Lights

Digital Image Synthesis

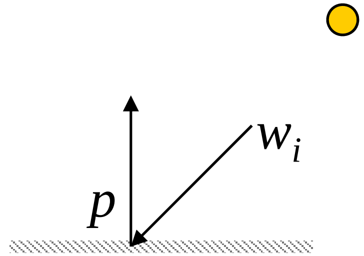
Yung-Yu Chuang

12/3/2008

with slides by Stephen Chenney

Lights

- An abstract interface for lights.
- Pbrt only supports physically-based lights, not including artistic lighting.



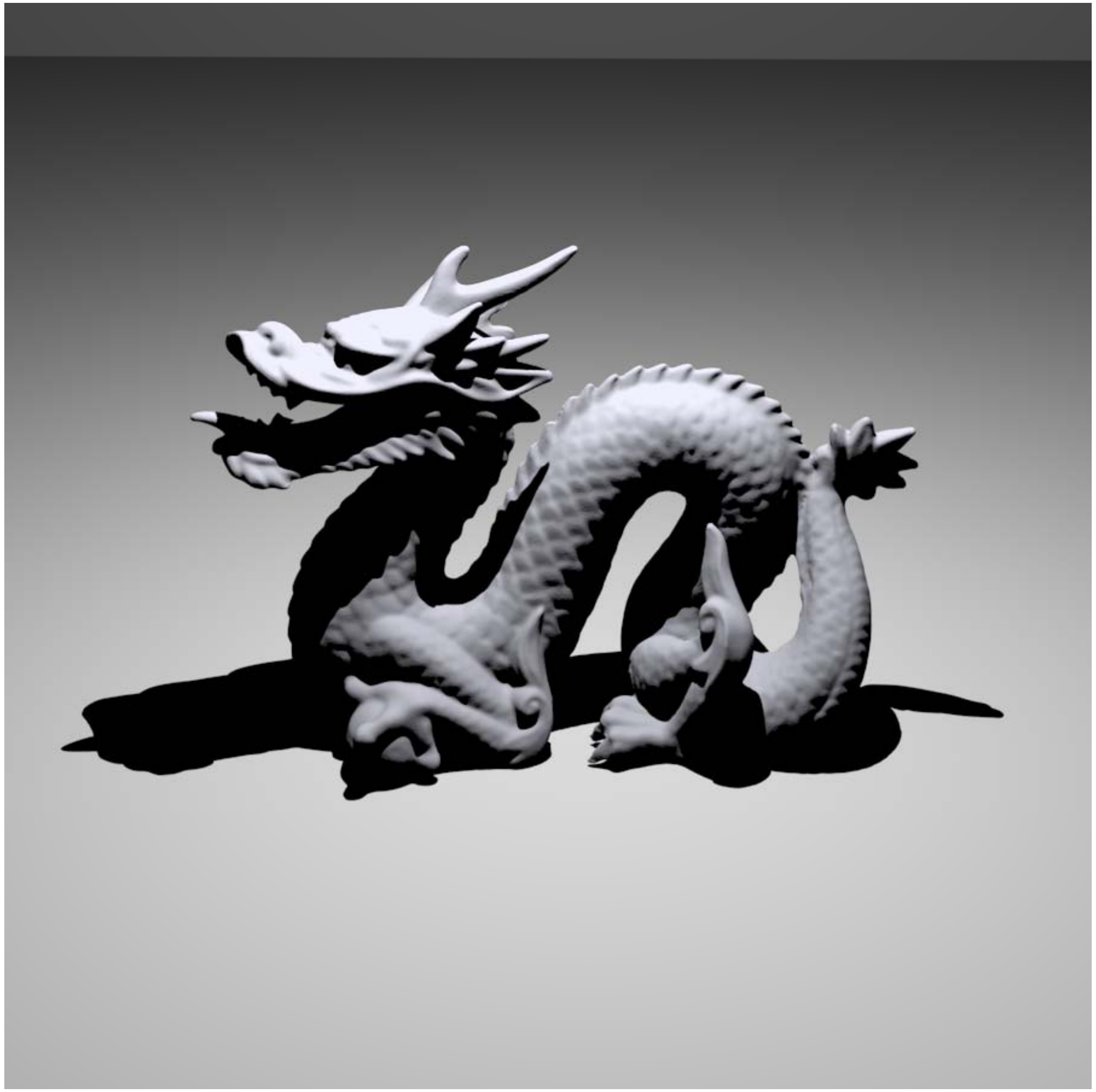
- **`core/light.* lights/*`**
- Essential data members:
  - **`Transform LightToWorld, WorldToLight;`**
  - **`int nSamples;`**
- Essential functions:

  returns **`wi`** and *radiance* due to the light assuming visibility=1; initializes **`vis`**

  - **`Spectrum Sample_L(Point &p, Vector *wi, VisibilityTester *vis);`**
  - **`Spectrum Power(Scene *);`** approximate total power
  - **`bool IsDeltaLight();`** point/directional lights can't be sampled

Point lights

- Isotropic
- Located at the origin

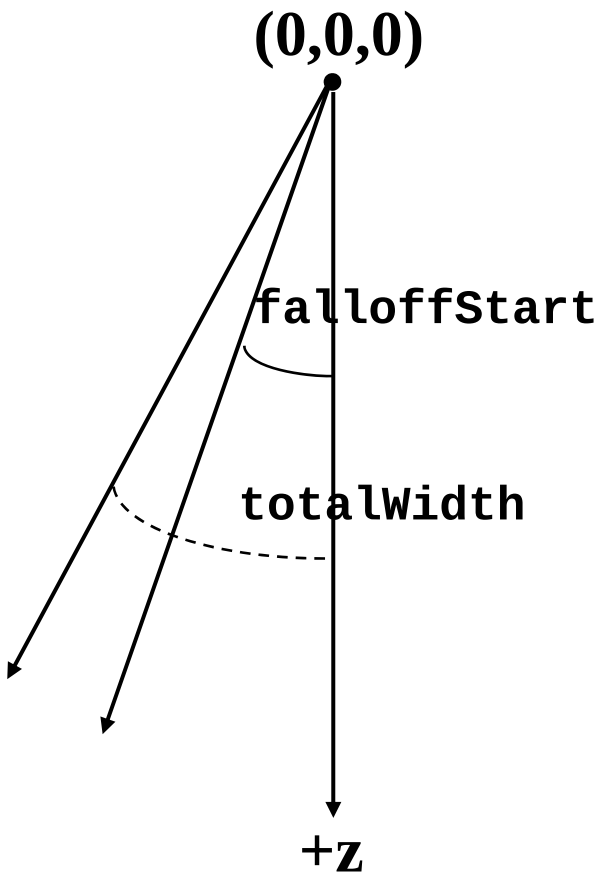


Point lights

```
PointLight::PointLight(const Transform &light2world,
  const Spectrum &intensity) : Light(light2world) {
  lightPos = LightToWorld(Point(0,0,0));
  Intensity = intensity;
}
Spectrum PointLight::Sample_L(Point &p, Vector *wi,
  VisibilityTester *visibility) {
  *wi = Normalize(lightPos - p);
  visibility->SetSegment(p, lightPos);
  return Intensity / DistanceSquared(lightPos, p);
}
Spectrum Power(const Scene *) const {
  return Intensity * 4.f * M_PI;
}
```

$$I = \frac{d\Phi}{d\omega} \qquad \Phi = \int_{s^2} I d\omega = 4\pi I$$

Spotlights



Spotlights

```
SpotLight::SpotLight(const Transform &light2world,
  const Spectrum &intensity, float width, float fall)
  : Light(light2world) {
  lightPos = LightToWorld(Point(0,0,0));
  Intensity = intensity;
  cosTotalWidth = cosf(Radians(width));
  cosFalloffStart = cosf(Radians(fall));
}
Spectrum SpotLight::Sample_L(Point &p, Vector *wi,
  VisibilityTester *visibility) {
  *wi = Normalize(lightPos - p);
  visibility->SetSegment(p, lightPos);
  return Intensity * Falloff(-*wi)
         /DistanceSquared(lightPos,p);
}
```

Spotlights

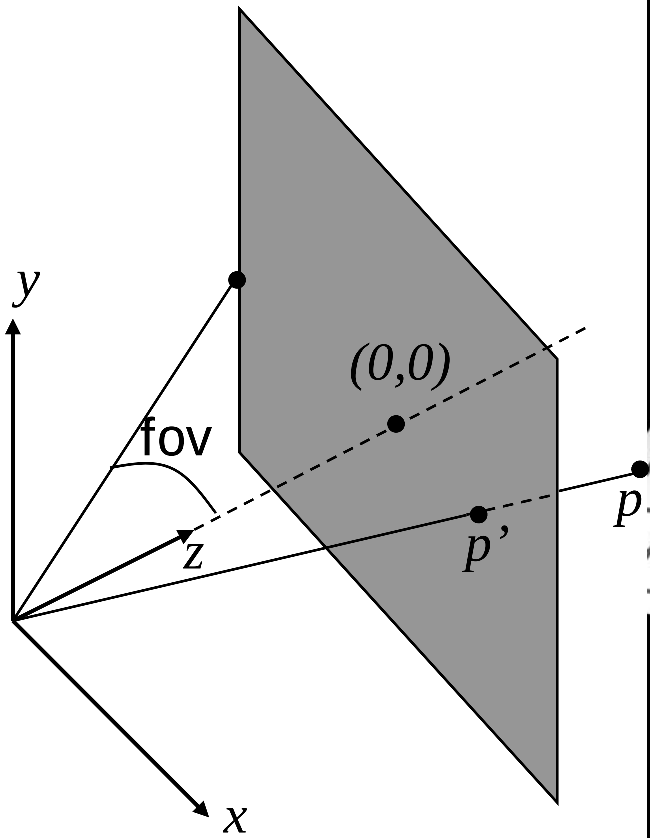
```
float SpotLight::Falloff(const Vector &w) const {
  Vector wl = Normalize(WorldToLight(w));
  float costheta = wl.z;
  if (costheta < cosTotalWidth)
    return 0.;
  if (costheta > cosFalloffStart)
    return 1.;
  float delta = (costheta - cosTotalWidth) /
                (cosFalloffStart - cosTotalWidth);
  return delta*delta*delta*delta;
}
```

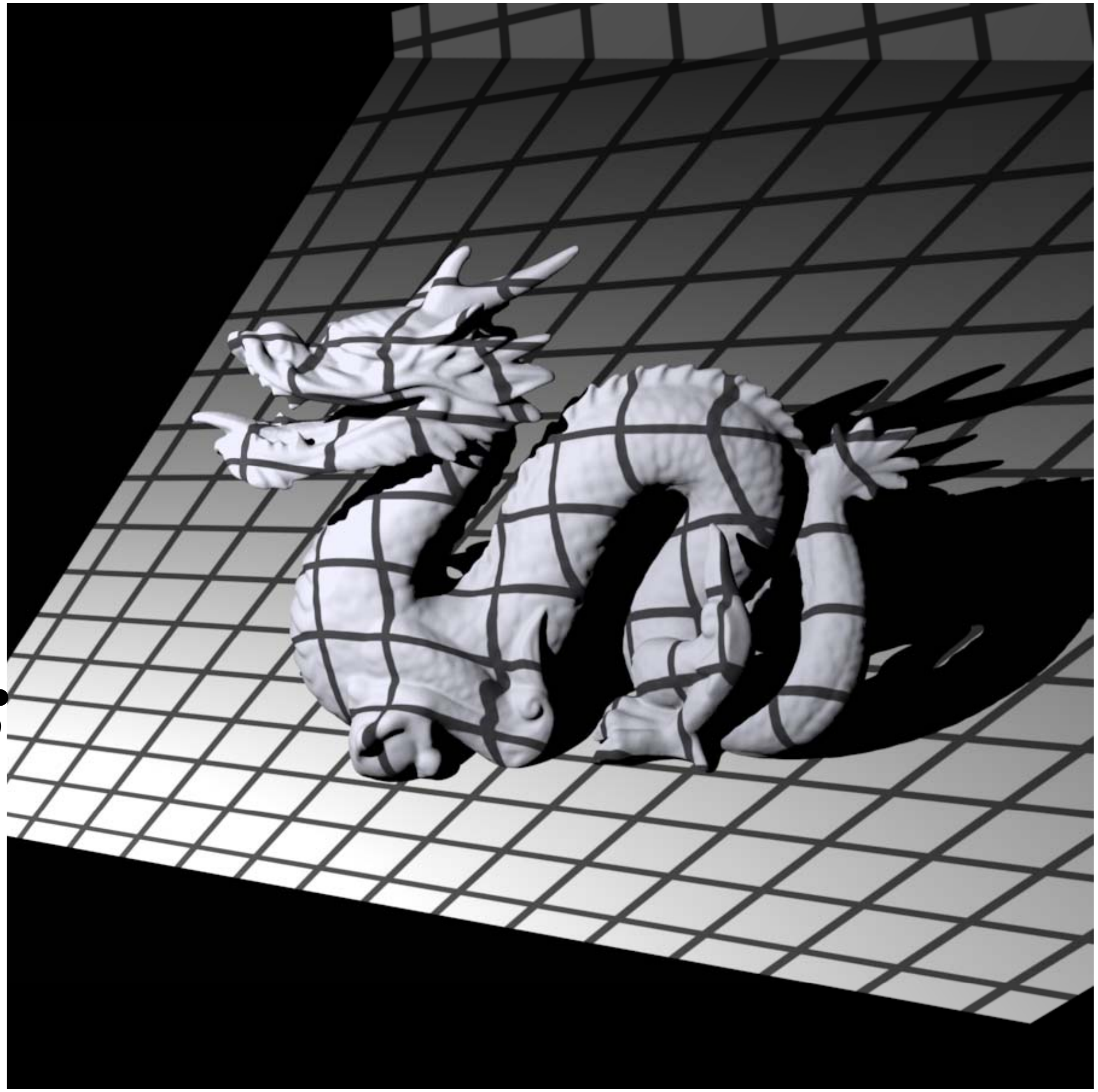
an approximation $$\int_{\Omega'} d\omega = \int_{\phi=0}^{2\pi}\int_{\theta=0}^{\theta'} \sin\theta d\theta d\phi = \int_{\phi=0}^{2\pi}(1-\cos\theta')d\phi = 2\pi(1-\cos\theta')$$

```
Spectrum Power(const Scene *) const {
  return Intensity * 2.f * M_PI *
    (1.f - .5f * (cosFalloffStart + cosTotalWidth));
}
```

Texture projection lights

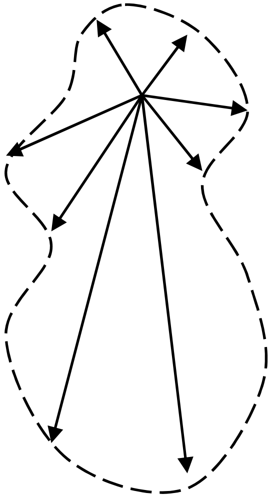
- Like a slide projector

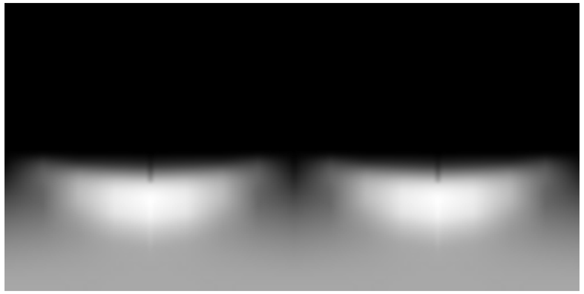


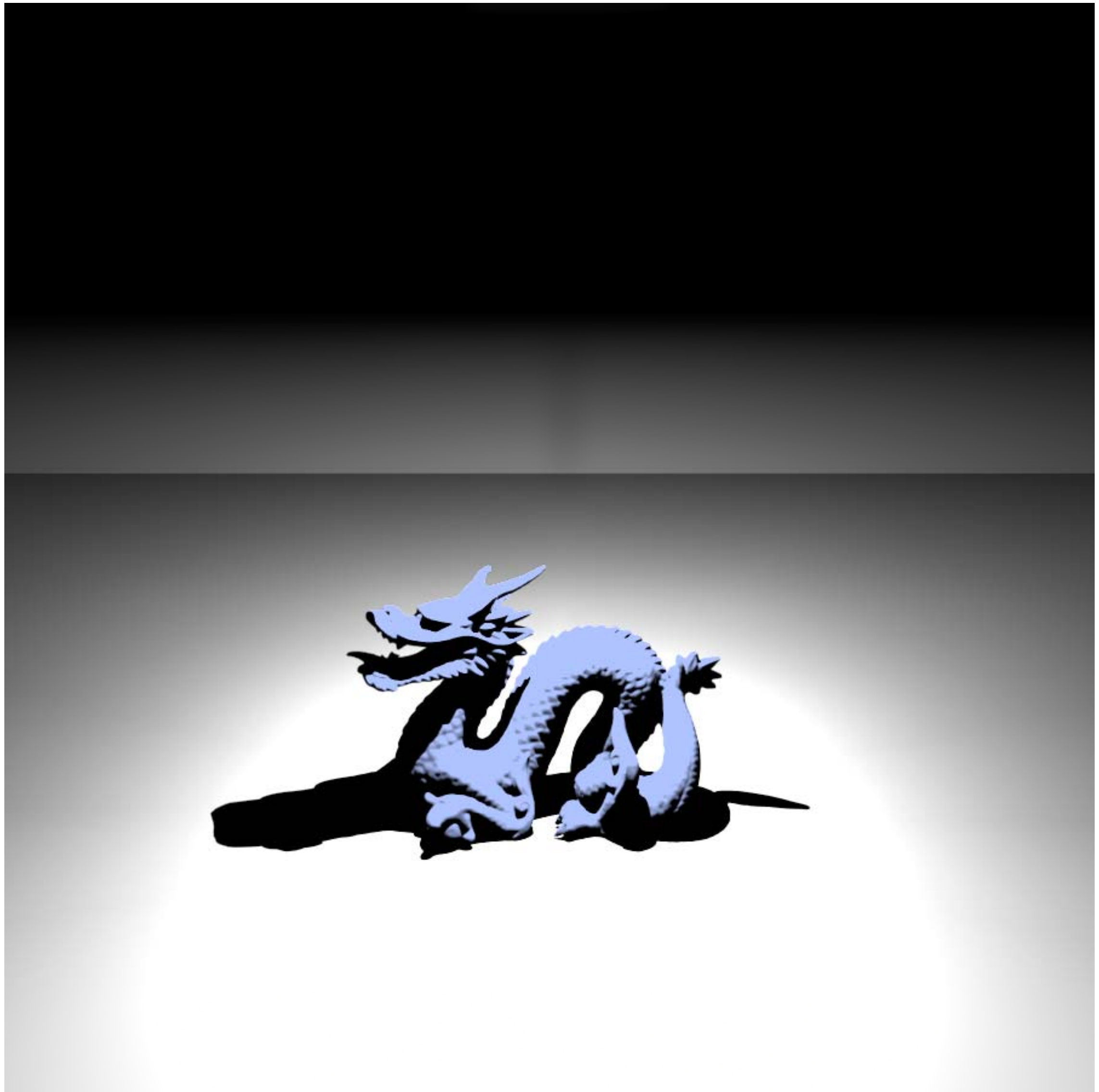


Goniophotometric light

- Define a angular distribution from a point light







Goniophotometric light

```
GonioPhotometricLight(const Transform &light2world,
  Spectrum &I, string &texname):Light(light2world) {
  lightPos = LightToWorld(Point(0,0,0));
  Intensity = I;
  int w, h;
  Spectrum *texels = ReadImage(texname, &w, &h);
  if (texels) {
    mipmap = new MIPMap<Spectrum>(w, h, texels);
    delete[] texels;
  }
  else mipmap = NULL;
}
Spectrum Sample_L(const Point &p, Vector *wi,
              VisibilityTester *visibility) const {
  *wi = Normalize(lightPos - p);
  visibility->SetSegment(p, lightPos);
  return Intensity * Scale(-*wi)
         / DistanceSquared(lightPos, p);
}
```

Goniophotometric light

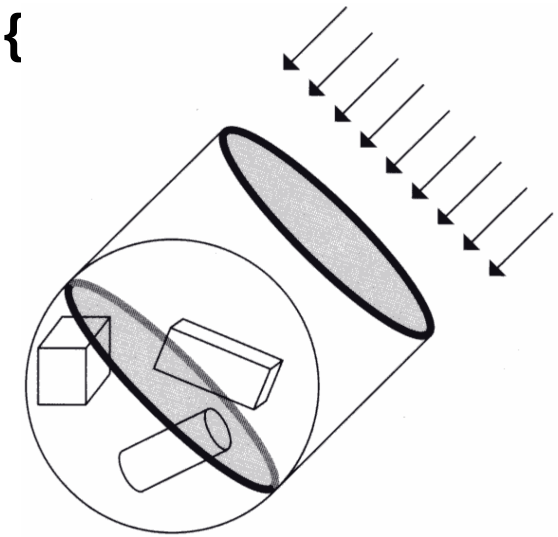
```
Spectrum Scale(const Vector &w) const {
  Vector wp = Normalize(WorldToLight(w));
  swap(wp.y, wp.z);
  float theta = SphericalTheta(wp);
  float phi   = SphericalPhi(wp);
  float s = phi * INV_TWOPI, t = theta * INV_PI;
  return mipmap ? mipmap->Lookup(s, t) : 1.f;
}

Spectrum Power(const Scene *) const {
  return 4.f * M_PI * Intensity *
         mipmap->Lookup(.5f, .5f, .5f);
}
```

Point lights

- The above four lights, point light, spotlight, texture light and goniophotometric light are essentially point lights with different energy distributions.

Directional lights

```
DistantLight::DistantLight(Transform &light2world,
Spectrum &radiance, Vector &dir):Light(light2world) {
  lightDir = Normalize(LightToWorld(dir));
  L = radiance;
}
Spectrum DistantLight::Sample_L(Point &p, Vector *wi,
  VisibilityTester *visibility) const {
  wi = lightDir;
  visibility->SetRay(p, *wi);
  return L;
}
Spectrum Power(const Scene *scene) {
  Point wldC; float wldR;
  scene->WorldBound().BoundingSphere(&wldC, &wldR);
  return L * M_PI * wldR * wldR;
}
```



Area light

- Defined by a **`shape`**
- Uniform over the surface
- Single-sided
- **`Sample_L`** isn't straightforward because a point could have contributions from multiple directions (chap15).

Infinite area light

area light+distant light

morning skylight

environment light

Infinite area light

midday skylight

sunset skylight

Infinite area light

```
InfiniteAreaLight(Transform &light2world,Spectrum &L,
   int ns, string &texmap) : Light(light2world, ns) {
  radianceMap = NULL;
  if (texmap != "") {
    int w, h;
    Spectrum *texels = ReadImage(texmap, &w, &h);
    if (texels) radianceMap =
                new MIPMap<Spectrum>(w, h, texels);
    delete[] texels;
  }
  Lbase = L;
}
Spectrum Power(const Scene *scene) const {
  Point wldC;  float wldR;
  scene->WorldBound().BoundingSphere(&wldC, &wldR);
  return Lbase * radianceMap->Lookup(.5f, .5f, .5f)
           * M_PI * wldR * wldR;
}
```

Infinite area light

```
Spectrum Le(const RayDifferential &r) {
  Vector w = r.d;
  Spectrum L = Lbase;
  if (radianceMap != NULL) {
    Vector wh = Normalize(WorldToLight(w));
    float s = SphericalPhi(wh) * INV_TWOPI;
    float t = SphericalTheta(wh) * INV_PI;
    L *= radianceMap->Lookup(s, t);
  }
  return L;
}
```

for those rays which miss the scene