

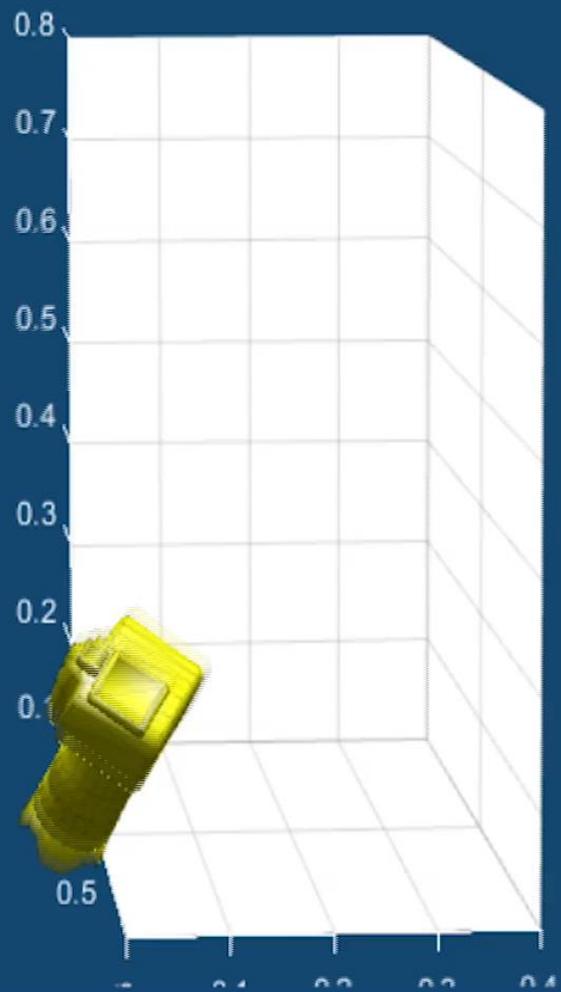


Benjamin Busam [b.busam@framos.com]

Tolga Birdal, Nassir Navab

Camera Pose Filtering with Local Regression Geodesics on the Riemannian Manifold of Dual Quaternions





Intuition

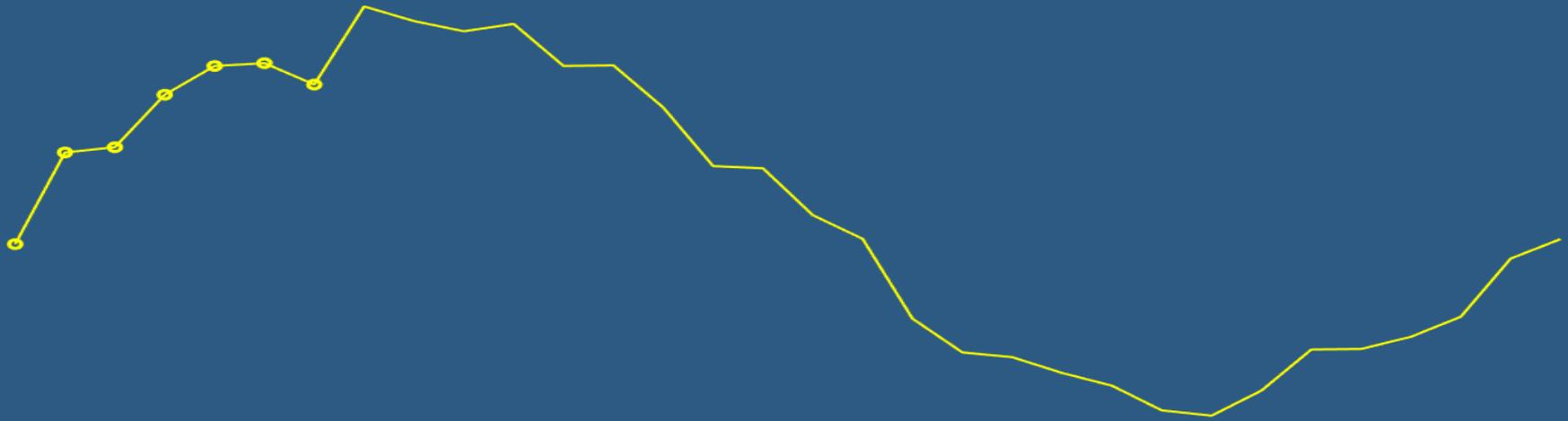
Smoothing 2D signal using local regression lines



[1] J. Fox et al. Time-Series Regression and Generalized Least Squares in R, An appendix to An R companion to applied regression. 2010.

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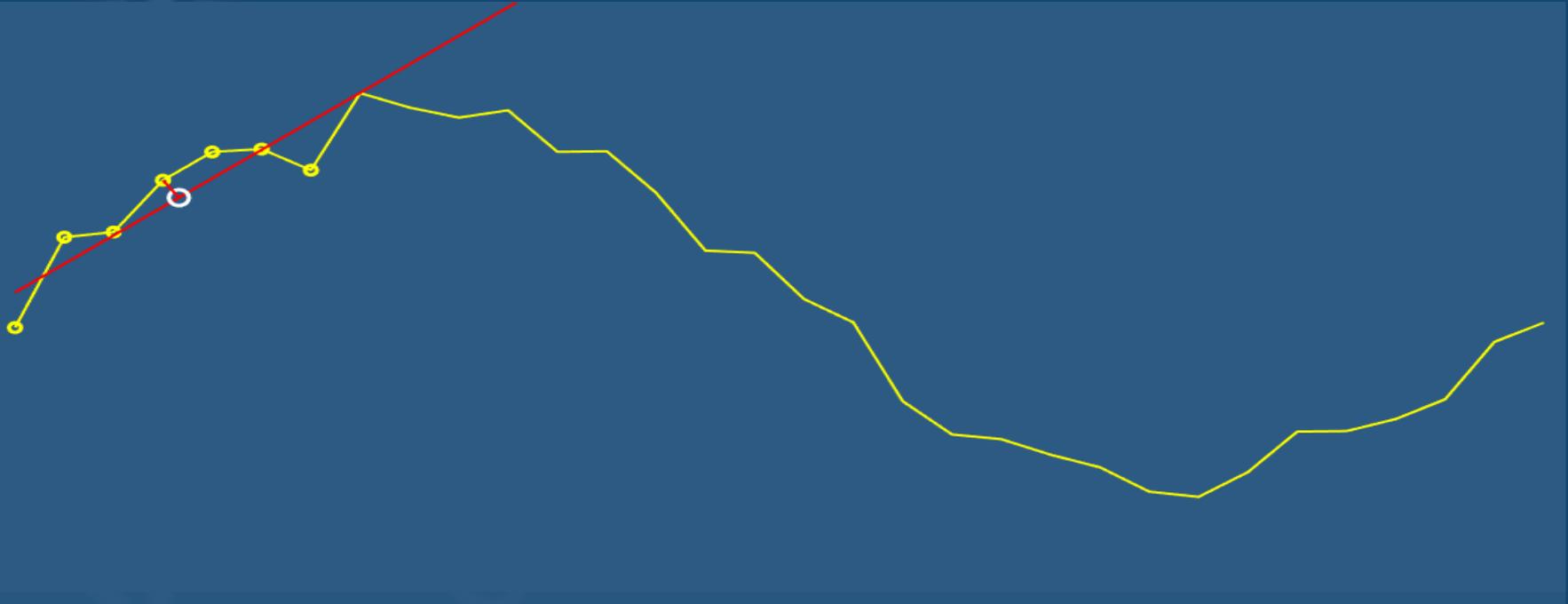
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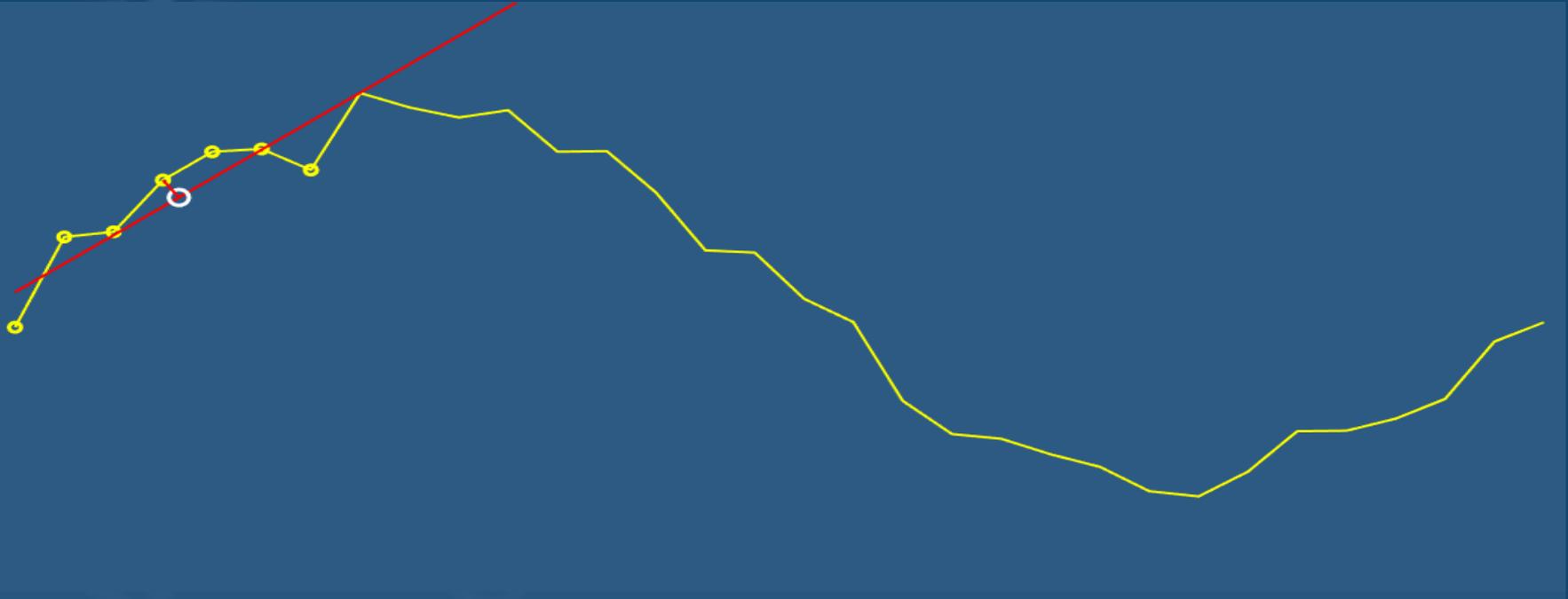
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**Linearize pose space locally
and perform similar smoothing**

Pose Parametrization of $SE(3)$

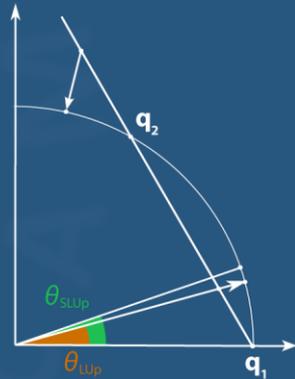
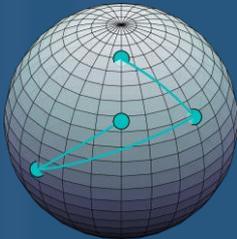
Motion as pose sequence in [dual] quaternion space

Quaternion and translation

$$\mathbb{H}_1 \times \mathbb{R}^3$$

- Rotation part non-Euclidean
- Geodesics on hypersphere
- Rotation

$$\mathbf{p} \mapsto \mathbf{q} \cdot \mathbf{p} \cdot \bar{\mathbf{q}}$$



[1] B. Busam et al. Quaternionic Upsampling: Hyperspherical Techniques for 6 DoF Pose Tracking. 3DV 2016.

Pose Parametrization of $SE(3)$

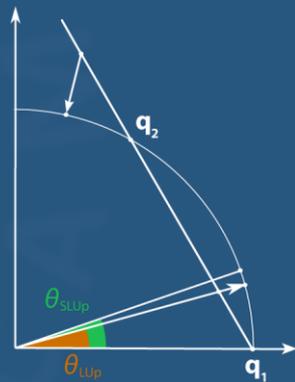
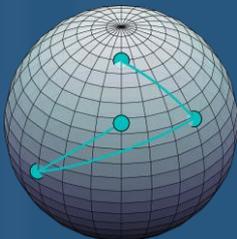
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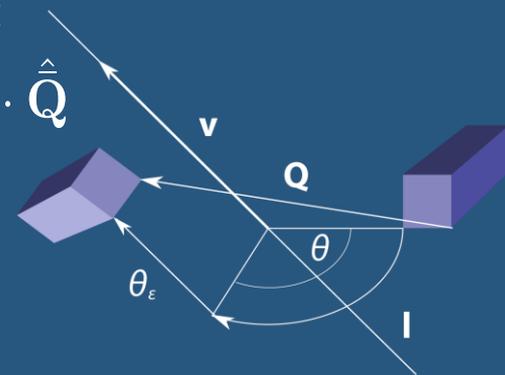


Dual Quaternion in \mathbb{DH}_1

$$\mathbf{Q} = \mathbf{r} + \varepsilon \mathbf{s}$$

- Non-Euclidean space
- Geodesics on Study quadric
- Displacement

$$\mathbf{P} \mapsto \mathbf{Q} \cdot \mathbf{P} \cdot \hat{\mathbf{Q}}$$

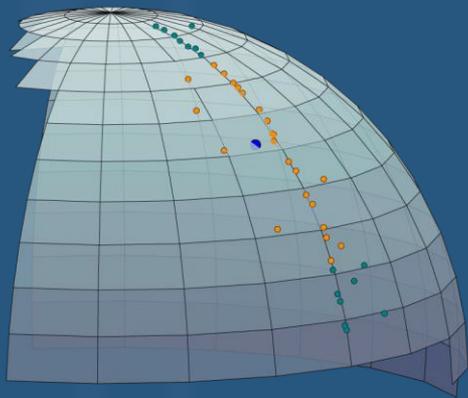


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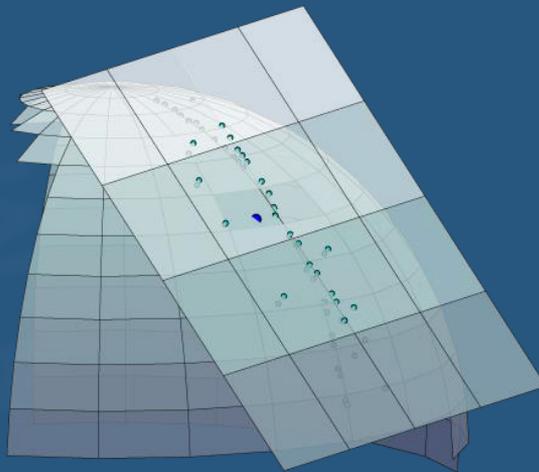
Robust Motion Stabilization

Principle component local regression

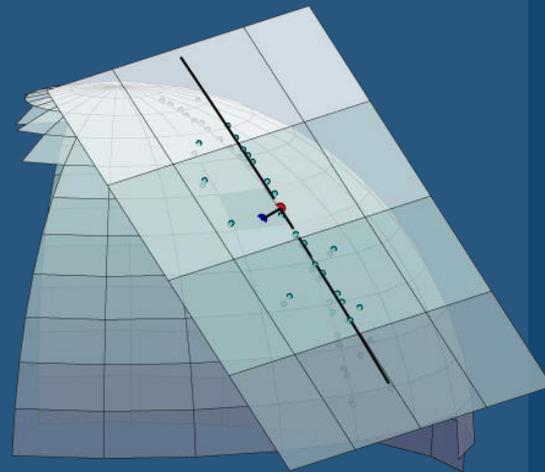
- \mathbb{H}_1 and \mathbb{DH}_1 are Riemannian manifolds
- Calculate log and exp



1. Local Points



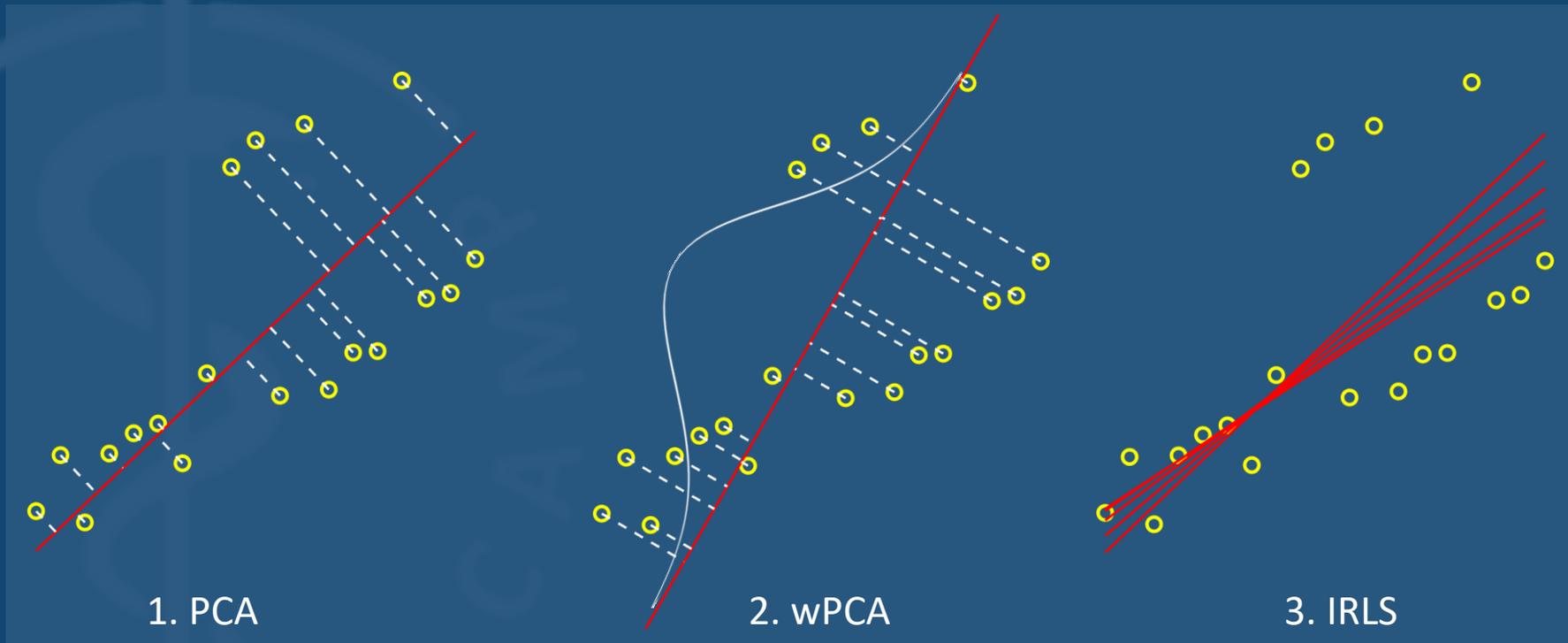
2. Tangent Space



3. Local Regression

Robust Motion Stabilization

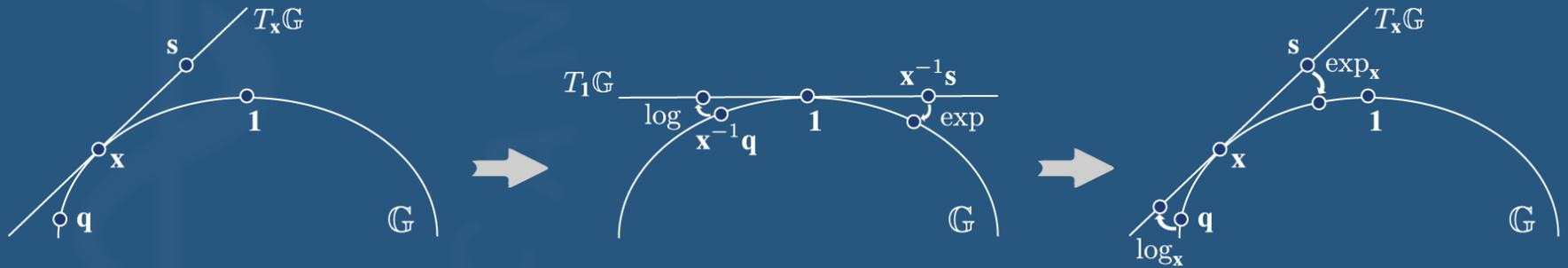
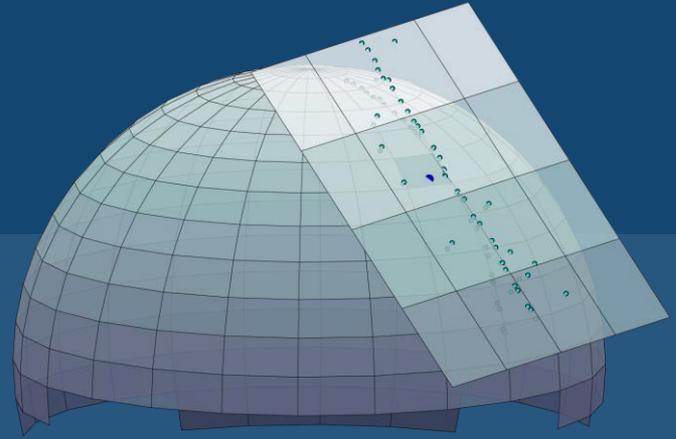
Local filter methods



Riemannian Geometry

Lie groups and parallel transport

- H_1 and DH_1 are Lie groups
- \exp and \log at identity are sufficient

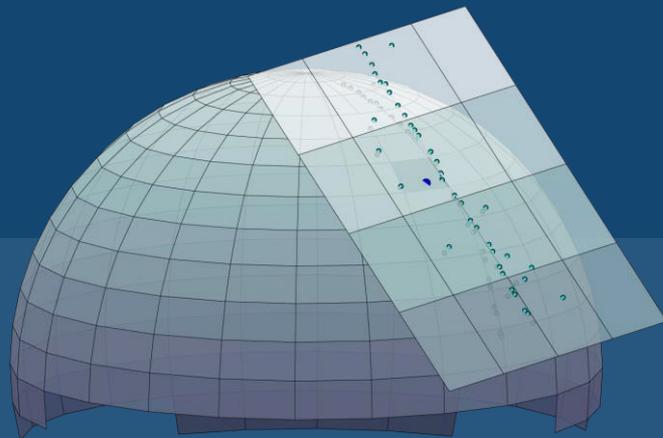


[1] J. Gallier. Notes on differential geometry and lie groups. University of Pennsylvania 2017.

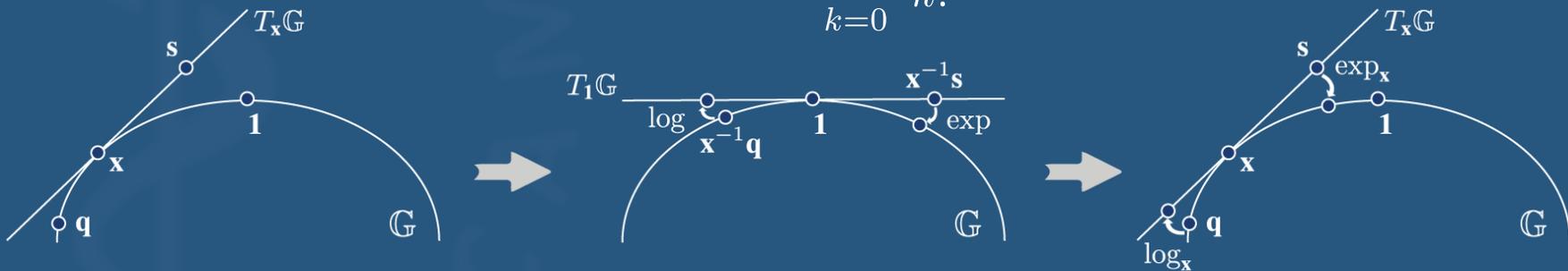
Riemannian Geometry

Lie groups and parallel transport

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$$\exp(\mathbf{Q}) = \sum_{k=0}^{\infty} \frac{\mathbf{Q}^k}{k!}$$



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Experiment 1

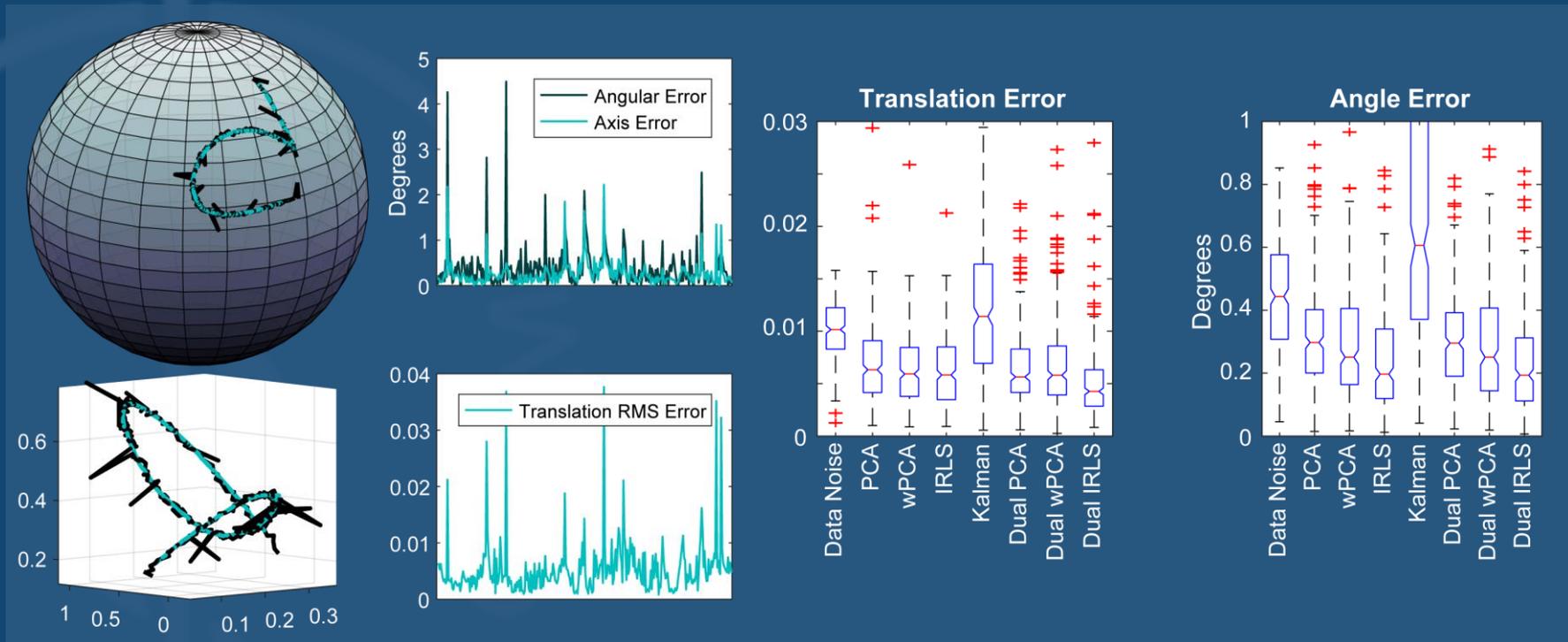
Synthetic Data
-
Rigid Body Motion with Noise

Experiment 1

Synthetic Data
-
Rigid Body Motion with Noise

Synthetic Evaluation

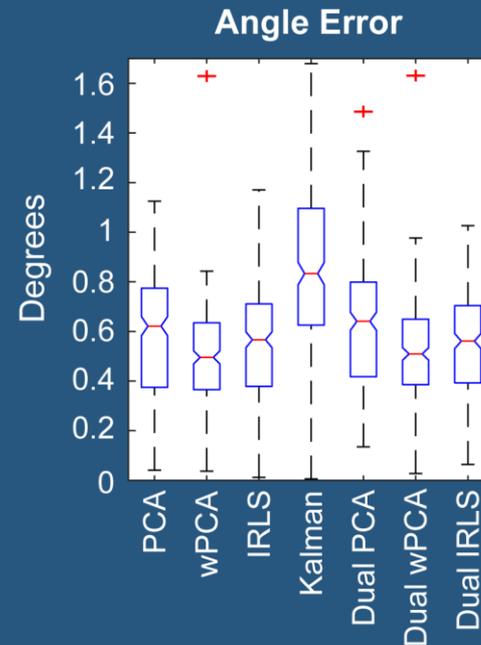
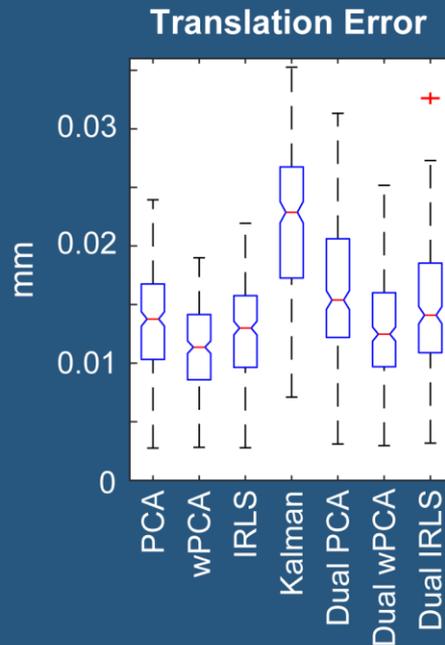
Dual IRLS compared to other methods



Real Data Evaluation

Quantitative comparison

- Stereo tracking dataset [1]
- Natural hand movements in cooperative robotics
- Accurate pose sequence
- No dual-space gain for reliable data



[1] B. Busam et al. A Stereo Vision Approach for Cooperative Robotic Movement Therapy. ICCVW 2015.

Experiment 2

RGB-D Data - Kinect Fusion Pose Filtering

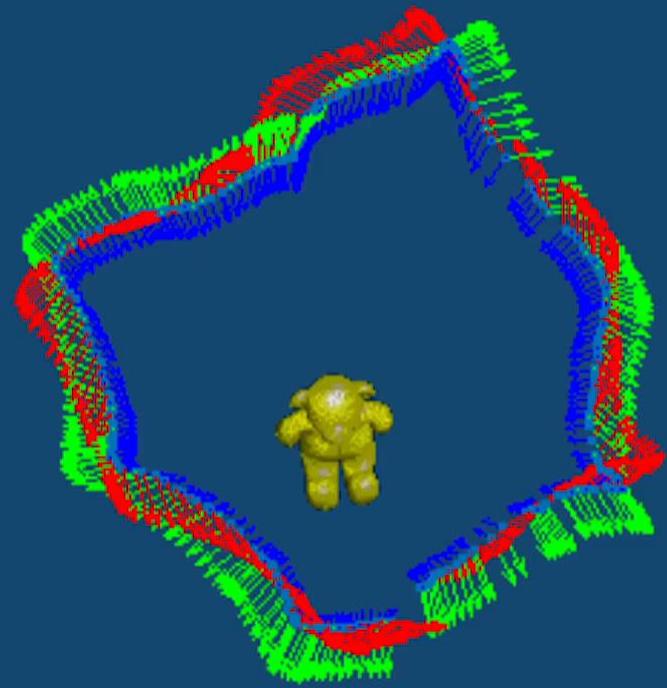
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Window Size



wPCA

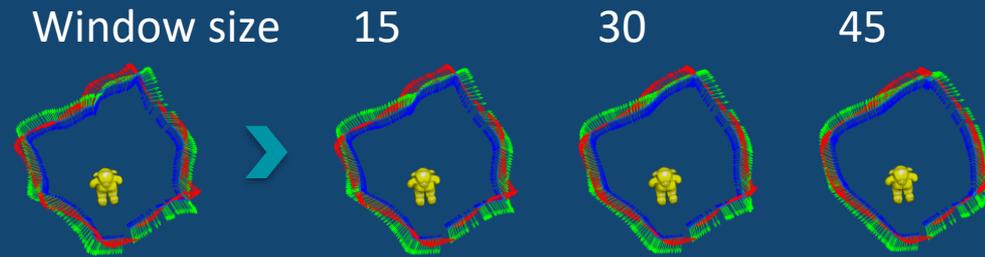


Pose Filtering



Conclusion and Discussion

Results and Outlook



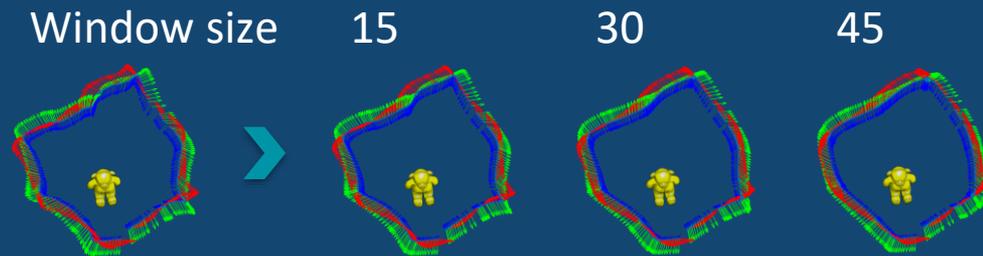
- Use shape of space for regression

Advantages

- ✓ Parameter-free online smoothing
- ✓ Outlier-aware IRLS method
- ✓ Dual quaternion robustifies filtering

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- ✓ Parameter-free online smoothing
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Disadvantages

- Dense sampling needed

Future work

- Include pose uncertainty
- Video stabilization

THANK YOU!

Grazie mille!

Poster Session
at 2 pm

Questions ?

