Projective Reconstruction from Line Correspondences in Multiple Uncalibrated Images

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Features of the Reconstruction Using Line Correspondences

- Can Deal with Occlusion
Features of the Reconstruction Using Line Correspondences

• Better Representation
(Point-based) Factorization Method

- Minimizing the sum of 2D reprojection errors
Line Reconstruction

Geometrical Interpretation

• The Reconstruction Process
How to make use of Point-based system

• Representation of Lines
Estimated 3D Points

Measured line with two end points

Estimated Camera Centre

Reprojected Points
The error from point to line
The Error Measure for Line Reconstruction

\[ \varepsilon^2 = \frac{1}{2n(A)} \sum_{(i,j) \in A} \left( (l_{ij}^T \bar{x}_{i,j})^2 + (l_{ij}^T x_{i,n+j})^2 \right) \]

- \( A = \{(i,j) \mid l_{ij} \text{ with end points is observed as the } j^{th} \text{ line on the } i^{th} \text{ view}\} \).
- The two end points will satisfy
  \[ l_{ij}^T x_{ij} = l_{ij}^T x_{i,n+j} = 0 \]
- where \( n \) is the total number of lines.
Reconstruction idea for using point-based approach?

• The idea becomes we choose two points on the 3D lines and project them on 2D images. We minimize the 2D reprojected errors to lines to determine the 3D points and cameras.
What will we get using previous idea?

• Both of the end points will converge to a single point and its reprojected points will lie on all the corresponding 2D lines.
• Hence, we can’t determine the exact position of the lines
Reconstruction Algorithm

- Given
  1. Measured Line Correspondences,
  2. Two Points lying on each of the Line

- Determine
  1. Projective Camera Matrices
  2. Space Lines, in term of two points lying on the line
Reconstruction Algorithm

\[ P_i \begin{bmatrix} \lambda_1^{n_1} & \cdots & \lambda_1^{m_1} \\ \vdots & \ddots & \vdots \\ \lambda_{mn}^{n_1} & \cdots & \lambda_{mn}^{m_1} \end{bmatrix} x_i^T \begin{bmatrix} \alpha_1^{n_1} & \cdots & \alpha_1^{m_1} \\ \vdots & \ddots & \vdots \\ \alpha_{mn}^{n_1} & \cdots & \alpha_{mn}^{m_1} \end{bmatrix} = a \begin{bmatrix} f_1 \\ \vdots \\ f_n \end{bmatrix} \begin{bmatrix} c_1 \\ \vdots \\ c_n \end{bmatrix} + \begin{bmatrix} x_1^1 \\ \vdots \\ x_n^n \end{bmatrix} \]
Reconstruction Algorithm

2. Initial Values of the Re-projected Points

\[ \hat{x}^1_{ij} = x^1_{ij} = \left[ u^1_{ij}, v^1_{ij}, 1 \right]^T \]

\[ \hat{x}^2_{ij} = x^2_{ij} = \left[ u^2_{ij}, v^2_{ij}, 1 \right]^T \]
Experimental Results

Synthetic data – the Scene
Experimental Results

Synthetic data - Performance

Performance of point-based factorization line reconstruction with noisy data

RMS 2d reprojection error / pixel vs. noise level / pixel
Experimental Results

Real data – Main Building

• Input Line Correspondences
Experimental Results

Real data – Main Building

• The Reconstructed Tower in Euclidean Frame
Experimental Results

Real data – Main Building

- Re-projected Line Segments
Experimental Results

Real data – Toy House
Experimental Results

Real data – Toy House
Experimental Results

Real data – Toy House