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A Methodology in Setting Auto-Flash Light Activation Level of Mobile Cameras

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Abstract

The mobile and Smartphone camera market is driven by consumers' desire for better picture quality. Auto-flash is the most common flash mode setting used by consumers on their smartphones. Auto-flash technique is used in modern cameras to turn on the flash light automatically when the light level is lower than a pre-defined level. The auto-flash activation light level varies among different cameras but should be set to a value that provides a balance between good picture quality and less battery consumption.

There is no published methodology on how to determine the correct light level for auto-flash activation, so I developed one based on Signal to Noise Ratio analysis, SNR10, and image sharpness analysis that determines the light settings for auto-flash mode. Then the aforementioned method was tested using the Apple iPhone and Samsung Galaxy. Finally, I determined the auto-flash light activation level for these phones using this methodology.

Key Words: *Flash Photography, Mobile Camera Phone, Auto-flash, Picture quality.*

Introduction

One of the important quality parameter of the camera is to capture good picture quality at lower and darker light conditions. Cameras are using flashlights to capture darker scenes. Flash modes that are used in almost all mobile cameras are Auto-flash, Flash-on (or Fill flash), and Flash-off. The other flash mode that is used in some cameras is Slow Sync Mode, in which the flash turns-on, but the exposure length would be longer than the auto-flash mode. This will maintain the ambient background light while the flash light illuminates the main subject.

Auto-flash technique is used in modern cameras to turn on the flash light automatically. Auto-flash turns the camera flash-on when the light level is lower than a pre-defined level. The auto-flash activation light level varies among different cameras but should be set to a value that provides a good compromise between good picture quality and less battery consumption.

Research Goal

The research objective was to establish a methodology to determine the correct auto-flash light level settings for mobile cameras**.**

Experimental Plan

Camera flash is used to capture low light and darker scenes. Low light photography is challenging specifically for mobile cameras as these systems are using image sensors with very small pixels that are less sensitive and have lower Signal to Noise Ratio (SNR). SNR is the ratio of the signal strength to the background noise and can be measured spatially using a single image or temporally by using more than one images.

SNR is also improved by image processing techniques that are used in cameras. Noise reduction filters suppress the image noise and result in a higher SNR. The penalty paid by using excessive noise filtering is the loss of image details and sharpness[1].

The methodology that was used to determine the correct activation level for the auto-flash was based on image SNR and sharpness analysis. SNR10 is commonly referred to in photography as the 1st acceptable image[2, 3]. This level was used on 18% grayscale chart as the minimum requirement for an acceptable SNR. [Note: Some may argue that the SNR10 does not necessarily reflect "good" image quality. In this case, they can use a higher SNR value as their minimum SNR requirement]. For sharpness analysis, the line frequency response was checked at different TV lines.

In brief, the research plan was to find the right activation level of the auto-flash by analyzing the image Signal to Noise Ratio, SNR10, and image sharpness. This is because:

- The light level determines the image SNR.
- It is common in photography to use SNR10 as the first Acceptable Image. Therefore, I used the SNR10 as the minimum SNR requirement.
- Camera Image Signal Processing (ISP) contains de-noising filters that the amount of filtering is also affected by the light level.
- The noise reduction filters increase the SNR. Excessive filtering reduces the image details.
- Line pairs response analyzed at different TV lines for image sharpness.
- The criteria to determine the correct light level for auto-flash activation is the least amount of light intensity that delivers:
    - SNR >= 10 without flash light (for a test chart with 18% reflectance), and
    - No discernible image sharpness loss compared to brighter images.

Test Plan

Two smartphones were used; Apple iPhone5 and Samsung Galaxy S4 for proof of concept using the below methodology:

- Find the light level that auto-flash turns on.
- Capture pictures of a test chart (Accu-Chart High Definition) at below, above, and auto-flash light level[4].
- Analyze images for SNR and sharpness by converting RGB to grayscale "Y". SNR calculated by dividing the average of pixels' intensities (Y) within 18% block by standard deviation[3,5].
- The criteria to determine the correct light level for auto-flash activation is the least amount of light level that delivers:
    - SNR >= 10 without flash light (for a grayscale test chart with 18% reflectance)
    - No discernible image sharpness loss by evaluating the line pair modulation transfer function at different spatial frequencies.

Based on the analysis above, it was determined whether the iPhone5 and Samsung S4 auto-flash light activation levels were set correctly by the manufacturer. If it was not set correctly, the correct auto-flash light level was calculated based on the above criteria.

Test Set-up

Figure 1 shows the test set up. First a mobile camera was placed 1m from test chart and the flash mode of the camera set to "auto-flash". There were two light projectors that were illuminating the test chart while the light intensities were monitored by a light meter that was placed next to the test chart. The color temperature of the projectors was set to 6000K. The auto-flash activation level was determined by reducing the projector light intensities to a level at which the flash light turned on. Test chart pictures were captured below, above, and at the auto-flash light activation level. Then the image SNR and sharpness were analyzed using ImageJ.

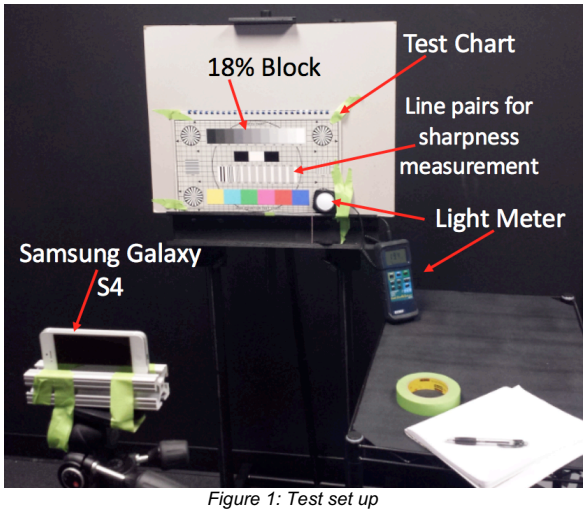
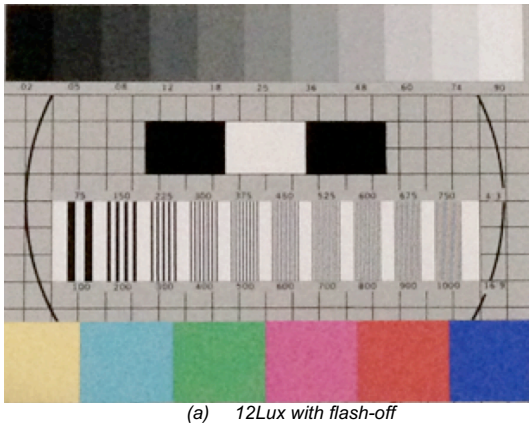


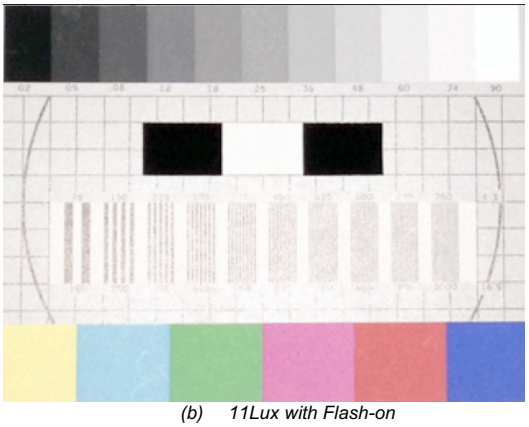
Figure 1: Test set up

Results - iPhone5

The auto-flash light was activated at 11Lux. This means that the flash light was off at 12Lux (and higher light intensities) and turned-on at 11Lux (and lower light levels). Test chart images were captured at 11 and 12 Lux as depicted in Figure 2.



(a) 12Lux with flash-off



(b) 11Lux with Flash-on

Figure 2: iPhone5 autoflash activation level is 11Lux

Referring to Figure 3, the SNR of the 18% reflectance block of 12Lux was measured as 18.8.

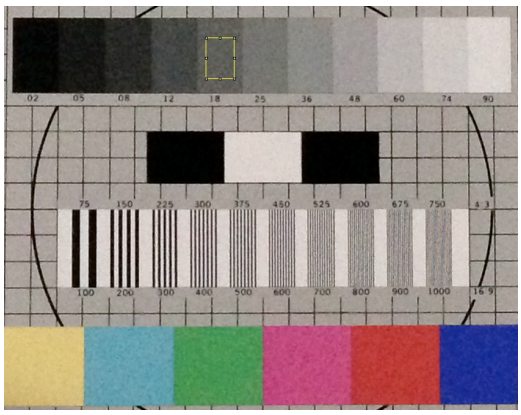
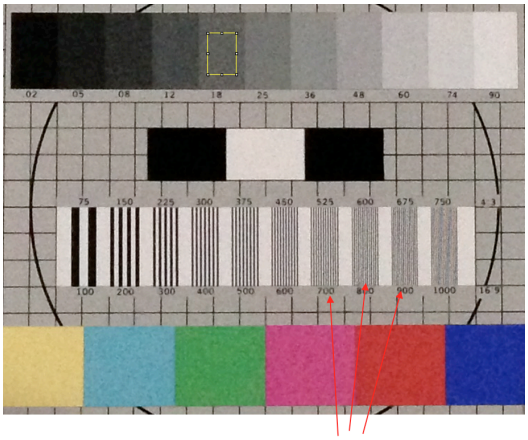


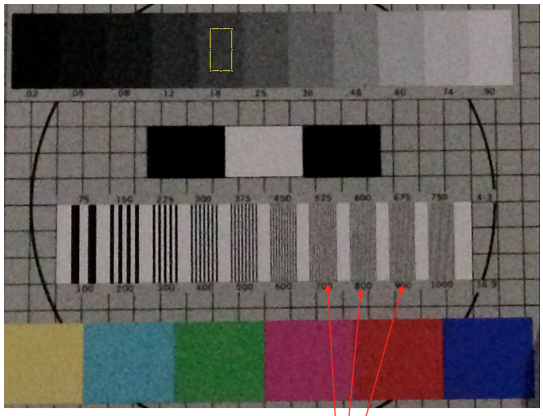
Figure 3: Test Chart image at 12Lux

The camera was put in "flash off" mode in order to turn the flashlight off at light intensities lower than 12Lux. The SNR of the 18% block was measured at light levels below 12Lux to find the light level that provided an SNR of ~10. An SNR of 10.1 was calculated at 6Lux.

The next criteria for finding the optimum auto-flash light activation level is to obtain no discernible image sharpness loss by evaluating the line pair transfer function at different spatial frequencies. Figure 4 shows the test chart images at 12Lux and 6Lux.



12Lux, can resolve finer line pair



6Lux, can not resolve finer line pair

Figure 4: Test Chart images at 6 and 12Lux

Figure 5 illustrates the line pair resolution loss for 6Lux compared to 12Lux (450 to 675 TV lines).

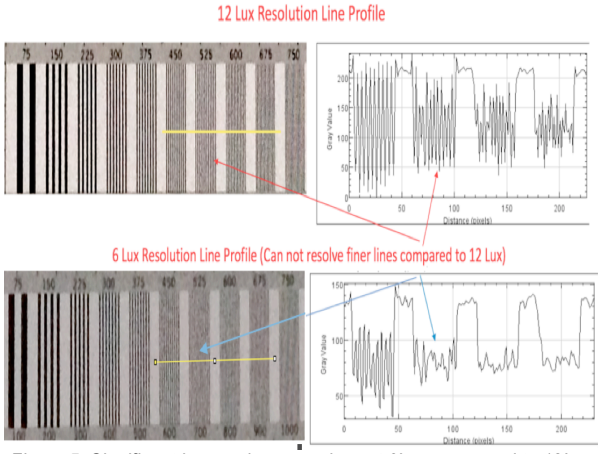
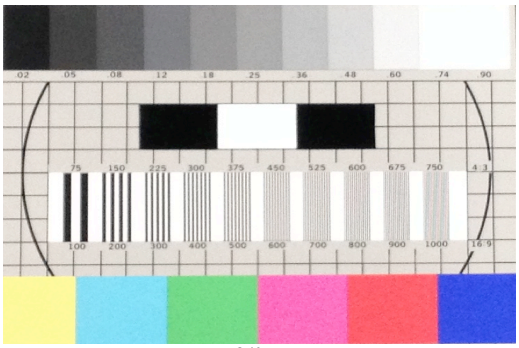
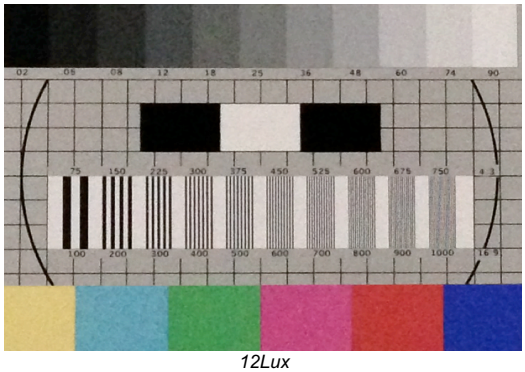


Figure 5: Significant image sharpness loss at 6Lux compared to 12Lux

The image sharpness was checked at all light levels below 12Lux and above 6Lux. All of them showed noticeable sharpness loss compared to 12 Lux. Then, the 12 Lux image sharpness was compared to those of higher light intensities, such as 21Lux as seen in Figure 6.



21Lux



12Lux

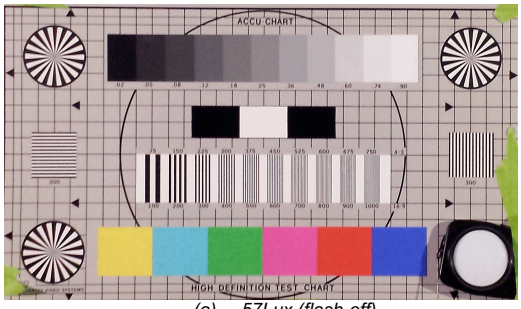
Figure 6: No noticeable difference in image sharpness

There was no noticeable sharpness degradation at 12 Lux compared to 21Lux. This was confirmed by checking the line pair profile at various TV Lines.

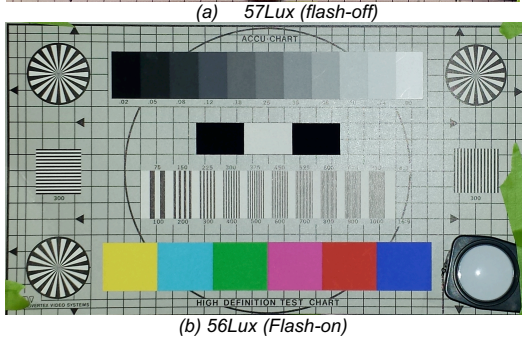
Conclusion for iPhone5: Apple auto-flash light activation level for iPhone5 is 11Lux and set correctly.

Results- Galaxy S4

The auto-flash light was activated at 56lux. The flash light was off at 57lux or higher (Figure 7).



(a) 57Lux (flash-off)



(b) 56Lux (Flash-on)

Figure 7: Samsung auto-flash turns on at 56Lux

SNR of the 18% reflectance block calculated as 70.4 at 57Lux. Set the camera in "Flash off" mode and reduced the light. SNR of 10.4 was measured at 7Lux as shown in Figure 8.

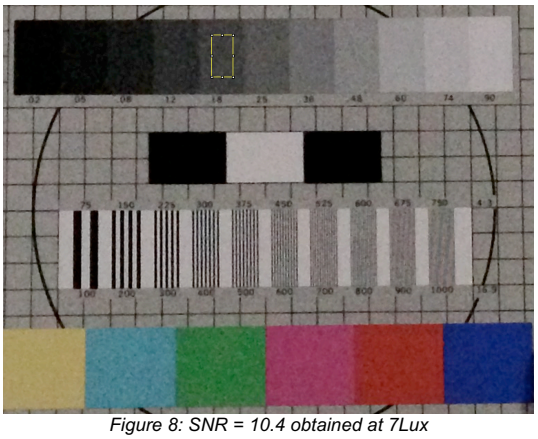
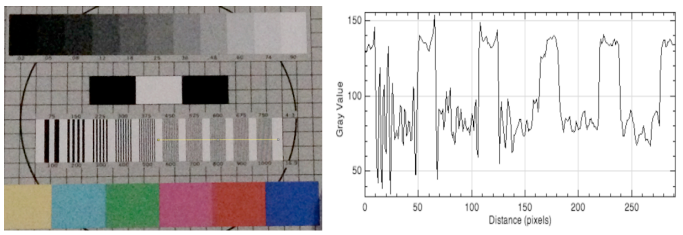
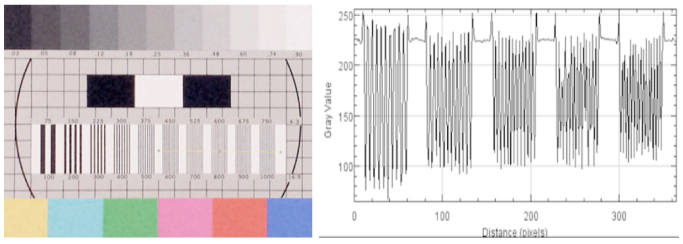


Figure 8: SNR = 10.4 obtained at 7Lux

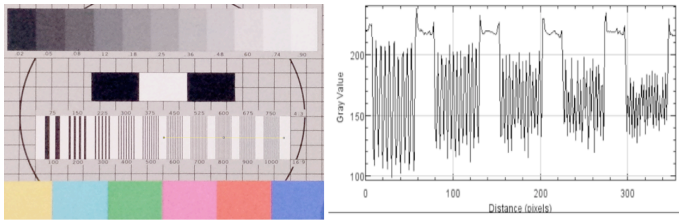
Referring to Figure 9-a, there is a large resolution loss at 7Lux. The image sharpness was checked at all light levels below 57 Lux and above 7 Lux (for 450 to 750 TV Lines). There was no line resolution loss at light levels above 30 Lux. Image sharpness started showing degradation at light levels below 30 Lux as shown in Figure 9-b and 9-c.



(a) *Line profile at 7Lux*



(b) *No fine line details loss at 30Lux*



(c) *Fine line details loss at 25Lux*

Figure 9: Line resolution at different light intensities

Conclusion for Galaxy S4: The Samsung auto-flash light activation level for the Galaxy S4 is 56Lux. According to this methodology, the auto-flash activation light for Galaxy S4 should be 30Lux.

Summary and Conclusions

A technique was developed to determine the light activation level for auto-flash mode. This was based on image SNR and sharpness evaluations at different light settings. This methodology was validated by testing on Apple iPhone5 and Samsung Galaxy S4. Based on this methodology, the iPhone5 auto-flash activation level is set correctly by Apple to 11Lux. However, the Galaxy S4 auto-flash light activation is set 26Lux higher than the optimal light setting.

For Future work, it is recommended to include the low contrast texture analysis by using Dead Leaves chart[1].

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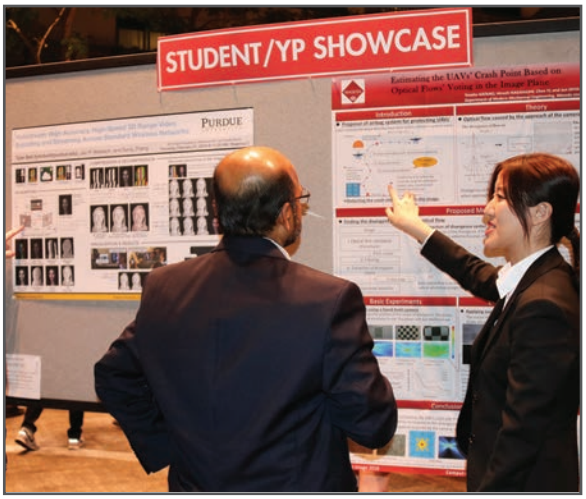

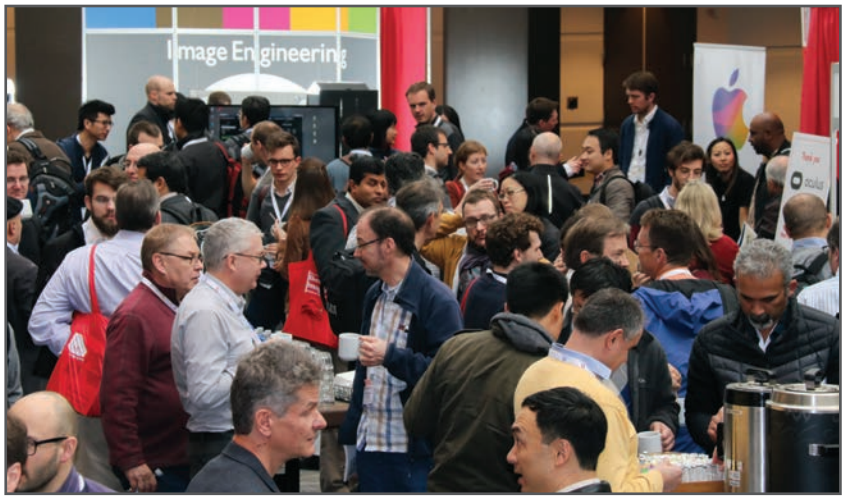

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