Yiqing Cai

Team G: The ExcalibR

Teammates:
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ILR05
Nov. 23, 2016

Individual Progress

Overview

For this stage of project, I was primarily responsible for setting up the light box and building the sensor noise and photometric calibration pipeline. We defined different functions according to its functionality and made them into different classes of different subsystems. We used the emergent vision technology HR-20000 cameras and AEROTECH linear actuator (act as the robot arm) in this stage of work.

Implementation

In the previous ILR, I mentioned the challenge that it's difficult to get the uniform surface and the uniform light source, but we did all the sensor noise (FPN) calculation based on this assumption. In order to get better results, we introduced the light box which is shown in Figure 1. It provides a nearly uniform light source and blocks out the environment light source. We also introduced a uniform white surface and put it in the light box to do the FPN image acquisition. Mandy and I set up the light box and integrate the image acquisition process in the sensor noise and photometric calibration pipeline.

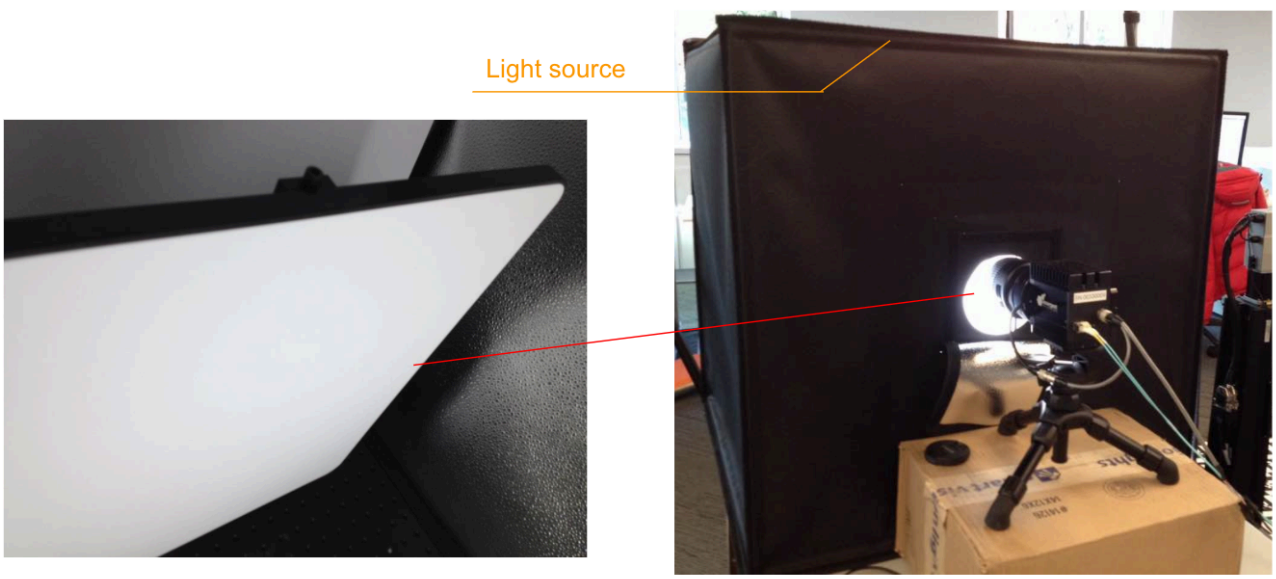

Figure 1. The uniform surface (left) and the light box (right)

The second task I implemented was to add the photometric calibration part into the sensor noise and photometric calibration pipeline and to make the whole process automatic. This process only needs to be done once for each camera, so we do not have to integrate it into the geometric calibration pipeline.

The pipeline is generally shown in Figure 2. After the FPN parameters is calculated and stored as a binary file, we need to move the camera out of the light box and put it towards a regular static scene. When we press a key, the pipeline will automatically call functions to capture images with different exposures. The number of images can be set by the user as an input of the image capture function.

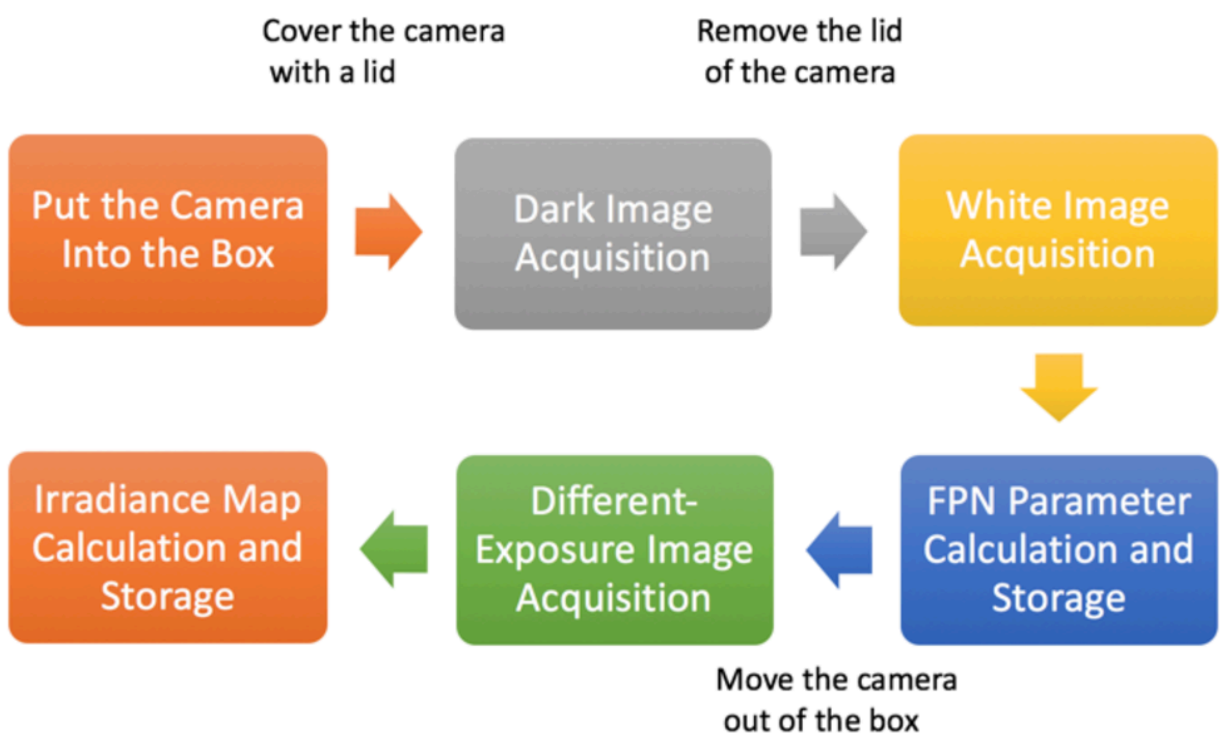

Figure 2. The sensor noise and photometric calibration automatic pipeline

When the multi exposure image capturing process is done, the pipeline will use the FPN parameters to calibrate the fixed pattern noise in those regular static scene images of different exposures and then we will calculate the camera inverse response function based on those images. The iteration time of the response function calculation can also be set by the user as an input of the generateInverseResponse function.

The result of the photometric calibration will be a binary file which contains 256 double values ranges from 0 to 255. Finally, we will save all the calibration parameters in to separate binary files and put them into one folder for each camera and name the folder as the serial number of the camera, which should be convenient to call and manage.

Challenges

The main challenges I faced during this task were:

1. In order to achieve high accuracy of the calibration result, we need to give strong validations to every subsystems. For the photometric calibration part which I was mainly responsible of, it's hard to find the ground truth. So we are now considering introduced some other devices to act as the ground truth. One option is to buy a photometer which can detect the intensity of the light illumination, the other option is to buy a device which can give out light of specific wavelength and intensity.

2. When integrating different part of the calibration pipeline, we need to find out the best way to store all the parameters and to design interfaces of different functions and classes. After several discussions we decided to make different classes according to the different subsystems and store all the parameters as binary files and put them into a single folder for one camera.

Teamwork

Work undertaken by each team member is as follows (see Table 1):

Member	Tasks
Huan-Yang Chang	Analysis of time cost and re-projection error with different number of images
Man-Ning Chen	Integrate FPN calibration into the pipeline and set up the light box
Yiqing Cai	Integrate photometric calibration into the pipeline and set up the light box
Sambuddha Sardar	Robot arm trajectory automatic generation and search for photometric device
Siddharth Raina	Validation of the sensor noise calibration

Table 1. Team co-work

Our team worked with great coordination during execution of the second stage of this project. We communicated during the entire task and solved problems together. Sam was working on the Robot (AEROTECH - 3 Prismatic Joint) Robot arm trajectory automatic generation and searching for suitable device to provide ground truth for the photometric calibration. Peter was working on figuring out the relationship among time cost, reproduction error and the number of images of the geometric calibration pipeline, trying to validate if we can meet the efficiency requirement. Mandy was working on integrating the sensor noise calibration to the pipeline and set up the light box with me. I was working on integrating the photometric calibration process to the pipeline and the light box. Sid is trying to give better validation of the sensor noise calibration results by doing FFT and documentation of other possible methods. We faced many difficulties but we worked them out eventually as a team.

Future Plans

From now on, my task will be focused on the validation of the photometric calibration part. In order to get robust calibration subsystems, we need to carry out more tests and better validation methods to make sure the accuracy of each subsystem.