Monocular Visual Odometry

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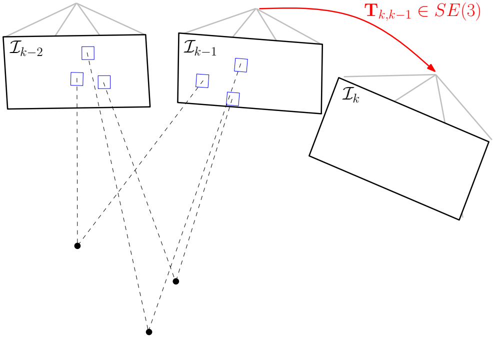
Feature-based Visual Odometry

Goal

Estimate relative pose $\mathbf{T}_{k,k-1}$ *of new frame w.r.t. previous frame.*

Pipeline

1. Feature selection
2. Feature matching
3. Pose estimation
4. Pose refinement
5. Triangulation



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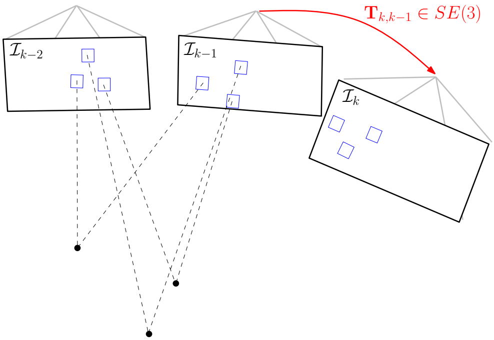
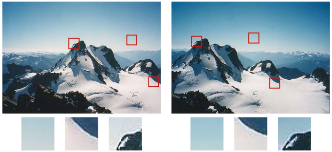


Which features?



Source: Szeliski, "Computer Vision: Algorithms and Applications", Springer 2010.

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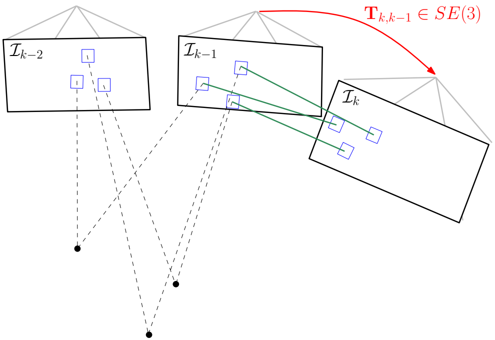
Matching Strategies

- Fast: SSD/NCC over small patch
- Robust: Match invariant feature descriptors



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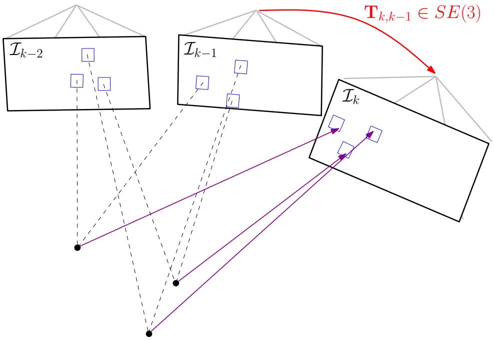

Epipolar Geometry

Three 3D point to 2D feature correspondences are necessary to estimate the 3D camera pose.

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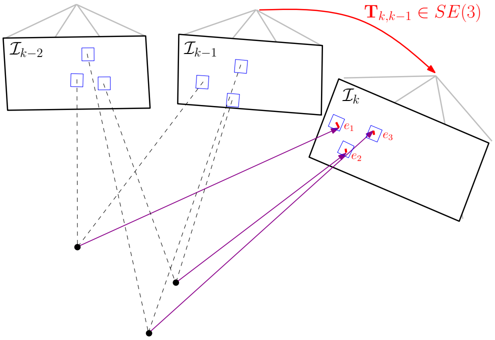

Minimize reprojection errors

$$\mathbf{T}_{k,k-1} = \arg\min_{\mathbf{T}} \frac{1}{2} \sum_i \| \mathbf{u}_i - \pi(\mathbf{T}\ _{k-1}\mathbf{p}_i) \|^2 .$$

Can be solved with Gauss Newton.

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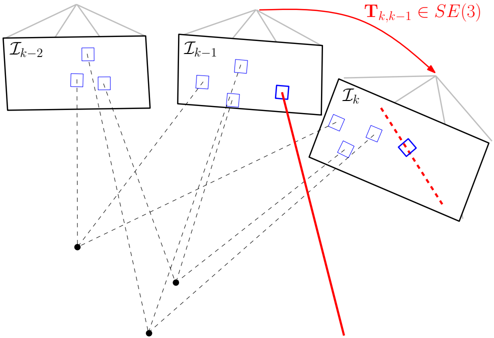

Triangulation

Search along Epipolar line for matching feature.

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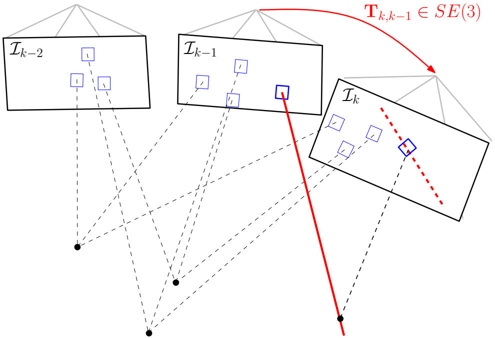

Dense Tracking

$$\mathbf{T}_{k,k-1} = \arg\min_{\mathbf{T}} \iint_{\bar{\mathcal{R}}} \rho\Big[\delta\mathcal{I}\big(\mathbf{T},\mathbf{u}\big)\Big] d\mathbf{u}.$$

$$\delta\mathcal{I}\big(\mathbf{T},\mathbf{u}\big) = \mathcal{I}_k\Big(\pi\big(\mathbf{T}\cdot\pi^{-1}(\mathbf{u}, z_{\mathbf{u}})\big)\Big) - \mathcal{I}_{k-1}(\mathbf{u}) \quad \forall\ \mathbf{u} \in \bar{\mathcal{R}},$$

- itemized item 1
- itemized item 2
- itemized item 3

Theorem

In a right triangle, the square of hypotenuse equals the sum of squares of two other sides.