A Correspondence-Free Color Chart Design for Color Calibration (Supplementary Material)

Anonymous submission

Discussion

This supplemental material provides additional results we were unable to include in the main paper due to the page limit of the main paper. Fig. 4, Fig. 5, and Fig. 6 show additional results of the compared methods by linear least squares, Funt and Bastani [2], and our histogram based approach using hyperspectral scenes from [3]. The last two figures show additional results of the camera's native CST, the CST estimated using least squares fit together with Funt and Bastani [2] of 24-patch color chart, and our histogram-based method of our color chart design. These are done for four different cameras – namely Google Nexus 6, Samsung S6-Edge, LG-G4, and Apple iPhone 7. Two additional test images (see Fig. 1) are used for the same camera set (see Fig. 7 and Fig. 8).

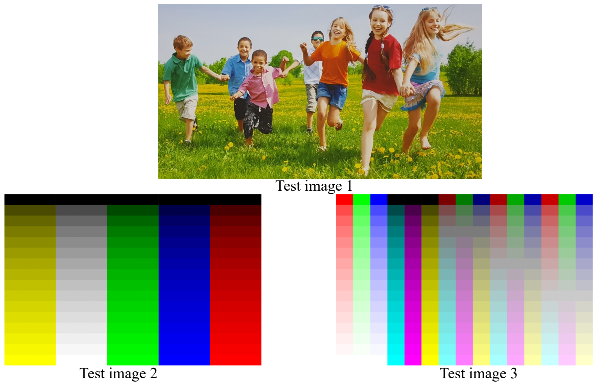

Figure 1. *Three printed test images are used to test the accuracy of the colorimetric calibration.*

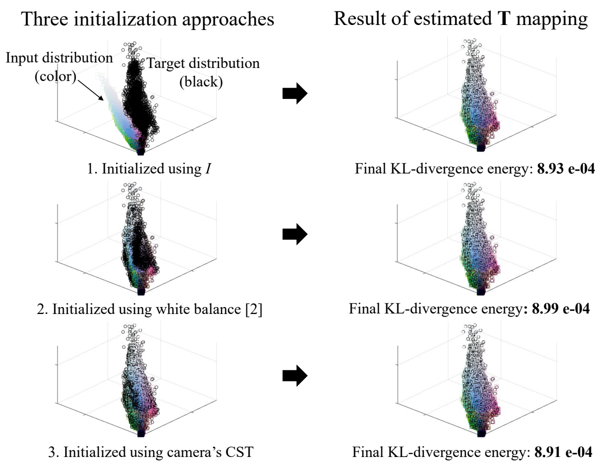

Figure 2. *Optimization results obtained from three different initializations (identity I, white balanced based on [1], and the camera's CST). This was performed using an Google Nexus 6 with fluorescent illumination. The final optimization energy for Eq. 2 in main paper is similar.*

Optimization Initialization

The input to our method is the color distribution extracted from the imaged chart in the camera-specific color space. This assumes the camera is capable of saving images in a raw image format, either native raw of the camera, or Adobe DNG.

The input distribution is dependent on the camera's spectral sensitivities, the calibration pattern design, and the scene illumination. As a result, the initialization of the input histogram does affect the final minimization results. We have found the following three initializations give good performance. The first is to use the identity matrix I with small random perturbations along the diagonal. The second is to do a rough white-balance estimation, such as applying the grey world method [1] to compute a diagonal 3×3 correction. The white-balanced distribution is used as the initialization. Finally, in many cases, the raw image file contains the necessary information to compute the camera's onboard pre-calibrated CST for the given image. As such, we can use the camera's own CST as an initialization. In general, we find that the CST gives the best result, however, we observed a few cases where other methods are better. Figure 2 shows an example with the three different initializations for a Google Nexus 6 captured under fluorescent illumination. The initialized input histogram is shown in color, while the target histogram is shown in black. In this particular example the white-balance initialization produces the lowest KL-divergence energy from Eq. 1 in main paper. As a result, one strategy is to compute the result with multiple initializations and take the best result.

Robustness

We performed an experiment to show the added advantages of our correspondence-free calibration pattern. We examine the situation where part of the calibration pattern is occluded. This is shown in Fig 3. In particular, we block a portion of the patch-based pattern and our pattern that has repetitious colors. In this situation, the patch-based calibration approach can still be used to estimate the CST by using only the patches for which correspondences can be established. As expected, this has significant impact on the CST estimated. Our histogram-based method with the redundant color design is naturally more robust to this situation and is still able to estimate a high-quality CST to improve the camera.

References

[1] G. Buchsbaum. A spatial processor model for object colour perception. *Journal of The Franklin Institute*, 310(1):1–26, 1980. 1

[2] B. Funt and P. Bastani. Irradiance-independent camera color calibration. *Color Research & Application*, 2014. 1, 2, 3, 4, 5, 6

[3] R. M. Nguyen, D. K. Prasad, and M. S. Brown. Training-based spectral reconstruction from a single rgb image. In *ECCV*, 2014. 1

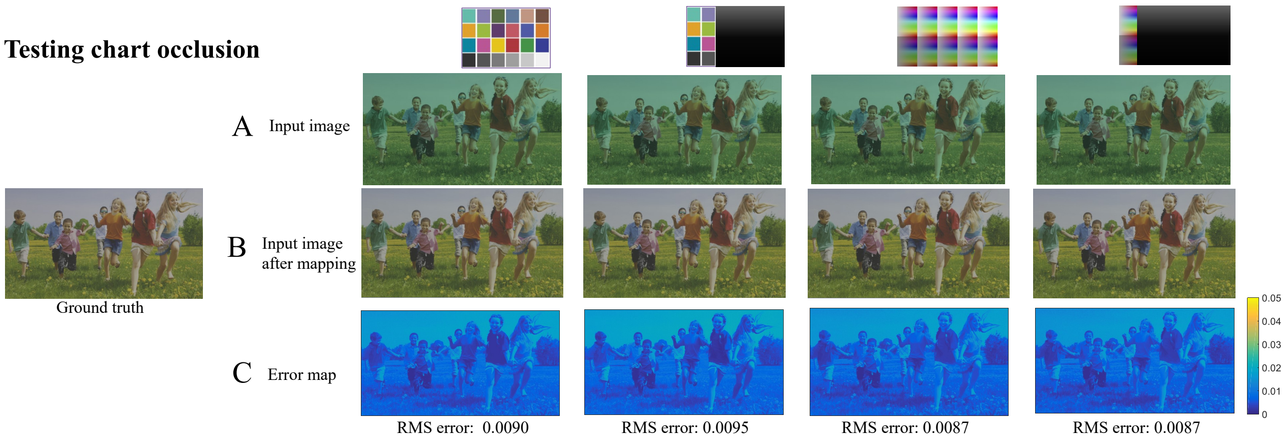

Figure 3. *This experiments shows that using a calibration design with redundant colors in the overall distribution can allow our method to still produce a good result when the chart is partial occluded. This is a drawback for the patch-based methods.*

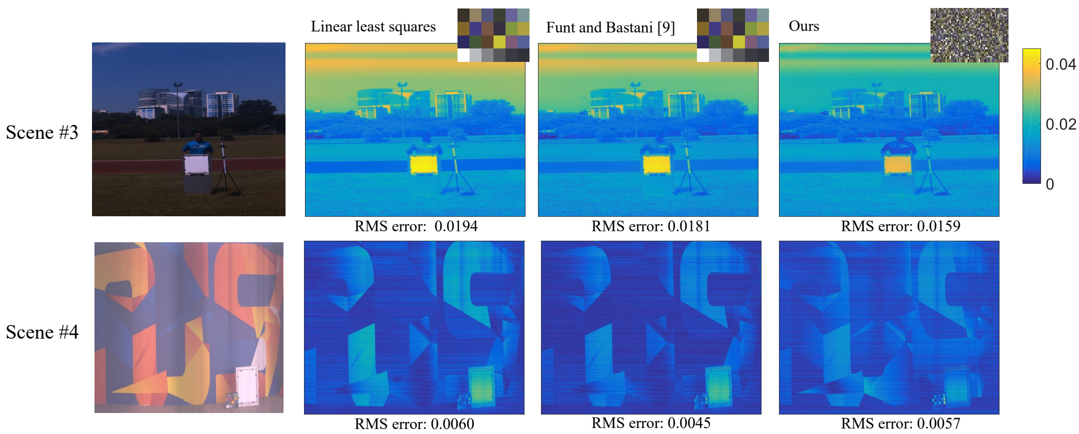

Figure 4. *This compares the colorimetric calibration results for the synthesized 24-patch colour chart and our pattern obtained by blending of the synthesized 24-patch colour chart pathces for three methods (linear least squares, Funt and Bastani [2], and our histogram-based method). Compared is the CST estimated from a 24-patch color chart, and our results based on our chart design. It should be noted that since Funt and Bastani [2] have to scale CST based on the brightness of the scene, this may affect their final outcome. The error map is for the scenes between 3-4.*

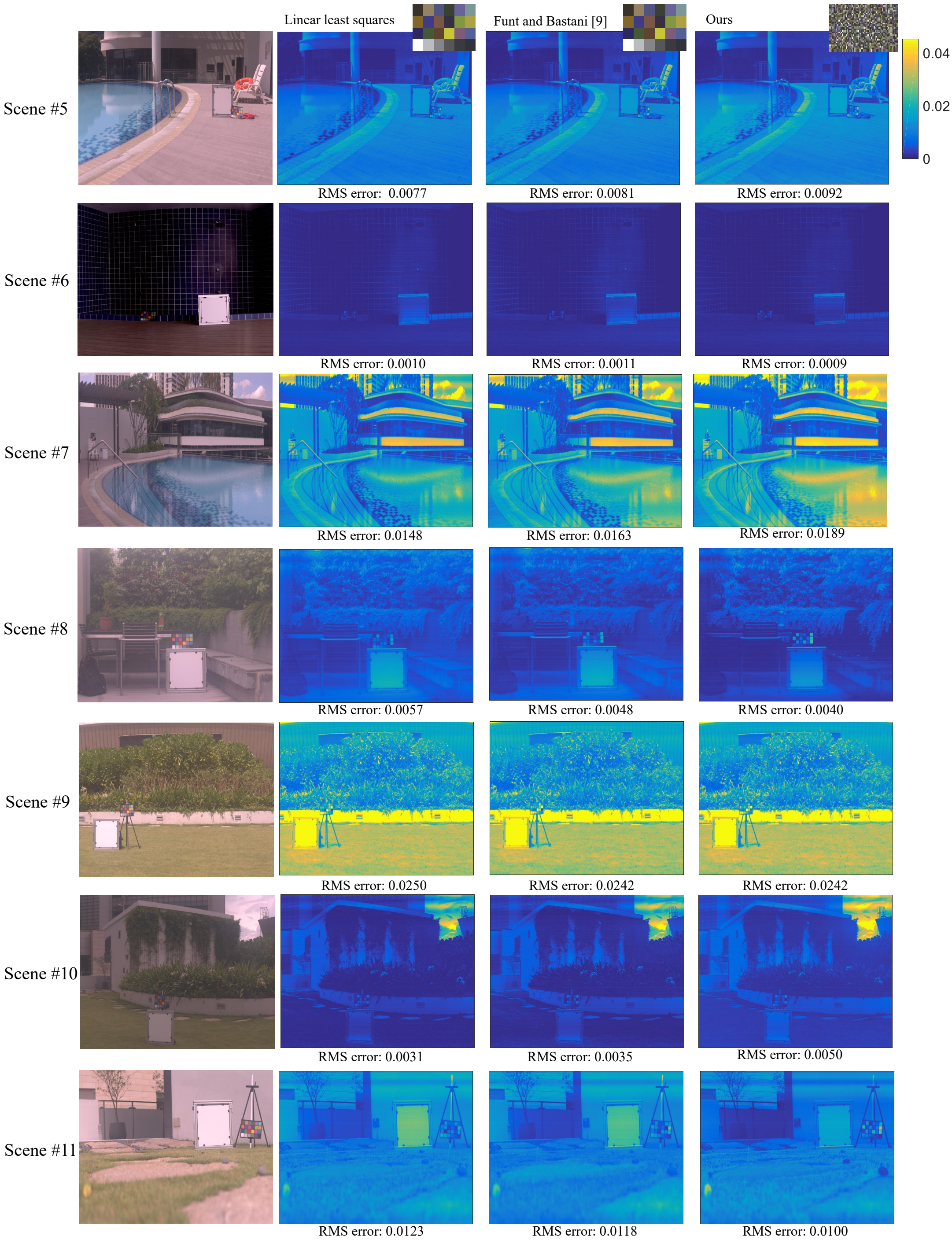

Figure 5. *This compares the colorimetric calibration results for the synthesized 24-patch colour chart and our pattern obtained by blending of the synthesized 24-patch colour chart pathces for three methods (linear least squares, Funt and Bastani [2], and our histogram-based method). Compared is the CST estimated from a 24-patch color chart, and our results based on our chart design. It should be noted that since Funt and Bastani [2] have to scale CST based on the brightness of the scene, this may affect their final outcome. The error map is for the scenes between 5-11.*

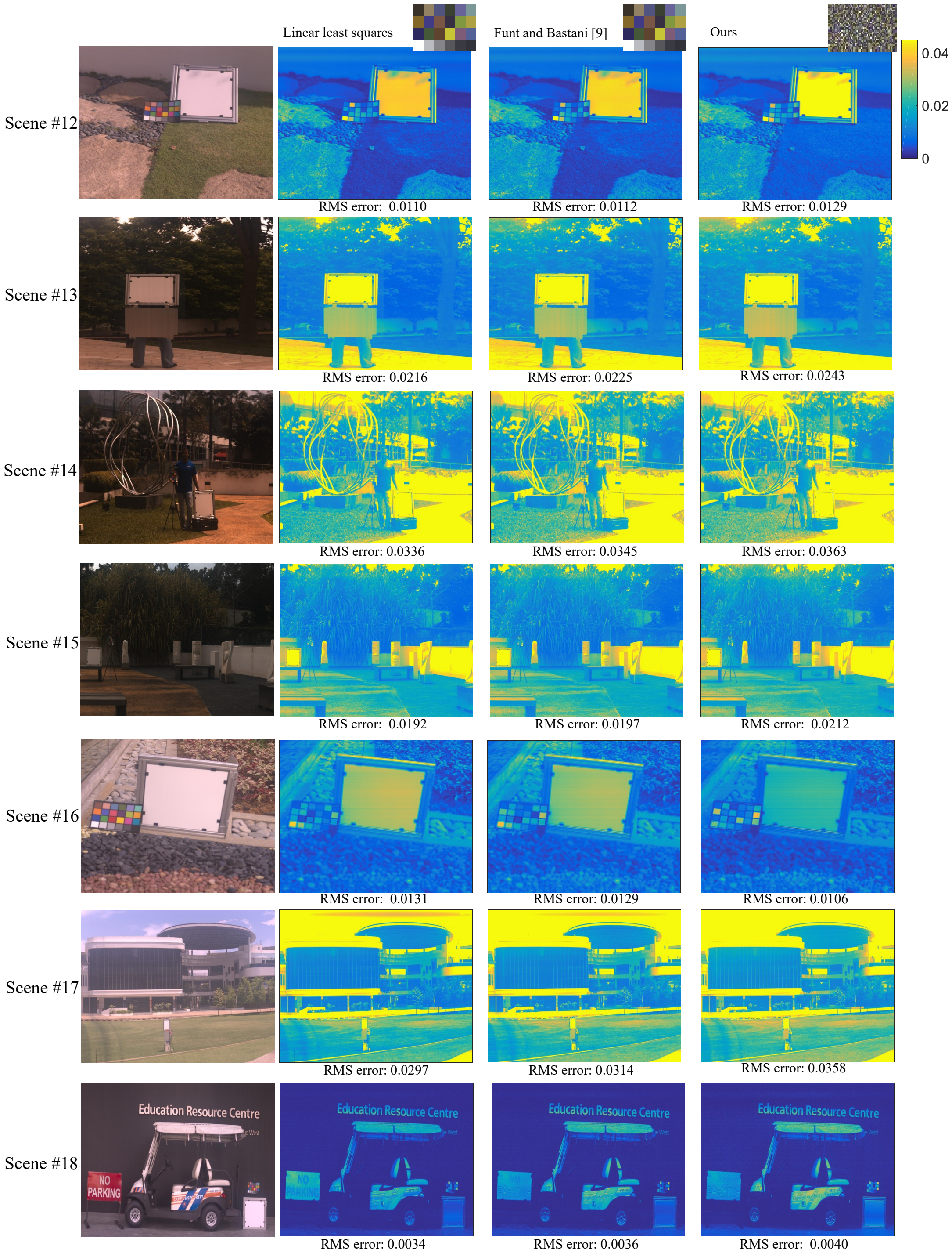

Figure 6. *This compares the colorimetric calibration results for the synthesized 24-patch colour chart and our pattern obtained by blending of the synthesized 24-patch colour chart pathces for three methods (linear least squares, Funt and Bastani [2], and our histogram-based method). Compared is the CST estimated from a 24-patch color chart, and our results based on our chart design. It should be noted that since Funt and Bastani [2] have to scale CST based on the brightness of the scene, this may affect their final outcome. The error map is for the scenes between 12-18.*

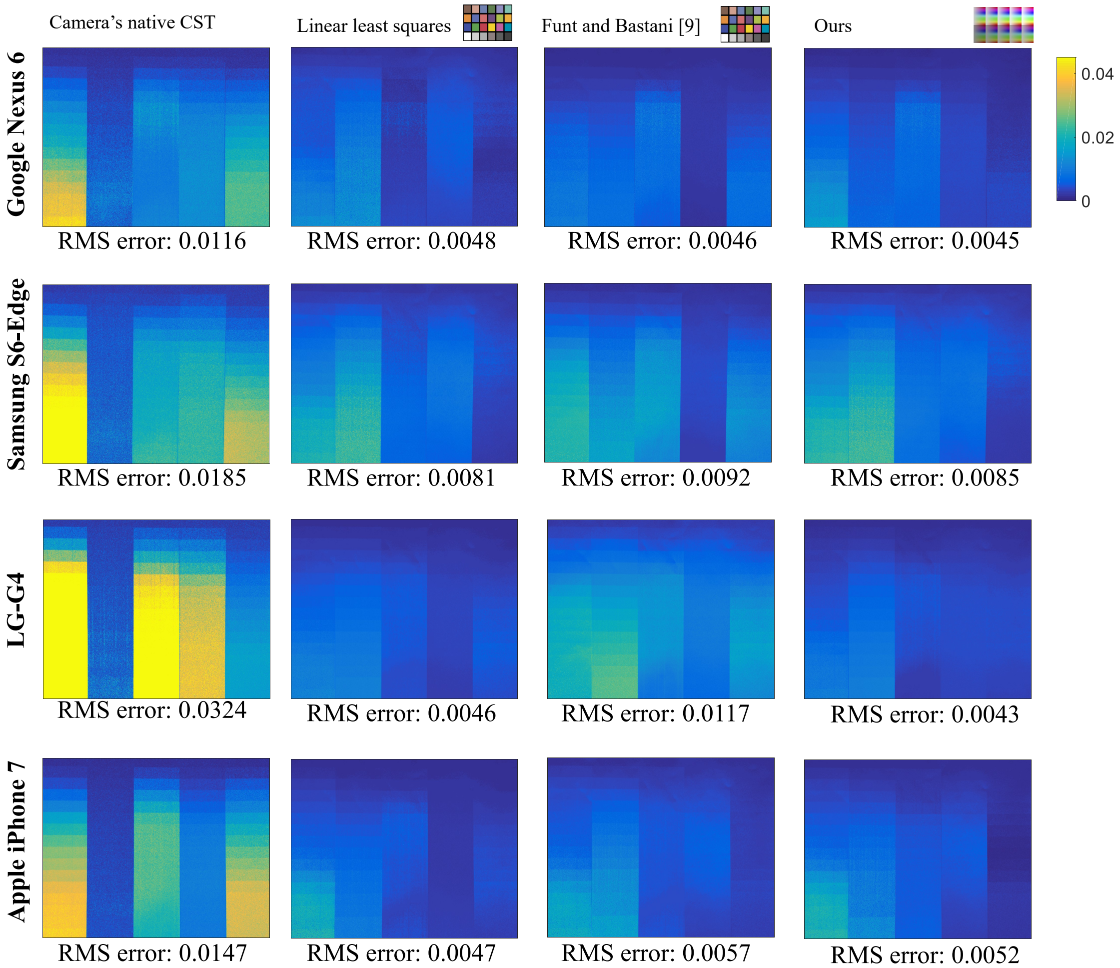

Figure 7. *This compares the colorimetric calibration results for the Google Nexus 6, Samsung S6-Edge, LG-G4, Apple iPhone 7. Compared is the camera's native CST, the CST estimated from a 24-patch color chart using linear least squares and Funt and Bastani [2], and our results based on our chart design. It should be noted that since Funt and Bastani [2] have to scale CST based on the brightness of the scene, this may affect their final outcome. The error map is for test image 2.*

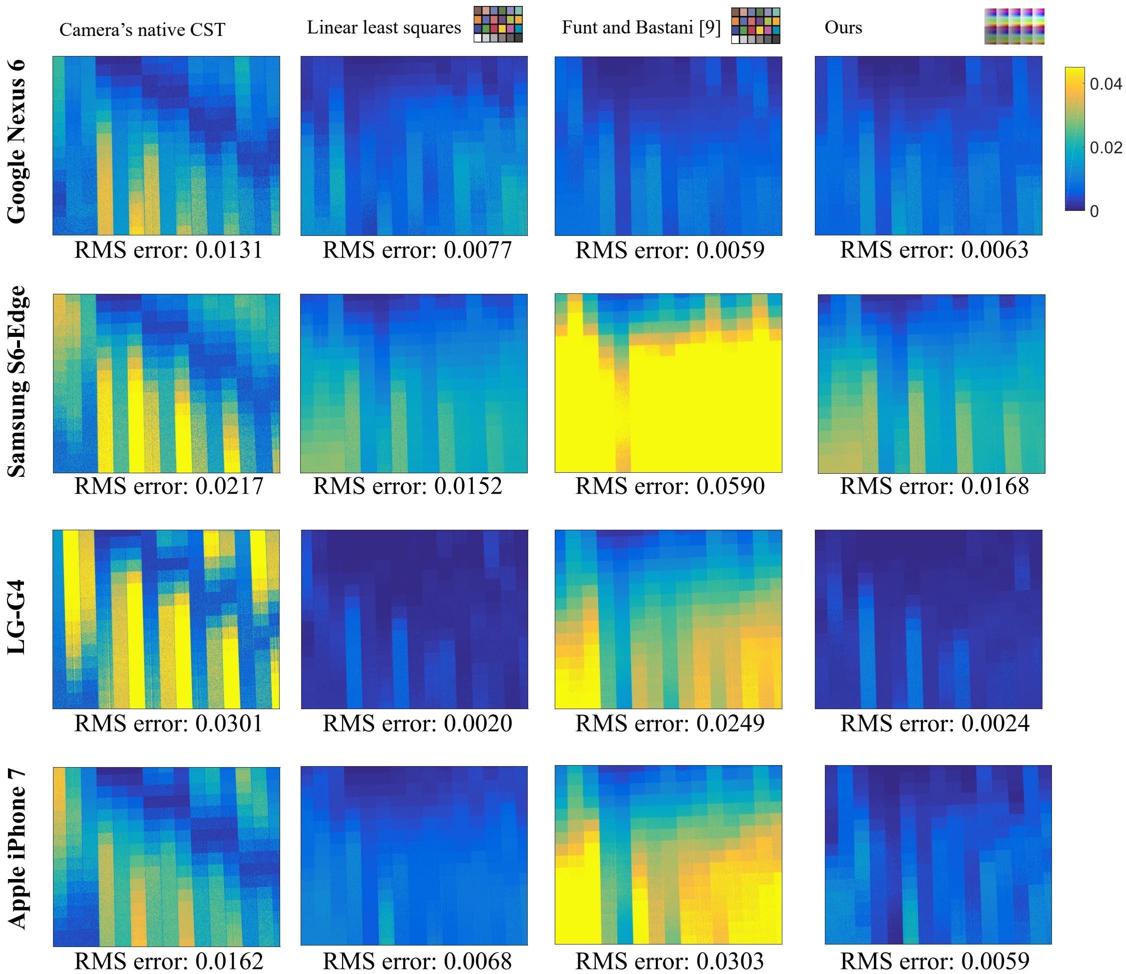

Figure 8. *This compares the colorimetric calibration results for the Google Nexus 6, Samsung S6-Edge, LG-G4, Apple iPhone 7. Compared is the camera's native CST, the CST estimated from a 24-patch color chart using linear least squares and Funt and Bastani [2], and our results based on our chart design. It should be noted that since Funt and Bastani [2] have to scale CST based on the brightness of the scene, this may affect their final outcome. The error map is for test image 3.*