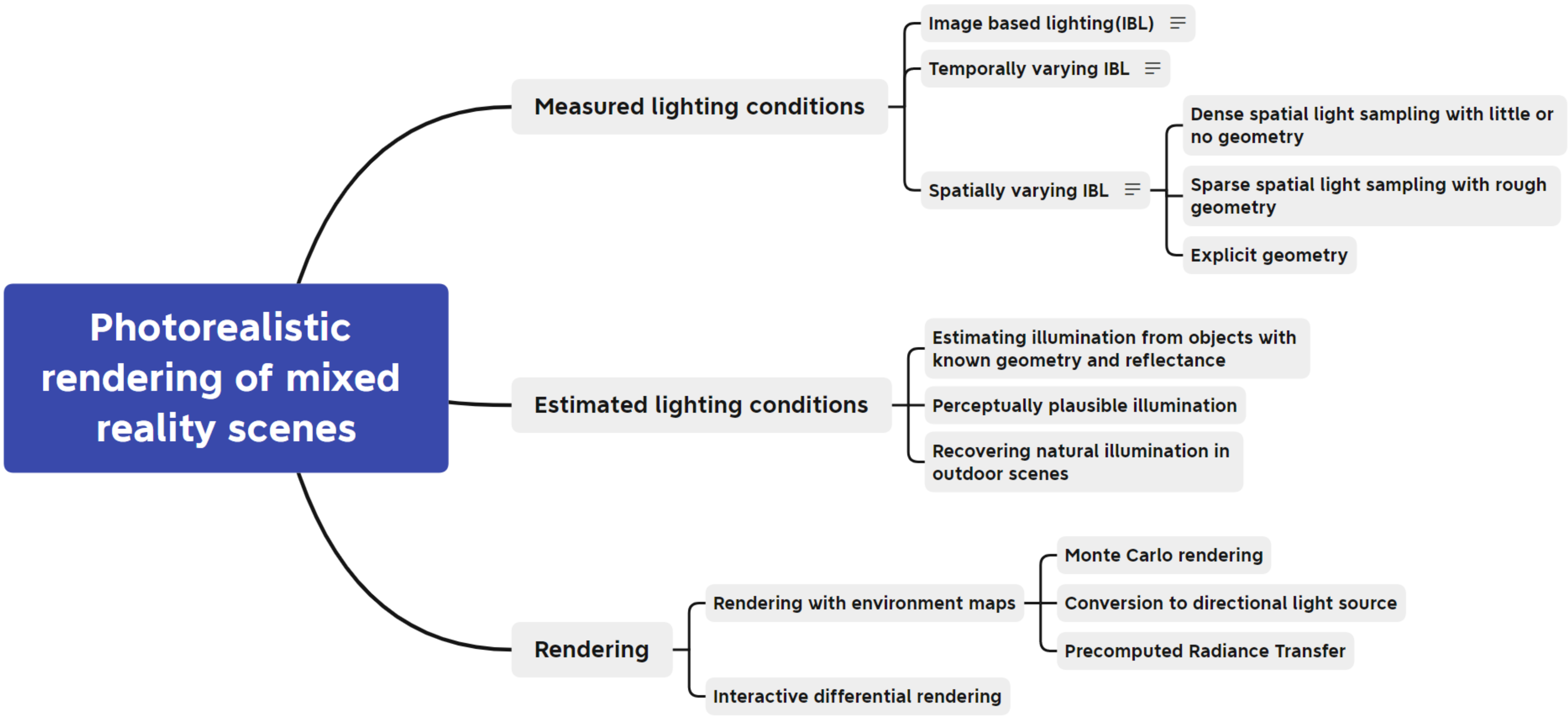
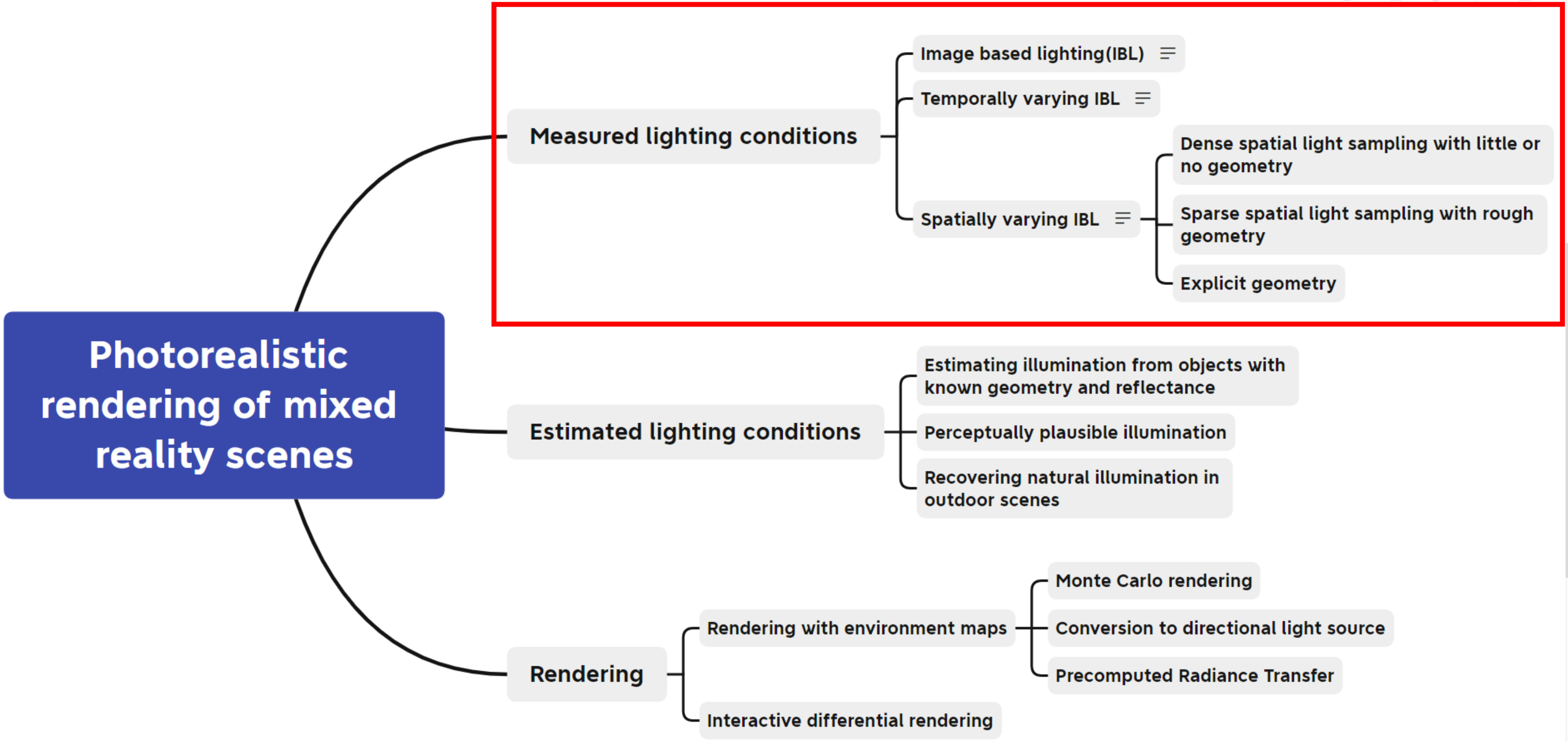
Photorealistic rendering of mixed reality scenes

Photorealistic rendering of mixed reality scenes. Joel Kronander, Francesco Banterle, Andrew Gardner, et. al. 2015


Photorealistic rendering of mixed reality scenes
Measured lighting conditions
Image based lighting(IBL)
Temporally varying IBL
Spatially varying IBL
Dense spatial light sampling with little or no geometry
Sparse spatial light sampling with rough geometry
Explicit geometry
Estimated lighting conditions
Estimating illumination from objects with known geometry and reflectance
Perceptually plausible illumination
Recovering natural illumination in outdoor scenes
Rendering
Rendering with environment maps
Monte Carlo rendering
Conversion to directional light source
Precomputed Radiance Transfer
Interactive differential rendering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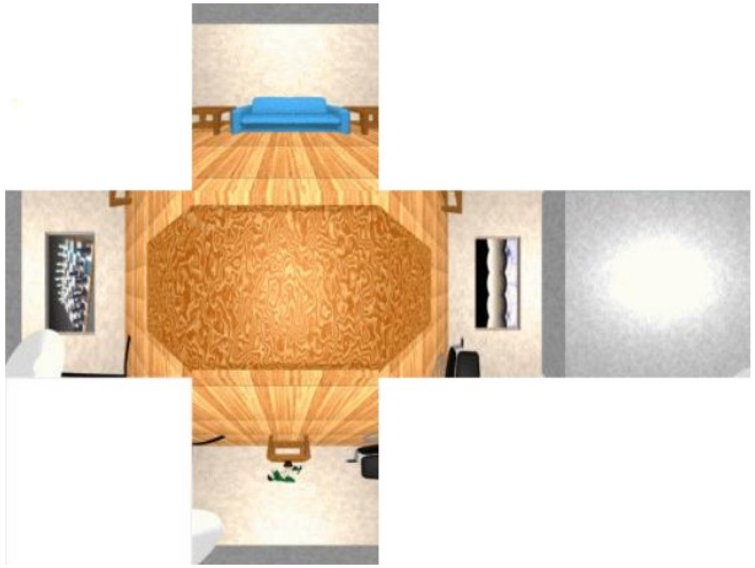
1. Measured lighting conditions

- Image based lighting (IBL)
  - relies on **a single environment map** to capture the lighting in the scene



Cube/Box Map

Latitude Map

Sphere Map

1. Measured lighting conditions

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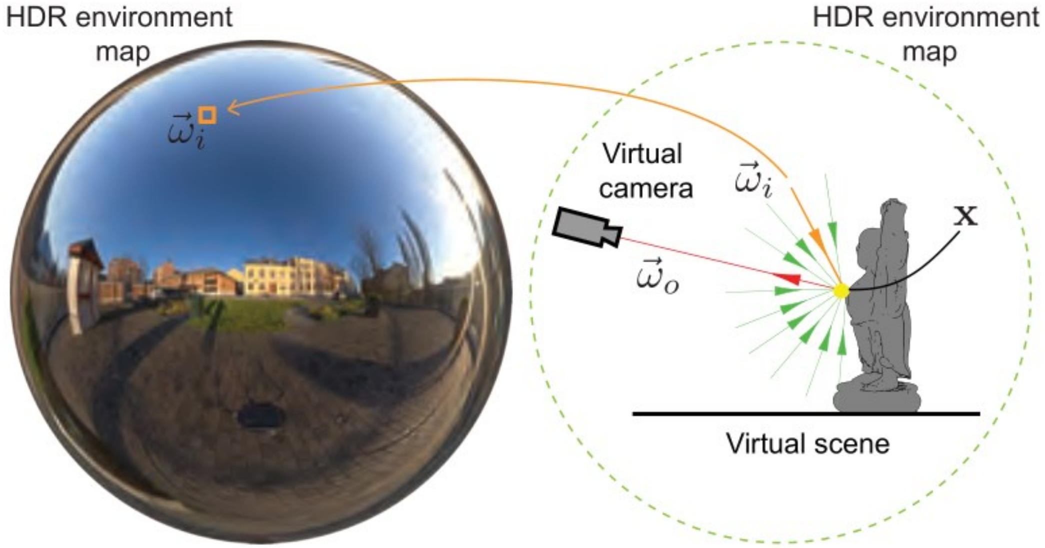


(a) Lighting is captured as a 360° HDR-panorama

(b) IBL rendering of the buddha model

1. Measured lighting conditions

- Image based lighting (IBL)
  - relies on **a single environment map** to capture the lighting in the scene
  - how to get the single environment map?

    a. one light probe

    b. parabolic or hyperbolic mirrors

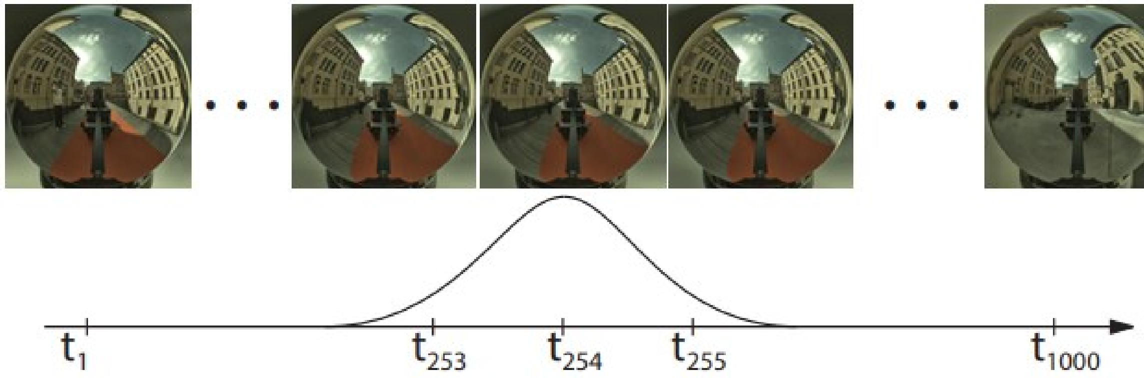
    d. fish-eye lenses

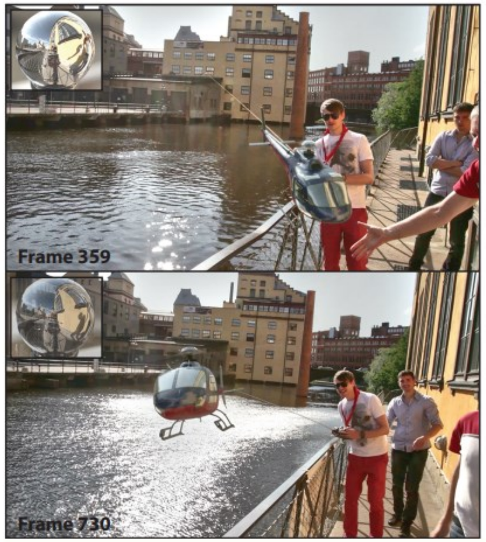
    e. panorama stitching

    f. ...

1. Measured lighting conditions

- Temporally varying IBL
  - extends to **the temporal domain** to capture **dynamically varying envmaps**
  - keyword: **temporal consistency**
  - problem: light probe sequences are subject to a large degree of **visual noise**
    a. temporal filtering of noisy light probe sequences
    b. using specially designed rendering methods



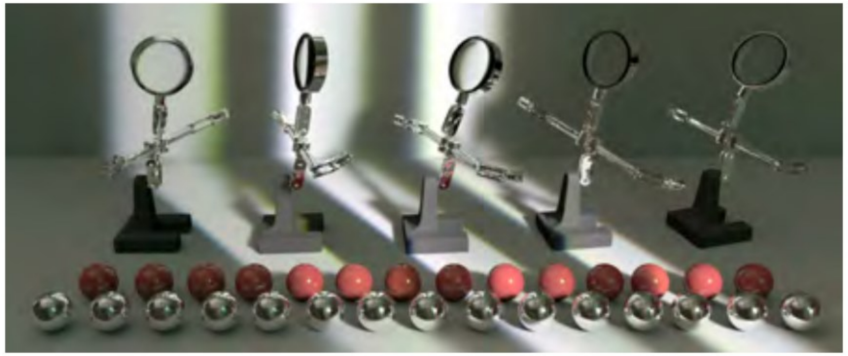


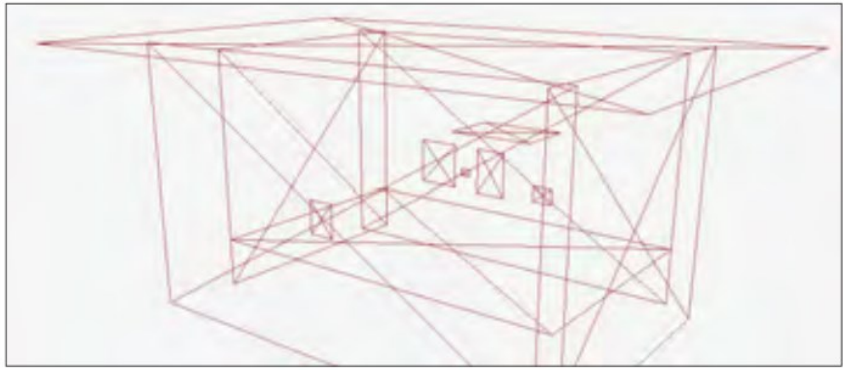
1. Measured lighting conditions

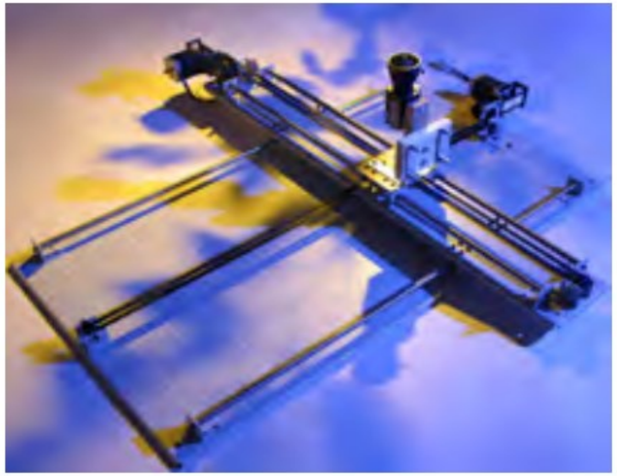
- Spatially varying illumination
  - requires the angular distribution of the scene lighting to be captured at several locations in the scene, and/or a capture of a geometric model describing the scene's structure (depth, parallax, etc.)
  - there are three main categories
    - **dense** spatial light sampling with little or no geometry
    - **sparse** spatial light sampling with rough geometry
    - explicit geometry

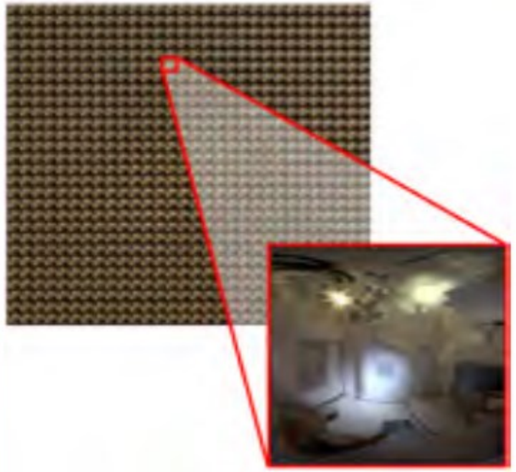
1. Measured lighting conditions

- Spatially varying illumination
  - **dense** spatial light sampling with little or no geometry



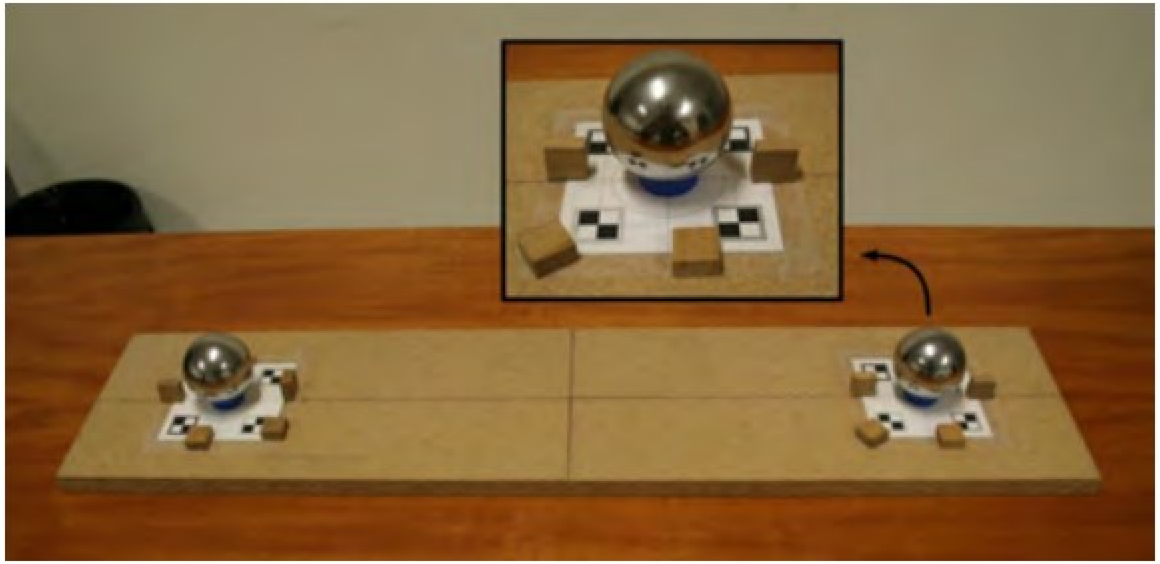


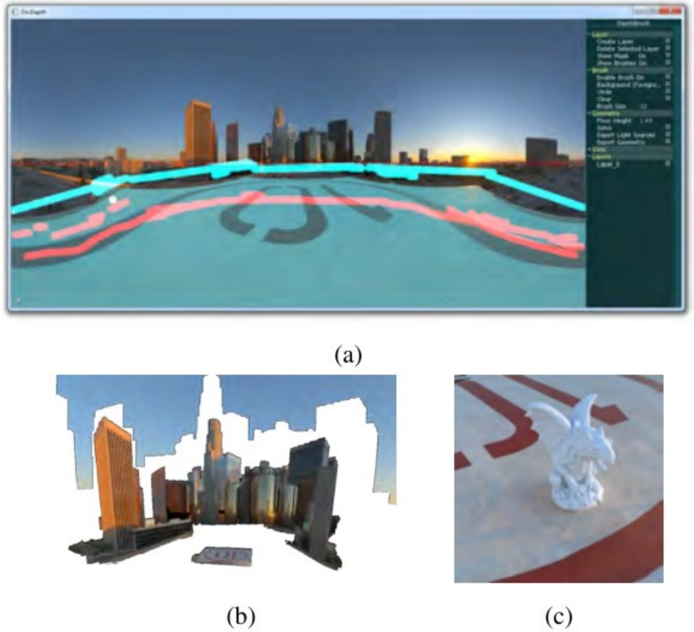




1. Measured lighting conditions

- Spatially varying illumination
  - **sparse** spatial light sampling with rough geometry
    - capture SV illumination with **very few HDR envmaps**, typically one or two
    - exploit **computer vision** to recover geometric information

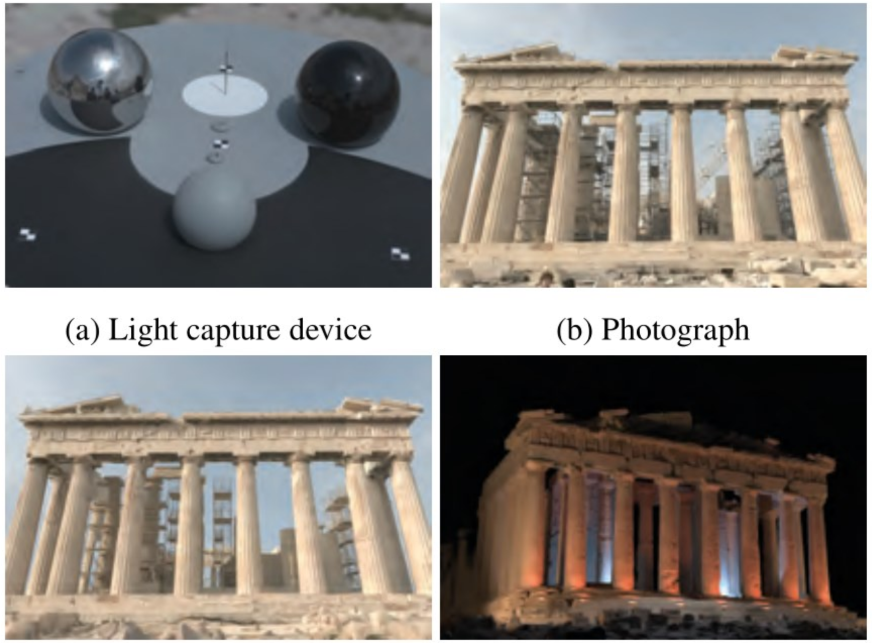




(a) (b) (c)

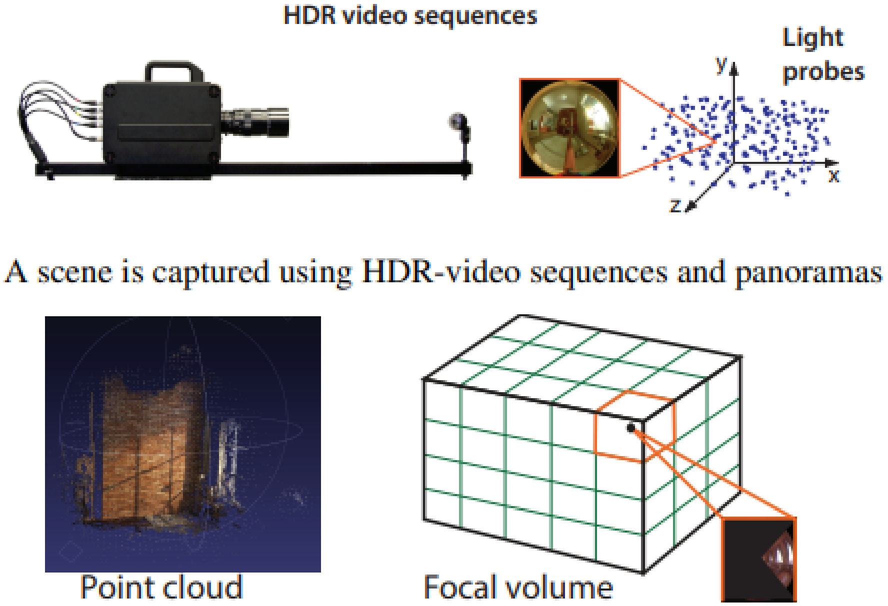
1. Measured lighting conditions

- Explicit geometry
  - **an accurate model of the scene is recovered**
    - dense geometry recovered using laser scanning or RGB-D camera, etc.



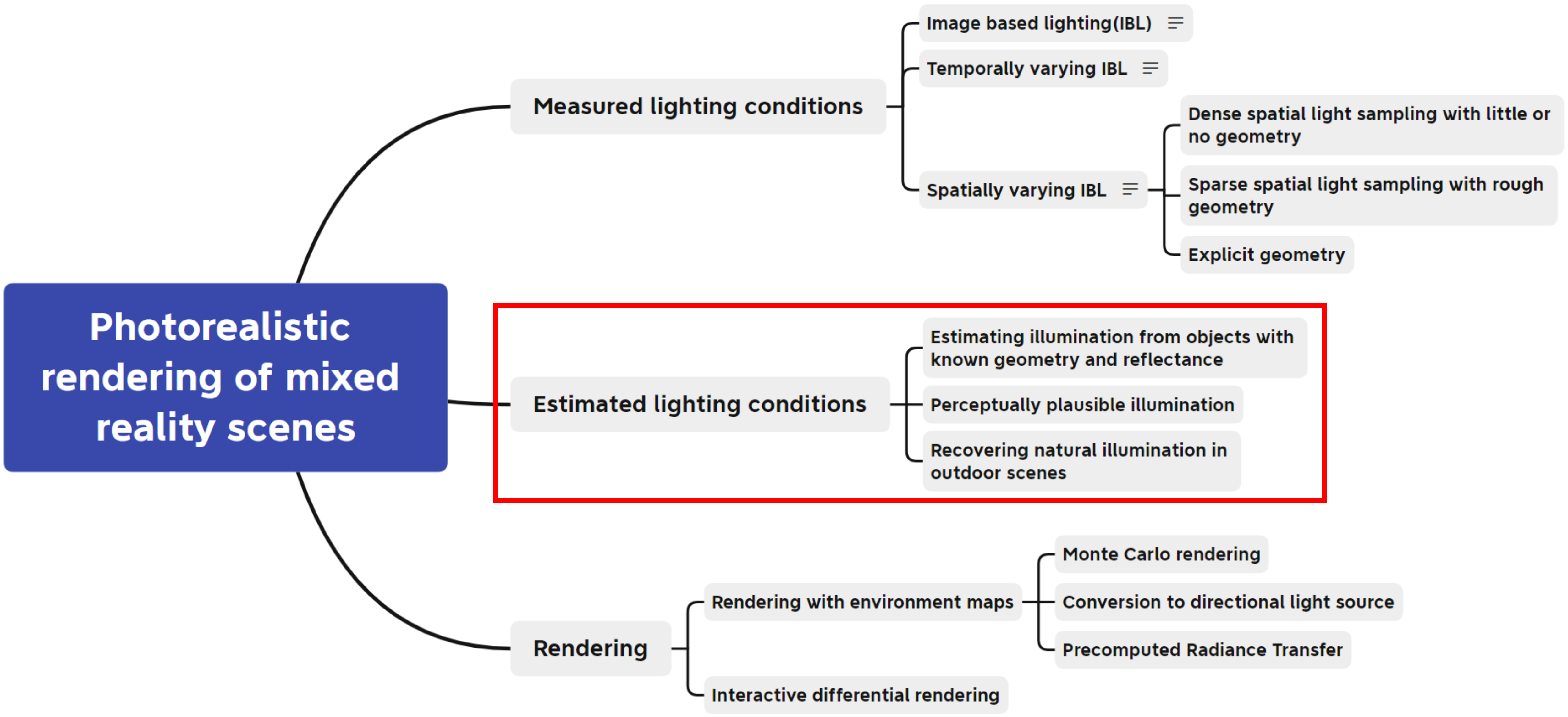
(a) Light capture device (b) Photograph

(c) Rendering (d) Rendering



(a) A scene is captured using HDR-video sequences and panoramas

(b) Point cloud and focal volume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2. Estimated lighting conditions

- Estimating from objects with known geometry and reflectance
  - in many scenes, common objects with known or trivial geometry and reflectance properties can be used estimate the incident illumination
    - put in some objects
    - with RGB-D camera

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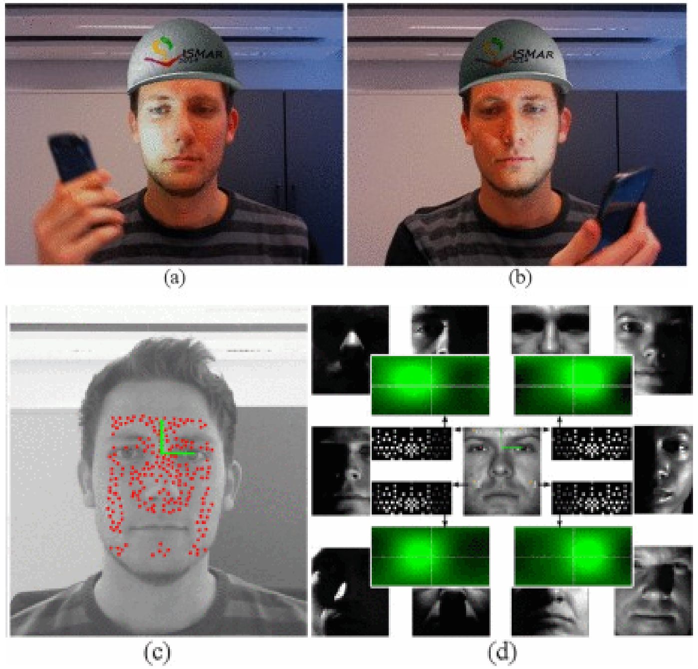
    - put in some objects
    - with RGB-D camera
    - **human faces**



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    - human faces
    - **eyes**

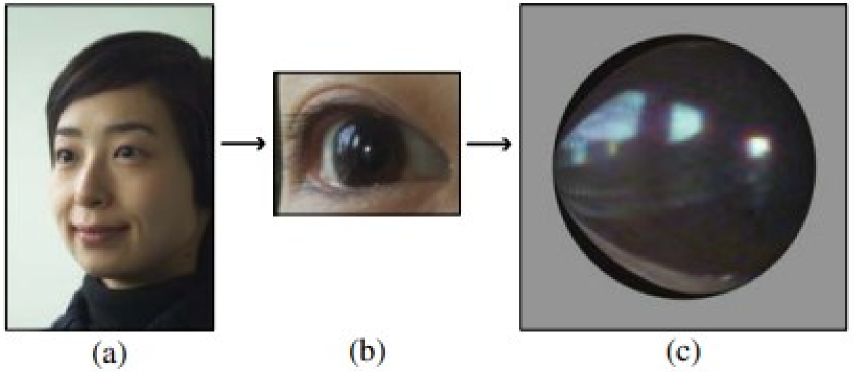


Figure 1: (a) An image of a face. (b) A magnified version of the image of the right eye of the person. (c) An environment map computed from (b). One can see the sky and buildings through the windows.

2. Estimated lighting conditions

- Estimating from objects with known geometry and reflectance
  - in many scenes, common objects with known or trivial geometry and reflectance properties can be used estimate the incident illumination
    - put in some objects
    - with RGB-D camera
    - human faces
    - eyes
    - **a planar surface, such as a book cover**

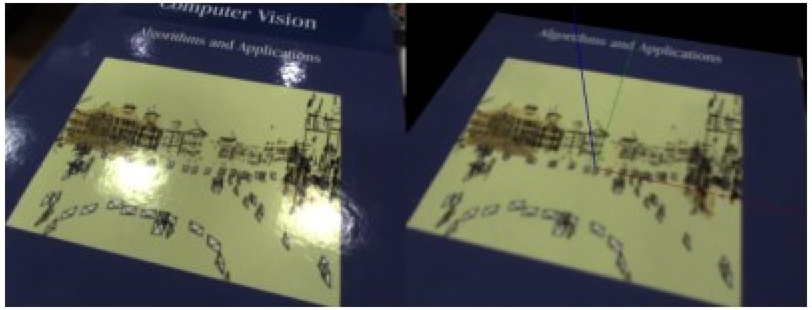


Figure 2: Live camera view (left) and the specularity-free diffuse texture (right) calculated from the medians of the lumispheres.

2. Estimated lighting conditions

- Estimating from objects with known geometry and reflectance
  - in many scenes, common objects with known or trivial geometry and reflectance properties can be used estimate the incident illumination
    - put in some objects
    - with RGB-D camera
    - human faces
    - eyes
    - a planar surface, such as a book cover
    - **shadow cast from objects**
    - ......

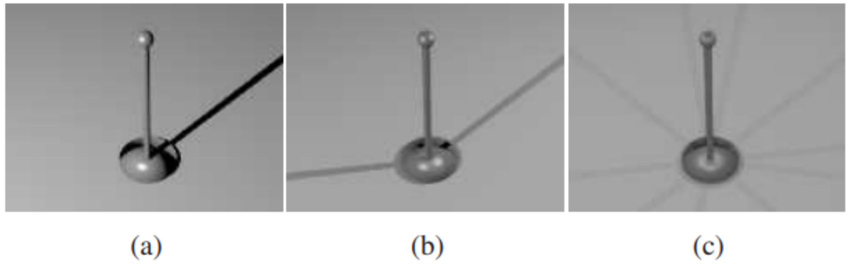
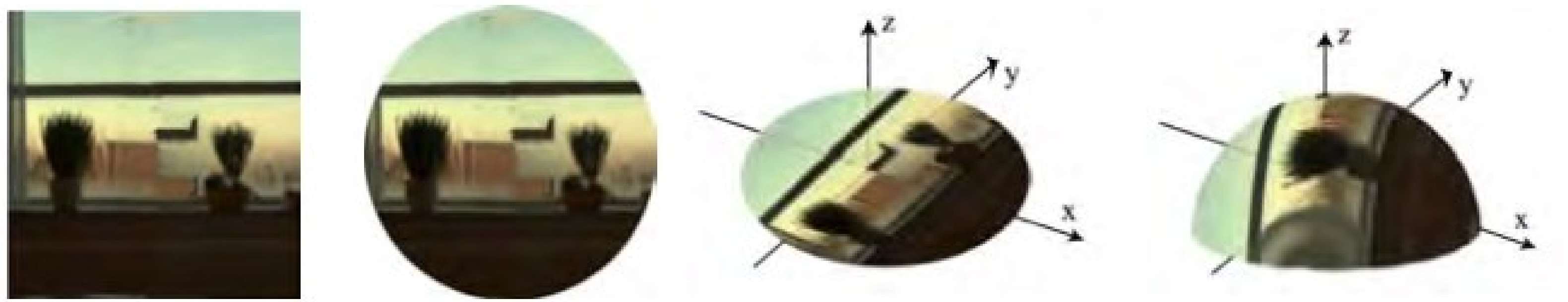


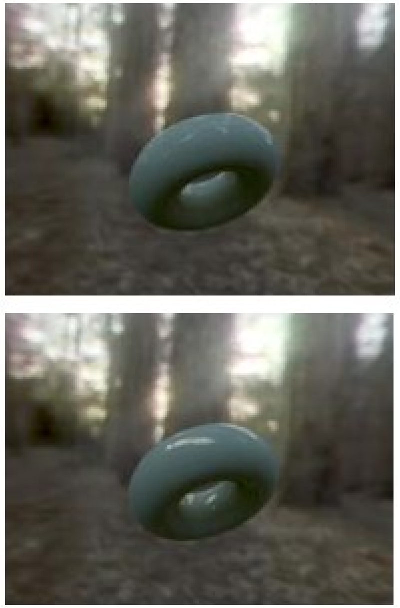
Figure 1. A flagpole rendered with one directional source (a), two directional sources (b), and ten directional sources (c). The shadows are lighter as the number of directional sources increases.

2. Estimated lighting conditions

- Perceptually plausible illumination
  - User studies have shown that local illumination consistency is more important than globally consistent illumination for humans



(a) Background image (b) Selected circle (c) Placed in image plane (d) Extruded to form half of the environment map



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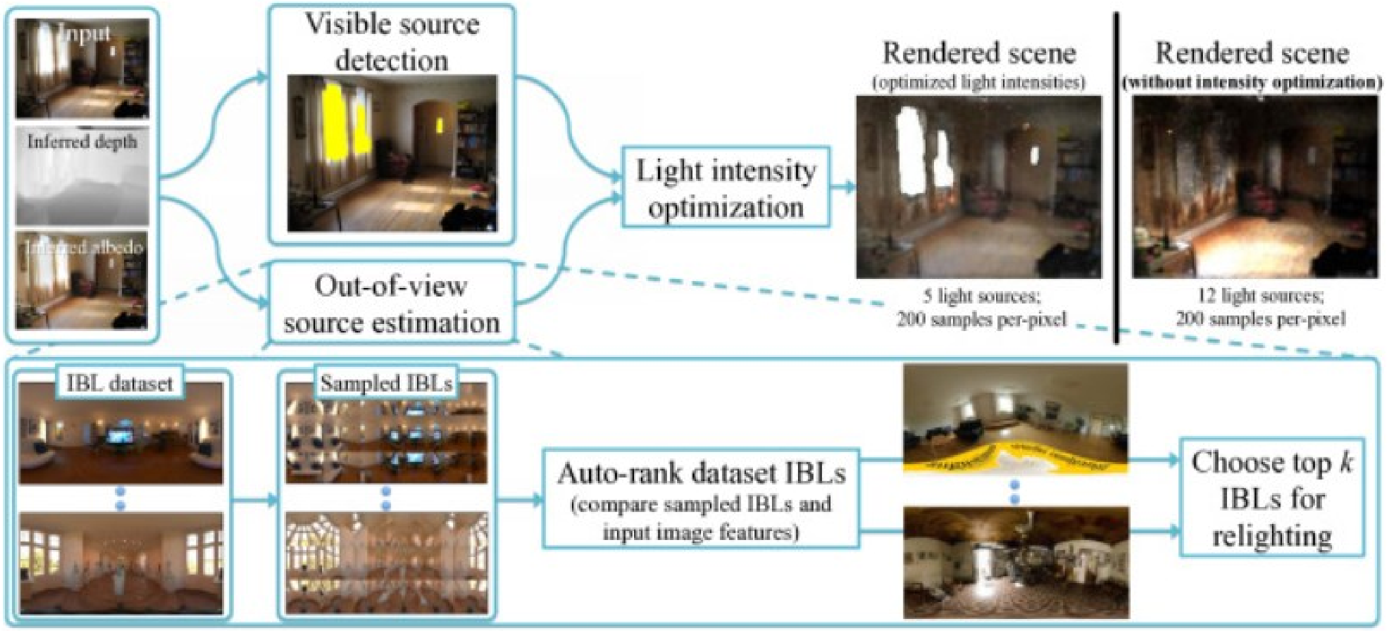


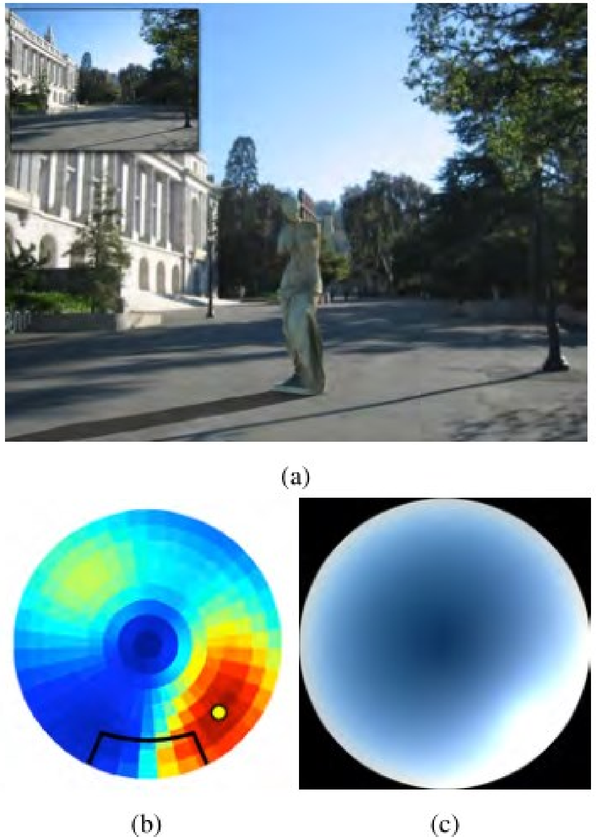
2. Estimated lighting conditions

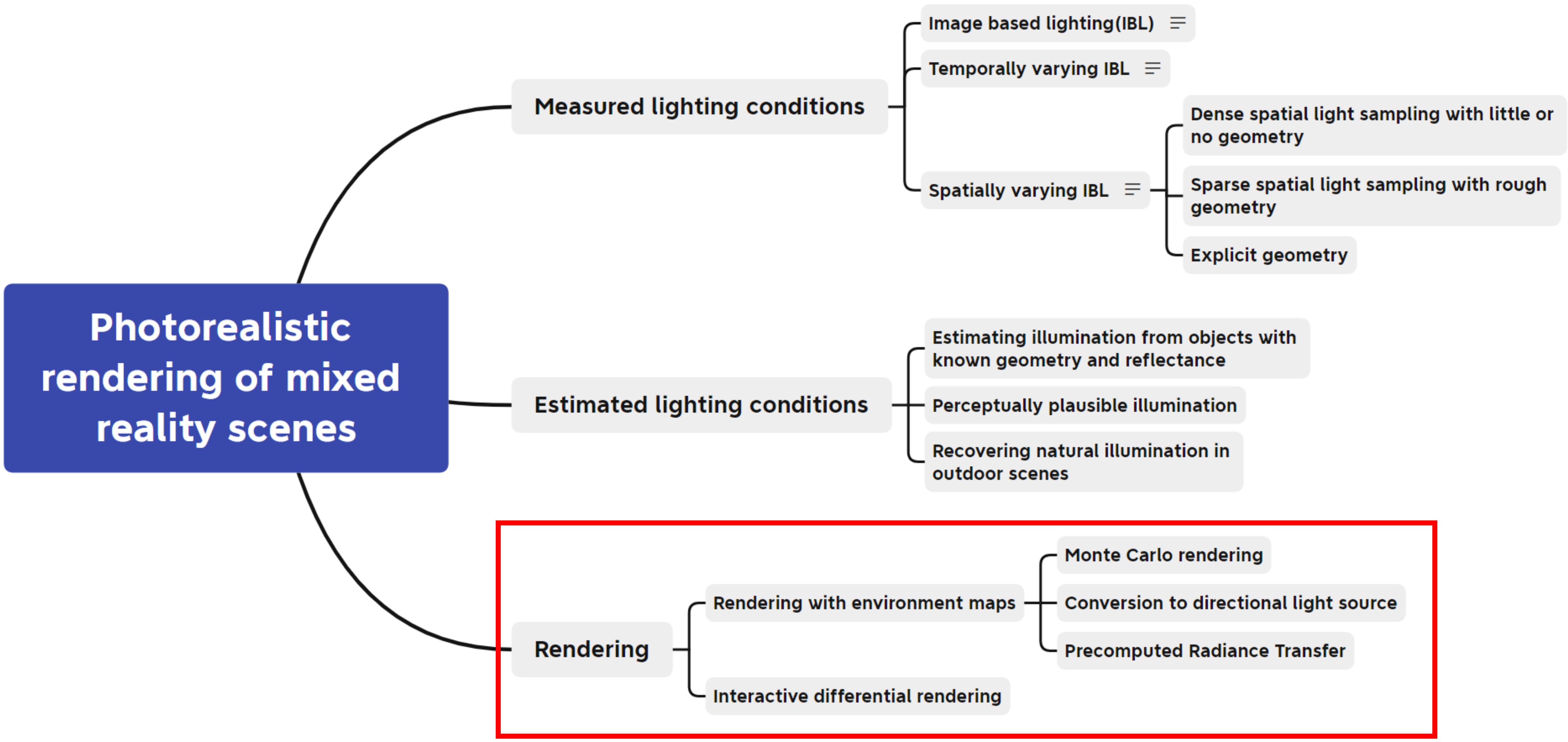
- Perceptually plausible illumination
  - User studies have shown that local illumination consistency is more important than globally consistent illumination for humans

(a) (b)

2. Estimated lighting conditions

- Recovering natural illumination in outdoor scenes
  - detecting the sun
    - assumed to be a directional light source
  - fitting physically based parametric sky models
    - always assumed to be a uniform area light source
  - shadows in outdoor scenes
    - even using GAN to generate fake shadows of the insert object
  - exploiting statistical properties of natural illumination
    - e.g., using the time of the capture to infer the sun position

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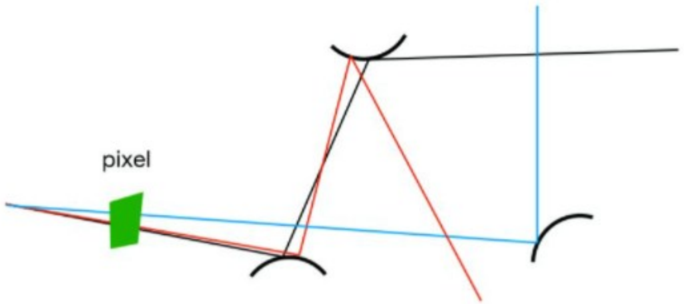
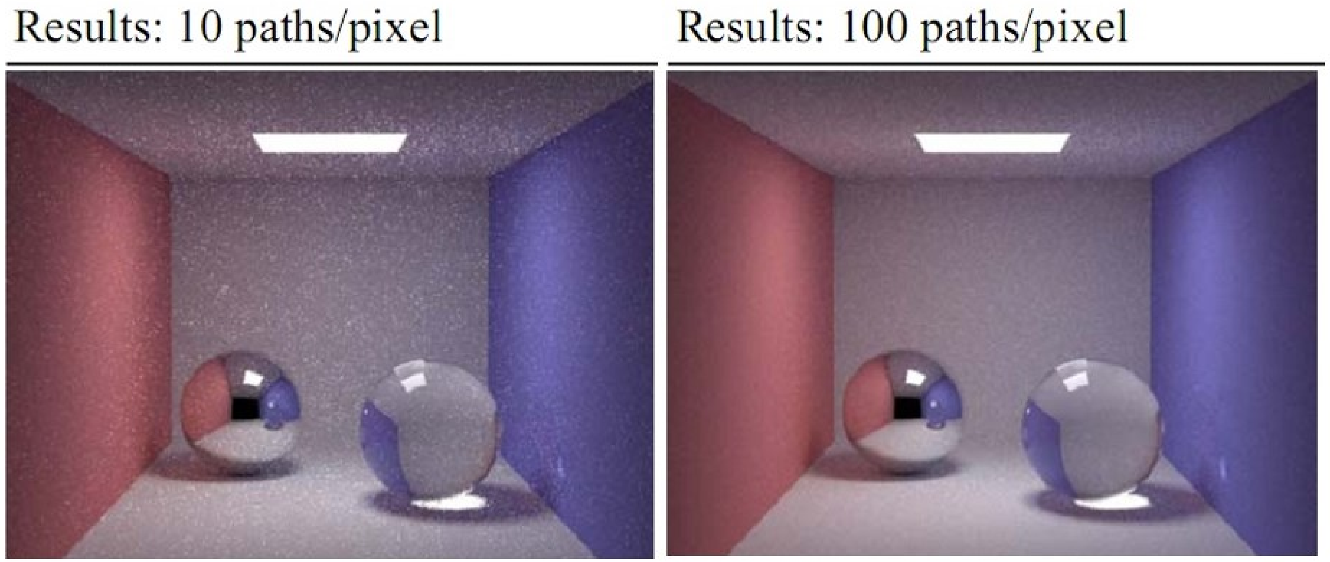
3. Rendering

- Rendering with environment maps
  - Monte Carlo rendering
    - rely on averaging considerable random samples of light transport in the scene

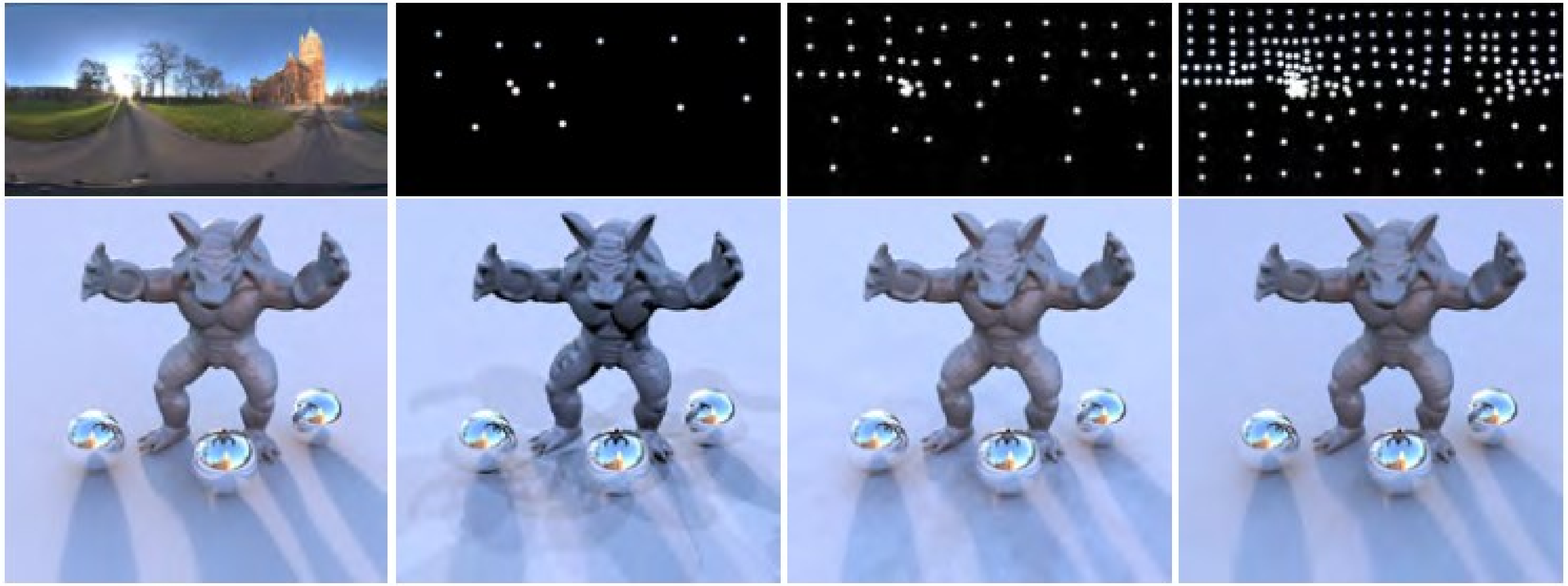
$$\int_a^b f(x)dx = \frac{1}{N}\sum_{i=1}^{N}\frac{f(X_i)}{p(X_i)}$$





3. Rendering

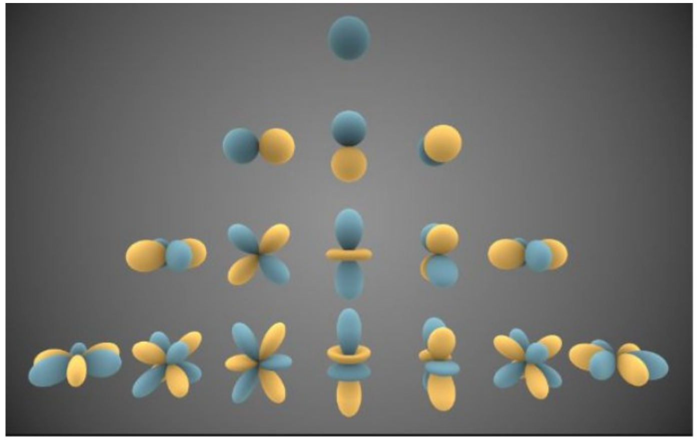
- Rendering with environment maps
  - Conversion to directional light sources
    - use a pre-processing step to transform the environment map to a set of finite directional light sources



(a) Reference (b) 16 lights (c) 64 lights (d) 256 lights

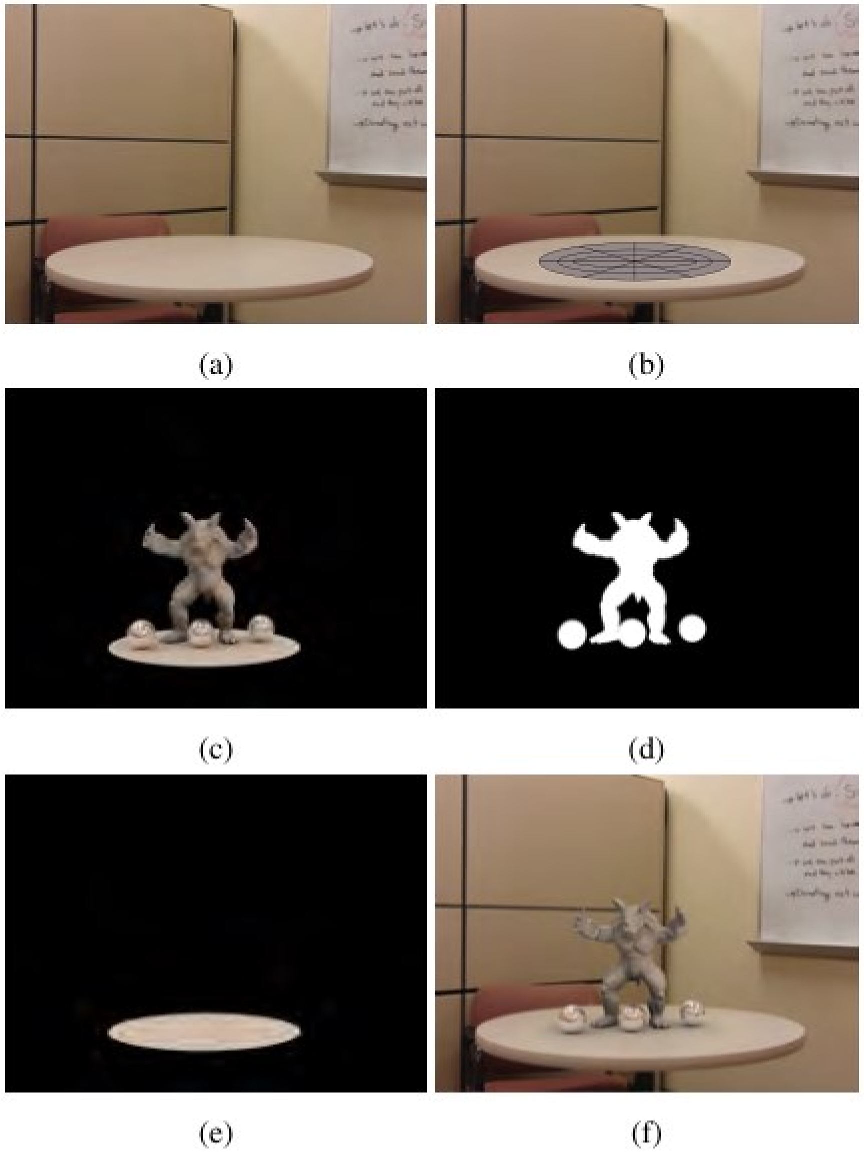
3. Rendering

- Rendering with environment maps
  - Precompute Radiance Transfer (PRT)
    - Given an environment map representing incoming radiance, the main idea of this method is to **precompute transfer functions** on the surface of an object.
    - These functions **locally map the incoming radiance to the outgoing radiance** and are computationally expensive. Both the environment map and the transfer functions are projected onto an orthogonal basis.
    - A large body of research has been devoted for finding a suitable basis.
      a. spherical harmonics (SH)
      b. wavelets
      c. radial basis functions
      d. principal components
      e. ……



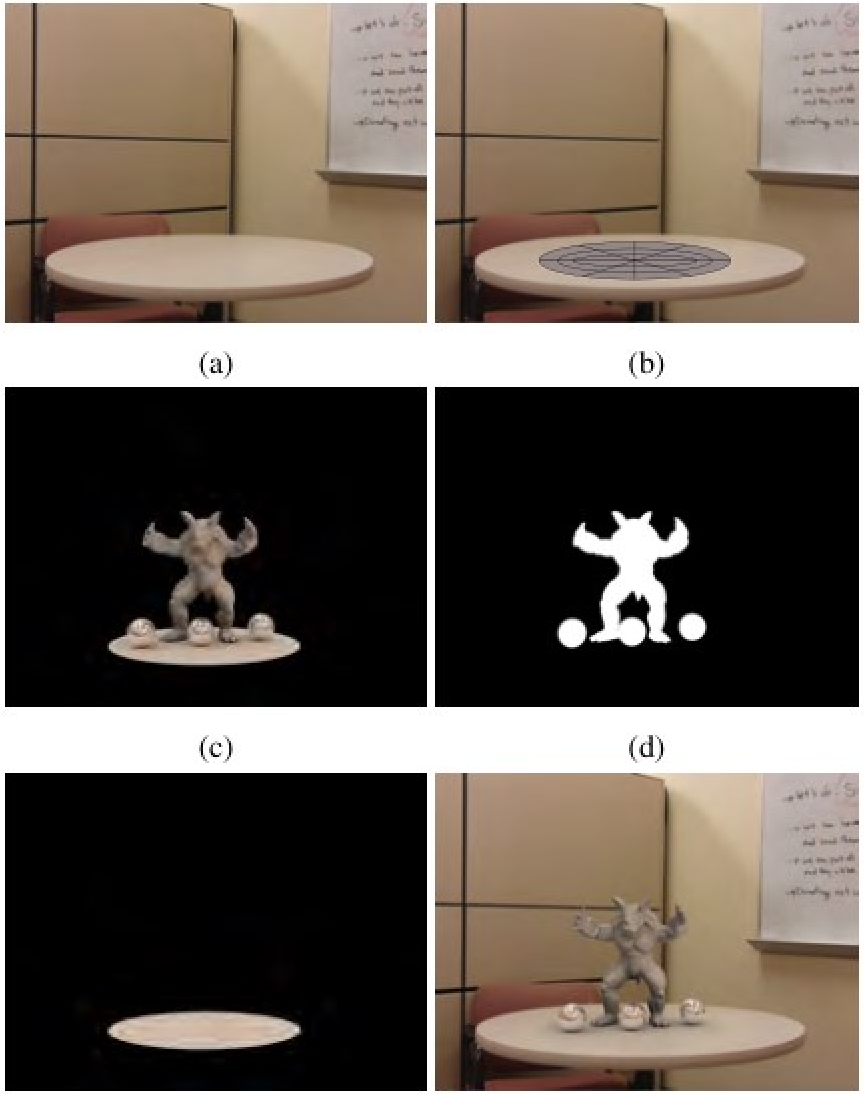
3. Rendering

- Interactive differential rendering
  - Standard differential rendering



3. Rendering

- Interactive differential rendering
  - Standard differential rendering
  - Single pass with photon map



(a) (b) (c) (d) (e) (f)

To be continued