CPS 843 (CP 8307) Problem Set 5

(25 points)

Purpose

- Familiar with the algorithm in computer vision
- Understand the basic concepts of camera calibration, two-view geometry, and 3D reconstruction

Requirements

- The assignment is due on Monday, December 4th @ 11:59pm. Late submissions will not be accepted.
- Submit all your work in a single PDF file through D2L (multiple submissions are allowed, but only the last submission will be considered for evaluation).
- Please properly resize all images so that they align with the text in your report.
- If your assignment involves any source code, please submit it along with the report for each relevant part.
- You are permitted to use available functions or software packages of Matlab in your work. Other programming languages and packages are also allowed.
- Complete the report independently. We will employ Turnitin® for similarity check.
- Start your report for each problem with a new page.
- Suggested report format: IEEE double-column format. The Word and LaTeX template can be found via the link below (please note that any other formats are also allowed) http://www.ieee.org/conferences_events/conferences/publishing/templates.html

Software:

The Structure from Motion Package of the Computer Vision Toolbox for Matlab as outlined in the following link
https://www.mathworks.com/help/vision/ug/structure-from-motion-from-two-views.html

Work to do:

1. Read the camera calibration paper "Flexible Camera Calibration by Viewing a Plane from Unknown Orientations - Zhang, ICCV'99" (the Calibration App is based on this paper). You may download the paper here https://www.microsoft.com/en-us/research/wp-content/uploads/2016/11/zhan99.pdf
2. Read the lecture notes about two-view geometry and 3D reconstruction (Lectures 10, 11)
3. Following the instruction and calibrate your camera using the Single Camera Calibration App given in the following link. Follow the workflow of the app to calibrate your camera and export the parameters to an object.
   https://www.mathworks.com/help/vision/ug/using-the-single-camera-calibrator-app.html

4. Using the calibrated camera, take a pair (or more pairs) of stereo images of a rigid object or static scene from two different viewpoints (to facilitate feature detection, it's better to choose the object or scene with rich texture).
5. Carefully read and follow the steps in the Structure from Motion Package, and perform the following steps: 1) read images; 2) load camera parameters; 3) remove lens distortion (optional); 4) find correspondences; 5) estimate the essential matrix; 6) compute the camera pose; 7) 3D reconstruction; and 8) display the reconstructed 3D points cloud. https://www.mathworks.com/help/vision/ug/structure-from-motion-from-two-views.html
6. You can directly use the given packages for calibration and reconstruction. You may make some necessary modifications based on your needs and understanding.

Report requirements:

- A brief technical overview of the camera calibration paper "Flexible Camera Calibration by Viewing a Plane from Unknown Orientations" (in about one page using your own works).
- A brief technical overview of the theory for 3D reconstruction we taught during class (in about one page using your own works).
- Following each step (except for the sphere fitting step), give a brief description of what that step is used for, and the results of that step, such as the camera parameters, essential matrix, matching results, etc.
- Make reasonable analysis and discussion of your results based on what you have learned and your understanding.

Available resources

- Reconstruction package: https://www.mathworks.com/help/vision/ug/structure-from-motion-from-two-views.html

- Calibration App: https://www.mathworks.com/help/vision/ug/using-the-single-camera-calibrator-app.html

- Structure from motion: https://www.mathworks.com/help/vision/structure-from-motion.html