CS395T: Numerical Optimization for Graphics and AI: Homework III

1 Guideline

- Please complete **2** problems out of **4** problems, and please complete at least one problem in the theory session.
- You are welcome to complete more problems.

2 Programming

Problem 1. In problem 1 of Homework 2, you were asked to implement a calibration method. This problem asks you to perform bundle adjustment to refine the intrinsic camera parameters:

$$\min_{K,R,\boldsymbol{t}} \sum_{i=1}^{N} \|\boldsymbol{x}_i, K(R,\boldsymbol{t})X_i\|^2, \tag{1}$$

where $(\boldsymbol{x}_i, \boldsymbol{X}_i)$ are corresponding 2D and 3D pairs. K denotes the intrinsic camera parameters. R and $\boldsymbol{t}$ are extrinsic camera parameters. It is expected that you use the initialization method you developed for problem 1 of Homework 2. The data can be downloaded from: `www.cs.utexas.edu/~huangqx/CS395T_HomeworkII_data.zip`.

- **Extra credit: please consider using a robust norm instead of the L2-norm.**

Problem 2. Again for the camera calibration problem, please compare different optimization techniques such as linear search methods (Gradient descent, Newton, Gauss-Newton, LM-Regularization) and trust-region methods (Cauchy-Point and Full Trust-Region).

3 Theory

Problem 3. Please compare line-search methods and trust-region methods from the following perspectives

- Efficiency.
- Global convergence.
- Applications in 3D Vision (Pick one application and discuss).

Problem 4. Derive necessary and sufficient conditions for $\boldsymbol{p}^\star$ being an optimal solution to the following optimization problem:

$$\begin{aligned} \underset{\boldsymbol{p}}{\text{minimize}} \quad & \boldsymbol{g}^T\boldsymbol{p} + \frac{1}{2}\boldsymbol{p}^T B\boldsymbol{p} \\ \text{subject to} \quad & \boldsymbol{p}^T A\boldsymbol{p} \leq d^2, \end{aligned} \tag{2}$$

where B is symmetric and A is positive definite.