Yiqing Cai

Team G: The ExcalibR

Teammates:
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Individual Progress

Overview

For this stage of project, I was primarily responsible for testing on the real robot arm and validate the path planning and position optimization procedure. The path should satisfy the coverage requirements for camera FOVs and the re-projection error requirements for geometry calibration. When the 3D calibration target moves along the designed path, the projection on camera FOVs should be of appropriate size and the target positions should be within the depth of field where the camera is able to focus. Last time, the camera settings are not good so we got images quite different from the simulation. This time we set the cameras more reasonably, and make the focal length of all the cameras to be 50mm. The results are much better. After the image capturing process, we pass all the valid images to the geometry calibration process and the re-projection error is 0.16 pixels. Besides, we also re-project all the detected corners on the calibration target back onto the image plane and check if the coverage of FOVs is more than 85%. We are now in the process of experimenting and testing, trying to prepare enough materials for the SVE.

Implementation

During this stage, we test on the real ABB Robot arm again with a more accurate setting identical with the simulation parameters. Due to the door of the dome, we set three cameras at the open area of the dome, and calculate the path based on this setting. The setting of the cameras are shown in Figure 1. All the possible positions (blue) for the calibration target (which is decided by the working space of the robot arm and the depth of field of cameras) and the selected positions (red) for calibrating the three set cameras are shown in Figure 2.

The images are size of 4096 * 3000 pixels, and the reasonable size of projections of calibration target should be between 600 ~ 1300 pixels in radius. As the focal length of the cameras are 50mm, and the dome is 270cm in radius, I set the focus distance to be 180mm, the corresponding depth of field is from 155cm to 205cm, and the size of projections of calibration target would then be between 700 ~ 950 pixels in radius.

Based on this setting, I generated original path and sampled 2400 points along all the possible positions for the calibration target within the working space of the robot arm and the depth of

field of cameras, then I evaluate all the positions referred to the score function and selected 80 points for the final path. So during the image capturing process, each camera took 80 images for geometry calibration. In the end, images from 77 different selected positions out of 80 were used for the geometry calibration and the re-projection error is 0.16 pixels.

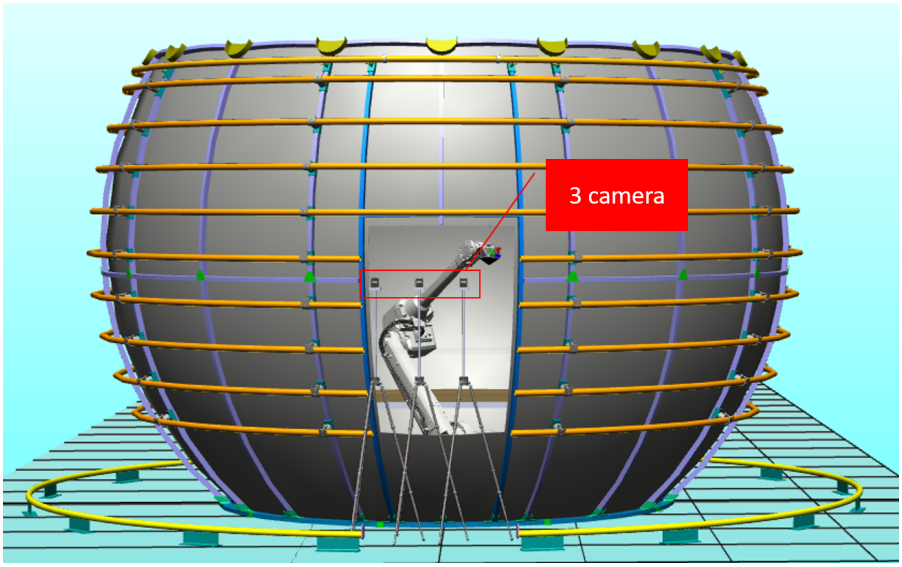

Figure 1. Three cameras setting at the open area of the real dome

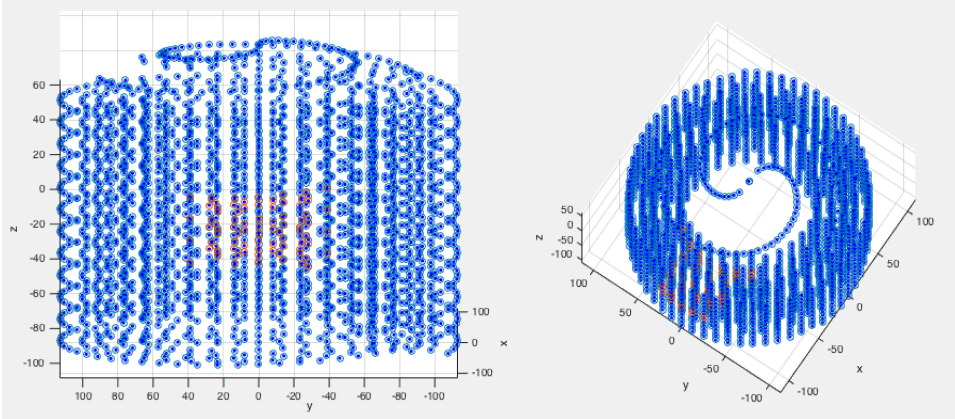

Figure 2. All possible positions(blue) and selected positions(red) for calibration target

For the validation of projection coverage of camera FOVs, we re-project all the detected corners of checkerboard patterns on the captured images of 3D calibration target back to the image plane according to the calibration results to visualize the actual projections and calculate the actual coverage, Figure 3 shows the visualization. According to the calculation, the coverage of the projection for each camera is 88.73%, 85.15% and 88.88% respectively.

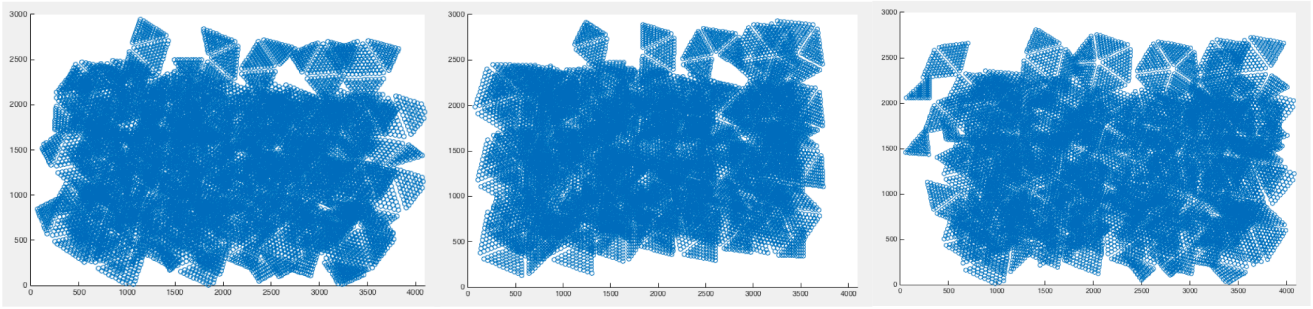

Figure 3. Visualization of actual projections on camera FOVs

The actual coverage of the projections on camera FOVs would look even denser than the images shown above, as the visualization is just the re-projected detected corners. Generally, if the projections are able to cover the majority area of the camera FOV, and the captured images are all clearly focused under an acceptable lighting condition, the geometry calibration can be done successfully and produced good calibration results (re-projection error smaller than 0.2 pixels as expected).

Challenges

As we are trying to test on the real ABB Robot arm in the real dome now, we have to deal with the differences between the real world and simulation cases. For example, it is hard to set the camera at a specific position and make it look at a certain direction. Although it doesn't have to be perfect as we are doing calibration to get the exact position and orientation of the camera, the error still can not be too big as we are planning the path for the calibration target relying on this setting. It took us more than an hour to set up the settings mentioned above, so we would have to prepare a lot before the SVE starts.

Teamwork

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

Member	Tasks
Huan-Yang Chang	Testing on real ABB robot arm and verifying the geometry calibration results
Man-Ning Chen	Testing on polynomial mapping function models for color correction
Yiqing Cai	Testing on real ABB robot arm and verifying the optimized path
Sambuddha Sardar	Rendering and generating virtual images in Blender
Siddharth Raina	Analyzing the noise model and building sensor noise calibration pipeline

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 rendering and generating virtual images in Blender. Peter and I was working with real ABB robot arm and trying to testing on it and verifying the optimized path, collecting valid images for geometry calibration test, and validate the geometry calibration results. Mandy was working on testing on polynomial mapping function models for color correction. Sid is analyzing the noise model and building sensor noise calibration pipeline. We faced many difficulties but we worked them out eventually as a team.

Future Plans

There are still some work left before SVE. For example, we need to set up the cameras and do the testing several more times to refine our planning results. We also would need to apply the sensor noise correction and color calibration to the captured images and do the geometry calibration again to see if the pre-calibration would improve the results.

For SVE, we still need to test and make sure our pipeline is robust and is able to apply to different settings of camera positions, orientations, focal length and different calibration target size.