IRYStec™
Perception Is Reality

White Paper

Camera-Perceived Image Quality Under Different Ambient Lighting With and Without IRYStec-Software

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Introduction

In this white paper, we present a methodology for evaluating IRYStec software. We will also show the results obtained from the application of our evaluation approach.

The quality of an image or video being viewed on a display-based device can be measured by multiple criteria, such as for example noise level, sharpness, dynamic range, and contrast. One way of evaluating an image based on these characteristics is by human observation in given lighting environment. However, human observation is subjective; we propose a more consistent image assessment procedure achieved using digital methods. As IRYStec software applies image processing adaptive to the ambient lighting conditions, we investigate image quality assessment in several ambient conditions, namely dark and bright.

Our quantitative analysis is based on the data acquired through physical photography. We use a digital camera to capture reference, processed, and unprocessed images shown on a physical display panel. We then used various IQA metrics to compare the processed and unprocessed content with respect to the reference images and to evaluate the difference in quality. Due to the digital camera capturing the image and not the human eye, device characterization can transform the output RGB of a camera to CIEXYZ color space, which is the correct color space when considering human color vision [1].

Experiments and results

In this experiment, we used an ambient illumination of 0 lux for very dark and 5000 lux for very bright environment, while the indoor reference environment was set to 150 lux. Illumination was provided by 5000K LED lamps whose color rendering image (CRI) is over 90. We used a Nexus 5x phone (1920x1080 resolution) to display images and a Canon EOS 5D mark III camera to capture the displayed image. Each camera setting (shutter speed, aperture number, ISO, etc…) was kept the same for the processed image and the non-processed image. However, the exposure setting is adjusted for each ambient environment (0 lux, 150 lux, 5000 lux) to simulate human eye adaptation based on current environment.

IRYStec-software increases the contrast and sharpness with the intention of making the perceived color and contrast similar to or better than the unprocessed reference image captured under indoor ambient lighting environment. To prove the effectiveness of the processing, we used Mean Square Error (MSE), Peak Signal to Noise Ratio (PSNR) and Structural Similarity index (SSIM) as quality measurements [2,3] on the images physically captured as described above.

Figure 1 The reference images captured under 150lux, with F-stop 2, exposure time 1/160sec. and ISO 400. From left to right and top to bottom: blackTest, blueFlower4, image1, image2, image3, image4, image5, image6, kid, map, old_gate, tulip, walk_stone

Dark ambient

In this study we tested 14 images. Figure 1 shows the reference images which were captured under indoor ambient (150 lux) with the following settings: exposure f-stop 2, exposure time 1/160 sec, ISO 400.

Figure 2 and Figure 3 show the non-processed (original) and processed images respectively, which were captured under dark ambient conditions (0 lux) with the following settings: exposure f-stop 2, exposure time 1/4 sec., ISO 400.

Figure 2 Non-processed (original) images captured under 0 lux, with F-stop 2, exposure time 1/4sec. and ISO 400.

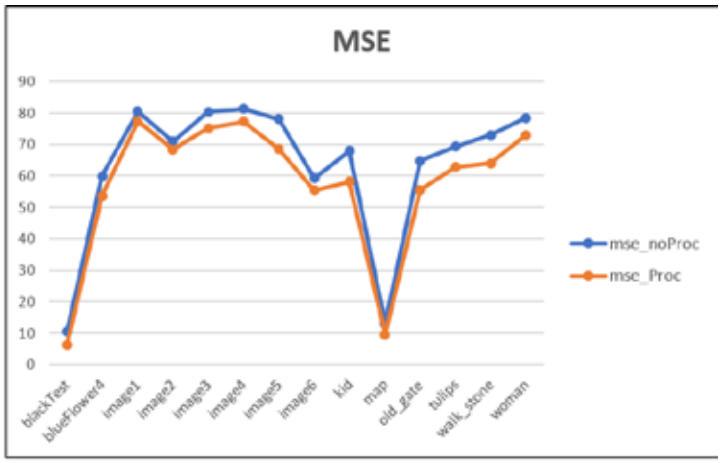
Figure 3 Processed images captured under 0 lux, with F-stop 2, exposure time 1/4sec. and ISO 400.

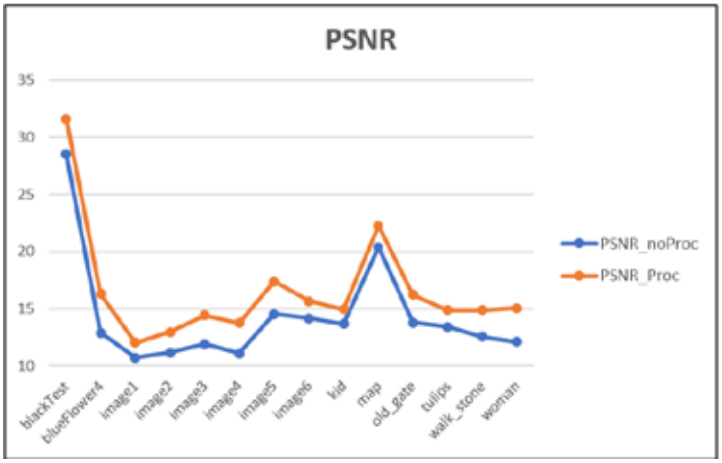
We then computed MSE, PSNR and SSIM for both following pairs: reference and processed, and reference and non-processed images, as shown in Figure 4. The table in Figure 4 shows the average of each metric (MSE, PSNR and SSIM) for each processed and non-processed images, as well as their absolute and relative difference.

For each metric, the processed images consistently have a 12.14% lower MSE on average, and their PNSR and SSIM are higher than non-processed images (except for the SSIM result of the map image), respectively 13.95% and 15.72% on average. This means that the processed images are closer to the reference.

Note that the reason why the SSIM score of the processed image map.jpg is lower than the non-processed image is because the background of this image is completely black, resulting in a very high SSIM value, even for the non-processed image. In other words, there is no processing technique that could improve the perception of totally black pixels. Unfortunately, for this kind of image, high SSIM value doesn't necessarily mean high visibility, which highlights the importance of additional subjective testing.

	MSE(RMSE)	PSNR	SSIM
noProc	63.39 (8.95)	14.35	0.645
Proc	57.51(8.47)	16.60	0.767
Diff	5.88	2.247	0.122
% of Diff	12.14%	13.95%	15.72%





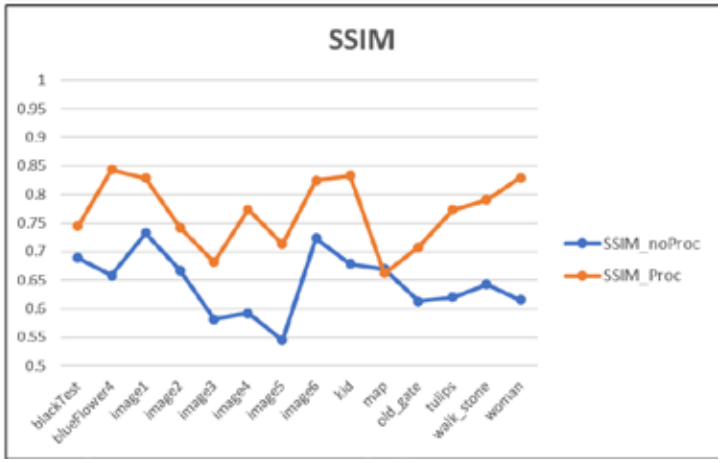


Figure 4 Result of MSE, PSNR and SSIM computation for non-processed and processed images, captured under dark (0 lux) ambient, based on the reference captured under indoor (150 lux) ambient. The table shows the average and the difference between non-processed and processed result.

Bright ambient

In this study, we tested 14 images, and Figure 1 shows the reference images which were captured under indoor ambient(150lux) with exposure setting as f-stop 5.6, exposure time 1/25sec., ISO 400.

Figure 5 and Figure 6 shows the non-processed(original) and processed images respectively, which were captured under bright ambient conditions (5000 lux) with the following settings: exposure f-stop 5.6, exposure time 1/100 sec., ISO 400.

Figure 5 Non-processed (original) images captured under 5000lux, with F-stop 5.6, exposure time 1/100sec. and ISO 400.

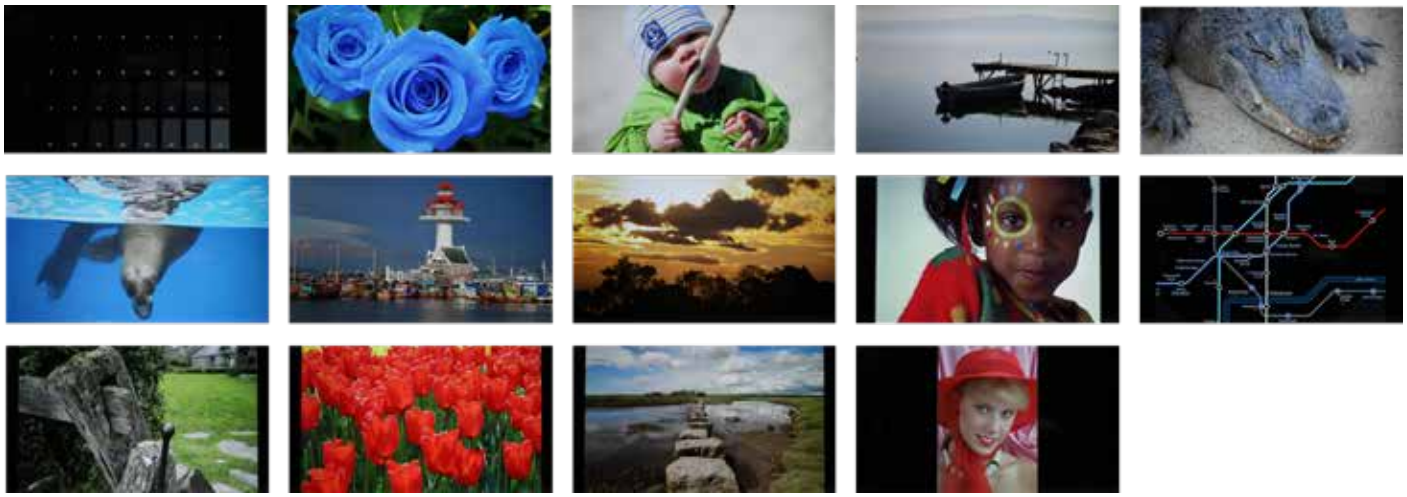
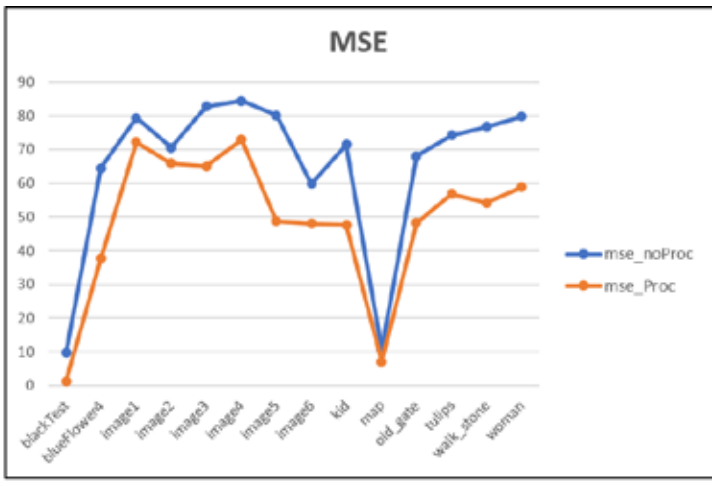


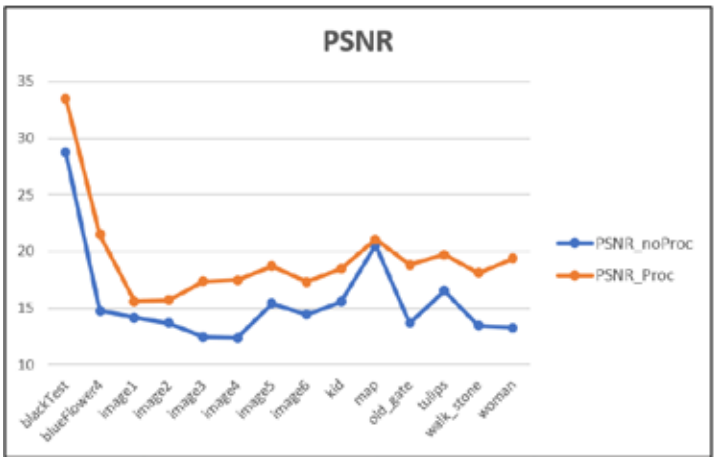
Figure 6 Processed images captured under 5000lux, with F-stop 5.6, exposure time 1/100sec. and ISO 400.

We then computed MSE, PSNR and SSIM for the following pairs: reference and processed, and reference and non-processed images, as shown in Figure 7. The table in Figure 7 shows the average of each metric (MSE, PSNR and SSIM) for each processed and non-processed image, as well as their absolute and relative difference.

For each metric, processed images consistently have a 29.55% lower MSE on average, and their PNSR and SSIM are higher than non-processed images (except for the SSIM result of image2), respectively 19.9% and 9.9% on average. This means that the processed images are closer to the reference.

	MSE(RMSE)	PSNR	SSIM
noProc	65.16 (9.05)	15.64	0.719
Proc	48.92 (7.71)	19.48	0.802
Diff	16.24	3.836	0.083
% of Diff	29.55%	19.90%	9.864%





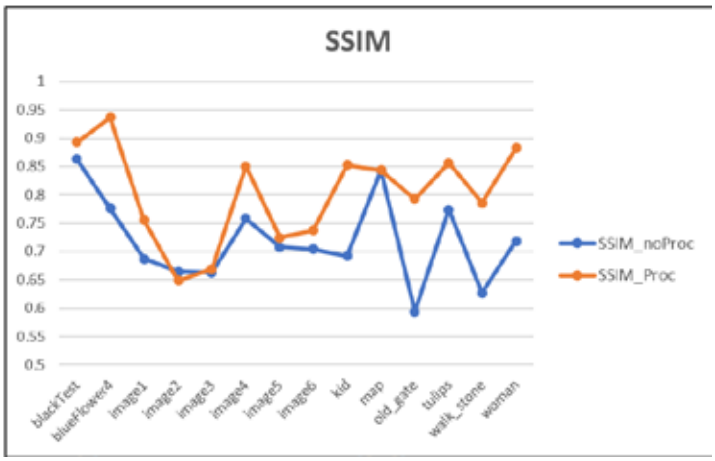


Figure 7 Result of MSE, PSNR and SSIM computation for non-processed and processed images, captured under bright (5000 lux) ambient, based on the reference captured under indoor (150 lux) ambient. The table shows the average and the difference between non-process

Conclusion

Using well established image processing metrics [3] such as MSE, PNSR and SSIM, we show that images processed by Irystec-software are 10% to 30% closer to the reference images as seen by a theoretical eye modeled by a digital camera. This trend is similar for all used metrics and ambient illumination conditions.

Even though there are some rare corner cases where a processed picture is marginally worse from the reference than the non-processed counterpart, on a large number of samples, the processed images are consistently closer to the reference than the non-processed ones. This implies that in almost every case, processed images will appear better than non-processed images to a theoretical eye.

References

[1] Balasubramanian, Raja. "Device characterization." *Digital color imaging handbook* (2003): 269-379.

[2] Wang, Zhou, et al. "Image quality assessment: from error visibility to structural similarity." *IEEE transactions on image processing* 13.4 (2004): 600-612.

[3] Pedersen, Marius. "Evaluation of 60 full-reference image quality metrics on the CID: IQ." *Image Processing (ICIP), 2015 IEEE International Conference* on. IEEE, 2015.