Supplementary Material of
Calibrating a Non-isotropic Near Point Light Source using a Plane
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In the supplementary material, we present additional experimental results analyzing the extent to which non-Lambertian surfaces satisfy the symmetry constraints described in the paper (Section 3.4).

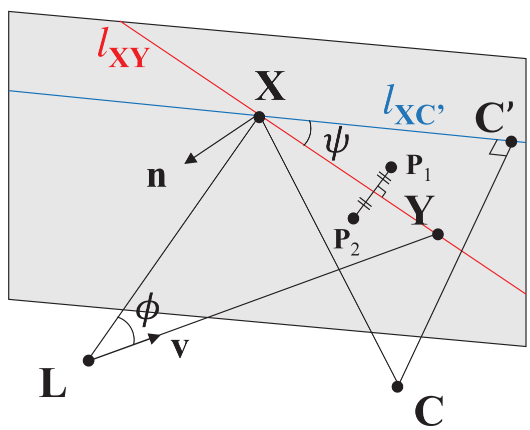


Figure 1. Camera-light rig geometry and notation: $\mathbf{L}$ and $\mathbf{C}$ denote the light and camera positions and $\mathbf{X}$ and $\mathbf{C}'$ denote the points on the plane closest to $\mathbf{L}$ and $\mathbf{C}'$ respectively. The light axis vector $\mathbf{v}$ intersects the plane at the point $\mathbf{Y}$ and $\mathbf{n}$ is the plane normal vector. Line $l_{\mathbf{XY}}$ passes through $\mathbf{X}$ and $\mathbf{Y}$, whereas line $l_{\mathbf{XC}'}$ passes through $\mathbf{X}$ and $\mathbf{C}'$ respectively. The angle between lines $l_{\mathbf{XY}}$ and $l_{\mathbf{XP}}$ is denoted ψ (This figure is the same as Figure 3(b) in the paper).

Definitions. Figure 1 shows a configuration of the rig in general position. For any rig position, the lines $l_{\mathbf{XY}}$ and $l_{\mathbf{XP}}$ intersect at the point $\mathbf{X}$ at different angles ψ. We assume the plane is made of a single material that has an isotropic BRDF. We measure the degree of asymmetry for various BRDF types as a function of the angle ψ.

The degree of asymmetry also depends on a second factor, ω which as defined in the paper, is equal to the ratio $\frac{\|\mathbf{LC}\|}{\|\mathbf{CC}'\|}$, where $\|\mathbf{LC}\|$ and $\|\mathbf{CC}'\|$ denotes the distance between $\mathbf{L}$ and $\mathbf{C}$ and $\mathbf{C}$ and $\mathbf{C}'$ respectively.

As described in the paper, we use κ to measure the degree of asymmetry in the BRDF map for a particular configuration.

$$\kappa = \frac{|\rho_1 - \rho_2|}{\max(\rho_1, \rho_2)}$$

where ρ_1 and ρ_2 are the BRDF values at points P_1 and P_2 that are equidistant from $l_{\mathbf{XY}}$ on a line perpendicular to it (Figure 1).

Experiments. We generate several rig configurations that correspond to values of $\psi \in [0, \pi/2]$ and values of $\omega \in [0.1, 1.0]$. We then analyze the values of κ as a function of ψ and ω for various materials. For each rig configuration, $\bar{\kappa}$ denotes the mean value of κ for all pairs of points considered in the corresponding image. We used the MERL-BRDF database[1] to simulate different BRDFs.

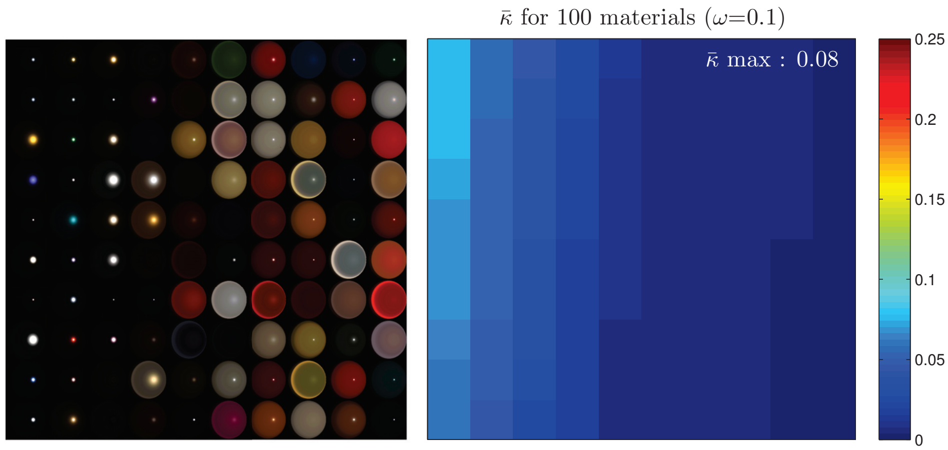
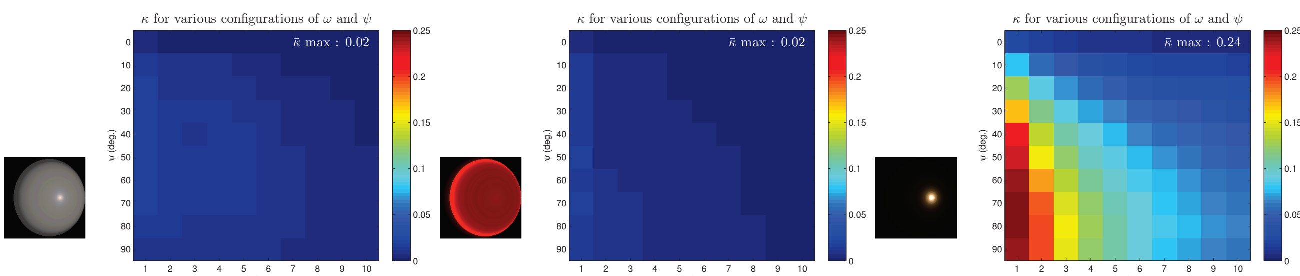


Figure 2. Analysis of 100 materials. (Left) BRDFs. (Right) The corresponding average value of $\bar{\kappa}$ for these materials obtained for different rig configurations where $\omega = 0.1$ but ψ lies in the range $[0, \pi/2]$. Materials that exhibit strong specular reflections tend to have higher values but the maximum value of $\bar{\kappa}$ is still quite small.

Results. First, we show overall results for 100 materials. In this experiment, we generate multiple rig configurations where $\omega = 0.1$ but ψ lies anywhere in the range $[0, \pi/2]$. For all 100 materials, the maximum value of $\bar{\kappa}$ is less than 0.08 (Figure 2). This shows that materials (mostly metals) that have a strong specular lobe in their BRDF can have slightly larger values of $\bar{\kappa}$. However, the degree of asymmetry for the worst case BRDF is reasonably small.



(a) (b) (c)

Figure 3. Asymmetry analysis on three different materials: (a) white paint, (b) pink-plastic, (c) alum-bronze. White paint has a small specular highlight and mostly diffuse reflectance component. It shows low asymmetry in all configurations whereas alum-bronze has a high degree of asymmetry in configurations where ψ is close to $\pi/2$ and the rig is very close to the plane.

In a second set of experiments, we analyzed results for rig configurations from the full range of $\omega \in [0.1, 1.0]$ and $\psi \in [0, \pi/2]$. Figure 3 shows the average $\bar{\kappa}$ maps for three materials – white paint, pink-plastic and alum-bronze. The maximum value of $\bar{\kappa}$ in these three cases is 0.02, 0.02 and 0.24 respectively for the full range of ω and ψ.

Conclusion These simulations confirm that when ψ increases, the degree of asymmetry in the BRDF maps can increase especially if the camera light rig is very close to the plane (Figure 3c). Our experiments also show that the degree of asymmetry is very small for most BRDFs when the distance between the light and the camera positions is equal to or smaller than about one-tenth the distance of the rig from the plane. Thus, as long as the user maintains sufficient distance from the plane while capturing images to be used for calibration, our method is well suited for most compact camera-light rigs even when the scene plane has non-Lambertian reflectance.

[1] Wojciech Matusik, Hanspeter Pfister, Matt Brand, and Leonard McMillan. A Data-Driven Reflectance Model. ACM Transactions on Graphics. 22(3) 2002.