1 The scene radiance is given by the following eq^n

$$I(x,y) = L \rho \, l^t \cdot N(x,y)$$ (Lambertian model)

I = scene radiance

L = Lighting intensity

$l = (-l_x, l_y, l_z)$ lighting direction (unit vector)

$N(x,y)$ = unit surface normal at the point (x,y)

$\rho(x,y)$ = surface reflectivity (albedo) at the point (x,y)

(Given that albedo is unknown but constant)

We know reflectance map & $N(x,y)$ ($\because$ geometry is known)

L and ρ are unknown. Note: $L\rho$ = constant

Take three points (x_1, y_1), (x_2, y_2) & (x_3, y_3)

The equations are

$I(x_1, y_1) = L\rho \, l^t \cdot N(x_1, y_1)$ —① $\quad I(x_2, y_2) = L\rho \, l^t \cdot N(x_2, y_2)$ —②

$I(x_3, y_3) = L\rho \, l^t \cdot N(x_3, y_3)$ —③

Now, divide ① & ② by ③

$$\Rightarrow \frac{I(x_1, y_1)}{I(x_3, y_3)} = \frac{l^t \cdot N(x_1, y_1)}{l^t \cdot N(x_3, y_3)} \quad —④ \quad \& \quad \frac{I(x_2, y_2)}{I(x_3, y_3)} = \frac{l^t \cdot N(x_2, y_2)}{l^t \cdot N(x_3, y_3)} \quad —⑤$$

Also, l is unit vector

$$\Rightarrow l_x^2 + l_y^2 + l_z^2 = 1 \quad —⑥$$

We have 3 unknowns l_x, l_y, l_z & 3 eq^n ④, ⑤, ⑥. On solving them we get the lighting direction.

Another method

$$I(x,y) = L\rho \, l^T \cdot N(x,y) = L\rho \cos\theta$$

$L\rho \to$ unknown constant

$\theta \to$ angle b/n normal and lighting direction

Now, find the point where $I(x,y)$ is maximum ($\because$ We know reflectance map). $L\rho\cos\theta$ will be maximum when $\theta = 0°$ $\Rightarrow$ ~~Lighting direction~~

$\Rightarrow$ Lighting direction = Normal at the point where $I(x,y)$ is maxima

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