IRL #3: Progress Review

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Team G: EXCALIBR

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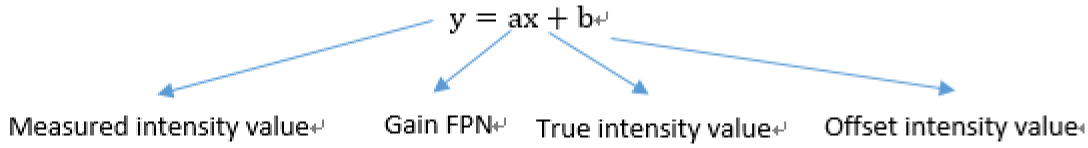
Individual Progress

Overview

Continue from where I left off, I finished CMOS sensor calibration this week. Realizing photometric calibration is highly related with CMOS sensor calibration result, we resume our works and start photometric calibration.

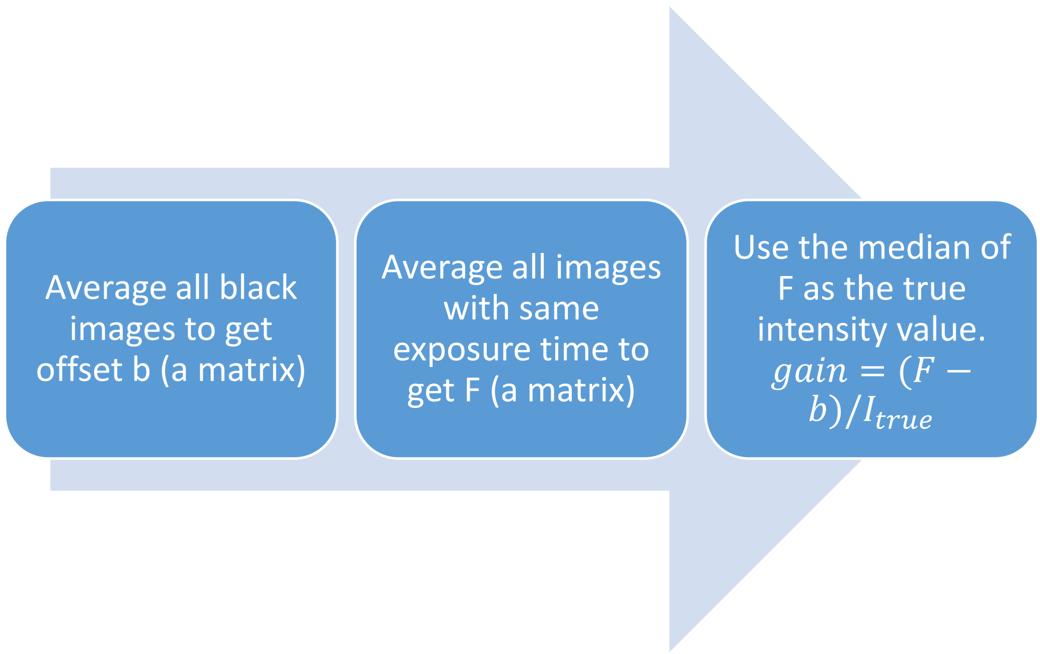
CMOS calibration

As explained last week, there are two kinds of fixed pattern noises : Dark Signal Non-Uniformity (gain FPN) and Pixel Response Non-Uniformity (offset FPN) within CMOS. The relation between pixel value and FPN can be written as follows,



Offset FPN is resulted from temperature and it exists even when there's no light source. Therefore it can be easily resolved by simply taking pictures when the camera is in dark. (when x=0, y = b).

Training process

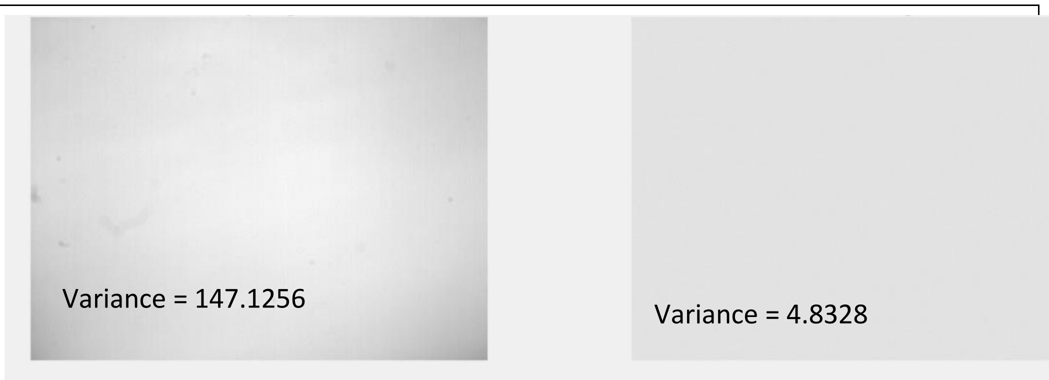


Evaluation:

$$I_{calibrated} = (raw\ image - b)/gain$$

Then, we can see if the variance of the calibrated image changes after the process.

Results:



Raw image	Calibrated image

Figure 1

Although we gave the camera uniform light source while taking the raw image, we can see that there are many black points in the pictures and vignetting around corners. After the calibration, the variance decreases dramatically and the photo looks much more uniform.

Photometric calibration

When photographing a scene, image values are rarely true measurement of relative radiance of the scene. Photometric calibration is regarding finding the relation –f between image pixel values and true measurement of radiance. We are now doing paper research of "Recovering high dynamic range radiance maps from photographs"[1] and "A photometrically calibrated benchmark for monocular visual odometry"[2]. According to these papers,

$$Z_{ij} = f(E_i \Delta t_j)$$ z: pixel value, E: irradiance, delta t: exposure time

Let $g = \ln f^{-1}$, irradiance E can be computed by the following equations:

$$g(Z_{ij}) = \ln E_i + \ln \Delta t_j \qquad w(z) = \begin{cases} z - Z_{min} & \text{for } z \le \frac{1}{2}(Z_{min} + Z_{max}) \\ Z_{max} - z & \text{for } z > \frac{1}{2}(Z_{min} + Z_{max}) \end{cases}$$

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

In also, we tried the source code provided in [1]. However, there would be a severe memory insufficiency problem if we use our original raw image. Therefore, currently, we downsample our pictures to 1/100 in x direction and 1/100 in y direction, which means 1/10000 of the original images, and get fairly good results.

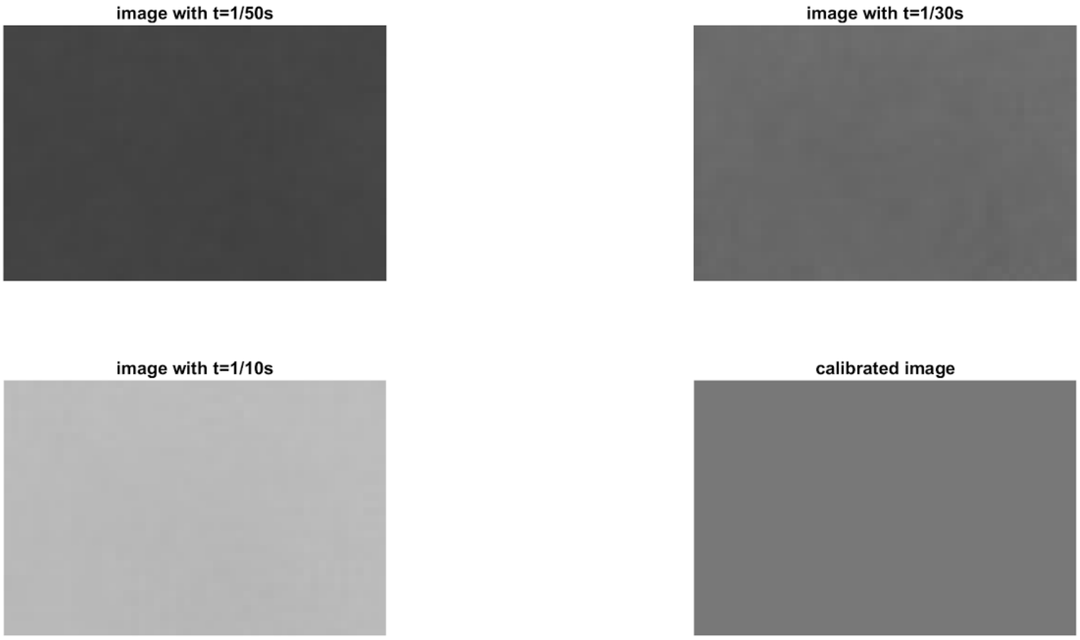


Figure2

Challenge

We are now working on a prototype located in Oculus office, rather than the real experiment room. Therefore, there are in fact a lot of noises and effects in our surroundings. Due to our high accuracy requirement, it is actually pretty difficult to get good enough input/ training data. For example, when we were taking uniform light source picture, I wanted to make the camera take pictures of this uniform light directly.


Figure 3

However, since the screen of the light would reflect fluorescent tubes on the ceiling, I had to cover the light with a lambertian paper. Yet, the paper was too big so I could only hold it in front of the light instead of sticking it to the light screen. This process might cause a lot of uncertainty and errors results in an unsatisfied uniform light source for the usage of sensor calibration. For now, we will try our best to get acceptable images and use them to run through the prototype process. After the construction of the experiment space completed, I suppose these problems will be mitigated.

Teamwork

Yiqing Cai	Photometric calibration paper research and implementation.
Huan-Yang Chang	Robot arm control
Siddharth Raina	Photometric calibration paper research
Sambuddha Sarkar	Robot arm setup

Future Plan

I plan to complete photometric calibration implementation and start geometric calibration code tracing next week.

References

[1] Debevec, Paul E., and Jitendra Malik. "Recovering high dynamic range radiance maps from photographs." *ACM SIGGRAPH 2008 classes*. ACM, 2008.

[2] Engel, Jakob, Vladyslav Usenko, and Daniel Cremers. "A photometrically calibrated benchmark for monocular visual odometry." *arXiv preprint arXiv:1607.02555* (2016).