Self-Calibration from Constraints on Essential Matrices

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The Essential Matrix

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- Related to the Fundamenta Matrix via intrinsic parameters:

$$\mathbf{E} = \mathbf{K}_2^{\mathrm{T}} \mathbf{F} \mathbf{K}_1$$

- Provides the camera motion:

$$\mathbf{E} = [\mathbf{t}]_\times \mathbf{R}$$

Self-Calibration

- The Huang-Faugeras constraints:

$$\sigma_1(\mathbf{E}) = \sigma_2(\mathbf{E}), \sigma_3(\mathbf{E}) = 0$$

Matrix	dof	constraints
$\mathbf{F}$	7	$\det(\mathbf{F}) = 0,$ unknown scale
$\mathbf{E}$	5	$\det(\mathbf{E}) = 0,$ unknown scale, equal singular values

Algorithm

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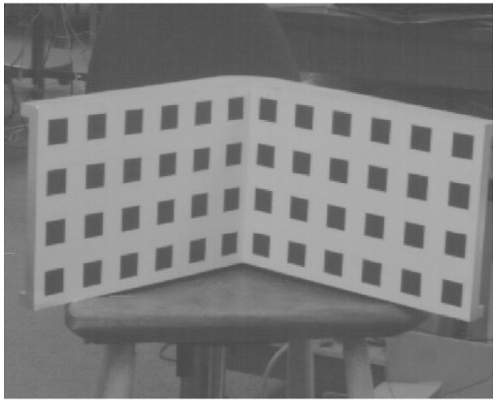
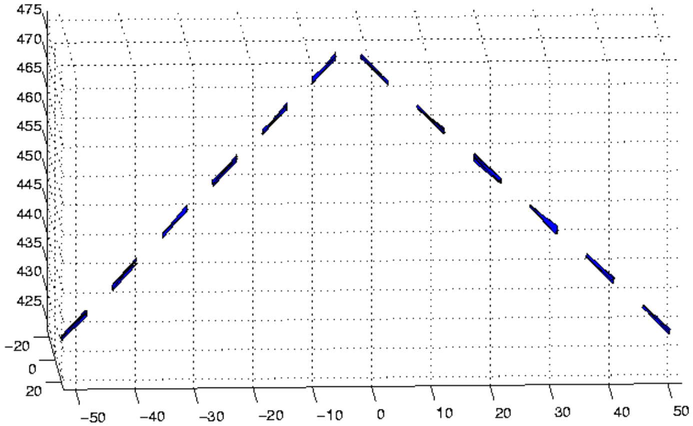
1. Compute Fundamental Matrices;
2. Initialise intrinsic parameters: $\mathbf{K}_i = \begin{bmatrix} \alpha_{u,i} & s_i & u_{0,i} \\ 0 & \alpha_{v,i} & v_{0,i} \\ 0 & 0 & 1 \end{bmatrix}$;
3. Compute ${}^{1,2,3}\sigma_{i,j}(\mathbf{K}_j^{\mathrm{T}}\mathbf{F}\mathbf{K}_i)$;
4. Minimise

$$C(\mathbf{K}_i, i = 1,2,3,\ldots,n) = \sum_{j=1}^{n-1} \sum_{k=j+1}^{n} \frac{{}^1\sigma_{j,k} - {}^2\sigma_{j,k}}{{}^1\sigma_{j,k}}.$$

Experimental Results

- Reconstruction of calibration grid:





The angle between the reconstructed planes is 89.7º.

Self-calibration experiments

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Experimental Results

- Outdoor sequence: