DAC: Detector-Agnostic Spatial Covariances for Deep Local Features

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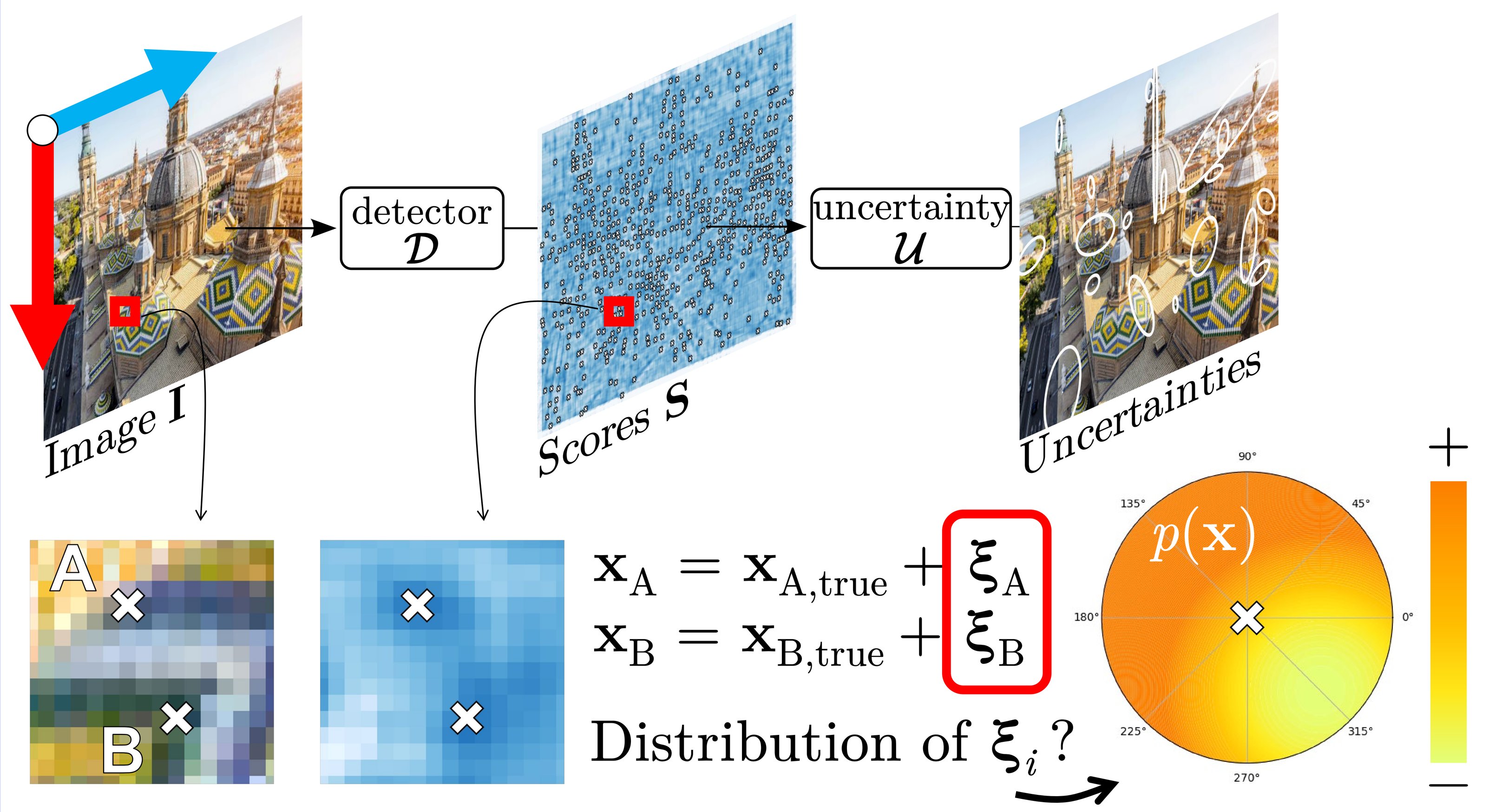
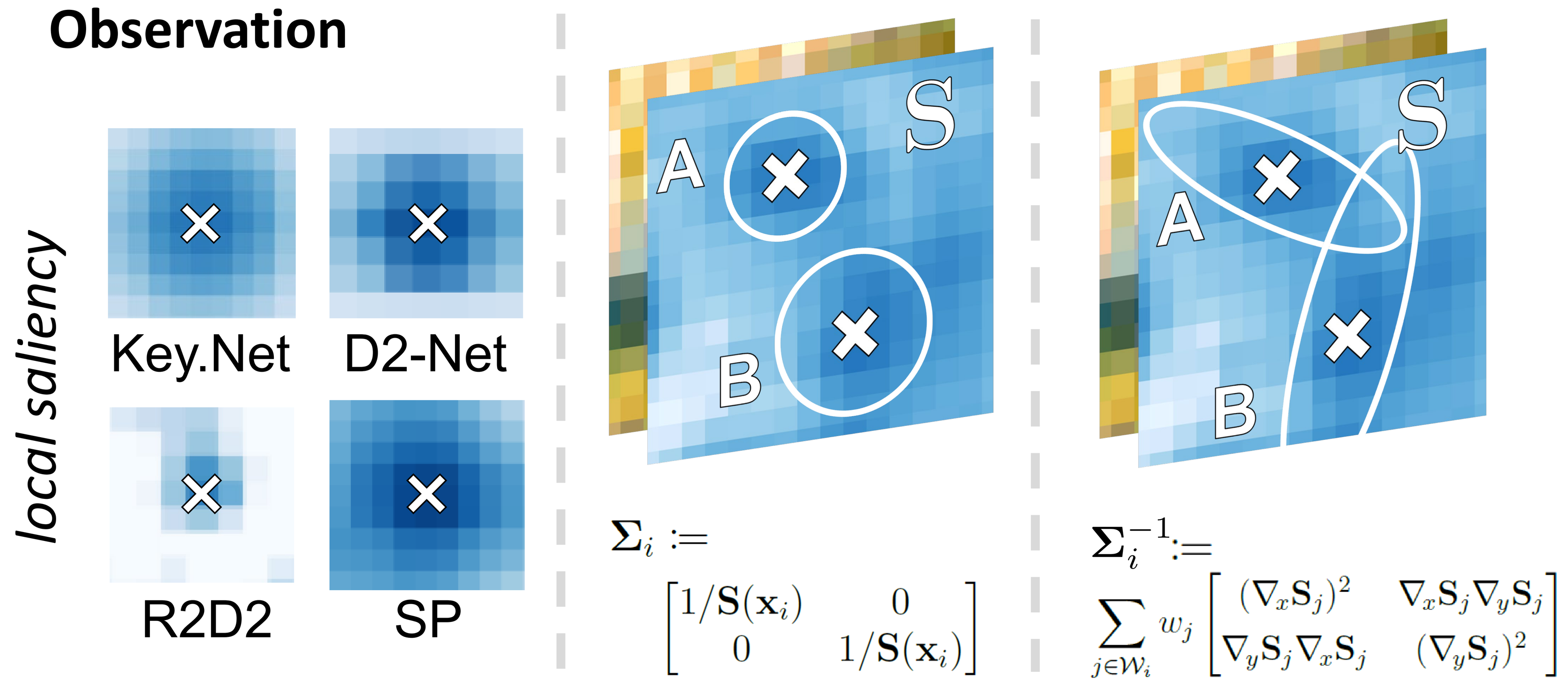
Task: Location uncertainty of deep local features



- **Detector-agnostic** uncertainty estimation
- **Applicable** to the vast majority of learned local-feature detectors

Our Proposals: Isotropic (iso) Anisotropic (full)

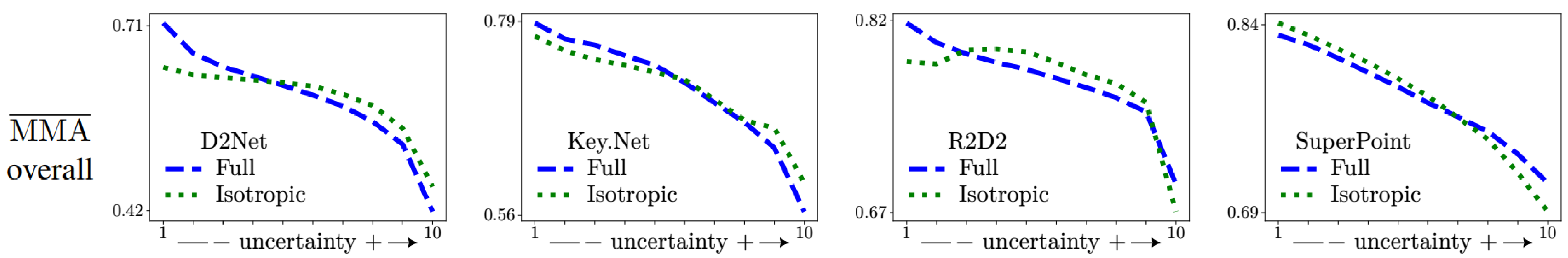


$$\Sigma_i := \begin{bmatrix} 1/S(\mathbf{x}_i) & 0 \\ 0 & 1/S(\mathbf{x}_i) \end{bmatrix}$$

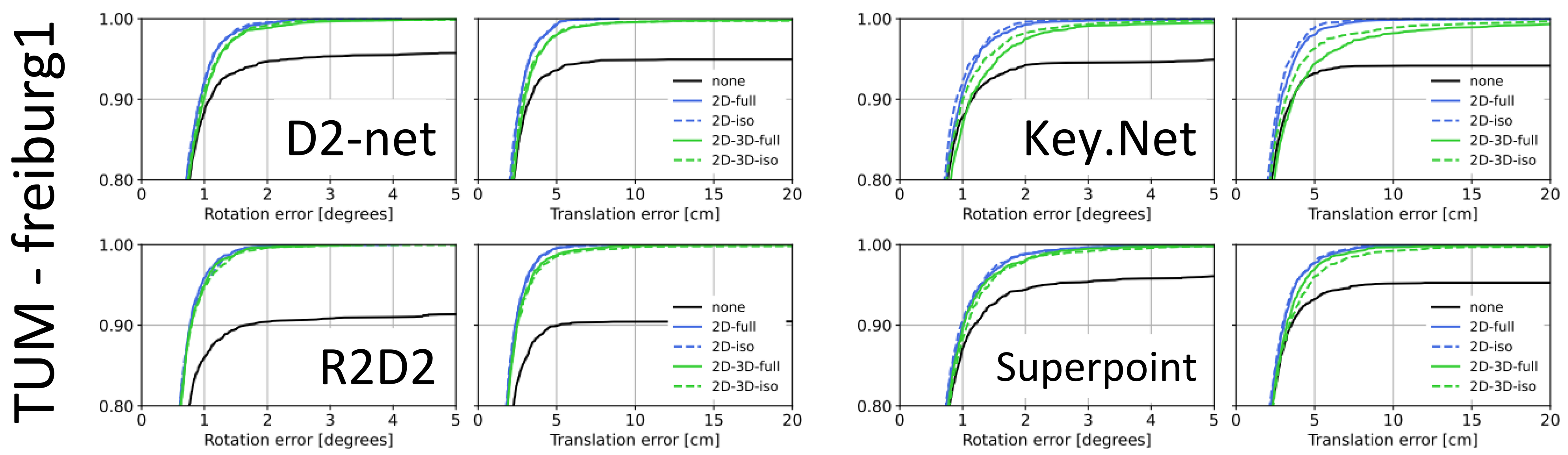
$$\Sigma_i^{-1} := \sum_{j \in \mathcal{W}_i} w_j \begin{bmatrix} (\nabla_x S_j)^2 & \nabla_x S_j \nabla_y S_j \\ \nabla_y S_j \nabla_x S_j & (\nabla_y S_j)^2 \end{bmatrix}$$

Results

Matching accuracy vs our uncertainty estimates: Lower uncertainty generally implies better matching accuracy ✓



Camera pose estimation in TUM and KITTI: Estimations become more robust when leveraging our 2D and 3D covariances ✓



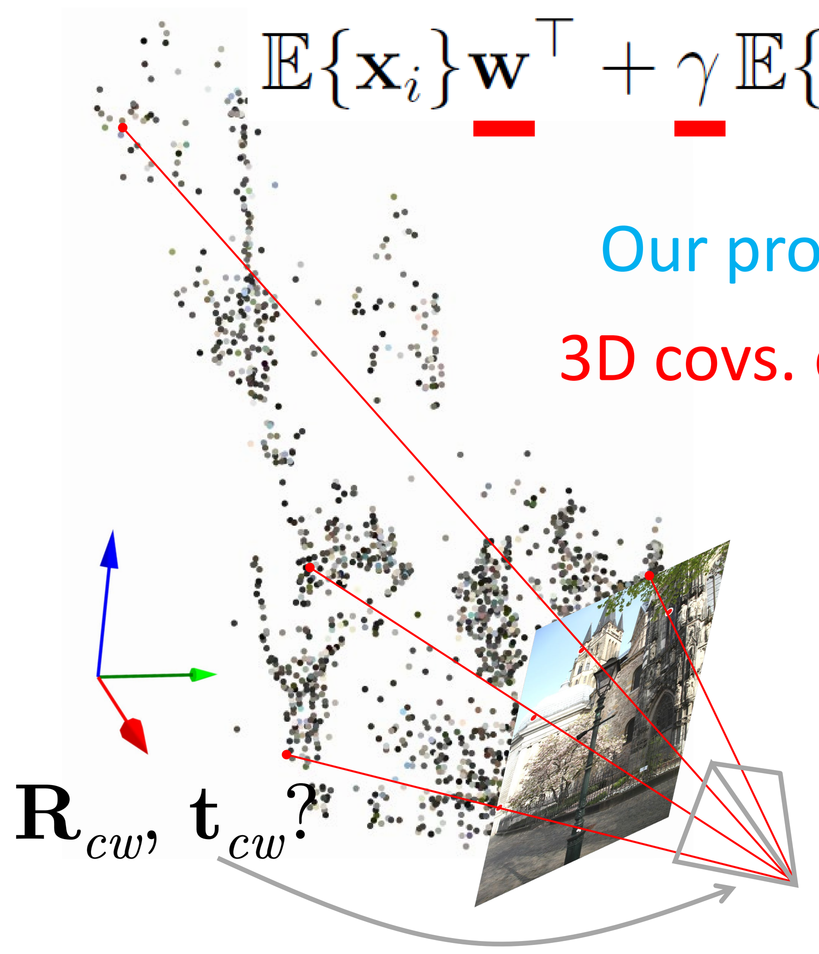
Applications

- **Perspective-n-Point (PnP) problem**

$$\Sigma_{\mathbf{r}_i} = \Lambda - \mathbf{w}\,\mathbb{E}\{\mathbf{x}_i\}^\top + \mathbb{E}\{\tilde{\mathbf{x}}_i^{(3)}\}^2 \Sigma_{\mathbf{x}_i} - \mathbb{E}\{\mathbf{x}_i\}\mathbf{w}^\top + \gamma\,\mathbb{E}\{\mathbf{x}_i\}\,\mathbb{E}\{\mathbf{x}_i\}^\top + \gamma \Sigma_{\mathbf{x}_i}$$

Our proposed 2D covariances

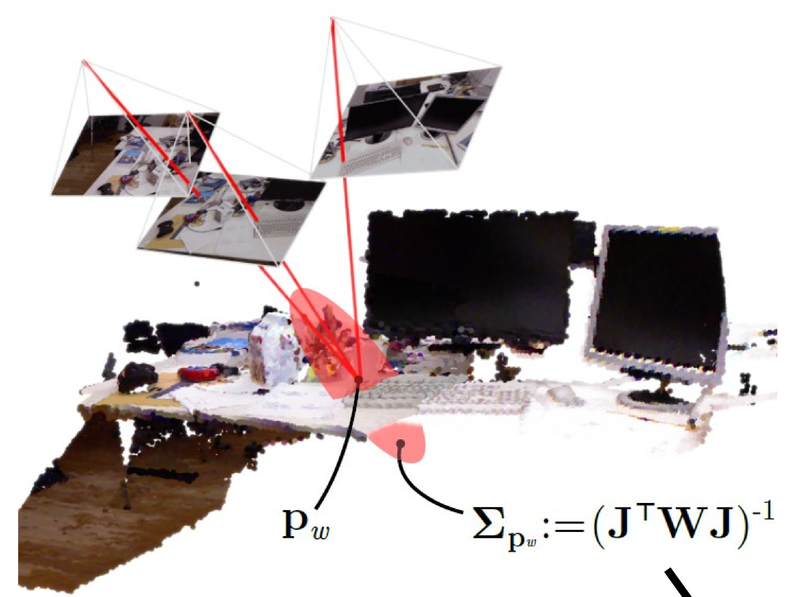
3D covs. derived from 2D covs.



Covs are used for weighing **PnP residuals**

- **Nonlinear optimizations**

$$\min \sum_j \left\| \mathbf{x}_j - \pi(\mathbf{R}_{cw}, \mathbf{t}_{cw}, \mathbf{p}_{w,j}) \right\|_{\Sigma_j}$$



Covs are used for weighing **reprojection errors.**

We optionally propagate available 3D covariances.

$$\Sigma_j := \Sigma_{\mathbf{x}_j} + \frac{\partial \pi(\mathbf{p}_{c,j})}{\partial \mathbf{p}_{c,j}} \mathbf{R}_{cw} \Sigma_{\mathbf{p}_{w,j}} \mathbf{R}_{cw}^\top \left(\frac{\partial \pi(\mathbf{p}_{c,j})}{\partial \mathbf{p}_{c,j}} \right)^\top$$