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INDIVIDUAL LAB REPORT 6

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1 INDIVIDUAL CONTRIBUTION

1.1 LITERATURE REVIEW OF VARIOUS IMAGE NOISE TYPES

I performed an in-depth literature study to investigate all the possible forms of noise which can degrade the image quality. After a comprehensive review, I identified the following types of sensor noise:

1. **SHOT NOISE:** When a camera is exposed to light, a stream of photons falls onto the sensor element of the camera. The flux of this photon stream is not uniform. The fluctuations of this flux of photons around the average flux constitute the Shot Noise. Variations due to shot noise are governed by Poisson statistics.

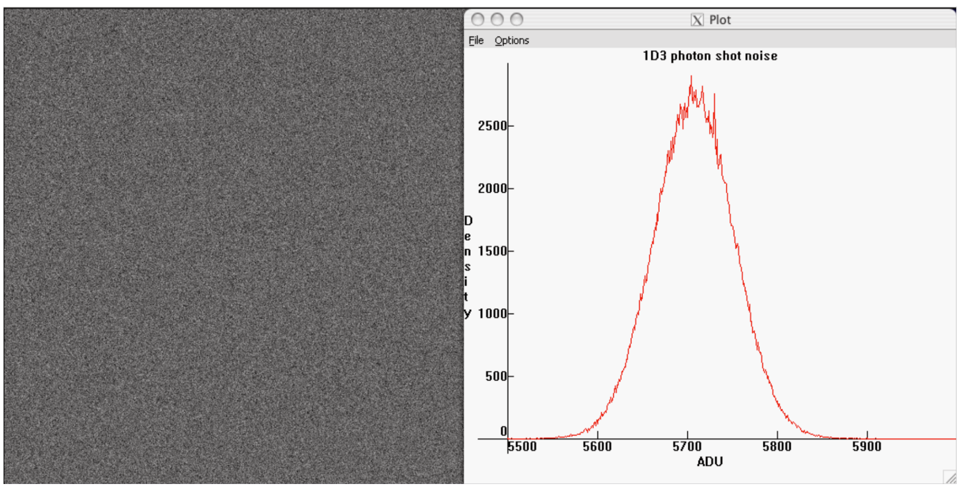

Figure 1: SHOT NOISE
REFERENCE: http://theory.uchicago.edu/ ejm/pix/20d/tests/noise

2. **READ NOISE:** After a sensor element is exposed to a stream of photons, it accumulates photoelectrons. These photoelectrons get converted to voltage signals. The photoelectrons are then multiplied by the ISO gain set in the camera and converted to a discrete voltage signal by the ADC. However, this digitization introduces noise in the image which is proportional to the photon count. The fluctuations caused due to the electronics of a sensor element constitute the read noise of the sensor.

3. **PATTERN NOISE:** The read noise is not uniform in all directions and exhibits striped patterns in the case of CMOS sensors. The human eye is especially sensitive to these kinds of bands/patterns which appear in the image. Hence pattern noise (even though a small component of the sensor noise) constitutes a significant part of the noise.

4. **THERMAL NOISE:** Due to thermal excitation, electrons are emitted which are indistinguishable from the photoelectrons. This induces an additional signal to the sensor element which is reflected in the output voltage. Thus, when we capture a dark frame, we get a few non-zero pixel values. This noise can be eliminated by subtracting a dark frame from the image captured.

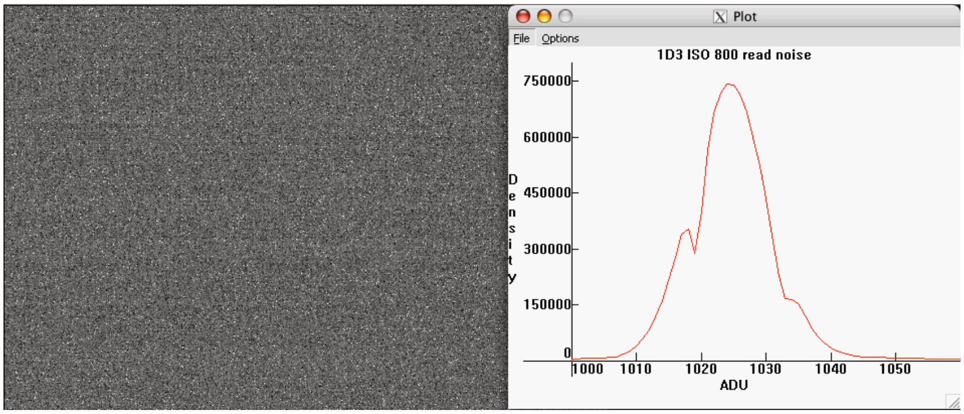

Figure 2: READ NOISE
REFERENCE: http://theory.uchicago.edu/ ejm/pix/20d/tests/noise

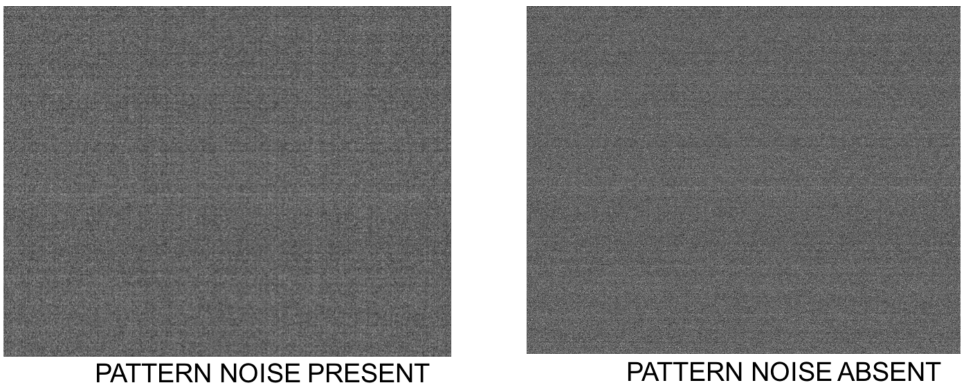

Figure 3: PATTERN NOISE
REFERENCE: http://theory.uchicago.edu/ ejm/pix/20d/tests/noise

Thermal noise increases with increase in the exposure time and vice versa.

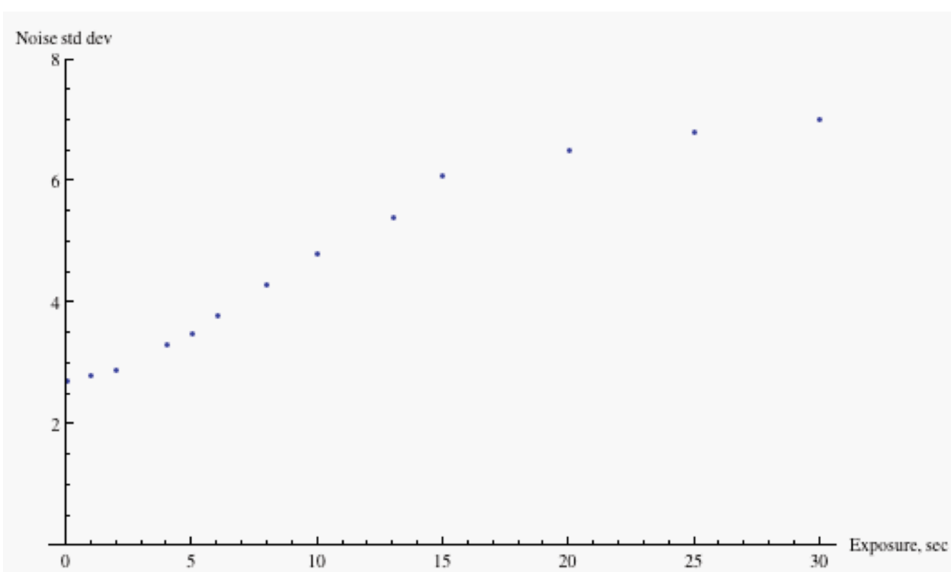

Figure 4: THERMAL NOISE
REFERENCE: http://theory.uchicago.edu/ ejm/pix/20d/tests/noise

5. **PIXEL RESPONSE NON UNIFORMITY:** Pixels in a camera sensor have a different

ability to capture and count photons which incident 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.

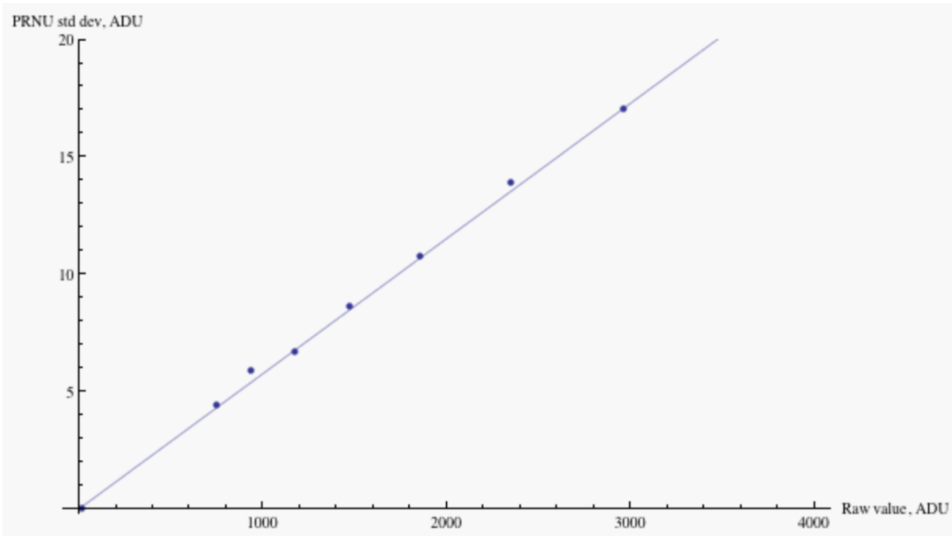

Figure 5: PIXEL RESPONSE NON UNIFORMITY
REFERENCE: http://theory.uchicago.edu/ ejm/pix/20d/tests/noise

2 CHALLENGES

So far I did not face any significant challanges while carrying out the literature review for the different types of sensor noise. The next step is to use a calibrating sphere to precisely calculate the amount of noise in captured images. I might face some challenges in using the calibration sphere.

3 TEAMWORK

1. **ABB ROBOT MODELLING AND SIMULATION: Peter** is currently working on the ABB robot arm modeling and simulation. He is working on methods to make the robot follow a particular planned path on the Robot Studio software.

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. We are using a color-checker board as ground truth for the evaluation of the actual color.

3. **PATH PLANNING: Cece** is currently working on the path planning of the ABB Robot arm. She 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.

4. **IMAGE RENDERING: Sam** is currently working on the image rendering part of the project. He is working on creating realistic images of the camera calibration target. After these images have been created, we can prototype our geometric calibration algorithm on them in orer to find the extrinsic and intrinsic camera parameters

4 FUTURE PLANS

The plan ahead is to use the literature and documentation created to measure and if possible eliminate all the different types of noise listed above. I am going to use an integrating (calibrating) sphere which will give me precise information about the amount of light entering the camera. This would enable me to accurately calculate the amount of sensor noise being introduced in the captured images.