Modeling metal materials in Radiance based on Bidirectional Reflection Distribution measurement

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The Bidirectional Reflectance Distribution Function (BRDF) is a four-dimensional function that defines how light is reflected at an surface.

\[ f(\theta_i, \varphi_i, \theta_o, \varphi_o) = \frac{dL_r(\theta_r, \varphi_r)}{dE_r(\theta_i, \varphi_i)} \]

- \(dL_r(\theta_i, \varphi_i)\) Radiance at surface in direction \((\theta_i, \varphi_i)\)
- \(dE_r(\theta_o, \varphi_o)\) Irradiance at surface in direction \((\theta_o, \varphi_o)\)
Metal samples

Scattering aluminum frontside mirror miro20-2000

Clear aluminum frontside mirror miro4-4000
Modeling procedure

1. BRDF measurement with goniophotometer
2. Resample the measurement data
3. Different fitting models with resampled data
4. Validation of fitted models
5. Simulation in Radiance with the best fit model
1. Measurement of BRDF

Goniophotometer Laboratory in SERIS

![Diagram of the Goniophotometer Laboratory in SERIS]
2.1 Resample data

Motivation of data resampling:

- Computationally demanding to fit tabulated BRDF data to analytical models
  - Data for one incident angle has over 14,000 data points and file size is over 4 MB
  - Fitting could not finish in reasonable time

After data resampling

- File size for one incident angle usually below 100KB
- Fitting time reduced to several minutes
2.2 Resample data
Finding the right resolution for resampling
3.1 Different fitting models

Scattering aluminum at 8 deg incident angle

Radiance Metal Model

Phong Model

New BRDF model
3.2 Different fitting models

Clear aluminum at 8 deg incident angle
4. Validations of fitting models
Scattering aluminum at all incident angles

<table>
<thead>
<tr>
<th>Incident angle</th>
<th>BRDF models</th>
<th>Default radiance model</th>
<th>Phong</th>
<th>New</th>
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<td>Overall</td>
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</table>
5.1 Radiance Simulation

Scattering aluminum

Radiance Metal Model  Phong Model  New BRDF model
5.2 Radiance Simulation

Clear aluminum

Phong model

New BRDF model

incidence angle: 08 deg
Conclusions

- Radiance calculation could be as accurate as the fitted analytical BRDF model
  - In order to minimize systematic error, various BRDF models should be tested to find an optimum fit for the measured data

- Future works include testing more materials including anisotropic samples and improve resampling method for specula reflection.
Thank you.