Attribute-preserving gamut mapping of measured BRDFs

Tiancheng Sun
Tsinghua University, Universidad de Zaragoza

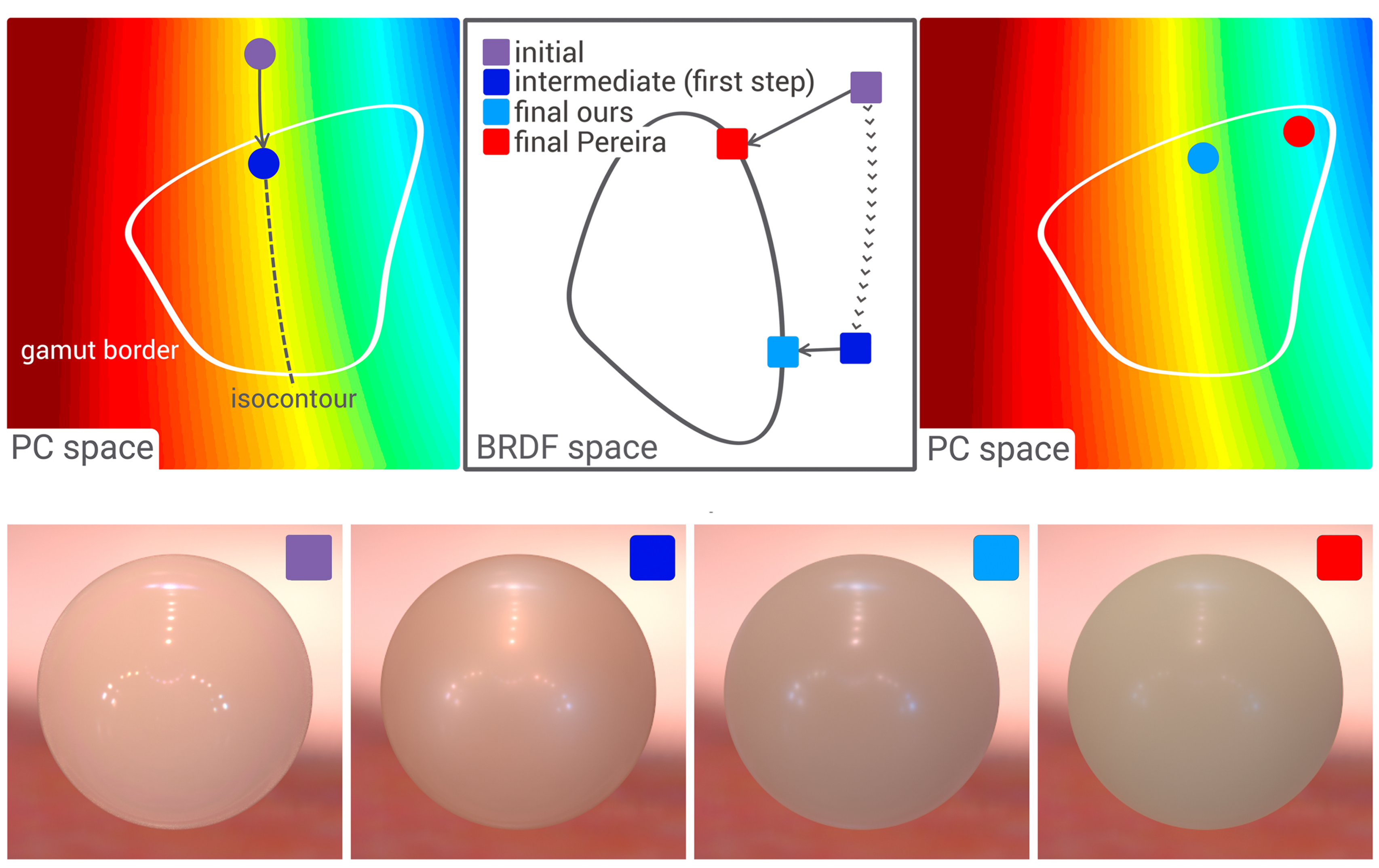
Ana Serrano
Universidad de Zaragoza

Diego Gutierrez
Universidad de Zaragoza

Belen Masia
Universidad de Zaragoza

Reproducing the appearance of real-world materials using current printing technology is problematic. The reduced number of inks available define the printer's limited gamut, creating distortions in the printed appearance that are hard to control. Gamut mapping refers to the process of bringing an out-of-gamut material appearance into the printer's gamut, while minimizing such distortions as much as possible. We present a novel two-step gamut mapping algorithm that allows users to specify which perceptual attribute of the original material they want to preserve (such as brightness, or roughness). In the first step, we work in the low-dimensional intuitive appearance space recently proposed by Serrano et al. [Serrano 2016], and adjust achromatic reflectance via an objective function that strives to preserve certain attributes. From such intermediate representation, we then perform an image-based optimization including color information, to bring the BRDF into gamut. We show, both objectively and through a user study, how our method yields superior results compared to the state of the art, with the additional advantage that the user can specify which visual attributes need to be preserved. Moreover, we show how this approach can also be used for attribute-preserving material editing.

Our Approach



Step 1: Luminance mapping in PCA space

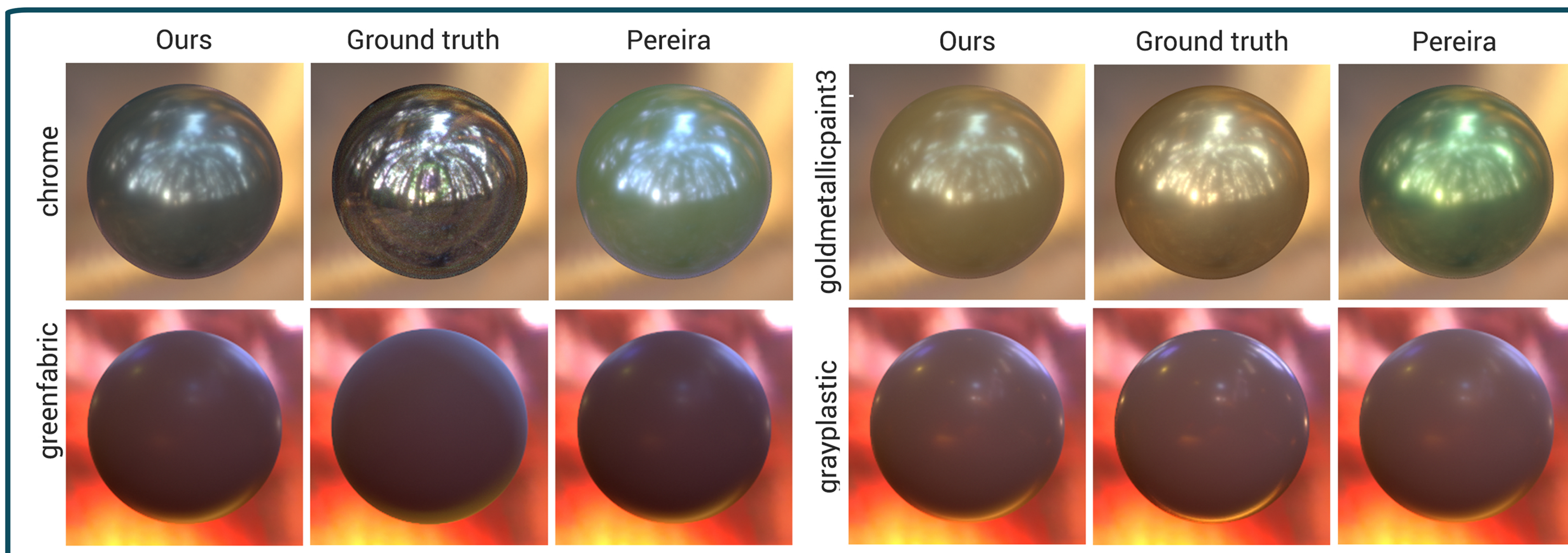
We represent the BRDF in a PCA space, and use the first 5 components to define a 5D space [Nielsen 2015]. Working on achromatic reflectance, we push the original BRDF into gamut (intermediate BRDF) in such PCA space by following isocontours that indicate the same value of a given perceptual attribute [Serrano 2016].

Step 2: Image-space optimization

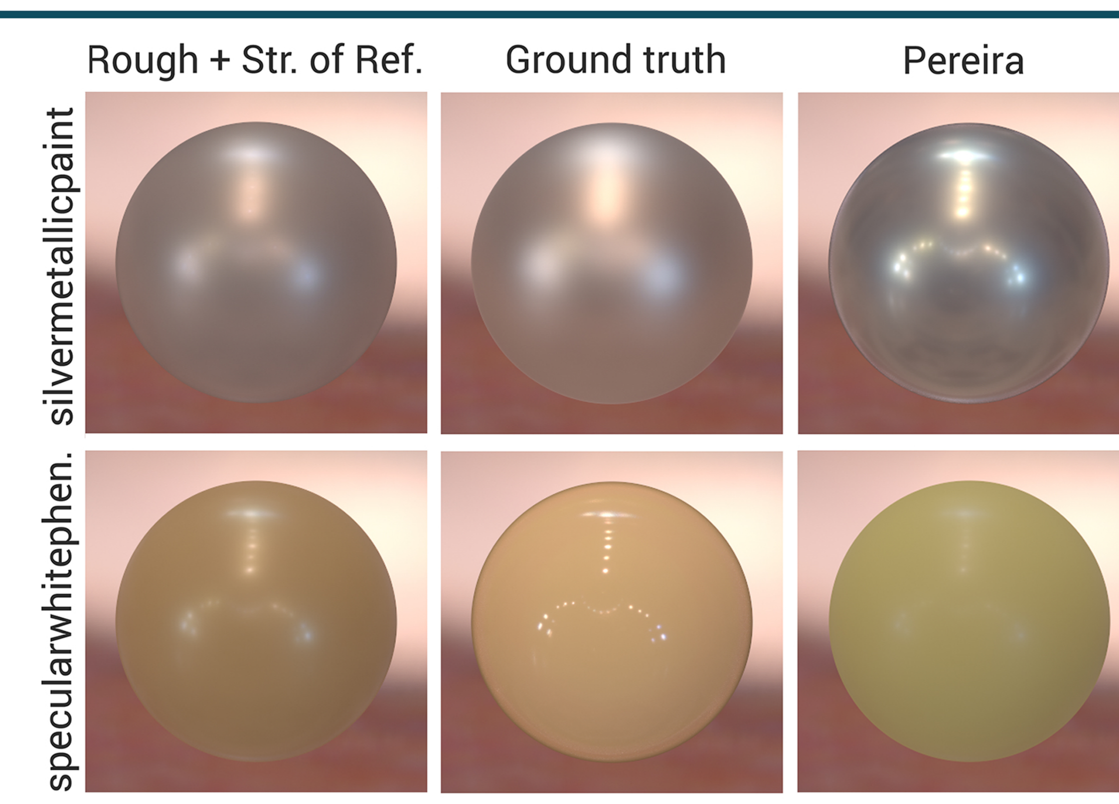
Back in the original BRDF space, the intermediate BRDF is not guaranteed to be in gamut; we apply an image-based optimization to bring it into gamut (final BRDF), and to obtain the coefficients for representing it as a combination of the available inks.

We compare our results over BRDFs from the MERL dataset [Matusik 2003] with a state-of-the-art single step method based on image optimization [Pereira 2012].

Results



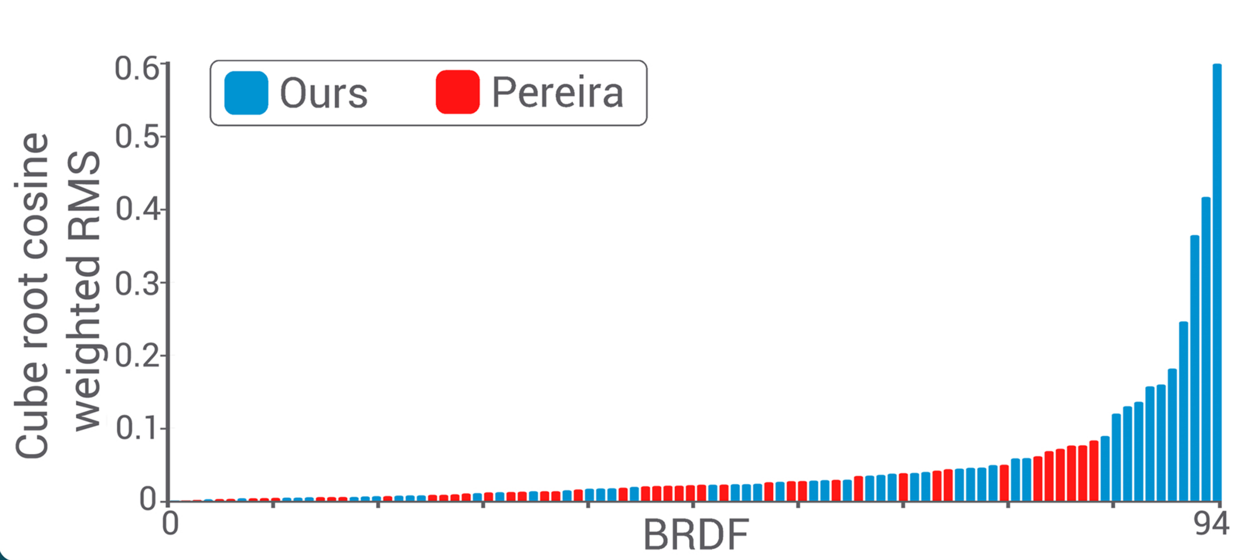
⇧ Comparison of our results and the state-of-the-art method by Pereira using different illuminations. Here we preserve the *metallic* and *brightness* attributes. Our method minimizes color shifts, while better preserving highlights and specular behavior. For very diffuse materials (e.g., greenfabric) neither method succeeds due to the specular nature of the inks used.



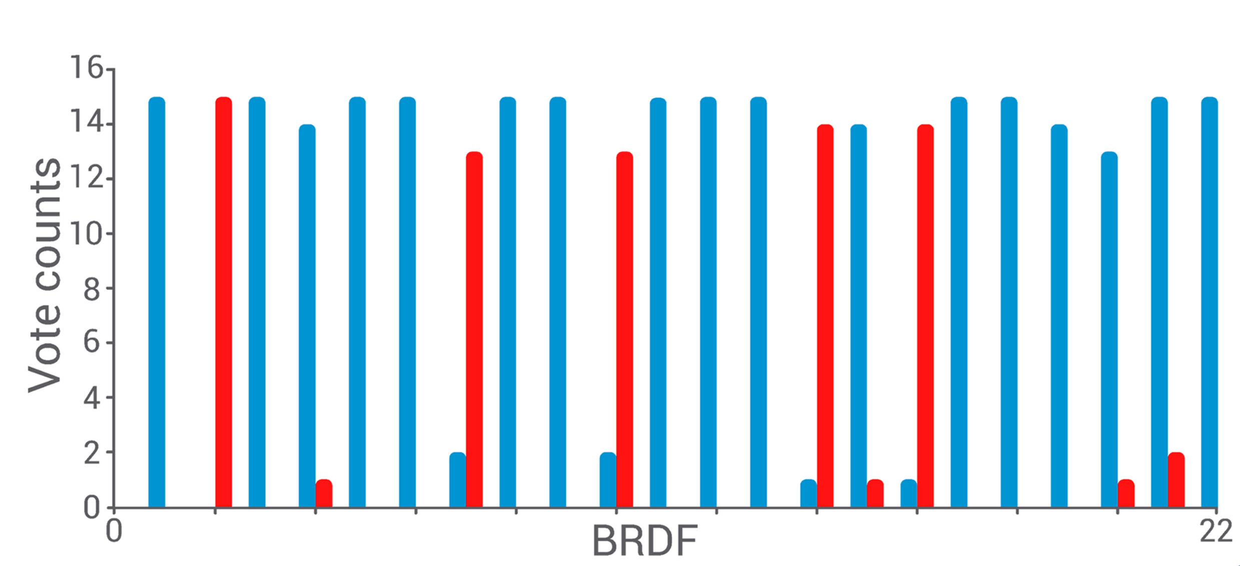
⇧ Results preserving the *roughness* and *strength of reflections* attributes in the first step of the method. This combination of attributes aims to better preserve the appearance of the reflections.

Validation

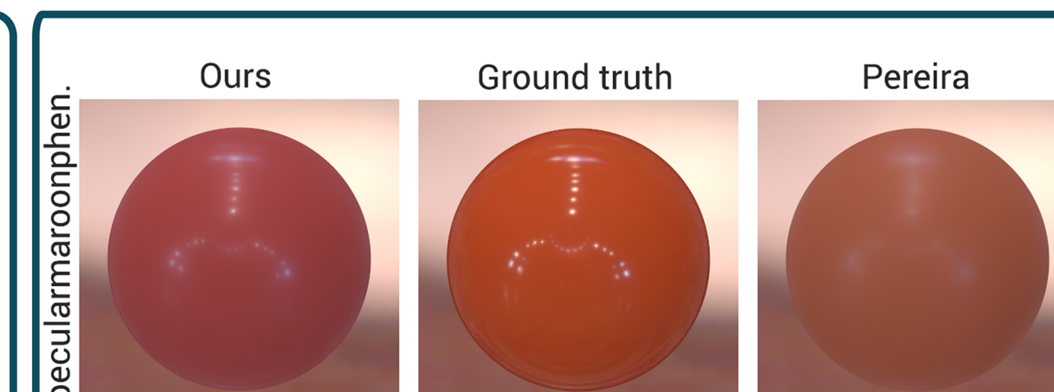
Difference between the error after the mapping of Pereira and that of our method with respect to the original BRDF. Blue indicates better results with our method.



Results of a 2AFC user study. Among the BRDFs that showed statistically significant diferences, our result was preferred 17 out of 22 times, with high agreement between users.



Limitations



If the BRDF lies very far away from the gamut both our method and the single-step state of the art are unable to find a satisfying match in appearance. Here, our method does a good job at preserving the specular behavior, but fails to accurately reproduce the diffuse color.

References

Matusik, W, Pfister, H., Band, M., and McMillan, L. 2003. A Data-Driven Reflectance Model. *ACM Transactions on Graphics 22*, 3 (July), 759–769.

Nielsen, J.B., Jensen, H.W., and Ramamoorthi, R. 2015. On optimal, minimal BRDF sampling for reflectance acquisition. ACM Transactions on Graphics 34, 6 (November), 186:1-186:11.

Pereira, T., and Rusinkiewicz, S. 2012. Gamut mapping spatially varying reflectance with an improved BRDF similarity metric. *Computer Graphics Froum (Proc. Eurographics Symposium on Rendering) 31, 4 (June).* 1557-1566.

Serrano, A., Gutierrez, D., Myszkowski, K., Seidel, H.-P., and Masia, B. 2016. An intuitive control space for material appearance. ACM Transactions on Graphics 35, 6 (November), 186:1-186:12.

CHAMELEON

MINISTERIO DE ECONOMÍA Y COMPETITIVIDAD
TIN2016-79710-P
TIN2016-78753-P

Graphics and Imaging Lab

Full paper accepted to
Eurographics Symposium on Rendering (EGSR) 2017

30 JULY–3 AUGUST Los Angeles SIGGRAPH2017

Contact: anase@unizar.es
bmasia@unizar.es