International Institute of Information Technology, Hyderabad
Spring 2024 CS7.505: Computer Vision
Assignment 1: Camera Calibration
22 January 2024

Instructions:

- The goal of the assignment is for you to get familiar with the process of camera calibration and the critical role it plays in measuring objects in the world based on images.
- You should upload the assignment as a jupyter notebook with appropriate cells (markdown and code) containing (1) code that you wrote, (2) keep relevant outputs, and (3) your report and observations (markdown cells). The file should be uploaded in the courses portal.
- We recommend Python, although other languages are acceptable too (C/C++, Matlab). If not using Python, you must share code along with instructions on how to run it, and a separate pdf report. You should still not use external libraries or toolboxes when restricted (P1).
- Include the assignment number, your name, and roll number in the first cell of the notebook submission.
- **Make sure that the assignment that you submit is your own work. Any breach of this rule could result in serious actions including an F grade in the course.**
- The experiments and report writing can take time. Start your work early and do not wait till the deadline.

Submission: Any time before *6th Feb 2024, 23:59 IST*

1 Assignment

This assignment requires you to implement/use multiple camera calibration techniques. We would also like to understand the parameters estimated from these calibration methods. You are expected to solve all questions:

Q1: Own Calibration [4 points]

1. [1 point] For the given image `calib-object.jpg`, identify the chessboard internal corners. You may use external libraries to detect the chessboard corners. Note, each square of the chess board is 2cm $\times$ 2cm.
2. [1.5 points] Implement the camera calibration process discussed in the lecture. Assume a world origin, create a set of corresponding points in the world coordinate and image plane, compute both extrinsics (translation vector, rotation matrix) and intrinsics (assume no skew) without using any external libraries for the `calib-object.jpg` image.
3. [1 point] Use the real-world measurements along with the estimated camera parameters to compute the image of a wireframe of the object (Hint: the wireframe is the outer corners of the actual chessboard pattern and has 6 points). Note that you should compute the location of image points as $x_i = PX_i$, where P is the projection matrix computed above. Overlay (draw) the wireframe over the actual image of the object using straight lines between the computed points x_i. What do you observe about the overlay?
4. [0.5 points] Given the rotation matrix, compute the three rotation angles. Explain the values that you obtain in terms of pan, tilt, and roll?

Q2: OpenCV Calibration [3 points]

1. [1.5 points] Now repeat the camera calibration process for `calib-object.jpg` using OpenCV calibration functions, continue to assume that there is no skew or distortion (Hint: see `calibrateCamera() FLAGS`). How does your result compare with Q1 above? Repeat the overlay of the wireframe using the new parameters. Describe your observations.
2. [1 point] Repeat Q2.1, for the second image `assign1.jpg`. Does the wireframe overlay show significant distortions? Comment. What can we say about the computed projection matrix when trying to do calibration based on world coordinate points that are co-planar? (Hint: we looked at co-planar points in two-view geometry).
3. [0.5 points] What is the image of the world origin, given the calibration matrix? Does this result agree with your observations?

Q3: Moving the Chessboard [3 points]

1. [1.5 points] Imagine that the chessboard in `assign1.jpg` was moved by 10 cm to the right (along the ruler). Overlay a wireframe (4 points) of the virtual chessboard on the image at the appropriate location. Does the wireframe look consistent with what you expect?
2. [1.5 points] Now, think of how you would move the actual pixels or pattern of the chessboard? Overlay the chessboard pattern within the predicted wireframe. Is the overlay consistent with what you expect?

2 Submission

We recommend that you submit a report as a single jupyter notebook with relevant cell outputs as mentioned at the top. In case you are not using Python, please share code (with instructions on how to execute) and a separate pdf report.

Submit the file in the courses / moodle portal before the deadline: **6th Feb 2024 23:59 IST**. The moodle portal may show a different date due to the grace period, do not get confused.

The report/notebook should contain:

- A description of the problem, algorithms, results and comparison of the calibration methods based on the experiments you performed.
- Code for calibration that you wrote.
- Images of the inputs and outputs for the different algorithms and cameras.
- Challenges you faced and learnings from the experiments.

Remember, you are expected to write the complete code for the assignment yourselves. DO NOT COPY ANY PART FROM ANY SOURCE not limited to your friends, seniors or the internet.