Effects of inconsistent white balance on HDR algorithm

Changlin Su
University of Toronto
sheldon.su@mail.utoronto.ca

Chenhao Gong
University of Toronto
chenhao.gong@mail.utoronto.ca

Abstract

High Dynamic Range algorithm, or HDR, is commonly used in smartphones and photography equipment today. While a critical part of the algorithm is the reconstruction of the camera response function (CRF), an incorrect estimation of the CRF may have an impact in the quality of the constructed high dynamic image. This report discusses a series of experiments and observations made on the effect an inconsistent white balance setting may have on the HDR algorithm.

1. Introduction

Algorithms that create high dynamic photo are becoming increasingly important on smartphone cameras in recent years. The size and weight of a smartphone pose a limit on its camera lens, which will not likely be as sophisticate as that of the professional cameras. In this scenario, smartphone manufacturers have to implement various algorithms to compensate the gap. One disadvantage of the of the smartphone camera is the dynamic range and the High Dynamic Range (HDR) algorithm partially compensate this issue. The core of the HDR algorithm is the reconstruction of the camera response function (CRF), and an incorrect estimation of the camera response function can effect the quality of the composite image. In this report we want to study how will inconsistent white balance between shots influence the camera response function and ultimately, the reconstruction of the scene.

2. White Balance

White balance is a important feature on all modern smartphone cameras. It is used to calibrate the colour of the objects in the scene. The colour of a object can be affected by the surrounding lighting conditions under which the object was viewed. Normally our brains and eyes will adjust to the lighting conditions when we observe an object, which enables us to always recognize the correct colour of the object regardless of the lighting conditions. Cameras, on the other hand, need to emulate this process by measuring the colour temperature of the light source. After measuring the color temperature of the light source, it shifts the color in the photo to account for the colour from the light source. [2]

3. Procedure

In this report, we will use the algorithm propose by Paul E.Debevec and Jitendra Malik [1] to produce the final image. In each of our test sets, we use the same set of 4 different shutter speeds while keeping the ISO setting consistent. We take two photos for each shutter speed, the first of which featuring a fixed particular white balance setting while the other having varying white balance settings to random values.

4. Test Results and Analysis

Figures 1 and 2 demonstrate the input and output images for our experiments over two of our Test Sets. In each of the figures, image (a) $\sim$ (d) are our input images with consistent white balance at increasing exposure time, with image (e) being the output image of the algorithm and (k) being the visualization of the CRF. For the same algorithm performed on input images with inconsistent white balance, image (e) $\sim$ (h) are the input images, (j) being the output image, and (l) being the CRF visualization. Note that for the input images, images (a) and (f), (b) and (g), (c) and (h) as well as (d) and (i) have respectively the same shutter speed.

Observing both of the test sets, we do not find a significant difference in the resulting output images whether or not a fixed white balance setting is applied in the input images. However, there are significant differences of the estimated camera response curve between consistent and inconsistent white balance for both test sets. The estimation from the set of images are much less stable than that of the one estimated from the image set with consistent white balance. After further comparison, we found that a more significant difference in the colour temperatures can be observed in Figure 1. In particular in Figure 1, the colour temperature of figure (j) is warmer than that of image (e). A warmer color temperature

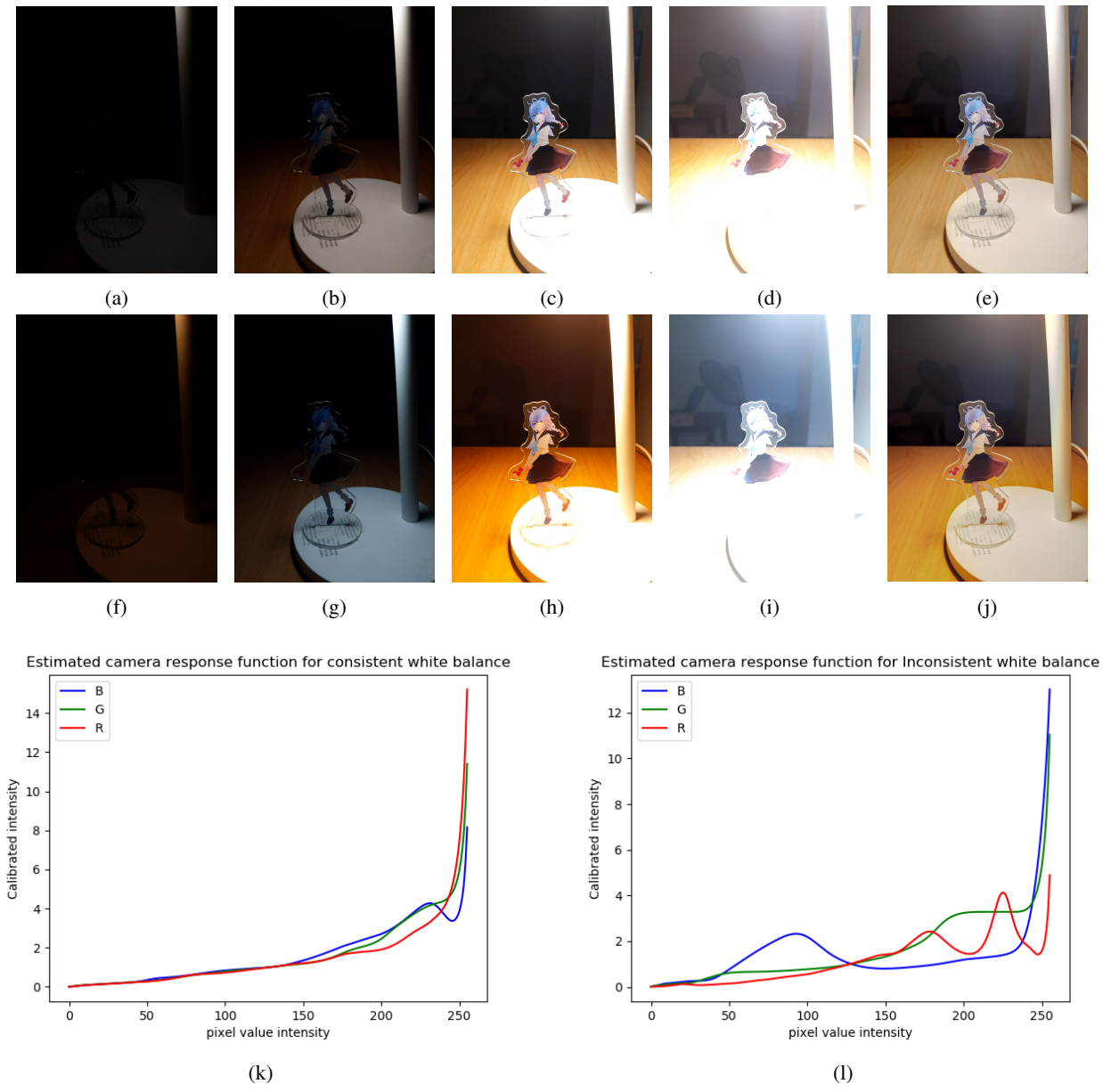
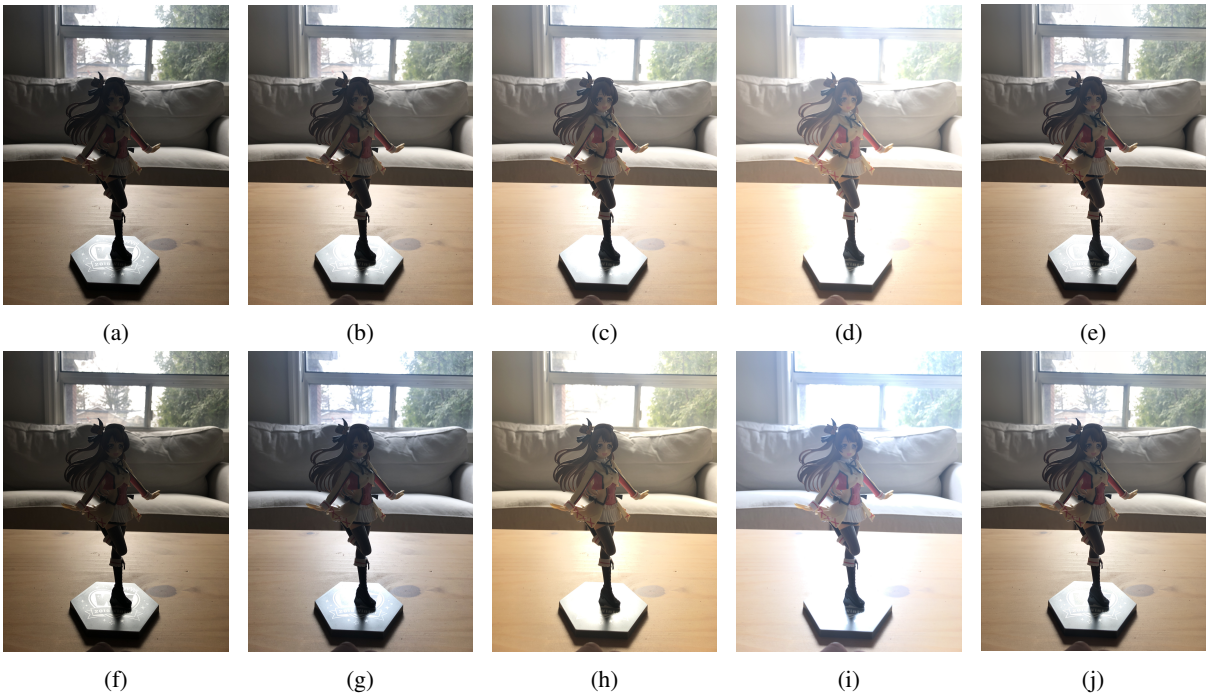


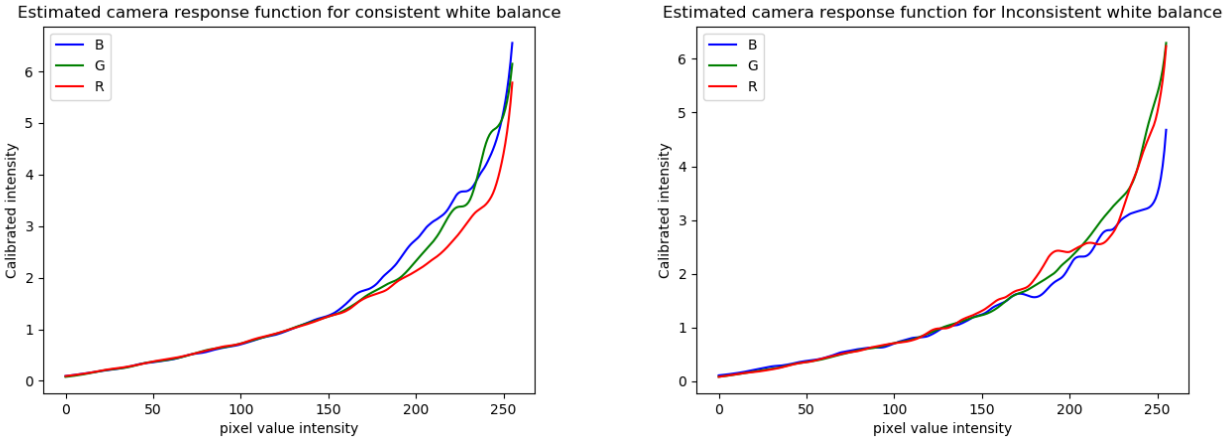
Figure 1: Input and Output Images of Test Set 1

means that the color tone of the image is shifted more towards the red channel. By further observing the estimated CRF producecd by the set of images with inconsistent white balance (image (l) in Figure 1), we noticed that the calibrated intensity for color red fluctuates significantly in the pixel intensity range of 150 to 250. The pixel values in this corresponding range is mainly contributed by the input image (f), since the algorithm propose by Paul E.Debevec and Jitendra Malik will recompose the radiance map by assign weight according to pixel value intensities where intensity closer to 0 or 255 have weight that is less than others. Therefore, the table in Figure 1(j) have a colour temperature that is warmer than Figure 1(e). Furthermore, notice that the background in Figure 1(j) has a colder colour temperature than the table in the foreground and figure. This inconsistency of colour temperature is largely contributed by the input image (i) where the white balance of this image is colder than that of the others for the background wall. This discrepancy is also visible on the on the estimated CRF represented in image (l): Most pixels in the background has a pixel intensity value in the range of 50 to 150, 200 and above. In this interval, the response function of colour blue



(a) (b) (c) (d) (e)

(f) (g) (h) (i) (j)



(k) (l)

Figure 2: Input and Output Images of Test Set 2

has a greater value than other colours. By equation:

$$\ln E_i = \frac{\sum_{j=1}^{P} w(Z_{ij})(g(Z_{ij}) - \ln \Delta t_j)}{\sum_{j=1}^{P} w(Z_{ij})} \quad (1)$$

where i is the pixel index in the image and j is the index of the image, one can conclude that larger $g(Z_{ij})$ will increase will contribute more to the result. Hence the wall in the background employed the colour temperature of figure 1(i).

Test Set 2 (as demonstrated in Figure 2) does not have the differences as significant as those in Figure 1, but the impact as described before still appeared in the output images. In particular, when observing image (j) (the output image with inconsistency in white balance in input images), we can find that the background portion has a cooler colour in comparison to the foreground (in this case, the anime character's figure on the table). This makes an inconsistency in the colour temperatures across the composite image, affecting the overall quality of the algorithm's output.

5. Conclusion

After a series of experiments, observations and analysis, we concluded that inconsistency of white balance in the input images to the High Dynamic Range (HDR) algorithm does have a impact on the quality of the output image. In specific, the variety of the white balance will likely lead to the inconsistency of the colour temperature in some region of the final radiance image. However, in most cases the effect is not significant.

In conclusion, preserving an inconsistency of white balance in the input images to the HDR algorithm does have a negative impact on the reconstruction of the camera response function and ultimately the quality of the radiance image. Therefore consistent white balance when trying to photograph a high dynamic range photo is necessary in some condition where the lighting condition is complex. For example, image photographing an HDR image in scenarios like the room with disco lighting while trough the window, or the sun setting and projects some afterglows into the room. In these cases, the auto white balance on cellphone might not be consistent during the length of the shot, hence manual white balance is needed.

References

[1] Paul E. Debevec and Jitendra Malic. Recovering high dynamic range radiance maps from photographs. *ACM SIGGRAPH 2008 Classes*, page 31, 2008.

[2] Lindsay Silverman. Setting white balance. `https://www.nikonusa.com/en/learn-and-explore/a/tips-and-techniques/setting-white-balance.html`. Online; Accessed on April 3, 2020.