16-681 - MRSD Project 1 | ILR #5

Individual Lab Report #5 | November 23, 2016

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1. INDIVIDUAL PROGRESS

1.1 Overview

In this ILR I would describe about the code auto code generator for the AEROTECH robot which was designed in MATLAB. I would also shed some light on the integration of Geometric and Photometric Calibration pipelines. I will discuss about the trade study on two principal methods of CMOS Sensor characterization in digital cameras.

Topics covered have been listed below for a quick overview.

1.2 Code Generator for Motion Composer: AEROTECH

I wrote a trajectory code generator for Aerotech programming environment implemented in MATLAB which enables me to just enter the trajectory type and required parameters and it will generate a code which can be directly run by Motion Composer Suite of Aerotech. This seems complicated but is actually quite easy, as we can generate new script files in MATLAB and with the help of conditional statements, switch cases and loops I could design a script generator. It basically prints out the commands with necessary input arguments.

The input arguments are generated from the input arguments of the MATLAB script itself, where in this case we enter the trajectory desired, the dimensions of the trajectory and resolution of the step size and PSO fire distance. Using these arguments, the MATLAB script generates the data for the input arguments necessary for the AEROTECH programming environment's command sets.

What this code generator helps us achieve are:

1. Reduced time for changing trajectory
2. Streamline the robot control
3. Make it user friendly

1.3 Trade Study: CMOS Sensor Characterization in Cameras

Problem: Obtain the absolute value of light intensity and calibrate the CMOS sensor output of the camera to match the said absolute value of light intensity.

There are two ways of approaching this problem:

1 **Method I**: Get the value of the intensity of light of the surface using Photometers/Lux meters/Radiometers.
2 **Method II**: Use a standardized light source with controllable wavelength and intensity.

A comparative overview of the two stated methods have been given below in Fig. 1.3, ***each advantage is given an unweighted score of 1***:

	Method I	**Method II**
Principle of Operation	Uses a transducer to convert light intensity to digital signal.	Uses a transducer to convert digital signals into light waves.
Sensor/Transducer	Silicon(doped) Photodiode	Silicon(doped) LED / Tungsten Filament
Pay-off Table		
Cost	$ - Cheap	$$$ - Expensive
Luminous efficiency error	9% - High	0.001% - Low
Dependence on ambient light	In-effective/false positives under fluorescent lighting	Independent of ambient lighting
Response time	5 s	0.500 s
Characteristics of oblique incidence/ Luminance Spatial uniformity	**Incidence** 10° ±1.5% 30° ±3% 60° ±10% 80° ±30%	**Spatial Uniformity** >94% over 360° x 200° field of view
Spectral range	Lux meter: 1 Photometer: 850 nm to 940 nm	Visible, 850 nm to 940 nm
Spectral mismatch	1%	>0.00001%
Luminescence range	0.0 to 999 cd/m²	10 to 700 cd/m²
Typical application	Lux meter: Ambient light Photometer/Radiometer: Color of surface.	Calibration of Lux meters, Photometers, Radiometers, Cameras & other optical equipment.
Operational features	-Comparatively less stable output -Needs regular calibration -Integration with desktop on select models.	-Precise control -Integration with desktop: easy -Long life -Stable output
Total score	**2/10**	**7/10**

Fig. 1.3

Result: Method II is the most desirable way to go about solving the problem at hand.

Recommendations:

1. **Gamma Scientific: http://www.gamma-sci.com/products/light_sources/**
2. **Labsphere: https://www.labsphere.com/labsphere-products-solutions/imager-sensor-calibration/**

References:

- https://www.labsphere.com/site/assets/files/2928/pb-13089-000_rev_00_waf.pdf
- http://ericfossum.com/Publications/Papers/1999%20Program%20Test%20Methodologies%20for%20Digital%20Camera%20on%20a%20Chip%20Image%20Sensors.pdf
- http://sensing.konicaminolta.us/2013/10/measuring-light-intensity-using-a-lux-meter/
- http://tmi.yokogawa.com/products/portable-and-bench-instruments/luxmeters/digital-lux-meters/
- http://ens.ewi.tudelft.nl/Education/courses/et4248/Papers/Niclass12.pdf
- http://photo.net/learn/dark_noise/
- http://ro.ecu.edu.au/cgi/viewcontent.cgi?article=2497&context=ecuworks
- http://personal.ph.surrey.ac.uk/~phs1pr/mphys-dissertations/2007/Wallis.pdf
- http://tmi.yokogawa.com/files/uploaded/BU510_EN_050.pdf

Foot Notes:

LED light source is preferred over tungsten filament based source as it has the below stated superiority:

1 Life
2 Heat/IR – minimum
3 Multitude of Wavelengths generated
4 Precise selection of Wavelength & Intensity

1.4 Calibration Pipeline Integration

My work involved helping the calibration team with integrating the Geometric and Photometric calibration pipeline into 1 complete pipeline. The stages included the robot motion, image capture, storage, calibration algorithms and validation. The individual stages were complete and operational, though the sponsor (Oculus VR, Research, Pittsburgh) have demanded more stringent validation of the results. We had problem with different scripts in different languages and that has to be dealt with, as we have decided on porting all the scripts to Python as Cpp is tedious when it comes to programming.

To summarize the robot motion is initiated using one mouse click, the image capture uses two mouse clicks (one for initiation and one for ending the capture session) and finally one for running the calibration algorithm scripts and generating the results.

In total there will be FOUR mouse clicks for our FVE for the system to do what we say it does.

2. CHALLENGES

There was only was one challenge which I faced during last week, which was integrating the Geometry Calibration pipeline and Photometric Calibration pipeline together, as some stages of validation need to be updated and/or modified. Also the calibration algorithm's codes are written in different programming languages: Cpp, Python and Emergent CVT programming environment (The Software which came with the cameras), this makes integration a bit difficult as the execution times of each script in the respective programming environment is different and the output hand-off from each script has to be synchronized.

3. TEAM WORK

The project work was divided among the team members and the task was assigned according to the strengths of the team members. The task division has been listed below in Table 3. The divided tasks can be completed in parallel; hence others can pitch in when some team members fall behind in their work.

Team Member	**Task**
Yiqing Cai, Man-ning Chen, Siddharth Raina & Huan-Yang Chang	- Speeding up geometry calibration - Integration of image processing, FPN, geometric calibration, photometric calibration.
Sambuddha Sarkar	- Auto generation of AEROTECH code using MATLAB - Trade study on CMOS sensor characterization techniques - System Integration of Geometric and Photometric calibration. - ABB Documentation Study.

Table 3, Task Division.

4. FUTURE PLANS

After the FVE, I have work assigned by the sponsor to work out industry ready validation techniques for all calibration stages. Also I am tasked with operating the ABB 6DOF robotic arm during the next stage of the project, I will be working on that in the near future.

Below I have included an outline of the work I will be doing during the winter break. This has been discussed and decided upon with the research team at Oculus.

1.a. CAMERA RESPONSE

Cece
Sam

1. Data Collection (from previous stage: sensor noise) : Background constant
2. Plot Curve: monotonically increasing:
   -number of exposure values
   -algorithm
3. Ground truth: Buy equipment **VERIFY**
4. UID system for images

2.a. AEROTECH

VERIFY

Peter
Sam

1. Position accuracy: check repeatability
2. Distance from camera to robot
3. Capture 2 images, subtract 2 images(convert to double) ---> check for RMSE(root mean squared error)
   - Motion Type
   - Speed
   - Dwell/No Dwell
   - Include Target weight
   - Camera resolution
4. Completely autonomous