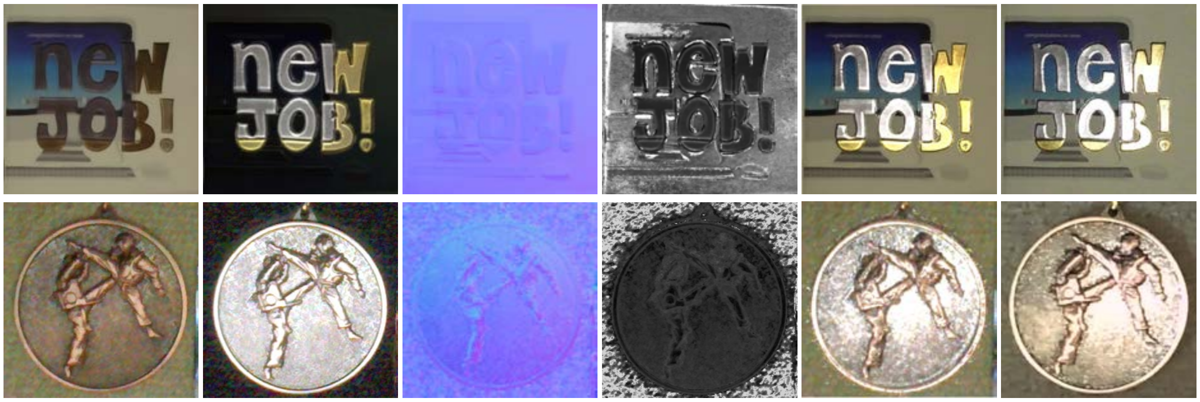
Mobile Surface Reflectometry

Jérémy Riviere[1] Pieter Peers[2] Abhijeet Ghosh[1*]
Imperial College London[1] College of William & Mary[2]



(a) diff. albedo (b) spec. albedo (c) spec. normal (d) spec. roughness (e) rendering (f) photograph

Figure 1: *Reflectance properties of flat samples acquired using a mobile device. Top-row: Hand held back camera-flash pair acquisition for rough specular BRDFs. Bottom-row: Tablet based acquisition using front camera and LCD screen illumination for highly specular BRDFs.*

Abstract

We present two approaches for acquiring spatially varying reflectance of planar samples using a mobile device. For samples with rough specular BRDF, we propose to employ the back camera and flash pair on any typical mobile device for freeform handheld reflectance acquisition using dense backscattering measurements under flash illumination. For samples with highly specular BRDF, we instead employ a 10" tablet for illuminating the sample with extended illumination while employing the front camera for reflectance acquisition. With this setup, we also exploit the tablet's LCD screen polarization for diffuse-specular separation.

1 Mobile camera-flash pair acquisition

We employ the back camera-flash pair of a mobile device to acquire the spatially varying reflectance of planar samples with rough specular BRDFs. For our acquisition, we employ a Fujitsu Stylistic M532 10" Android tablet which has an 8MP back camera and LED flash. We acquire reflectance data using the back camera in video mode at full HD resolution. With this setup, the acquisition proceeds as follows: The user points the mobile device's back camera and flash pair at the flat reflectance sample from a distance of roughly 50 cm above the sample and then proceeds to capture a video sequence while sequentially capturing data from several directions over the upper hemisphere. A typical capture sequence lasts about 15 seconds and around 300 frames are recorded of the sample from several surrounding viewpoints. Such a capture sequence results in dense measurement of backscattered reflectance by the camera-flash pair. To calibrate for the handheld measurements and variation in distance to the sample, we place an Xrite ColorChecker chart next to the sample during measurement and scale the measurements based on observed intensity variations in the diffuse gray squares of the chart similar to Ren et al. [2011]. However, Ren et al. use a static mobile phone camera just for recording reflectance in conjuction with a linear light source. Instead, we only require a handheld mobile device and exploit the internal accelerometer readings to estimate the backscattering direction for each captured frame. Since the flat sample is recorded from various different viewpoints during the sequence, the data needs to be registered to a cononical frontal viewpoint before reflectance fitting. For this step, we employ a combination of sparse SURF feature detection and dense optical flow. Once the data is registered and calibrated, we estimate the diffuse albedo and a diffuse normal per pixel using photometric stereo computation after discarding the top 20% bright samples. Specular albedo is then estimated as the hemispherical integral of the diffuse subtracted measurements. We also estimate a specular normal based on the weighted average of the brightest reflection directions. Finally, we fit the observed backscattering profile to a microfacet BRDF model to obtain per pixel specular roughness for rendering (Fig 1, top-row).

2 Tablet LCD screen based acquisition

The previous method may fail for highly specular BRDFs due to insufficient sampling density with flash illumination. Instead, for such materials we propose to employ extended illumination for reflectance acquisition using the tablet's LCD panel. We statically mount the tablet 45 cm above the sample with the LCD panel facing the sample at normal incidence and acquire reflectance using the tablet's front camera. We also exploit the inherent polarization of the LCD screen for diffuse-specular separation by mounting a sheet of linear polarizer in front of the front camera. We emperically found the axis of polarization of the LCD screen to be at 45° angle with respect to the screen's axis. With this setup, we record the response of the flat sample to polarized second order spherical gradient illumination conditions [Ghosh et al. 2009]. We first capture the reflectance under parallel polarization and then repeat the measurements after rotating the polarizer on the front camera to be cross-polarized with respect to the screen. With this procedure, we obtain the diffuse and specular reflectance and normal maps required for rendering specular materials (Fig. 1, bottom-row).

*email:ghosh@imperial.ac.uk

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References

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