Assignment_1: Camera Calibration

1. Overview

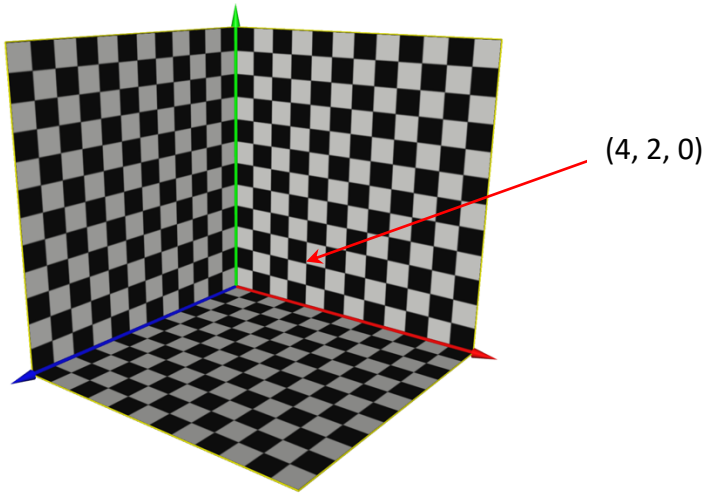
In this assignment, you will gain hands-on experience in camera calibration. Specifically, you will practice:

1) Basic linear algebra operations;
2) Setting up and using a (virtual) apparatus to collect a set of 3D-2D corresponding points;
3) Computing the SVD and inverse of a matrix;
4) Extracting intrinsic camera parameters;
5) Extracting extrinsic camera parameters;
6) Using open-source libraries to visualize and validate your calibration results.

2. The tasks

Task #1: **Collect at least 6 pairs of 3D-2D corresponding points (10%)**

Compile and run the viewer. You will see a virtual calibration rig as follows



In this rig, the **red**, **green**, and **blue** arrows are the ***X***, ***Y***, and ***Z*** axes, respectively. With the grid texture, you can easily figure out the 3D coordinate of any points on the grid.

You can use your mouse to manipulate the scene (i.e., move and reorient your camera).

Take a picture of the scene by pressing the "s" key. Then you will see a dialog asking for a file name. You can provide any name, e.g., "image_01.png", and save it to your disk.

With the image, pick ***n (n>=6)*** points on the virtual scene, and figure out their corresponding image points. To make the access to the data easier, please store these correspondences in a "***.txt***" file in which each line has 5 coordinates separated by space, i.e., the first 3 coordinates represent a 3D point and the subsequent 2 coordinates represent the corresponding 2D image point. See the two examples in "/resources/data".

Data: you can use the provided data for testing your camera calibration algorithm. In your submission, you must include the test results base on your collected 3D-2D correspondences. We assume every team collects different data for experiment.

Image coordinates: The image below shows the image coordinate system. Image coordinates are denoted in pixels, with the origin point (0, 0) corresponding to the top-left corner of the image. The X-axis starts at the left edge of an image and goes towards the right edge. The Y-axis starts at the top of the image towards the image bottom. All image pixels have nonnegative coordinates.

Directions and pixel positions in the image coordinate system.

Task #2: **Implement the camera calibration algorithm.**

In the file "/A1_Calibration_Code/Calibrationcamera_calibration_method.cpp", the function "calibration" is defined but not implemented. Comments and guidance are left in the function. Example code is also provided within the function for you to get familiar with the necessary data structures and algorithms.

Camera calibration can be achieved by tackling the following subtasks:

- Construct the *P* matrix (10%).
- Solve for *M* (the whole projection matrix, i.e., *M = K * [R, t]*) (20%).
- Extract intrinsic parameters from *M* (20%).
- Extract extrinsic parameters from *M* (20%).

3. About the code framework

We use the vector and matrix data structures provided by *Easy3D*[1].

The viewer is based on the Easy3D viewer, which provides visualization of 3D scenes and cameras. It also serves as a means to intuitively validate the camera calibration results.

[1] https://github.com/LiangliangNan/Easy3D
The code framework uses a stripped earlier version of Easy3D, which is not compatible with its current version.

The usage of the viewer:

Left button:	*rotate the camera*
Right button:	*move the camera*
Key s:	*snapshot (i.e., take a picture)*
Key t:	*show/hide the virtual camera*
Key space:	*run the camera calibration algorithm*

I assume you have some experience with C++ and you are able to compile and run the code of this assignment. If not, please have a look at:

https://github.com/LiangliangNan/Easy3D/blob/master/How_to_build.md

4. Submission (Deadline: Mar. 5th)

Your submission should include:

- **A report** (20%)
  - Test your algorithm on both the provided data and your data.
  - Take a snapshot of your result and put it along with the input image.
  - Include how you verify intermediate result of each step.
  - Discuss how you determine the sign of ρ.
  - Discuss the accuracy and how to improve it.
  - A short description of "who did what".
- **Data**
  - Your input 3D-2D point pairs (in *txt* format).
  - A screenshot of the input image.
- **Source code**
  - All source code to be able to compile, run, and reproduce your results.
  - Include the link to the GitHub repository (if you use GitHub for collaboration)

Please compress all the above into an archive file and name it in the following format:

GEO1016_Assignment_1_Group_X.zip

where 'X' is your group ID, which can be found here:

https://docs.google.com/document/d/1WMPXgWD0_2F9oDSub1K-g6NdRKqIRyWj3sUFDCpfFSk/edit