Spring 2023 **CSCE 867: Computer Vision**

Project #1

Due time: 11:59pm EST, Sunday, Feb 19th, 2023

Part 1: **Camera calibration using linear method (50pts)**

- Implement the conventional camera calibration method introduced in class – estimating camera parameters from the projection matrix using 2D-3D correspondence using a programming language you choose, e.g., C++ or Matlab.
- Perform experiments on a given data set and estimate the calibration performance in terms of projection error. You should use part of the data for calibration - training, and the remaining data for error analysis - testing. The projection error can be defined as

$$\varepsilon = \frac{1}{N}\sum_{i=1}^{N} \|\mathbf{m}_i - \widehat{\mathbf{m}_i}\|$$

  where N is the number of points for error analysis. $\mathbf{m}_i$ is the ground truth (given) 2D image point and $\widehat{\mathbf{m}_i}$ is the estimated 2D image point by projection. $\|\mathbf{m}_i - \widehat{\mathbf{m}_i}\|$ is the L2 norm between the ground truth point and the estimated point.

Part 2: Robust camera calibration (50pts)

As introduced in class, we can use the RANSAC method when there are outliers in the data.

- Implement the RANSAC method and perform experiments on the given data set and estimate the calibration performance in terms of projection error.
- You can assume the whole data set may contain up to 20% outliers.

Bonus question: (10 pts)

We have shown in class that the projection matrix can be estimated as a solution to $\mathbf{Av} = 0$. When rank($\mathbf{A}$) = 11, $\mathbf{v}$ can be estimated by performing SVD on $\mathbf{A} = \mathbf{UDV}^{\mathrm{T}}$. Prove that $\mathbf{v}$ is the last column of the $\mathbf{V}$ matrix with an unknown scalar.

Requirement: you need to submit your project as **a SINGLE zipped file named as Lastname-Firstname-Proj1** through Blackboard including

1. A written project report includes a brief introduction on the addressed problem, a succinct description on the methods you implemented with the major steps, the experimental results and analysis, conclusion, and reference.

   Note: the experimental results must include

   - The experimental setting, e.g., the number of points used for calibration, the number of points used for calculating the projection error, and the number of iterations used in RANSAC
   - The estimated camera parameters
   - The calibration performance in terms of projection error

   For analysis, you may consider what happen if you change the experimental settings.

2. Code with appropriate comments.

Your report must be well organized and be easy to follow. There should be no spelling and grammar errors!