andrew id: sraina1
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INDIVIDUAL LAB REPORT 8

SIDDHARTH RAINA

TEAM G
Siddharth Raina
Sambuddha Sarkar
Yiqing Cai
Man-Ning Chen
Huan-Yang Chang

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1 INDIVIDUAL CONTRIBUTION

1.1 PIPELINE FOR NOISE MEASUREMENT AND CALIBRATION

An illustration of the pipeline for sensor noise mesurement has been shown in the figure below:

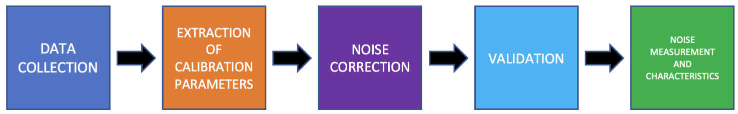

Figure 1: THE SENSOR CALIBRATION PIPELINE

1.2 DATA COLLECTION

DATA COLLECTION PARAMETERS

Based on the experiments performed on the EVT HS 12000N camera, the data was collected according to the plan which was to collect 10 images of both dark and flat images of exposure values ranging from 1000 μs to 30000 μs on intervals of 100 μs from each camera.

DATA COLLECTION PLAN

- The images have been named according to a standard naming scheme.
- The illustration of the directory structure and image naming scheme for the data collection plan can be seen in Fig.2.

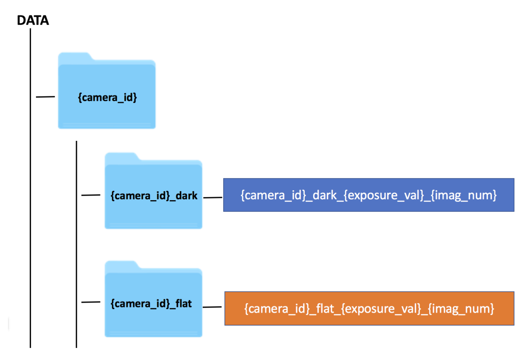

Figure 2: THE DIRECTORY STRUCTURE FOR THE COLLECTION OF DATA

1.3 NOISE MEASUREMENT

SHOT NOISE: Noise introduced due to non uniform flux of this photon stream falling on the camera sensor.

READ NOISE: Noise introduced while converting the flux of incomimg photons to a voltage signal.

PIXEL RESPONSE NON UNIFORMITY: Pixels in a camera sensor have a different ability to capture photons which fall on their respective sensor elements. Due to this difference, each pixel is associated with a gain parameter which is a measure of its efficiency in capturing the amount of light falling on the respective sensor element. PRNU increases with the exposure time.

MEASUREMENT OF READ AND SHOT NOISE: Two consecutive images of a uniform light source are taken at the same exposure and are subtracted to cancel out the effects of thermal noise and PRNU. The standard deviation of the noise (standard deviation of all the pixel values) from the resulting image is then calculated and divided by $\sqrt{2}$ as independent noise sources adds up in quadrature,

$$\sigma(N_1)^2 + \sigma(N_2)^2 = \sigma(N_{total})^2$$
$$\sigma(N_1) \approx \sigma(N_2)$$
$$\sigma(N_1) = \sigma(N_{total})/\sqrt{2}$$

This would give us a datapoint $\{E_i, \sigma(N_i)\}$ and the steps can be repeated for a set of exposure values. An illustrative visualization for the measurement of the shot noise and read noise can be seen in Fig.3.

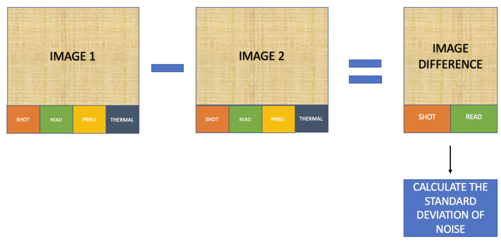

Figure 3: CALCULATING THE READ AND SHOT NOISE

RESULTS: The results can be seen from Fig. 4 and Fig. 5, The square of the standard deviation of the noise is a linear function of the averaage signal (average amount of pixel brightness for a given frame).

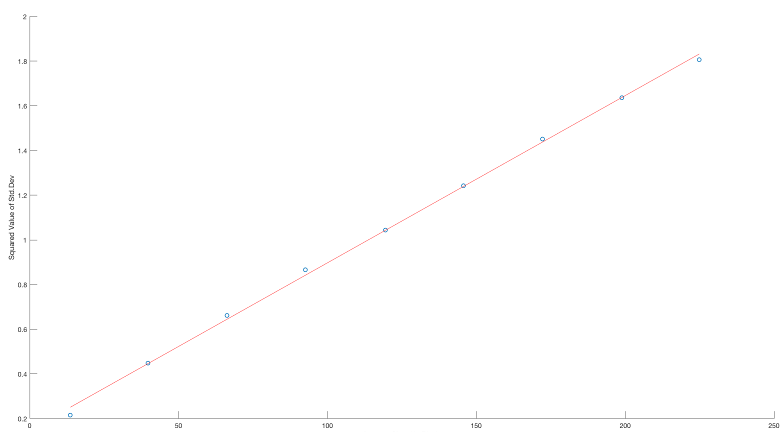

Figure 4: NOISE BEFORE IMAGE SATURATION

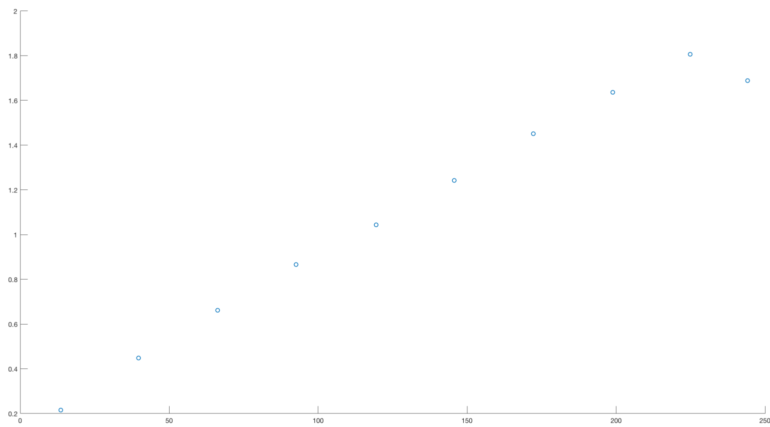

Figure 5: NOISE AFTER IMAGE SATURATION

It can be seen from Fig.5 that after a point, the total read and shot noise decrease. This is because the images start to saturate and the noise doesnt get captured.

MEASUREMENT OF PRNU : For the measurement of PRNU, we have to take flat images for the set of exposure values defined in the data collection section. For each exposure value E_i, the following steps need to be carried out:

1. subtract the corrosponding exposure value dark frame from the image.
2. subtract in quadrature, the read and shot noise already calculated at this exposure.

$$\sigma(N_{total})^2 = \sigma(N_{read})^2 + \sigma(N_{shot})^2 + \sigma(N_{PRNU})^2$$

$$\sigma(N_{PRNU}) = \sigma(N_{total})^2 - (\sigma(N_{read})^2 + \sigma(N_{shot})^2)$$

3. This would give us a datapoint $\{E_i, \sigma(N_{PRNUi})\}$

An illustrative visualization for the measurement of PRNU can be seen in Fig.6.

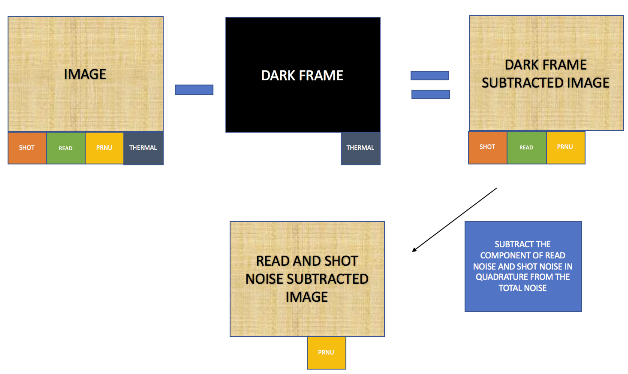

Figure 6: CALCULATING THE PIXEL RESPONSE NON UNIFORMITY

RESULTS

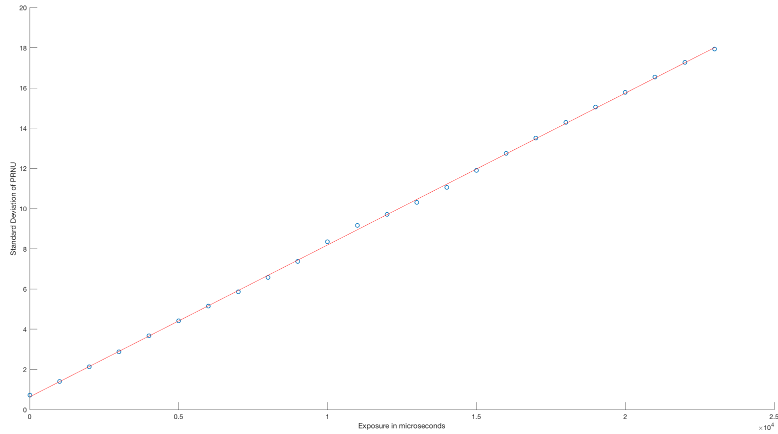

Figure 7: VARIATION OF PRNU WOITH EXPOSURE

It can be seen from Fig.7 that PRNU increases uniformly with exposure

2 CHALLENGES

The results obtain are similar to the expected results. So far I have not faced any challenge. However, I might have a challenge in plotting the thermal noise response due to the maximum exposure constraints on the camera I am using currentlythe camera : evt HS 12000N.

3 TEAMWORK

1. **ABB ROBOT MODELLING AND SIMULATION: Peter** is currently working on the ABB robot arm modeling and simulation. He has written a matlab script to automatically generate the RAPID code by importing points to a configuration space and creating collision free paths for the ABB robotic arm.

2. **COLOR CALIBRATION: Mandy** is currently working on the color calibration problem. Given the lighting conditions, she is working on mapping the observed color of the image to the actual color.She is experimenting with different models to generate a good color mapping function.

3. **PATH PLANNING: Cece** is using the field of view of a system of cameras to calculate the ideal camera placement and an optimized path for the end effector of the robotic arm on which the calibration target is attached. She has assigned scores for different camera projections.

4. **IMAGE RENDERING: Sam** is currently working on creating a simulation of the calibration target traveling in a provided trajectory. He has created a pipeline for image creation using blender.

4 FUTURE PLANS

The plan ahead is to use the test plan to measure the thermal noise. Currently, I used a non reflecting surface for data collection I am going to use an integrating (calibrating) sphere which will give me precise information about the amount of light entering the camera and enable me to accurately calculate the amount of sensor noise being introduced in the captured images. I will measure the amount of noise and create plots for each noise type. I will then compare the characteristics of the plots from different cameras.