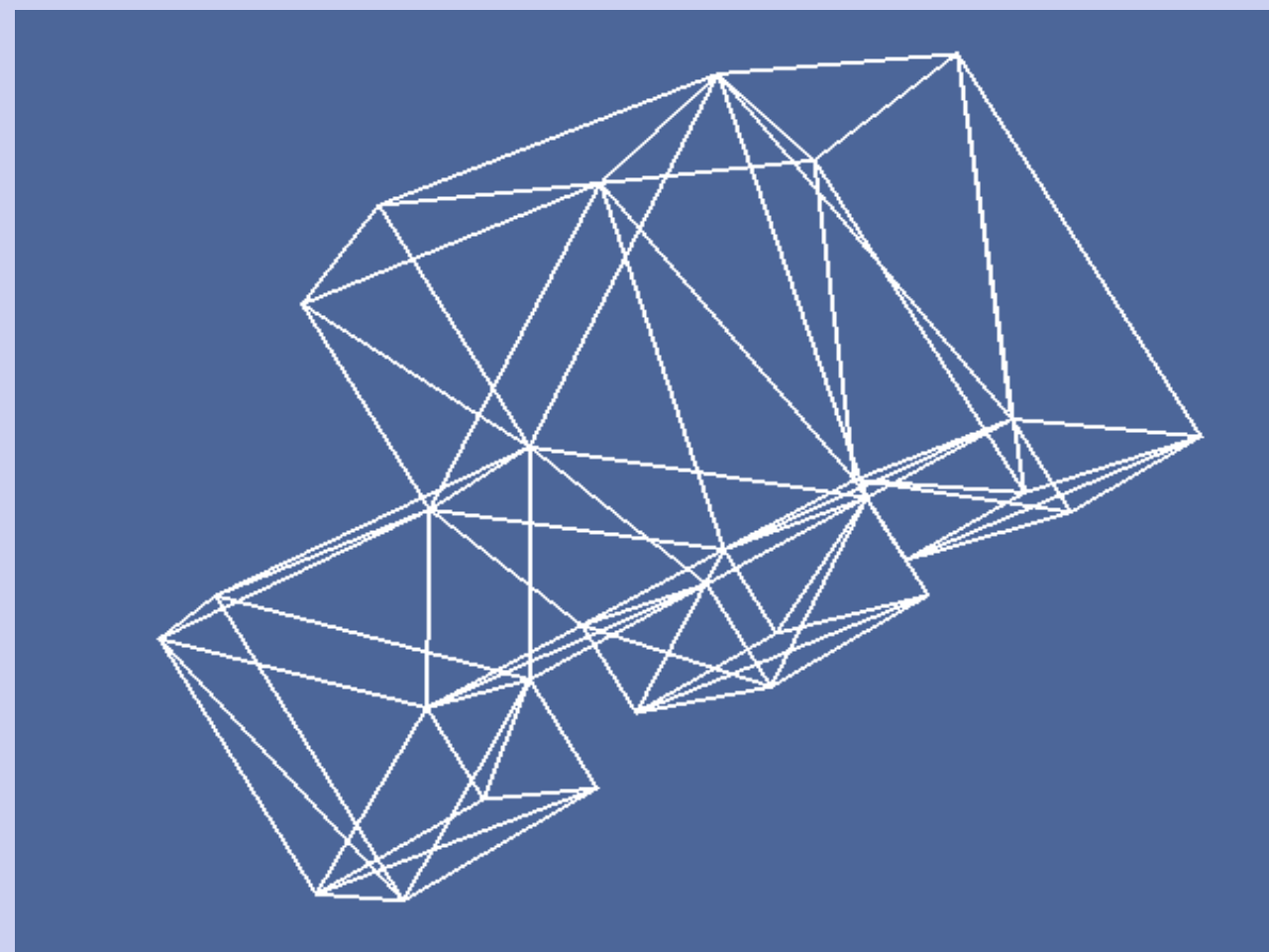
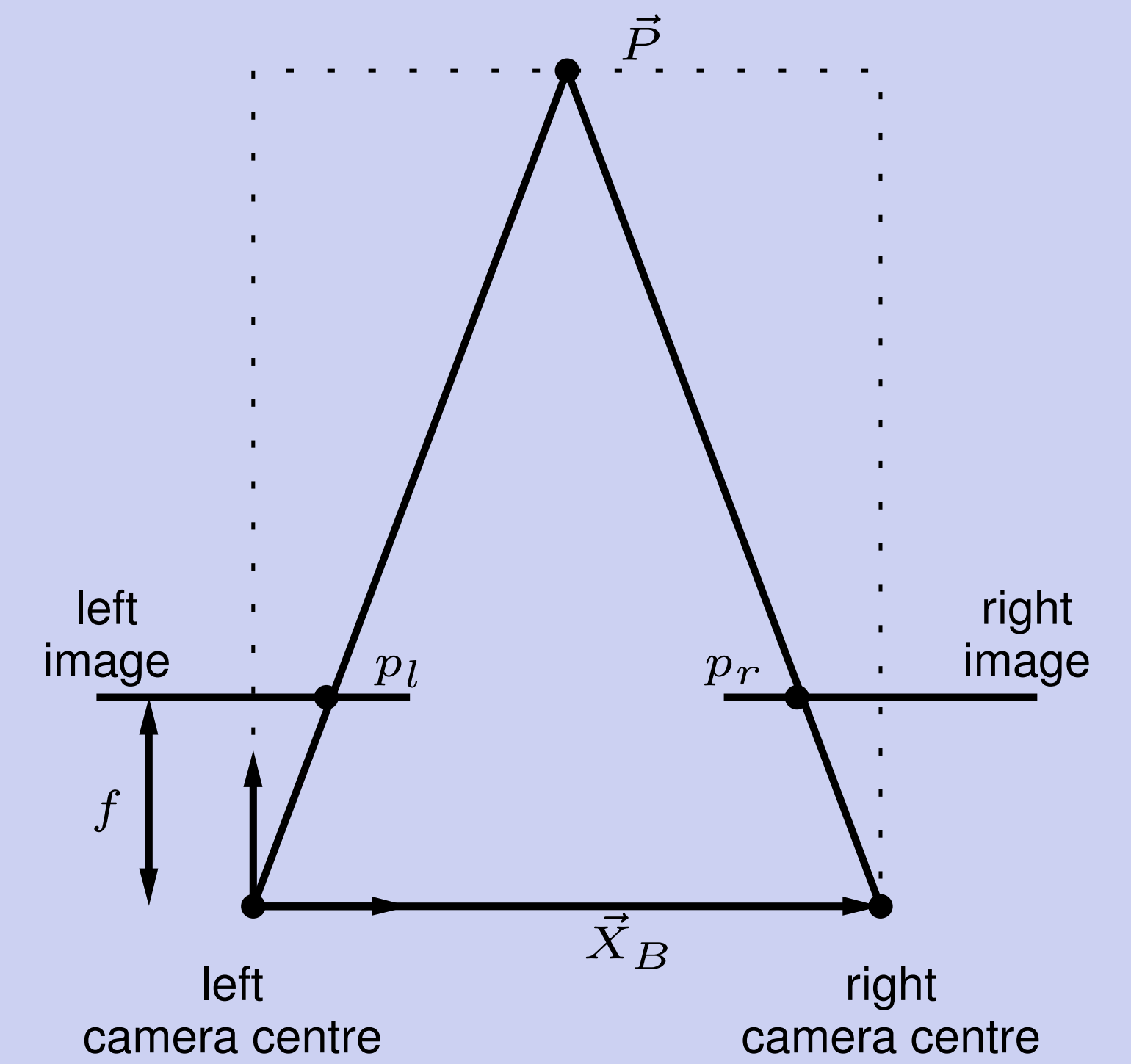


EXTRINSIC CALIBRATION OF A STEREO CAMERA SYSTEM USING A 3D CAD MODEL CONSIDERING THE UNCERTAINTIES OF ESTIMATED FEATURE POINTS

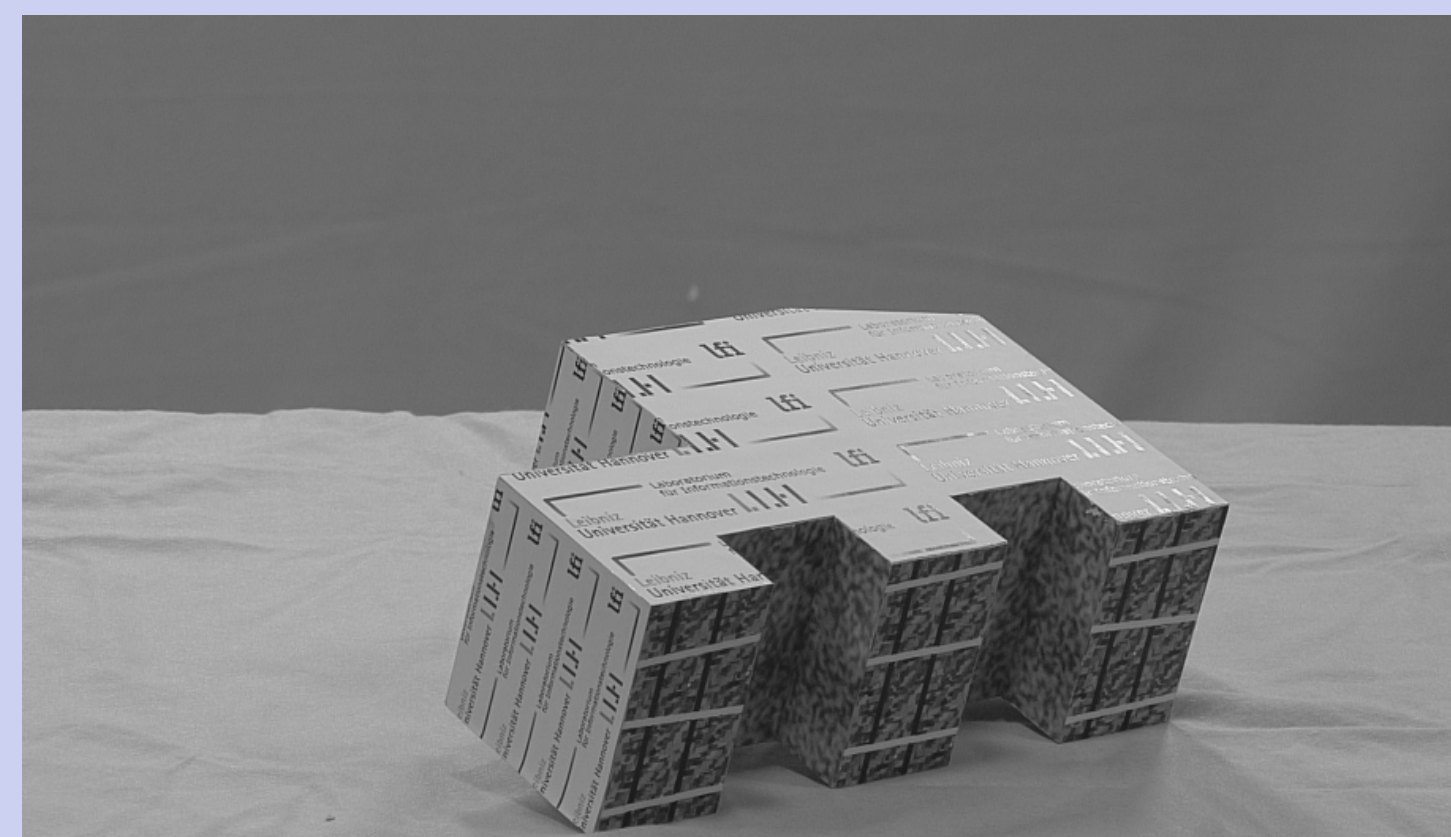
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System Overview

- ▶ Object coordinate system: describes object surface \mathcal{S}
Surface \mathcal{S} given by CAD model
- ▶ Camera coordinate system: describes 3D points \vec{P}_i
 \vec{P}_i obtained by triangulating corresponding feature points in the images
- ▶ Calibration $T_{calib} : \vec{P}_i \mapsto \mathcal{S}$
 $T_{calib} : \vec{P}'_i = \mathbf{R} \cdot \vec{P}_i + \vec{C}$, $P'_i \in \mathcal{S}$
Minimize robust cost function: $\sum_i d_r(\vec{P}'_i, \vec{P}_i) \rightarrow \min$
- ▶ Goal: increase accuracy of state-of-the-art techniques



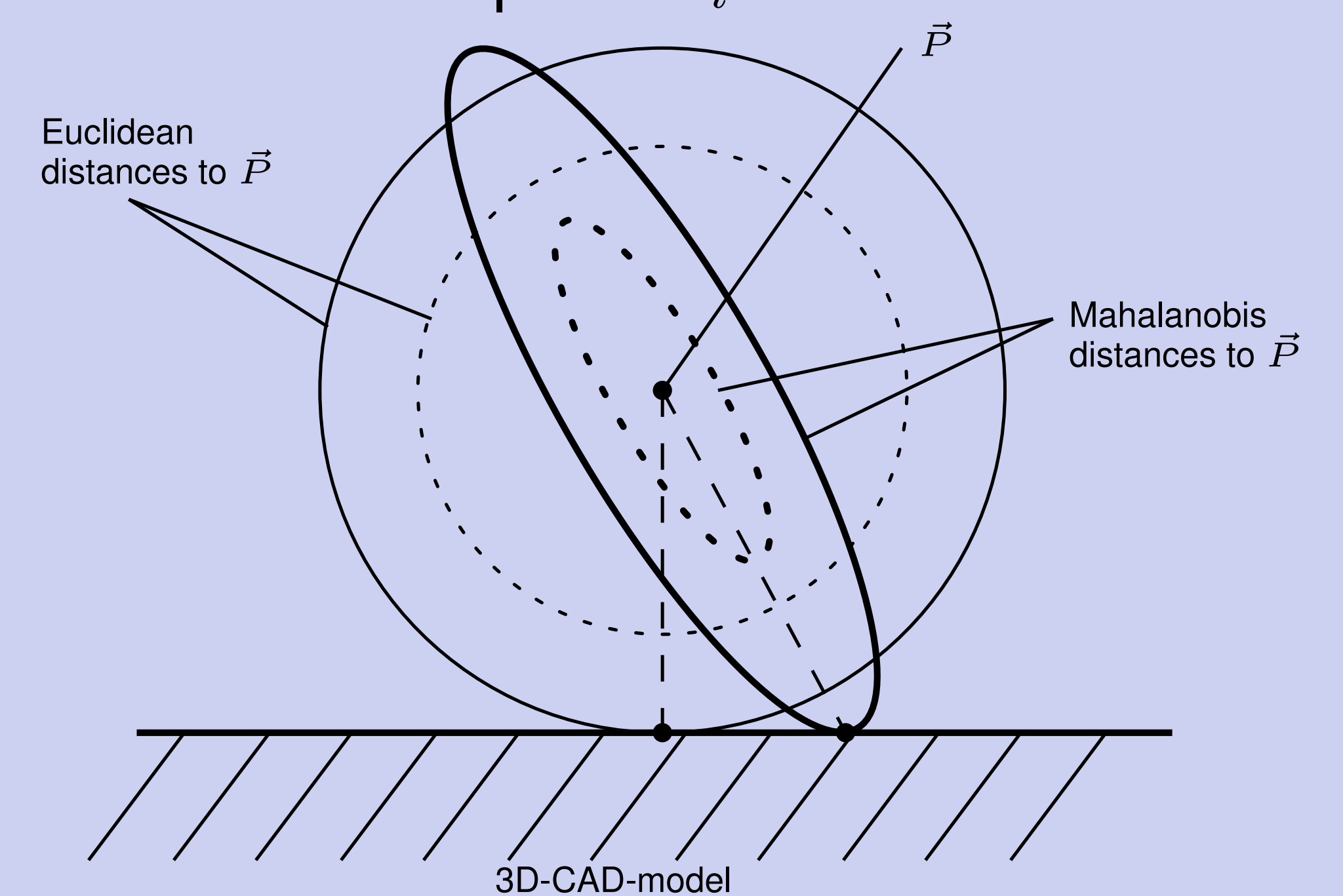
CAD model of calibration object



Left and right image of stereo camera, $|\vec{X}_B| = 250.33 \text{ mm}$

Contributions

- ▶ Use Gaussian approximation of image gradients for the localization of a feature point instead of a parabolic function
Eliminate systematic error (0.025 pel) in parabolic subpel interpolation
- ▶ Use uncertainty of an image feature to calculate the accuracy of the triangulated 3D feature point \vec{P}_i
Mahalanobis distances
- ▶ Two-stage Differential Evolution for global optimization
Stage 1: Euclidean distances d_e
Stage 2: Robust Mahalanobis distances d_m



Results

- ▶ Evaluate error variance of 1000 stereo image pairs $\Rightarrow \sigma^2$ of 1000 calibrations
- ▶ Combine translational / rotational values to get error variance σ_{max}^2
 - ▶ Scheme [A]: Robust Estimation (RE)
 - ▶ Scheme [B]: RE + Gaussian Approximation (GA)
 - ▶ Scheme [C]: RE + GA + Feature Uncertainties
 \Rightarrow Error variance σ_{max}^2 decreases by a factor of 80

