Advanced Graphics

Additional Notes Lecture 4&5

Image-Based Lighting

- Image-based representation of the surrounding illumination.
- Surrounding illumination is far enough away that it can be considered *infinitely far away*.
- For practical purposes assume any light source that is more than a few meters away can be approximated as being infinitely far away.
- Approximations consider that direction of the light source is more important than its position.
- Object is surrounded by dome of light, photographs of object are captured with varying illumination.

Capturing Light Probe

- Capturing light probe is typically done using *mirror ball* on a tripod.
- A camera is placed in front of the ball facing straight on and exposure stack is captured to cover the dynamic range.
- Theoretically a single photo of mirror ball can cover 95-98% of the entire environment because it gives almost 360° field of view (<u>not</u> 180° as might be thought at first).
- That is because at the edges of the mirror ball the surface normals are orthogonal to camera's viewing direction. Due to reflection equation the light gets reflected on the other side of the mirror ball.

Calibrating Mirror Ball Reflectivity

- Once environment map is captured with mirror ball, need to calibrate for its *reflectivity*.
- Typical way to determine mirror ball reflectivity is to photograph it together with a target of known reflectance (e.g. color checker charts).
- Next step is to compare brightness of the corresponding pixels on mirror ball and the target object from the photograph.
- The *ratio* of the two tells the reflectivity of the mirror ball.
- Cheaper mirror balls typically have lower reflectivity.

Capturing Light Probe

- Although capturing one photograph of mirror ball gives wide field of view, there might be potential sampling problem.
- Sampling of the back hemisphere is rather poor compared to the front.
- In fact, ¾ of the pixels reflect the front hemisphere while the rest reflects the back.
- To fix sampling problem need to capture more than one photograph of the mirror ball from different viewpoints and hence create a relatively well-sampled light probe for both hemispheres.

Capturing Light Probe

- Capturing for *back and front* viewpoints has several problems:
  - Photographer will be present in both environment maps.
  - Opposite hemispheres are poorly sampled for each viewpoint, hence merging environment maps might be problematic.
- Instead capture two photographs with *orthogonal viewpoints*, which eliminates the aforementioned problems.

Capturing light probe can be done with other means instead of mirror ball, e.g. wide angle lenses, stitched images, special scanning devices.

Environment Mapping

- Different formats, e.g. cube map, latitude/longitude map, etc.

- Latitude/longitude format results from stretching sphere into a cylinder and unwrapping. Due to that the poles are massively stretched compared to almost no stretching around the equator.

For some more information on environment mapping check http://cgvr.cs.uni-bremen.de/teaching/cg_literatur/Spherical,%20Cubic,%20and%20Parabolic%20Environment%20Mappings.pdf

Omnidirectional Images

- *Mirrored ball* and *angular map* have different distances between orthogonal directions.

- Mirrored ball gives most of the sampling to the front hemisphere (distance between +X and –Z is much *smaller* compared to distance between +Z and +X)

- In angular map the front hemisphere is squished to occupy relatively same amount of area as the back hemisphere, leading to better sampling of both hemispheres in one map (distance between +X and –Z is *roughly equal* to distance between +Z and +X)

Capturing Light Probe

- Extended HDR photography with the mirrored ball not often possible due to the scene being not completely static and controlled (e.g. people walking in the background, clouds moving, etc.).
- Hence, quite often we have to do limited exposure photography (typically 3 images for outdoors conditions).
- However, even in short exposures the sun can be saturated in the light probe.
- Need to recover missing energy corresponding to saturated pixels, e.g. pixels on the sun.

Recovering Energy

- Model the sun as a point light source.
- Model the rest of the sky and the background as a light probe.
- Assume there is missing energy α of a point light source in addition to the captured saturated light probe. When added together they can produce an unsaturated light probe.

Solution

- Make dual measurement with mirror and diffuse ball.
- Diffuse ball typically has 30-50% reflectivity.
- Therefore, even in bright outdoor conditions the sky that is saturated on mirror ball won’t be saturated on the surface of diffuse ball.
- By knowing direction of the sun in the mirror ball we can also know corresponding direction to look at on the diffuse ball.
- That information can tell the total incident irradiance of the sky plus the sun, which captures clamped measurement of the illumination.

Solution

- Then compare rendering of diffuse sphere with clamped environment map and search for additional energy α of point light source, such that when added to environment map it would match intensity of the rendered diffuse sphere.
- The process is referred to as *inverse rendering,* i.e. analysis by synthesis.