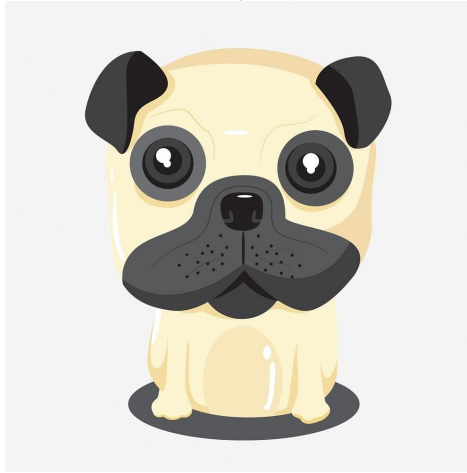
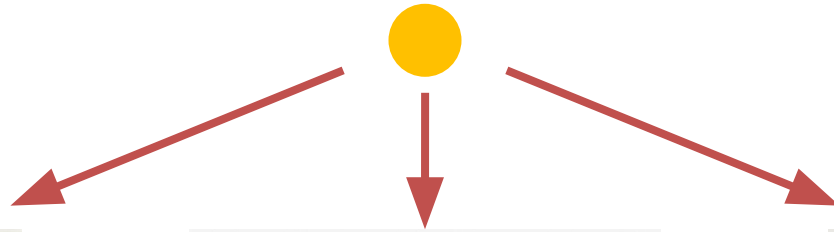


relighting (shading + shadow)

Outline

- Models of light
 - Point light
 - Directional light
 - Environment light
 - lightmap images, spherical harmonics
- Lighting estimation
 - HDR light probes
- Relighting
 - Shadow map

Point Light

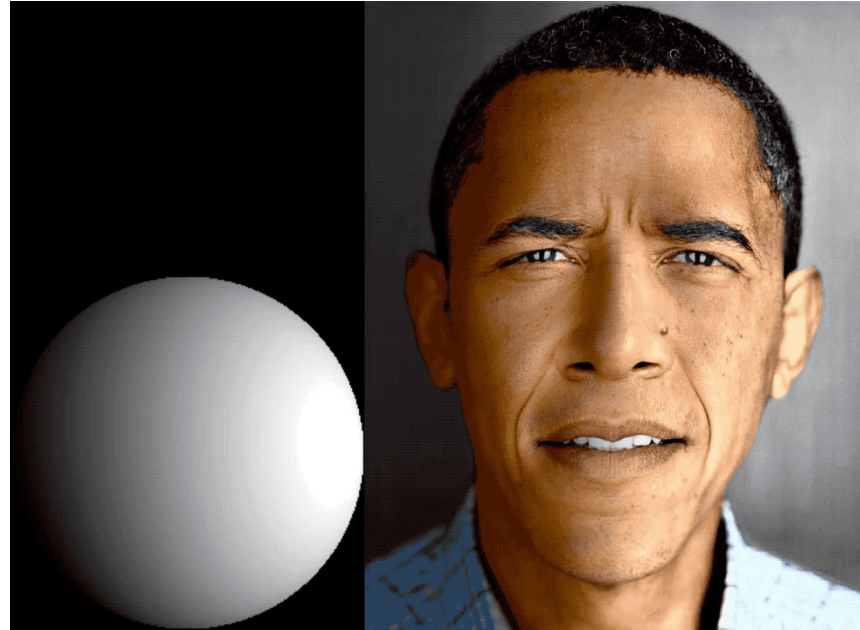


Directional Light



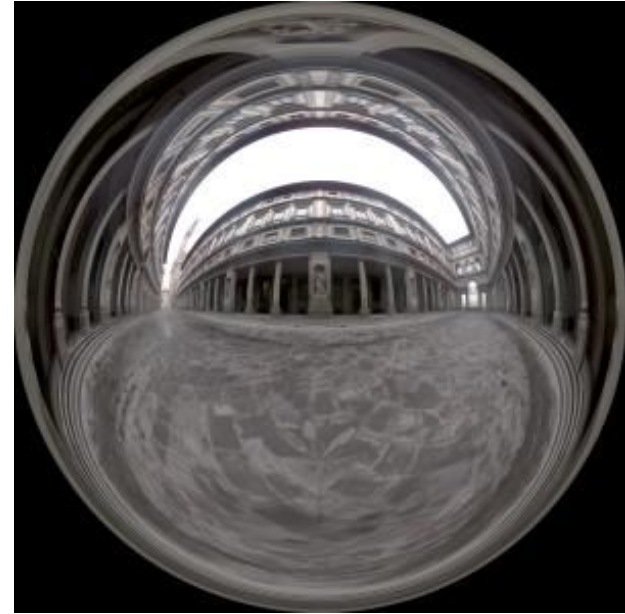
Environment Light

- A mapping representing distant lighting from all directions



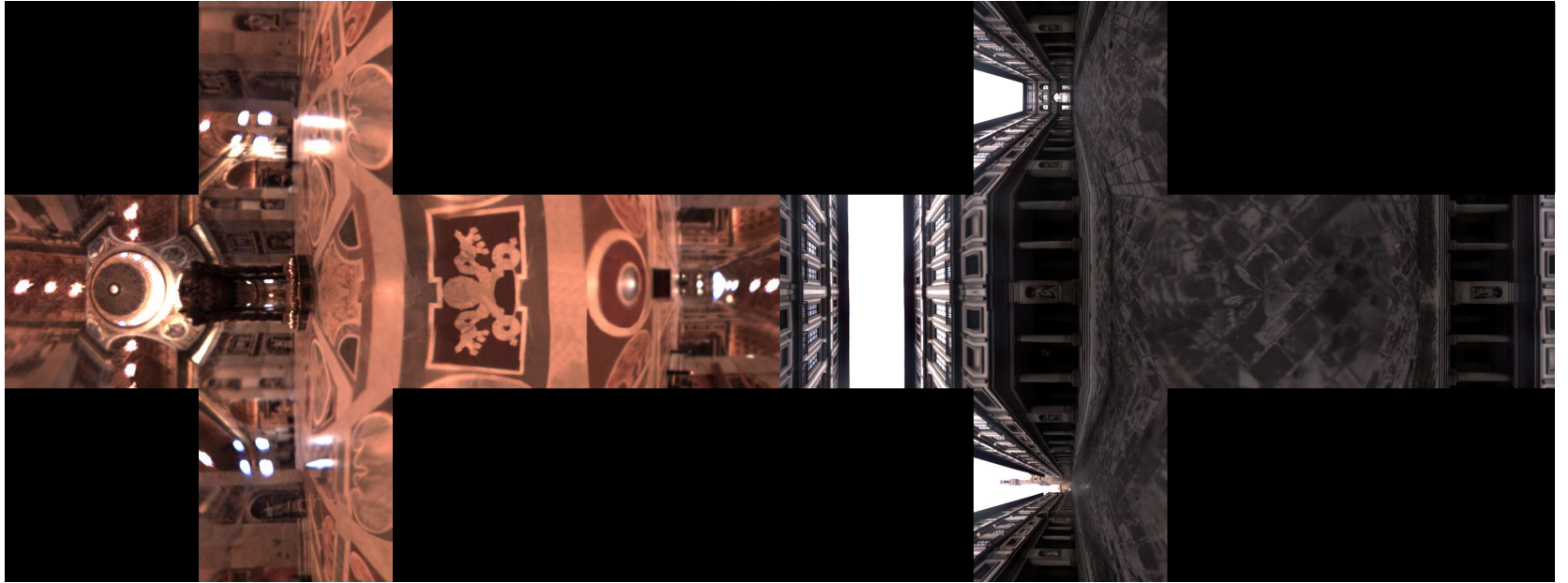
$f(\mathbf{x}, \theta, \varphi)$
= light intensity

Lightmap Images



spherical map

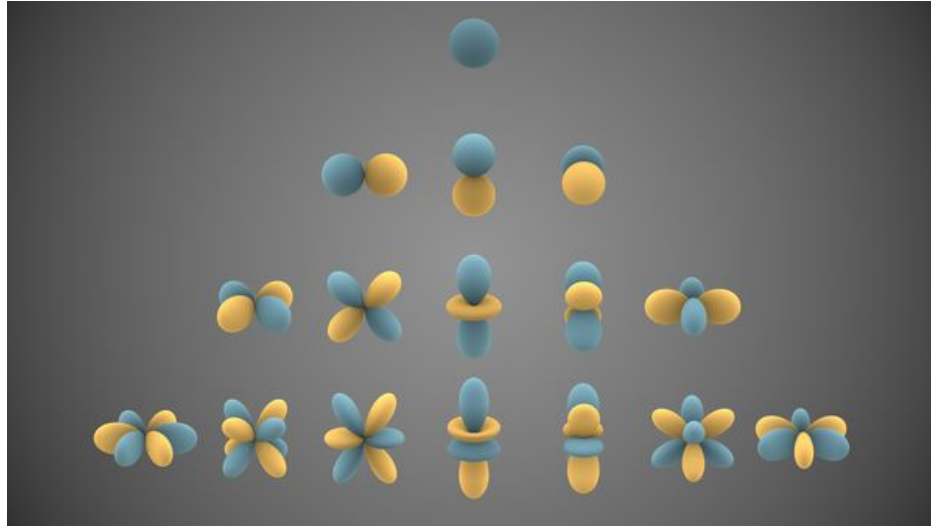
Lightmap Images



cube map

Spherical Harmonics

- A set of basis functions to represent functions defined on the surface of a sphere



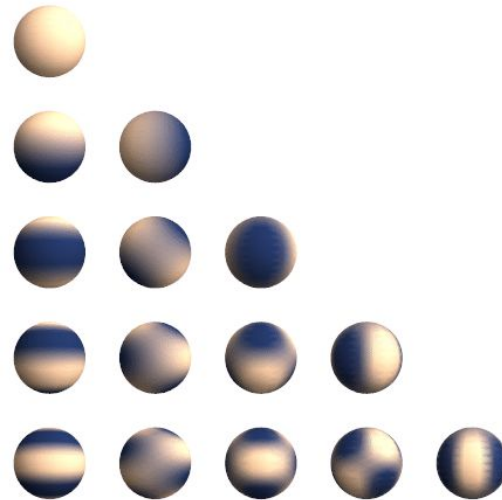
Spherical Harmonics

$$Y_l^m(\theta, \varphi) = N e^{im\varphi} P_l^m(\cos \theta)$$


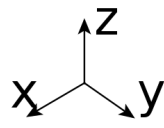
















































Y_ℓ^m — **spherical harmonic function** of degree $\ell \in \{0, 1, 2, \dots\}$ and order $m \in [-\ell, \ell]$

P_ℓ^m — associated Legendre polynomial

N — normalising constant



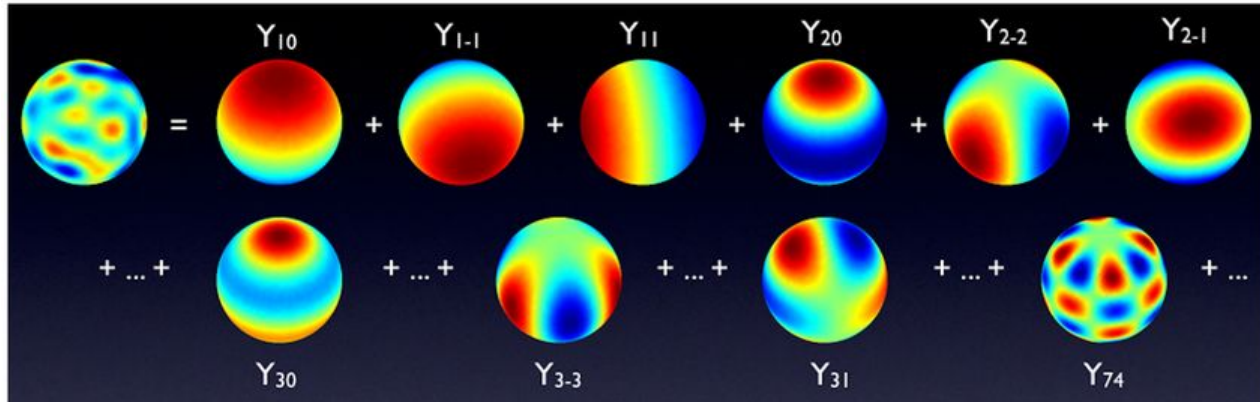
Spherical Harmonics

l:		$P_\ell^m(\cos\theta) \cos(m\varphi)$	$P_\ell^{ m }(\cos\theta) \sin(m \varphi)$											
0	s													
1	p	 												
2	d	  	 											
3	f	   	  											
4	g	    	   											
5	h	     	    											
6	i	      	     											
	m:	6	5	4	3	2	1	0	-1	-2	-3	-4	-5	-6

Spherical Harmonics

- Use the coefficients of the spherical harmonic functions to represent illumination

$$f(\theta, \varphi) = \sum_{l=0}^{\infty} \sum_{m=-l}^l a_l^m Y_l^m(\theta, \varphi)$$



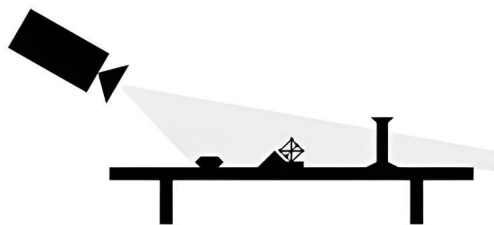
	Spherical harmonics	Lightmap images
Storage	compact	memory intensive
Computation	fast	expensive
Accuracy	limited	high
Editability	difficult	controllable
Generalisability	yes	no

Lighting Estimation

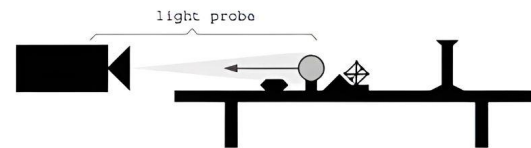


light probe images

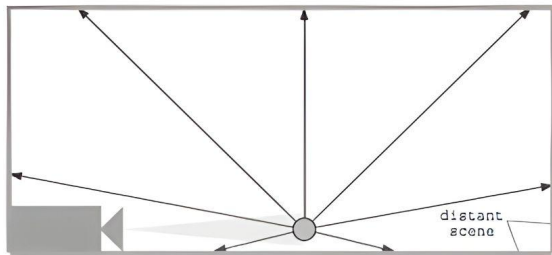
Light Probes



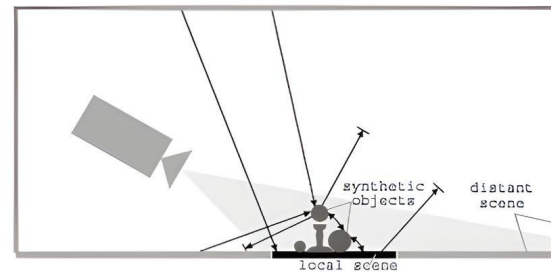
(a) Acquiring the background photograph



(b) Using the light probe



(c) Constructing the light-based model

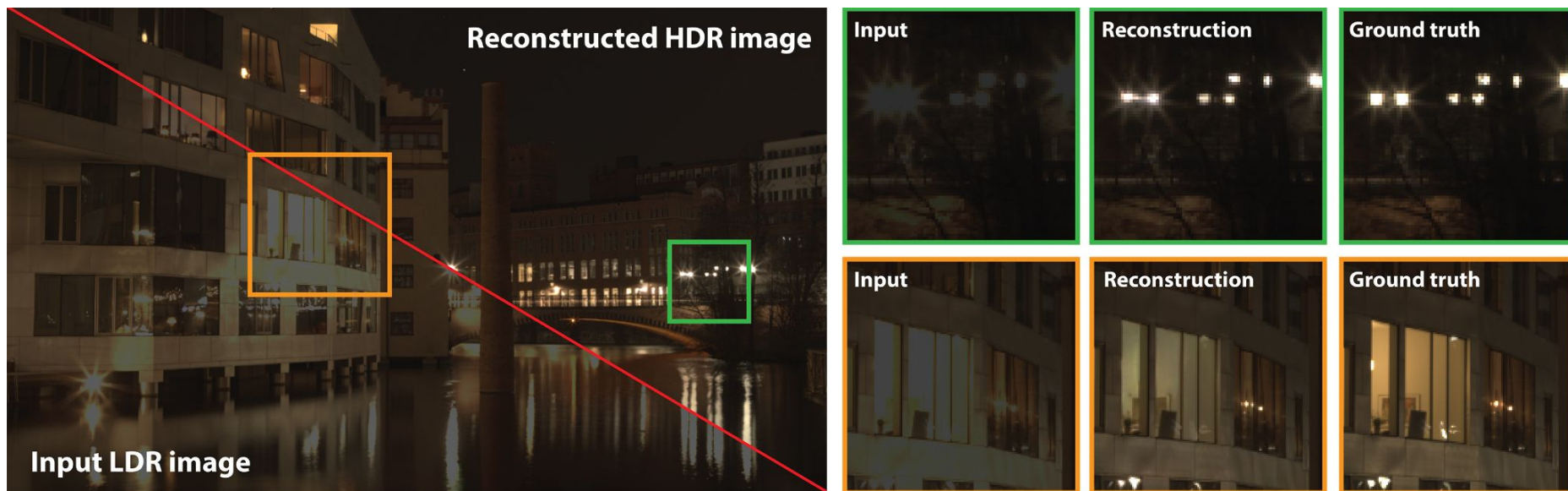


(d) Computing the global illumination solution

Light Probes



HDR Estimation

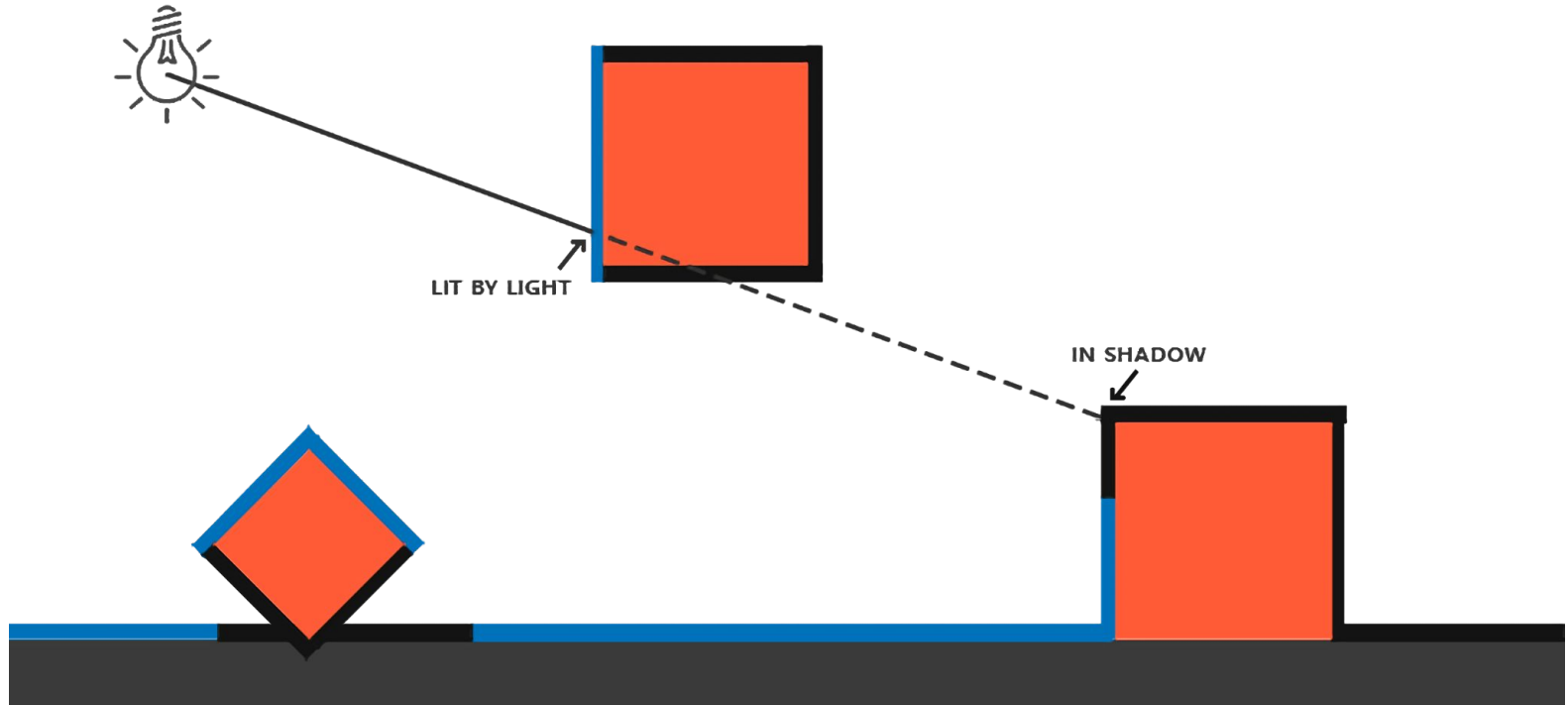


Relighting

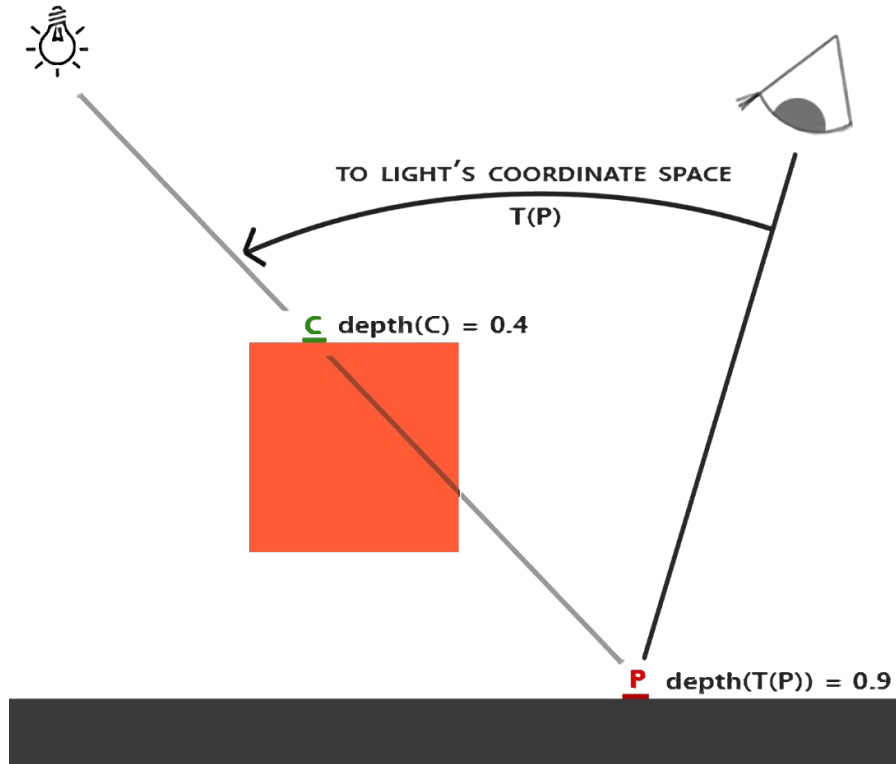


relighting = shading + shadow

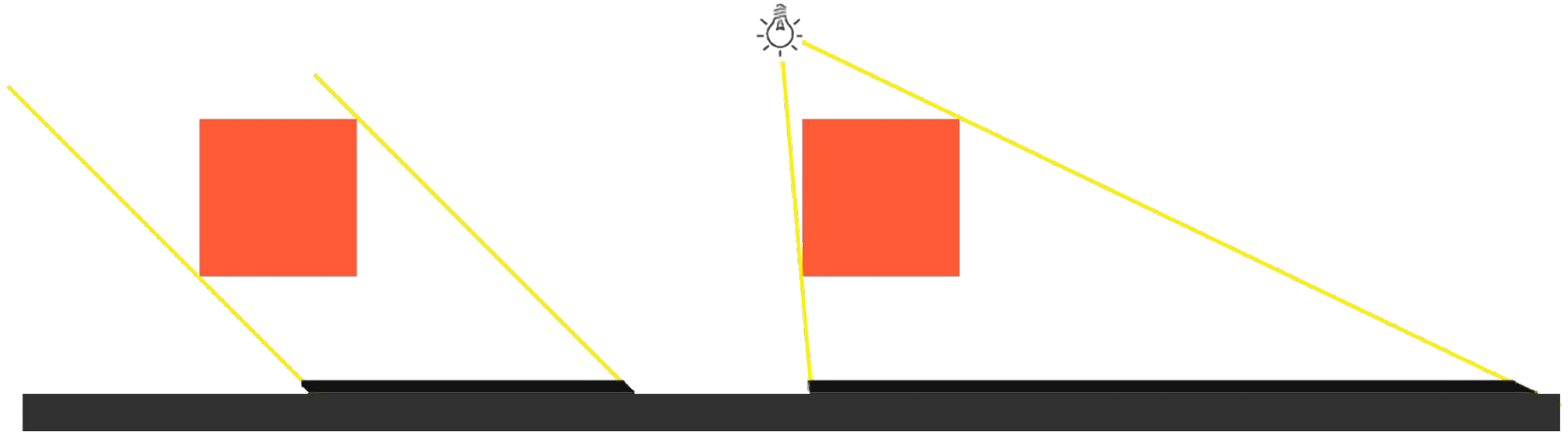
Shadow Mapping



Shadow Mapping



Shadow Mapping



orthographic projection
(directional light)

perspective projection
(point light)

Shadow Mapping



Relighting



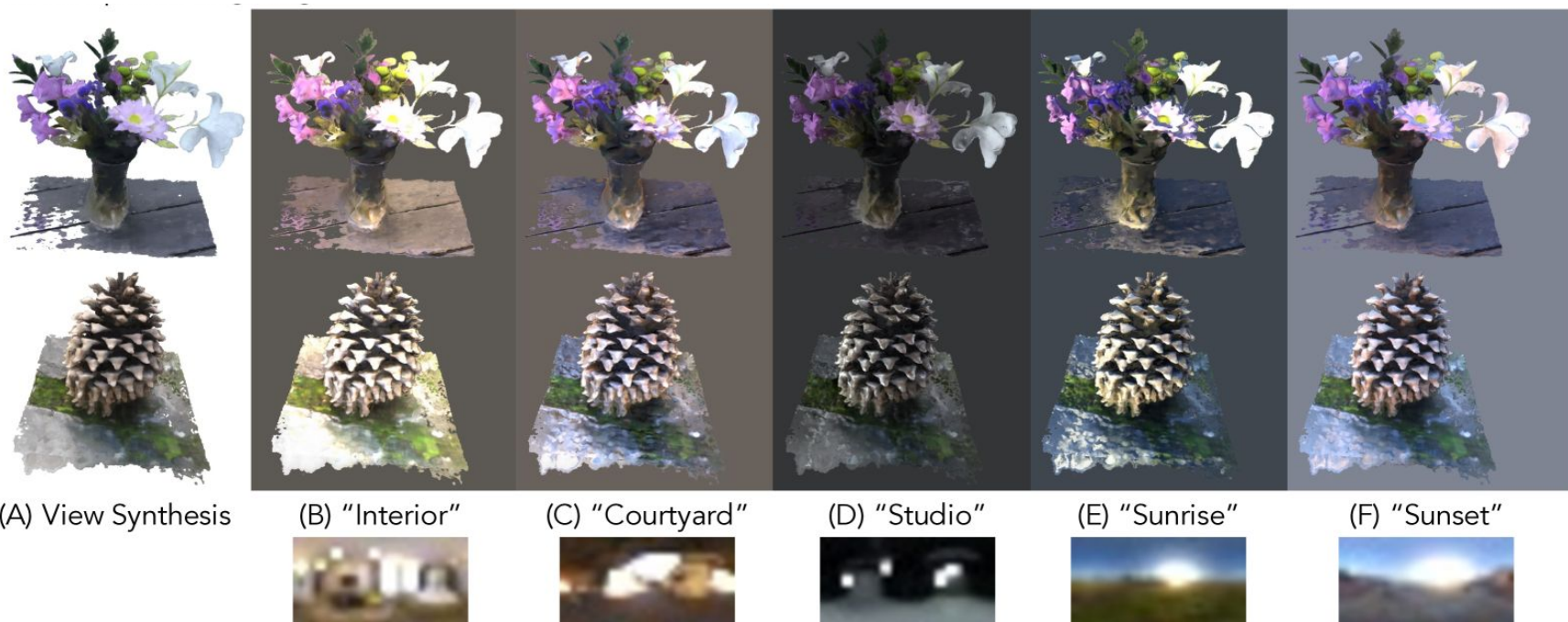
ARCore relighting

Relighting



Input Image

Relighting



A desert landscape with a road leading to a castle floating in the sky. The castle is a large, multi-story building with a flat roof and several towers, appearing to be made of stone or brick. It is positioned in the upper left quadrant of the image, floating in the sky. The background shows a vast, flat desert with sparse vegetation and a clear sky. The road is a dark, paved path that leads from the bottom center towards the horizon. The overall scene is surreal and dreamlike.

Castle in the Sky: Dynamic Sky Replacement and Harmonization in Videos

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