Lab 4 introduction

General reminders

- Please be aware that you and your lab partner both need to join a lab group for every single lab.Otherwise the grade only gets assigned to the student who uploaded the lab.
- If you are working alone then you do not have to join a group, but we recommend that you do, as any comment you leave is going to be invisible to us from our main grading UI if you are not in a group.
- Ask questions in the discussion forum instead of individual emails to helps other to benefit from yourquestions. Can be done anonymously.

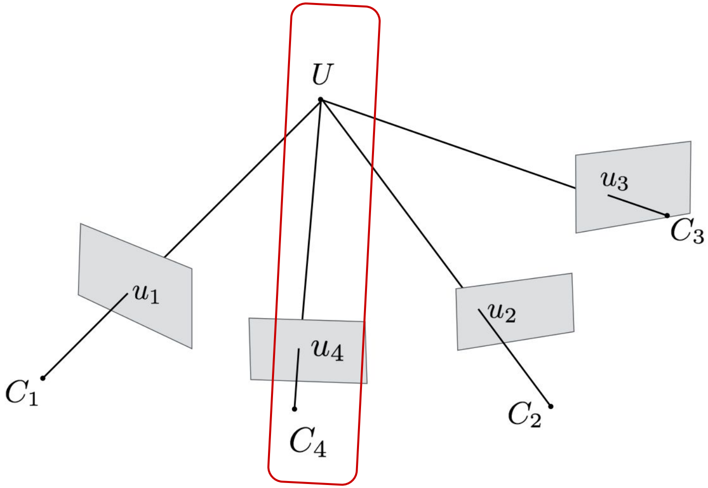
Study points

- From 2D-2D image correspondence to 2D image-3D point correspondence

2D-2D image corr.	2D-2D image corr.+camera matrix P
Affine transformation estimation	3D point estimation
estimated_affine()	minimal_triangulation()
residual_lgths()	reprojection_error()
ransac_fit_affine()	ransac_triangulation()
ransac_fit_affine_ls()	Least squares triangulation *Don’t forget that points with negative depth should be outliers
	compute_residuals()
	compute_jacobian()
	refine_triangulation()

Ransac Triangulation

- Given: projection matrices P and 2D image points u
  - Insides RANSAC loop
    - Triangulate point using **minimal solver**
    - Determine inliers based on reprojection error
  - Refine point position by minimizing sum of squared errors.
  - **minimal_triangulation()**
    - One 2D-2D correspondence ~> 6 equations with 5 unknown parameters
      - How?
      - Hint: See lecture notes page 97



$$\lambda \mathbf{x} = \mathrm{P}\mathbf{X} \quad \Leftrightarrow \quad \begin{pmatrix} \lambda x \\ \lambda y \\ \lambda \end{pmatrix} = \begin{pmatrix} \mathbf{P}_1 \\ \mathbf{P}_2 \\ \mathbf{P}_3 \end{pmatrix} \mathbf{X}$$

Reprojection error

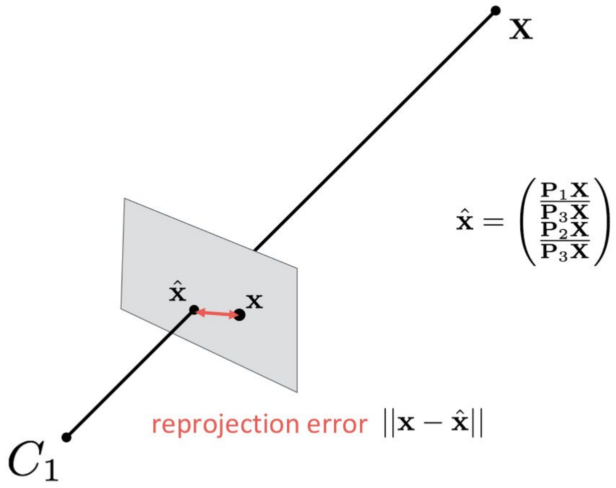
- compute_residuals() ~>2*N

$$\lambda \hat{u} = \lambda \begin{pmatrix} \hat{x} \\ \hat{y} \\ 1 \end{pmatrix} = P\hat{U} = \begin{pmatrix} a^T\hat{U} \\ b^T\hat{U} \\ c^T\hat{U} \end{pmatrix} \quad \text{with} \quad \lambda > 0$$

$$\lambda = c^T\hat{U}, \quad \hat{x} = \frac{a^T\hat{U}}{c^T\hat{U}} \quad \text{and} \quad \hat{y} = \frac{b^T\hat{U}}{c^T\hat{U}}, \quad \text{if} \quad c^T\hat{U} > 0$$

$$\boxed{r(\theta) = \begin{pmatrix} \hat{x} \\ \hat{y} \end{pmatrix} - \begin{pmatrix} x \\ y \end{pmatrix}, \quad \text{if} \quad c^T\hat{U} > 0.}$$

- reprojection_error() ~>N
    - The norm of the residual is reprojection error.
- See lecture notes page 98 for more details.



Refine triangulation

- After performing Ransac and removing the outliers.
  - How to use the remaining inlier measurements?
- Gauss-Newton algorithm
  - compute_residual()
  - compute_jacobian()
    - For loop is needed to construct J for different number of image points.
  - See lecture notes page 99 for more details.

$$\bar{r}(\theta) = \begin{pmatrix} \boxed{\begin{matrix} r_{1,x}(\theta) \\ r_{1,y}(\theta) \end{matrix}} \\ r_{2,x}(\theta) \\ r_{2,y}(\theta) \\ \vdots \end{pmatrix}$$

$$J = \begin{pmatrix} \frac{\partial r_{1,x}}{\partial \theta_1} & \frac{\partial r_{1,x}}{\partial \theta_2} & \cdots \\ \frac{\partial r_{1,y}}{\partial \theta_1} & \frac{\partial r_{1,y}}{\partial \theta_2} & \cdots \\ \frac{\partial r_{2,x}}{\partial \theta_1} & \frac{\partial r_{2,x}}{\partial \theta_2} & \cdots \\ \vdots & \vdots & \ddots \end{pmatrix}.$$