CMSC 491G/691G

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Lighting & Illumination

- Interaction of light with surfaces
- Local Illumination
  - Each point independent of every other
- Global Illumination
  - Lighting at one point affects others

Lights

- $L = P_L - P_S = w_S \, p_L - w_L \, p_S$
- Directional: (x, y, z, 0)
  - Far enough away that rays are parallel
- Point: (x, y, z, 1)
  - Shines in all directions from point
  - Normally no falloff with distance
  - Physical: Attenuate I_L by $1/(L \cdot L)$
    - May require $I_L > 1$

Lights

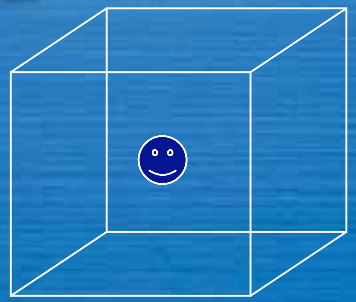
- Spot
  - Point + direction and cone
    - Scale I_L by $L \cdot D^e$
- Area
  - Line: like florescent tube
  - Patch: like light fixture
- Environment

Environment map

- Approximate light from all directions as seen by each point on surface
- Instead use light from all directions as seen by one representative point
- Distant environments
- Direction-based texture map

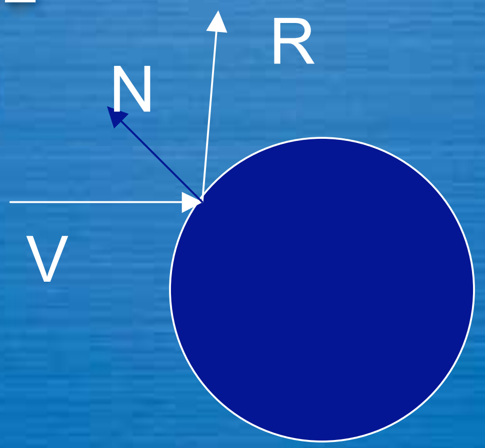
Direction-based mapping

- Vector R = (x,y,z)
- Cube map
  - Six images on cube faces
  - Divide other two components by largest
  - Say it is y: (s,t,q) = (x, z, y)
    - S = x/y; T = z/y
  - Scale into texture: (S+1)/2, (T+1)/2



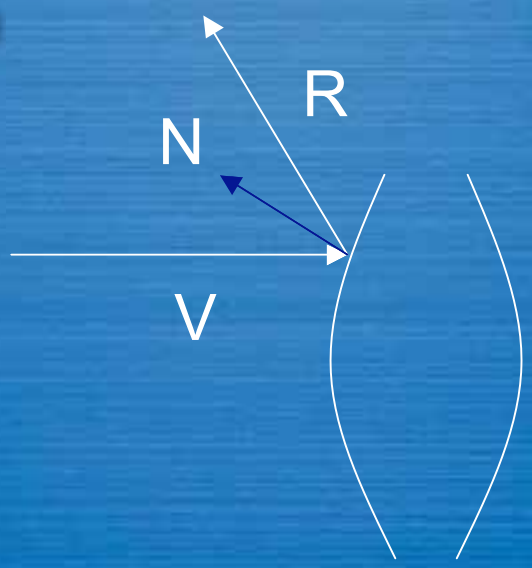
Direction-based mapping

- Sphere map
  - (s,t) = (x,y) on shiny sphere refl. V to R
    - $V = (0,0,-1)$
    - $f(x, y, z) = x^2 + y^2 + z^2 - 1 = 0$
  - N half way between V and R
    - $N = (V+R)/|V+R| = (2x, 2y, 2z)/2$
  - $(s,t,q) = x,y,\mathrm{sqrt}\left(x^2+y^2+(z-1)^2\right)$



Direction-based mapping

- Parabolic maps
  - $(s,t) = (x,y)$ on shiny parabola
    - Need two
      - $V=(0,0,1)$; $f(x,y,z) = z + (x^2 + y^2)/2=0$
      - $V=(0,0,-1)$; $f(x,y,z) = z - (x^2 + y^2)/2=0$
  - $(s,t,q) = (x, y, z - 1)$
  - $(s,t,q) = (x, y, 1 - z)$

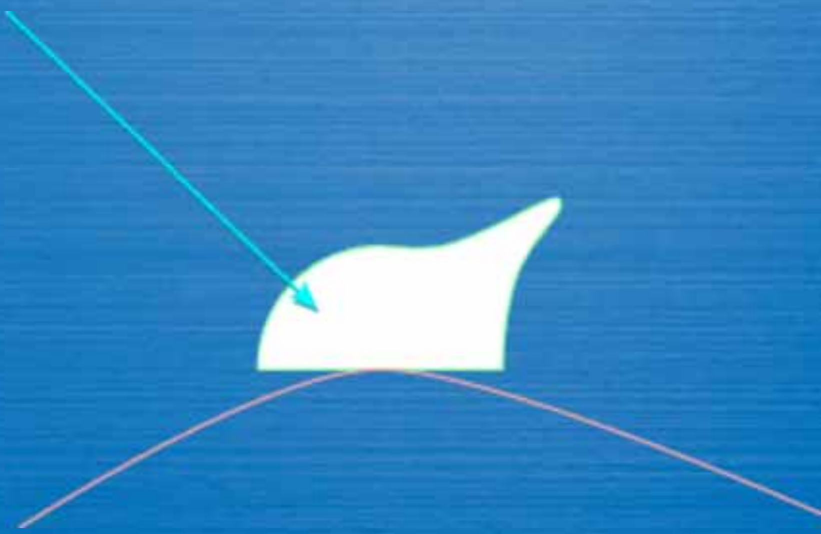


BRDF

- Bidirectional
  - Incoming & outgoing light directions
- Reflectance
  - Attenuation of reflected light
  - Not transmission or emission
- Distribution
  - Light in distributed to outgoing directions
  - Don’t create new light
- Function

BRDF

- In terms of local surface coordinates
  - Only above surface
  - Direction: ϕ, θ or U, V (N)
  - $f(\phi_i, \theta_i, \phi_o, \theta_o)$
- Polar/spherical plot

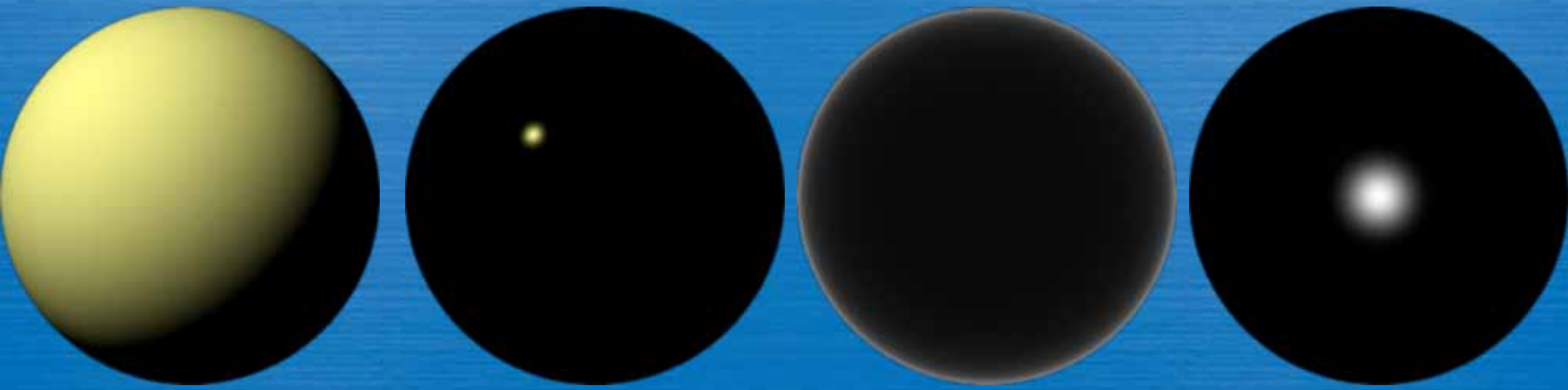


Physically plausible BRDF

- Positive everywhere
  - No negative light
- Conservation of Energy
  - No more light out than you put in
  - $\int f(V,L)\, dL \leq 1$
- Reciprocity
  - No one-way light valves
  - $f(V,L) = f(L,V)$

Decomposition

- Often decompose into components
  - $f_{diffuse} + f_{specular} + f_{Fresnel} + f_{retroreflect} + \dots$

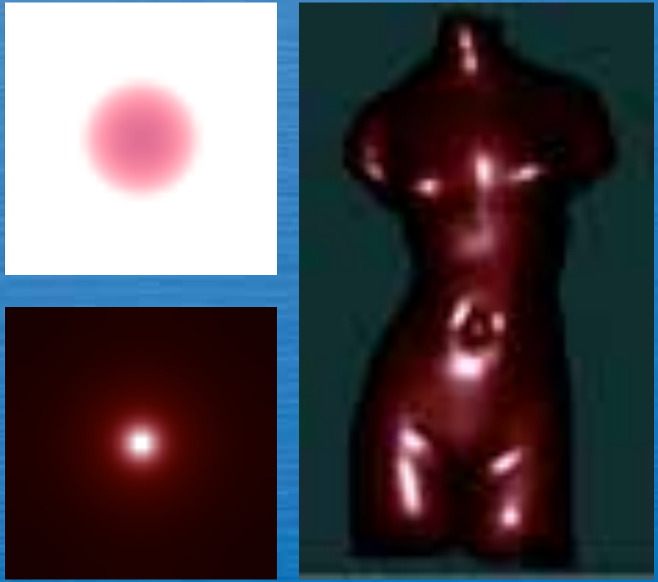


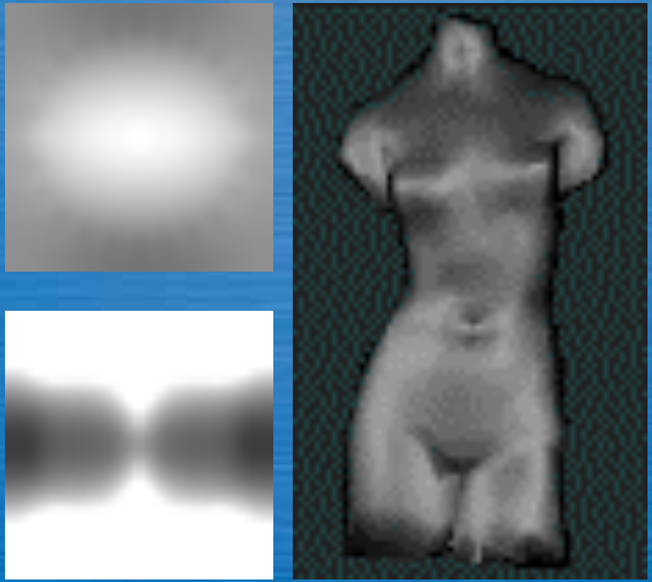
Microfacet models

- Microscopic reflective facets
- Probability distributions
  - Reflectance: Chance a facet has normal H=V+L
  - Shadowing: Chance another facet blocks L
  - Masking: Chance another facet blocks V

Homomorphic + Microfacet

- Factor into f(V), f(H), f(L)
- f(V) = masking = f(L) = shadowing
- f(H) = reflectance





Homomorphic Factorization

- $f(V,L) = f_0(v_0)\ f_1(v_1)\ f_2(v_2)\ \ldots\ f_n(v_n)$
- Pick $v_0 \ldots v_n$, functions of V & L
- $\log(f) = \log(f_0\ f_1\ f_2\ \ldots\ f_n)$
  - $= \log(f_0) + \log(f_1) + \log(f_2) + \ldots + \log(f_n)$
  - + smoothness terms
  - Solve for elements of $\log(f_i)$
    - Big least-squares problem
  - Use $\exp(\log(f_i))$ as texture & v_i as texture coordinates

Reflectance map

- Diffuse: I(N) = texture
- Specular: I(H) = texture
  - Filtered environment map
  - BRDF as Filter