Perceptual Gloss Space BRDF Projection, Uniformity Validation, and Lightness Distance Metric

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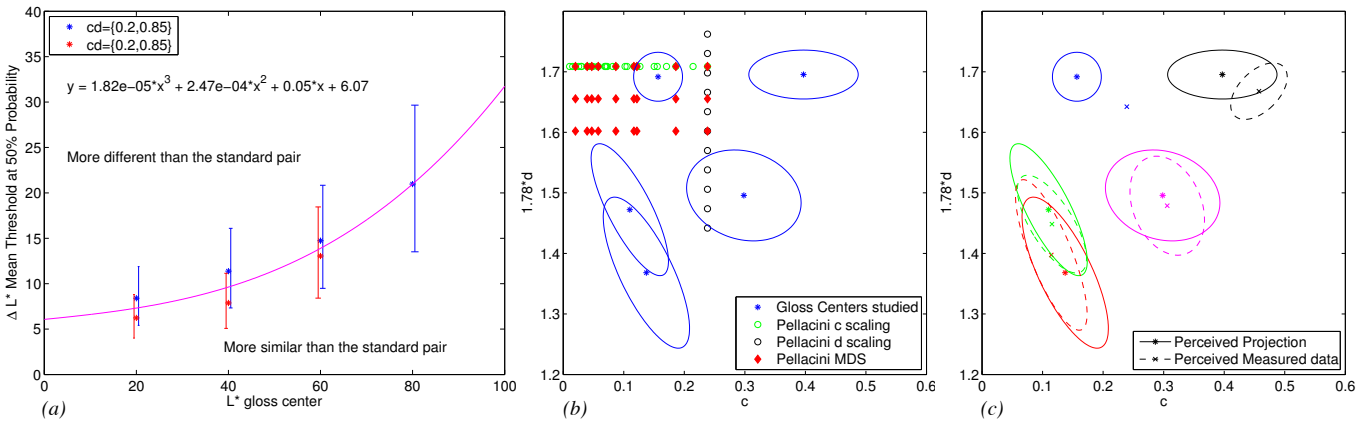

Figure 1: *(a) The lightness discrimination of the space depends on lightness. (b) Gloss Centers studied, showing the non-uniformity of the space outside of the samples used to create the gloss space in Pellacini et al. [2000]. (c) Perception of the measured data and its projection in the space. Our projection is perceived to be near or below the JND threshold of the space for four of the five materials studied.*

1 Introduction

A perceptually uniform gloss space was defined in Pellacini et al. [2000] as a reparameterization of the Ward BRDF model. Two dimensions, distinctness-of-image gloss and contrast gloss, were found to be enough to describe gloss perception, and the CIELAB lightness function was added to represent the diffuse component.

In this work, we added a lightness function to the distance metric of the space, found that the space is not uniform outside the samples used to create it, and defined and validated a projection for arbitrary BRDFs to the space.

2 Our Approach

Three psychophysical experiments were performed in order to: define a lightness distance metric, evaluate the space uniformity around 5 gloss centers, and validate the projection of 5 measured materials. Two pairs of images, standard and test pair, were presented for each trial to the 21 observers that participated in the study. For each trial, the observers had to answer the following question: *Which pair of images is more similar?* The gloss perception using a common LDR display is studied in this work, similar experiments would need to be performed to study the gloss perception in physical objects or when using HDR displays.

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The original space's distance metric does not allow relating differences in lightness to the other dimensions. The lightness discrimination at different lightness levels was studied for two positions in the cd space in the first experiment. Our first key finding is that the lightness discrimination decreases as lightness increases (see Figure 1a). Its function was then included to the distance metric.

Our main contribution is the definition of a projection for arbitrary BRDFs to the gloss space. The basis for the projection is the relation between the ASTM standards (DOI, Bloom, Haze, Diffuseness) and the d dimension, as each ASTM standard varies in a different region of d while at the same time being independent of the c dimension. Then, the diffuse reflectance is obtained from the 45:0 measurement, as in colorimetry, and finally the specular reflectance is set to match the peak of the projected BRDF.

This projection was used on 5 materials of the MERL Database, and the space uniformity around those positions was studied in the second experiment. Figure 1b shows the 95% confidence ellipse for the test samples considered to be more similar to the gloss center than the standard pair for 50% or more of the observers. Our second key finding is that the space is not uniform outside the samples used to create it, and that an improved distance metric is required.

The last experiment was used to perceptually validate the projection to the gloss space for arbitrary BRDFs. In this case the gloss center was the measured data itself. For each material, the location and ellipse of the measured data and projection would match if the same perception was achieved (see Figure 1c). The results obtained show that the result of our projection is perceived to be near or below the JND threshold of the space for four of the five materials evaluated.

References

PELLACINI, F., FERWERDA, J. A., AND GREENBERG, D. P. 2000. Toward a psychophysically-based light reflection model for image synthesis. ACM, SIGGRAPH '00, 55–64.