Verification of BRDF Improvements to Cook-Torrance Model by Comparisons to MERL Data
Jessica Slattery1,2,3, Samuel Butler1, Michael Marciniak1
1Department of Engineering Physics, Center for Directed Energy, AFIT, 2Southwestern Ohio Council for Higher Education (SOCHE), 3Department of Physics, Miami University

Abstract
Bidirectional Reflectance Distribution Function (BRDF) models are mathematical functions that describe the reflectance of light from surfaces. These models have use in scene generation, computer graphics, and remote sensing.1 With this in mind, researchers work with surfaces. These models have use in scene generation, computer mathematical functions that describe the reflectance of light from Bidirectional Reflectance Distribution Function (BRDF) models are capabilities.2

To further this research, we replaced the Hyper-Cauchy distribution function in the Cook-Torrance model with the newly proposed t-Norm distribution function. This derived function incorporates a new parameter, q, to control the shape and distribution of the function, thus attempting to model a wider range of materials by expanding data fitting capabilities.2

Methodology
Using MATLAB, we compared the two different BRDF methods:
• Method 5 – Cook-Torrance model with the Hyper-Cauchy distribution function1:

  \[ f_r(\theta_i, \theta_r) = \frac{(q - 1)(\alpha^2)\gamma^{-2}}{\cos^2(\theta_i) - \cos^2(\theta_r)} \]

  \[ + \frac{\alpha^2}{\pi} \]

• Method 6 – Cook-Torrance model with the new t-Norm distribution function2:

  \[ f_r(\theta_i, \theta_r) = \frac{(q - 1)(\alpha^2)\gamma^{-2}}{\cos^2(\theta_i) - \cos^2(\theta_r) + \cos^2(\theta_r) \sec^2(\theta_r)} \]

After utilizing a least-squares-optimizer to fit the methods to the MERL database, we calculated the normalized relative errors of Methods 5 and 6 and compared them to see whether or not the t-Norm improved the model.

Results
From plotting Method 5 and Method 6, we find the normalized relative errors for both methods to be nearly indistinguishable for each material.

We plot the normalized relative error for each material and observe the minute differences. The points above the zero-axis reveal a greater error with the new t-Norm distribution, whereas points below the zero-axis reveal a greater error with the Hyper-Cauchy distribution. For nearly all materials, the difference in error is negligible.

Conclusions
The data analysis showed the fitted parameters for the two models are quite similar; however, there is a ratio of ½ between the s parameter in the Hyper-Cauchy and q in the t-Norm. Through error analysis, we see that the new t-Norm distribution function does not significantly improve the overall fitting of the Cook-Torrance BRDF model.

References