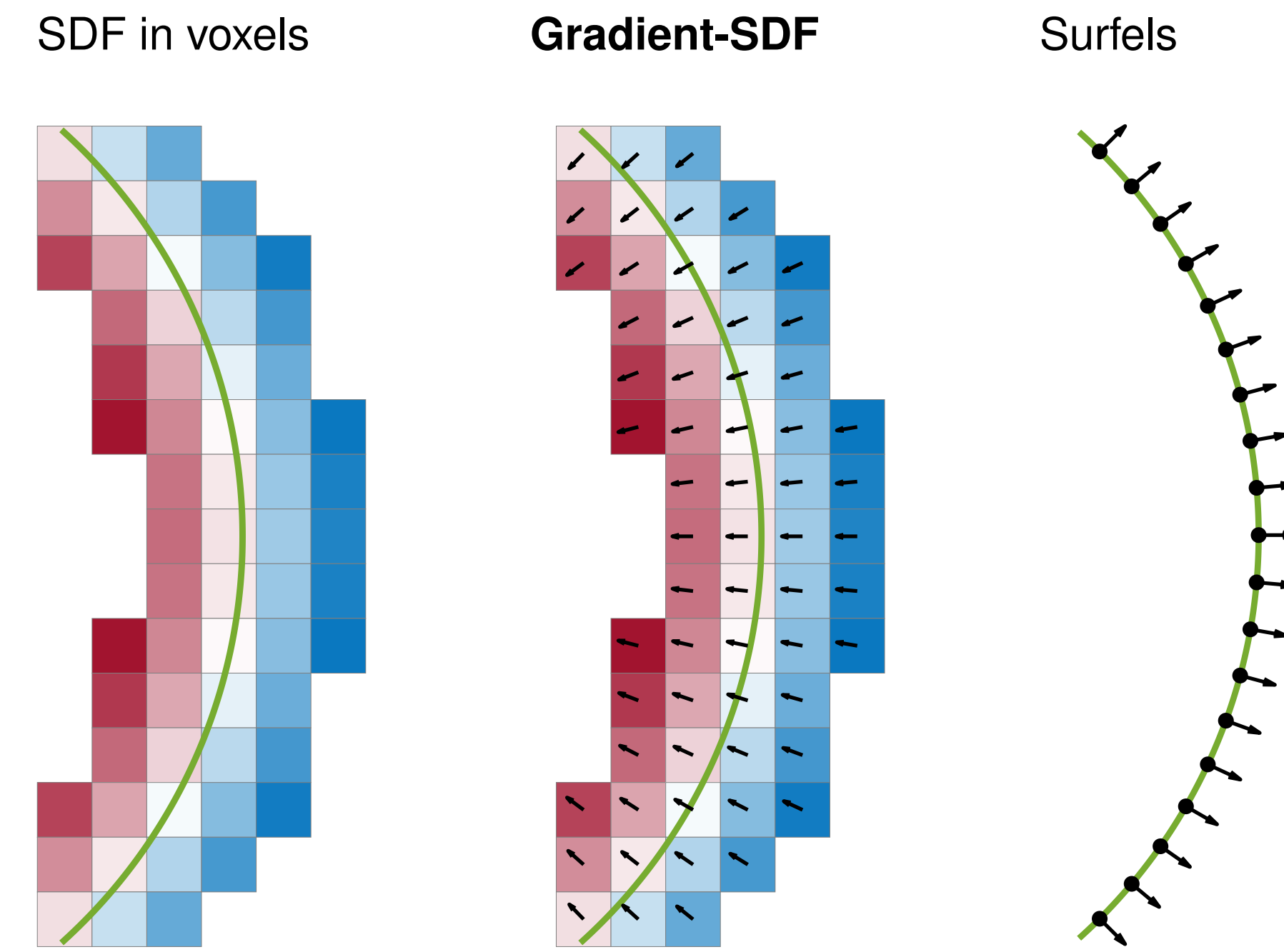


## Geometry Representations for 3D Vision



## Camera tracking using Gradient-SDF

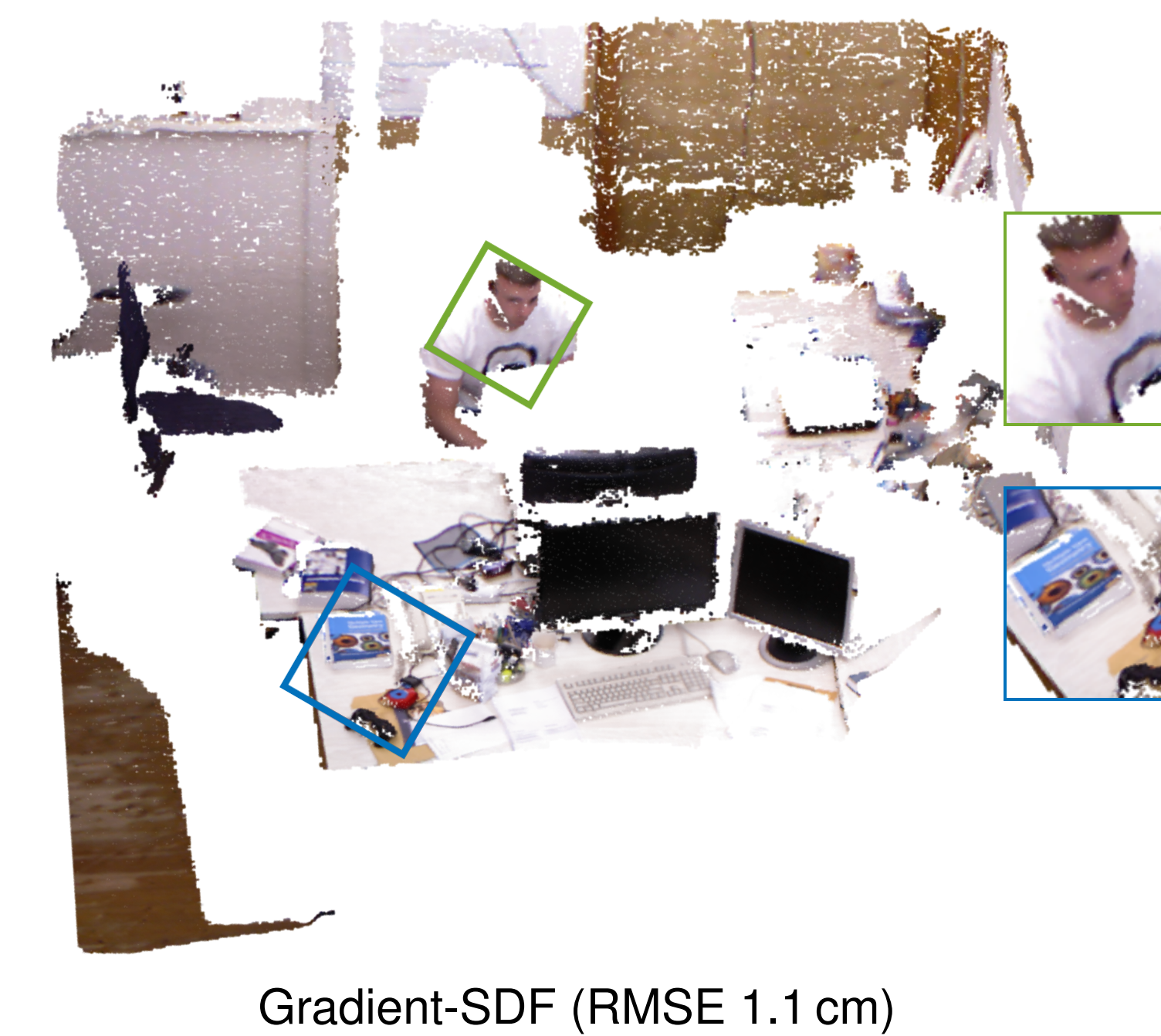
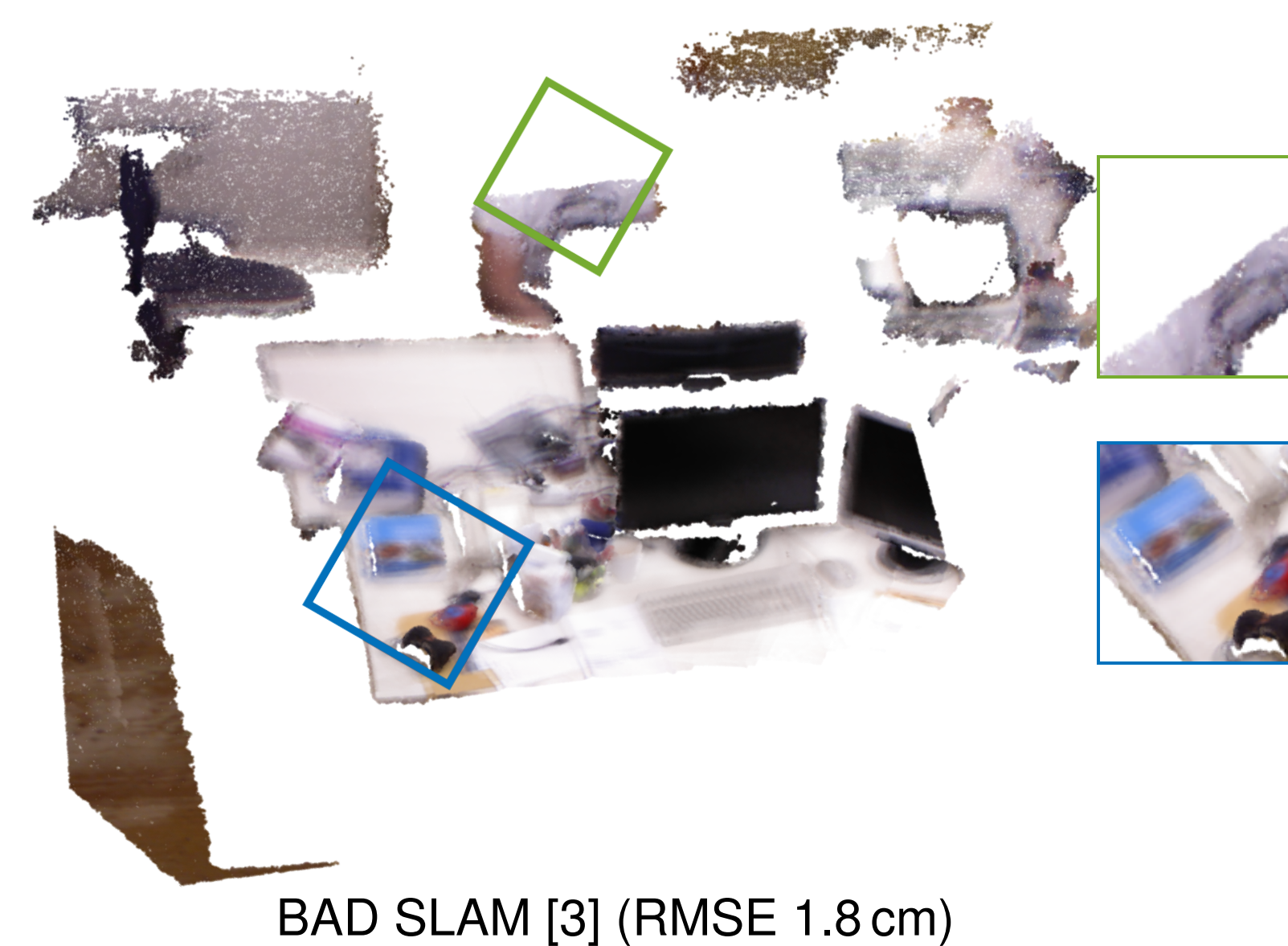
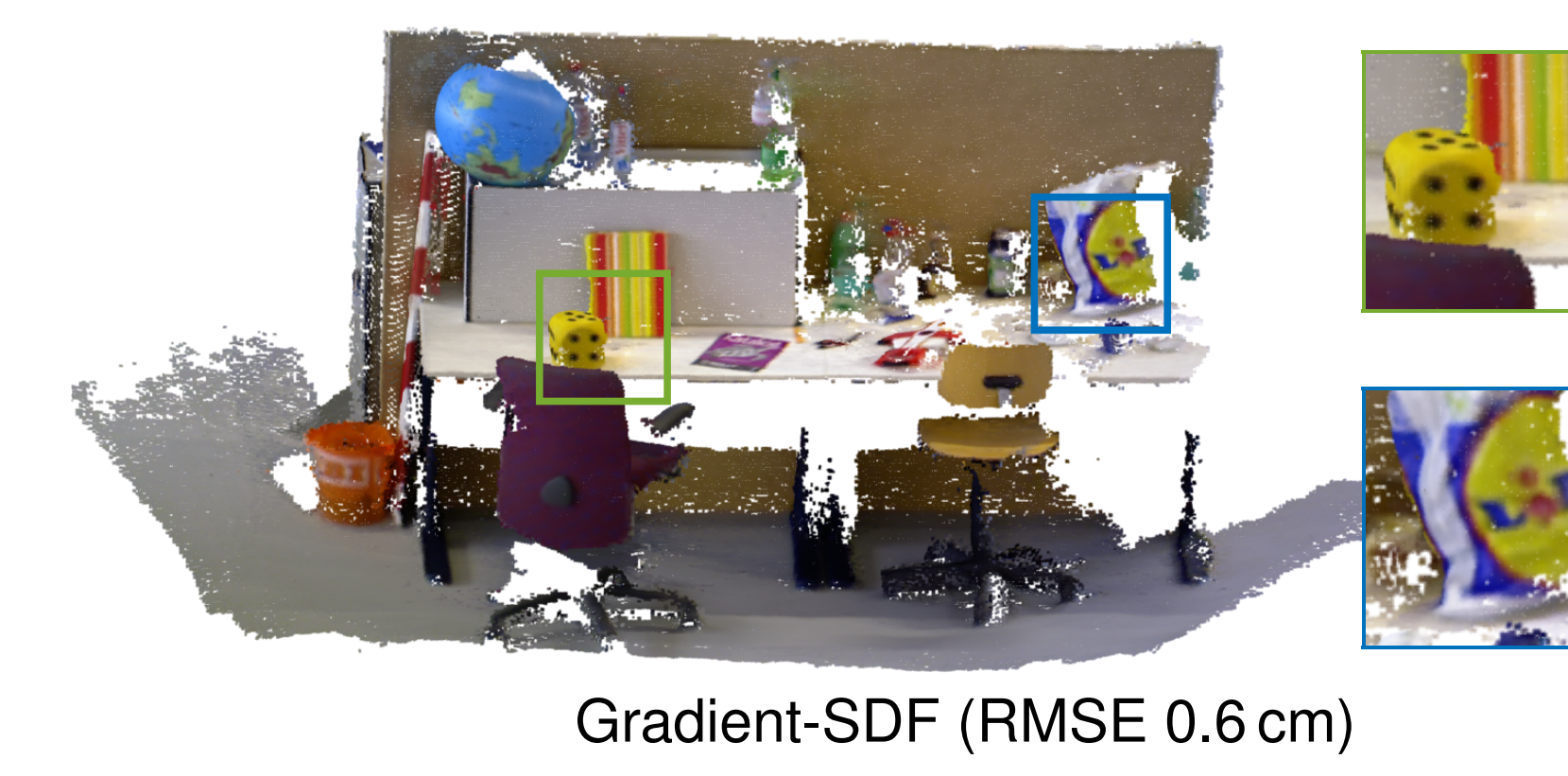
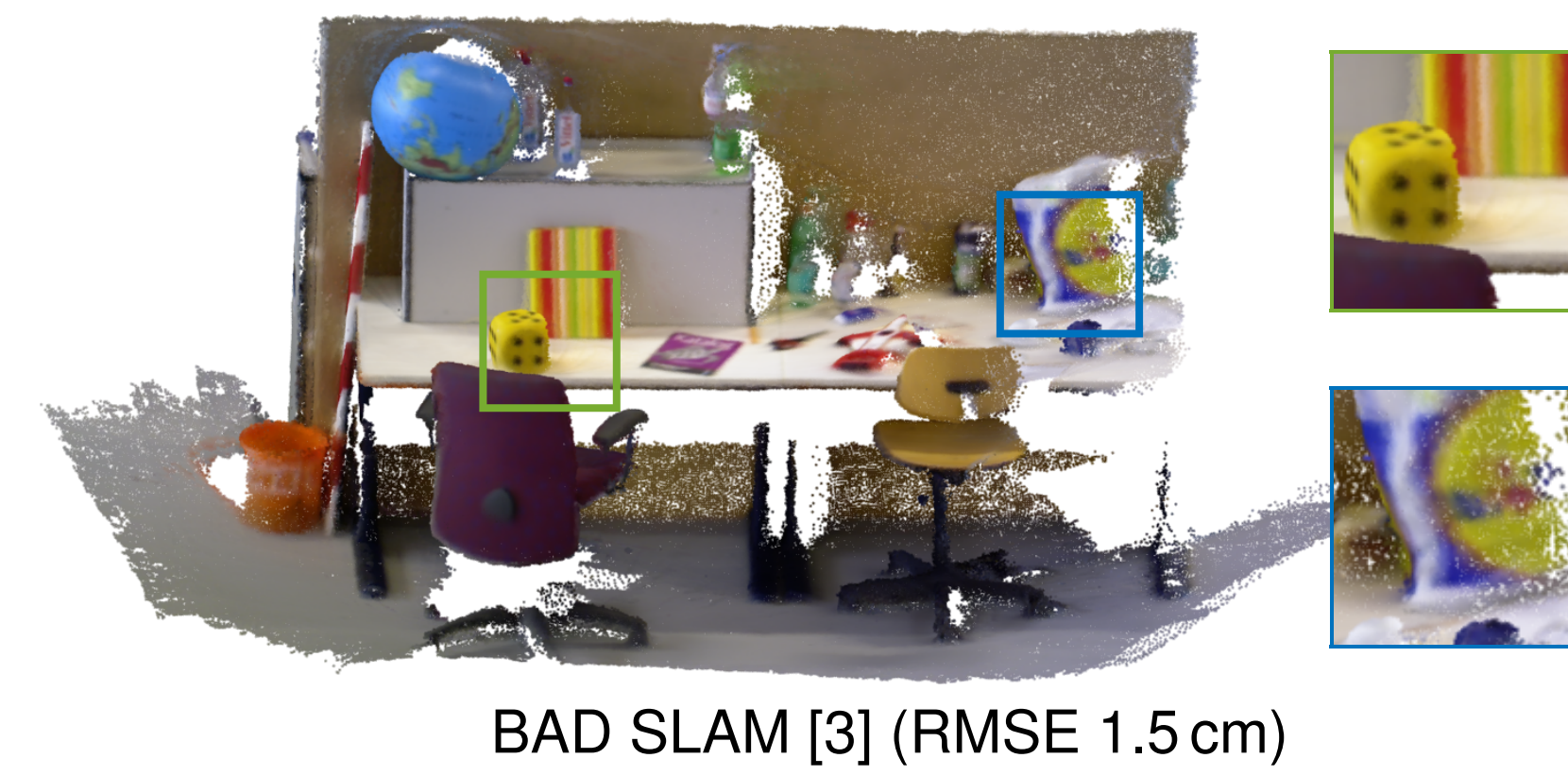
Weighted least squares energy similar to [1, 2]:

$$E(R, \mathbf{t}) = \sum_k w_k d_S(R\mathbf{p}_k + \mathbf{t})^2.$$

We approximate  $d_S$  and  $\nabla d_S$  using a first-order Taylor expansion:

$$\begin{aligned} d_S^{\text{our}}(\mathbf{p}) &= \psi_0 + (\mathbf{p} - \mathbf{v}_{j^*})^\top \hat{\mathbf{g}}_{j^*}, \\ \nabla d_S^{\text{our}}(\mathbf{p}) &= \hat{\mathbf{g}}_{j^*}, \\ j^* &= \arg \min_j \|\mathbf{p} - \mathbf{v}_j\|. \end{aligned}$$

## Reconstruction Results



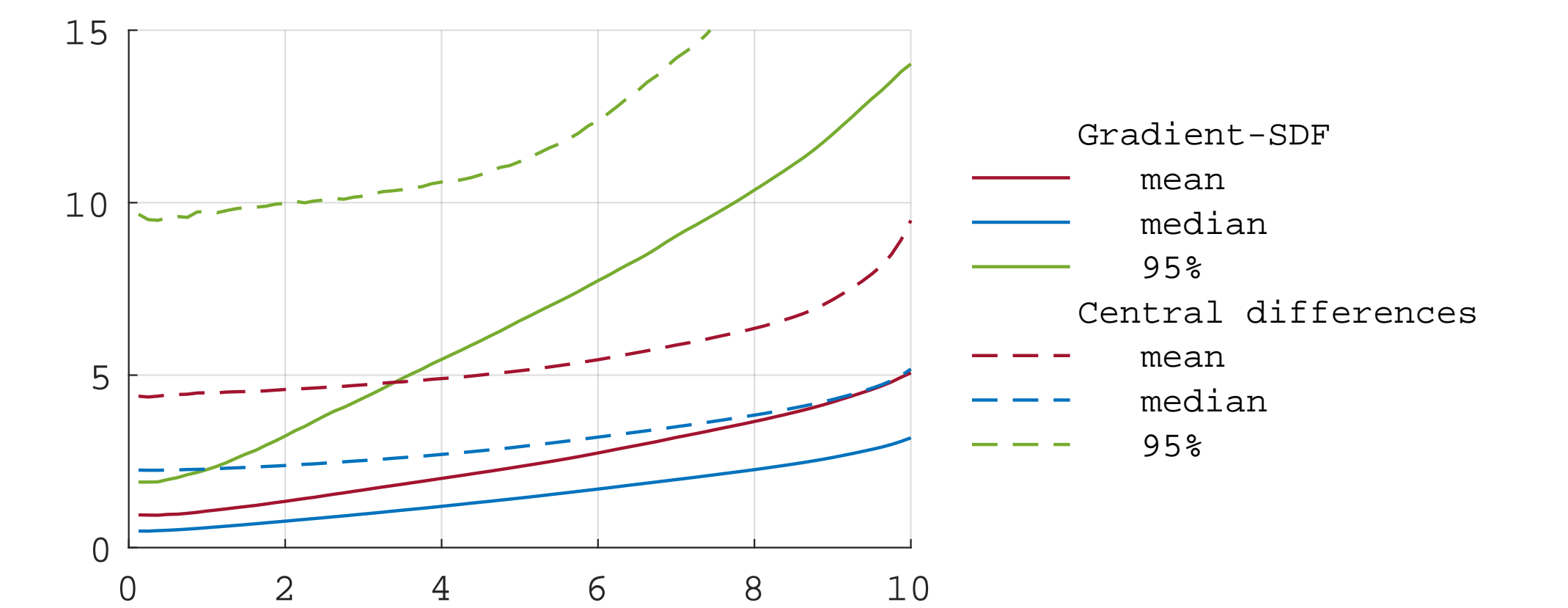
## Pose optimization and bundle adjustment

Implicit bundle adjustment energy:

$$\begin{aligned} E(\{R_i, \mathbf{t}_i\}, \psi) &= \sum_{i,j,c} \nu_{ij} \Phi(I_{ij}^c - \frac{1}{N_j} \sum_i \nu_{ij} I_{ij}^c), \\ I_{ij}^c(\{R_i, \mathbf{t}_i\}, \psi_j) &= I_i^c(\pi(R_i^\top(\mathbf{v}_j - \psi_j \hat{\mathbf{g}}_j - \mathbf{t}_i))). \end{aligned}$$

Effectively, we minimize the color/intensity variance of 3D points.

## Gradient quality on synthetic data



The  $y$ -value of the curve indicates the angular deviation of voxels closer than  $x$  voxels to the surface. Our Gradient-SDF gradients are by far more accurate than those computed by finite difference schemes.

## Abstract

We present **Gradient-SDF**, a hybrid representation for 3D geometry between signed distance fields stored in a voxel grid and surfels.

- It allows us to perform direct SDF tracking from depth images, using efficient storage schemes like hash maps.
- It enables us to perform photometric bundle adjustment directly in a voxel representation (without transforming into a point cloud or mesh).
- It is a fully implicit optimization of geometry and camera poses and allows easy geometry upsampling.

## Code & Contact

Code is available open-source:

<https://github.com/c-sommer/gradient-sdf>

## Contact:

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