CSCE 452 Homework 4: Camera calibration

Any camera-based measurement would require camera intrinsic parameters which are in a form of K matrix

$$K = \begin{bmatrix} f_x & 0 & p_x \\ 0 & f_y & p_y \\ 0 & 0 & 1 \end{bmatrix}.$$

If a 3D point $\begin{bmatrix} X \\ Y \\ Z \end{bmatrix}$ is located in camera coordinate system (CCS), which has its z-axis overlapping with the optical axis and x and y axes overlapping with u- and v- axes of the image plane. Then the point projects itself to an image point (u, v) can be characterized as,

$$\begin{bmatrix} u \\ v \\ 1 \end{bmatrix} = \lambda K \begin{bmatrix} X \\ Y \\ Z \end{bmatrix},$$

where λ is a constant. If the point is located in an arbitrary Euclidean coordinate system which is related to CCS by rotation matrix R and translation t, then

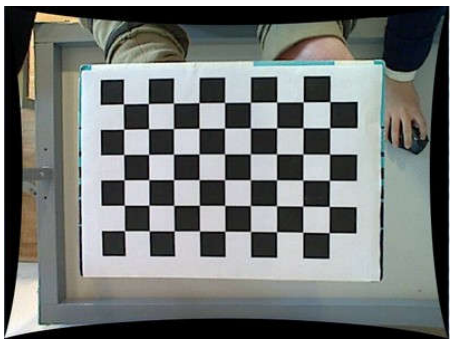
$$\begin{bmatrix} u \\ v \\ 1 \end{bmatrix} = \lambda K \left(R \begin{bmatrix} X \\ Y \\ Z \end{bmatrix} + t \right).$$

This process is called perspective projection, a.k.a. pinhole model, in computer vision. It is clear that intrinsic parameter matrix K is the crucial parameter matrix. Unfortunately, camera manufacturer does not provide this matrix and it has to be obtained from camera calibration. In this homework, you need to learn how to use camera calibration tools to calibration a camera of yours (e.g. your cellphone camera). Please do NOT use any cameras with vari-focus lens (i.e. those that can zoom in and out) because they do not have constant parameters.

The reference document that I would recommend you to read,
https://www.docs.opencv.org/3.2.0/d4/d94/tutorial_camera_calibration.html

The homework requirements are,

1) Please install and run OpenCV.
2) Read the instructions in the reference document.
3) Print a checkboard pattern and put it on a cardboard or any hard planar surface.
4) Calibrate your camera.



Please write a report that includes,

1) Your distortion coefficients (10pt) and K matrix (10pt). You may use the xml file generated by opencv but please readout the output. Also, let us know what camera that you have used in testing. If it is a phone or tablet mounted camera, please provide model and manufacturer of the device.

2) Please include an intermediate result image like the one below
   https://www.docs.opencv.org/3.2.0/fileListImage.jpg
   It should include the checkboard pattern that you used and the detected corners like the example. (40pt)

3) Please also include images about distortion removal effects by providing images before and after distortion removal. (40pt)