Recovering Spectral Reflectance under Commonly Available Lighting Conditions

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Commonly available light sources

- daylight
- Camera flash
- fluorescent
- tungsten

Can we capture spectral images with conventional cameras and lights?

Our Method

Radiance can be represented by

\[ I = \int_\lambda I(\lambda)P(\lambda)R(\lambda) d\lambda \]

Based on the PCA model, reflectance can be represented using less dimensions

\[ \hat{R} = BT^{-1} \]

Two images are usually sufficient to recover the scene reflectance. Therefore, \( T \) becomes a 6x6 matrix.

\( T \) can be pre-computed if we know the reflectance of six points in the scene. In practice, we use a ColorChecker. Once \( T \) is obtained, reflectance can be recovered as follows,

\[ \hat{R} = BT^{-1} \]

Reflectance can be recovered by optimizing difference in radiance, reflectance, or perceptual color.

\[ \min \| \hat{I} - I \| \quad \min \| \hat{R} - R \| \quad \min \| E(\hat{R}, R) \| \]

Validation on CCDC

<table>
<thead>
<tr>
<th>Lighting Combinations</th>
<th>Z (Gaussian noise)</th>
<th>Z (Photon noise)</th>
<th>( \rho )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Horizontal/ Fluorescent</td>
<td>5.11e+6</td>
<td>3.31e+5</td>
<td>0.034/0.342</td>
</tr>
<tr>
<td>Studio flash/ tungsten</td>
<td>3.52e+6</td>
<td>1.25e+5</td>
<td>0.072/0.521</td>
</tr>
<tr>
<td>Cool White/ Horizontal</td>
<td>6.11e+5</td>
<td>4.22e+4</td>
<td>0.051/0.716</td>
</tr>
<tr>
<td>Fluorescent/ Tungsten</td>
<td>3.34e+6</td>
<td>2.28e+4</td>
<td>0.031/0.317</td>
</tr>
</tbody>
</table>

\( \rho = \frac{\| W \|}{\| \hat{W} \|} \)

Noise analysis

Which light sources are overall the best for recovering spectral reflectance?

\[ Z = I^* W \hat{R}^*-A \quad W = BT^{-1} \]

Given two light sources, which reflectance can be best recovered?

\[ \rho = \frac{\| W \|}{\| \hat{W} \|} \]

The noise is assumed to be photon noise

\[ \rho = \frac{\| W \|}{\| \hat{W} \|} \]

Summary

A simple spectral imaging method to recover the scene reflectance

Two predictors based on noise analysis

Several applications using spectral imaging

More experimental results are: