# Bundle Adjustment Numerical — Revise part-1

(1) 3-DoF 6-DoF camera (pos$^n$ and orientation)

Least squares approach to estimating camera pose and 3D points.

Reprojection error

projection parameters

distortion.

$$a x'_{ij} + a\hat{V} x'_{ij} = \lambda_{ij}\ a\hat{P}_j(x_{ij}, P, 2)\ X_i$$

$a x'_{ij}$: point $i$ is observed in image $j$; $\lambda_{ij}$: connection; $X_i$: 3D point.

$i = 1 \ldots \bar{i}_j$; $j = 1, \ldots J$

$\bar{i}_j$ # points in image $j$; $J$ # images.

## Unknowns

3D location

1D scale factor

6D exterior orientation

5D projection parameters (interior o)

non-linear distortion parameter $\zeta$.

## Eliminating the scale factors

13M unknowns to 1M unknowns

## setting up and solving the system of normal equations.

with unknowns $x$ and observations $l$

Set up normal equations.

$$A^T \Sigma^{-1} A \underline{\Delta x} = A^T \Sigma^{-1} \underline{\Delta l}$$

$\underline{\Delta x}$: unknowns; $\underline{\Delta l}$: observations.

This provides the estimate.

$$\underline{\hat{\Delta x}} = (A^T \Sigma^{-1} A)^{-1} A^T \Sigma^{-1} \underline{\Delta l}$$