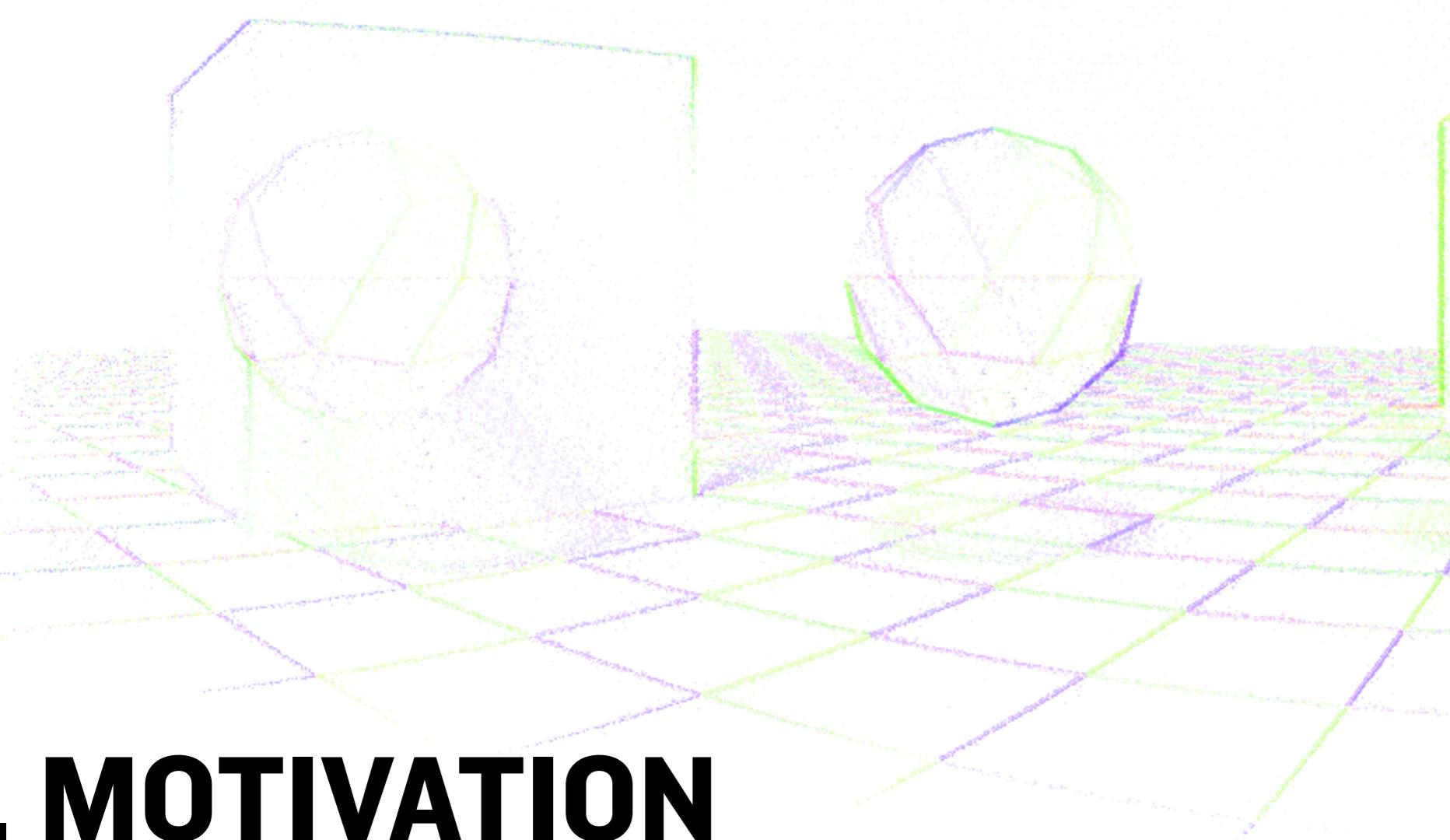


IMAGE RECONSTRUCTION FROM DVS

MARCEL GEPPERT, SAMUEL BRYNER

BASED ON WORK BY KIM ET AL. [1]

SUPERVISOR: PETRI TANSKANEN

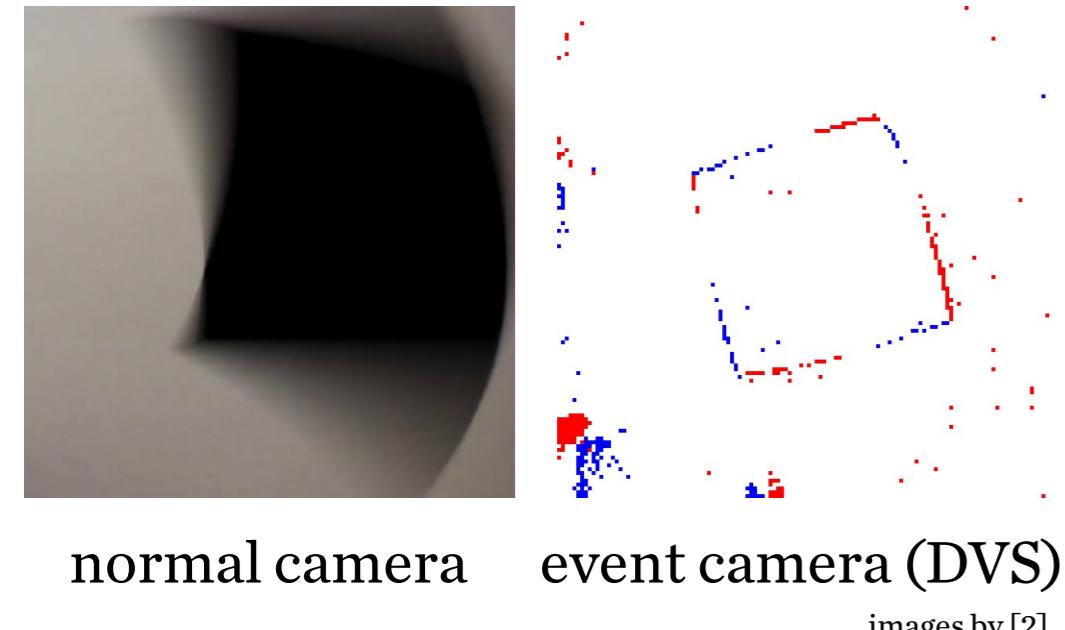


1. MOTIVATION

- increase robustness and speed of visual odometry / SLAM by replacing normal cameras with event cameras

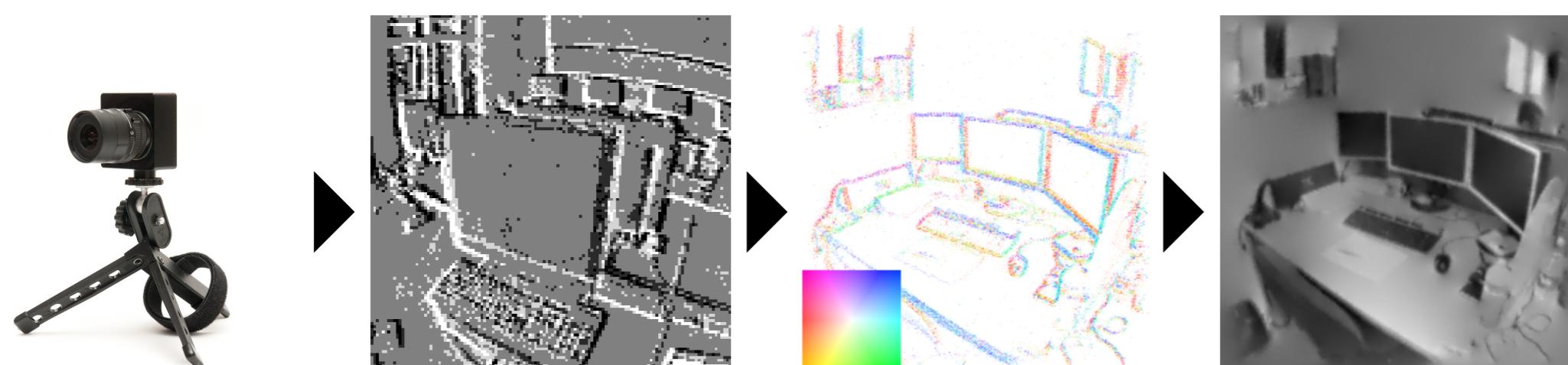
- reduce SLAM problem to camera rotation in a static scene and reconstruction of a complete image

2. DYNAMIC VISION SENSOR



- a DVS delivers **instantaneous changes** in image brightness ("events") instead of periodic full frames
- practically no motion blur
- very high dynamic range
- drastically reduced bandwidth incurs significantly lower computational costs

3. CORE ALGORITHM



Jointly track the global rotational motion of a camera and estimate the gradients of the scene around it. The gradient map is then upgraded to a full image-like mosaic.

Each of these components essentially believes that the current estimate from the other is correct.

RECONSTRUCTION

Use movement between current and last event of the pixel to estimate gradients (intensity change) at event pixel.

ASSUMPTIONS

- a change in brightness is caused by a movement of the camera (static scene)
- only rotation, no translation and therefore no parallax displacement

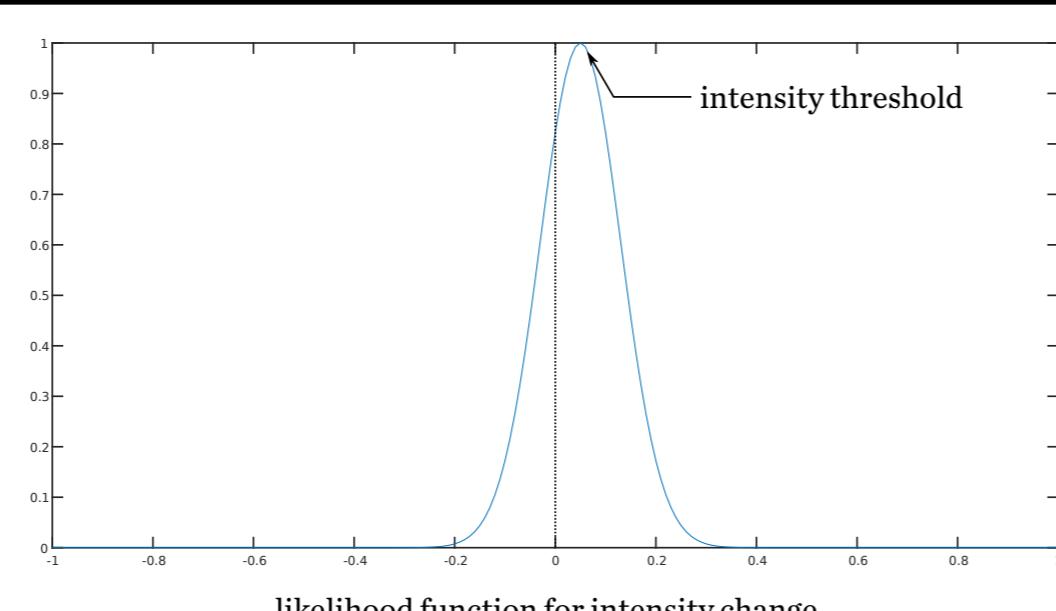
- extended Kalman filter reduces noise in the image
- Poisson-solver computes grayscale image from gradients.

MOVEMENT TRACKING

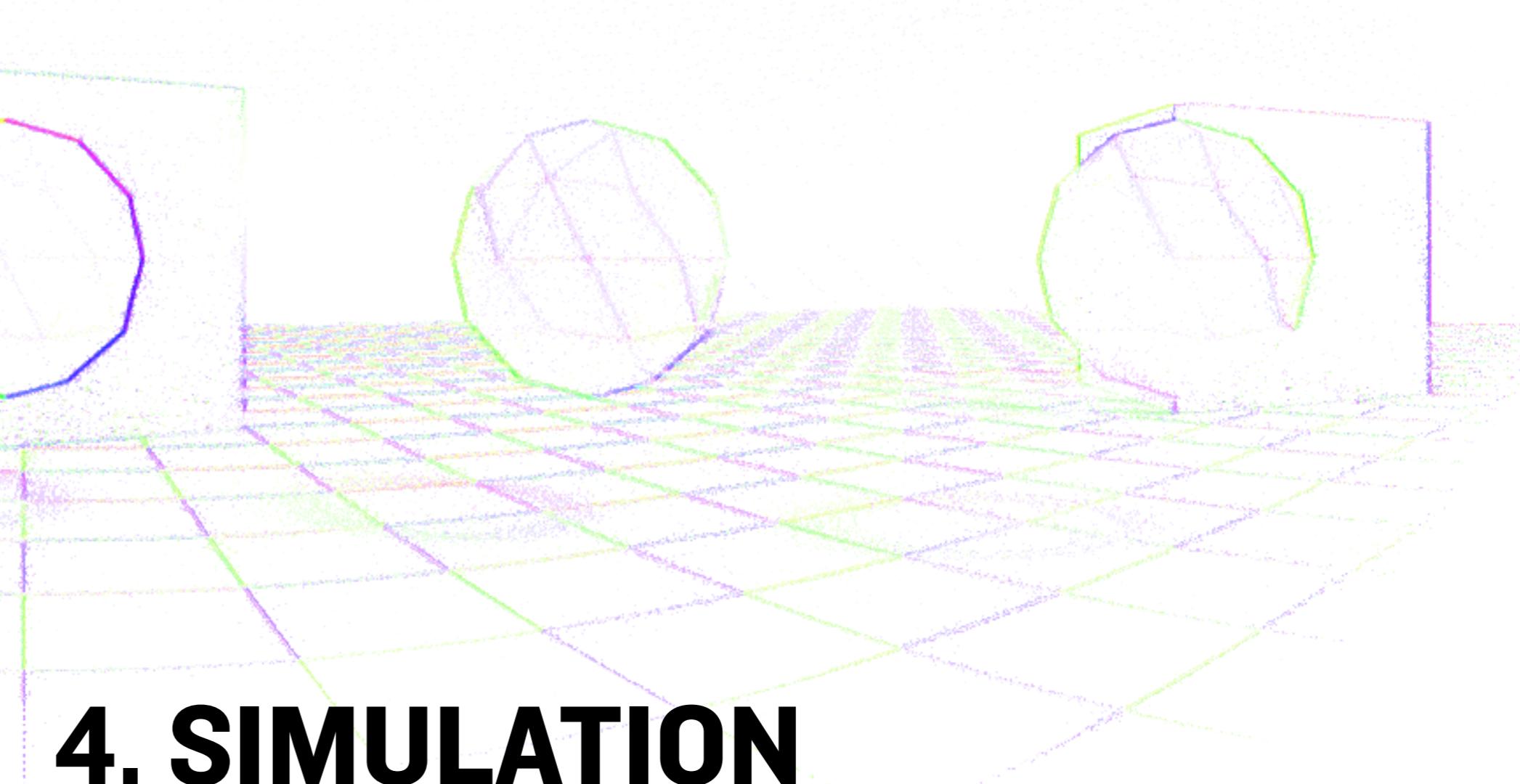
- rotation tracking with particle filter and constant position motion model
- for every event, compare intensity at event position for every possible camera rotation to intensity at (assumed) position of last event:

$$z := \log(M(\mathbf{p}^t)) - \log(M(\mathbf{p}^{t-1}))$$

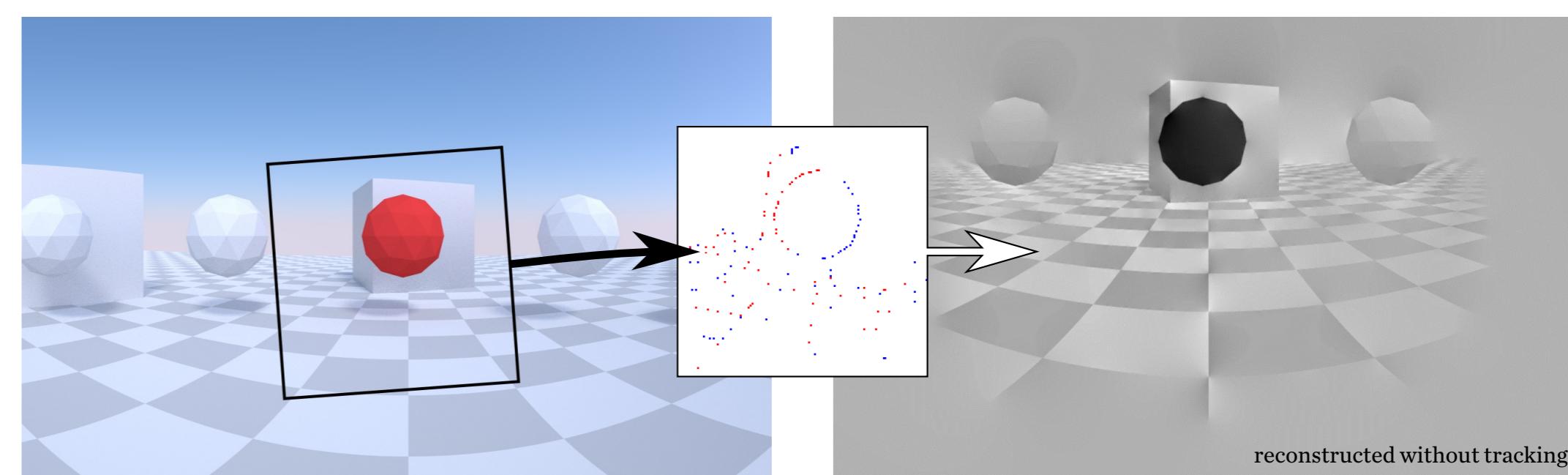
the closer the intensity change to the camera's threshold the more likely is the proposed movement



- bootstrap: start with a small known patch at the center. See also initialization in section 5.

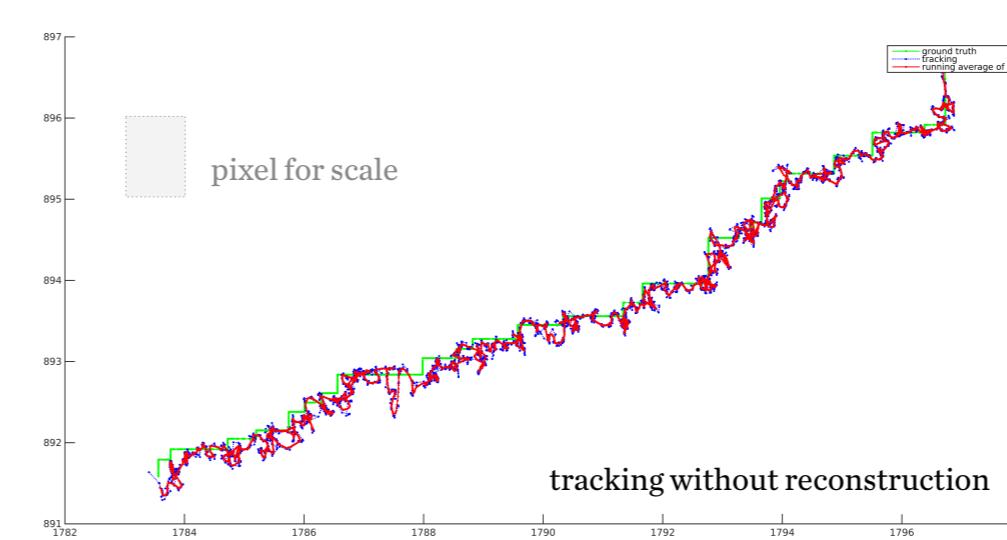


4. SIMULATION



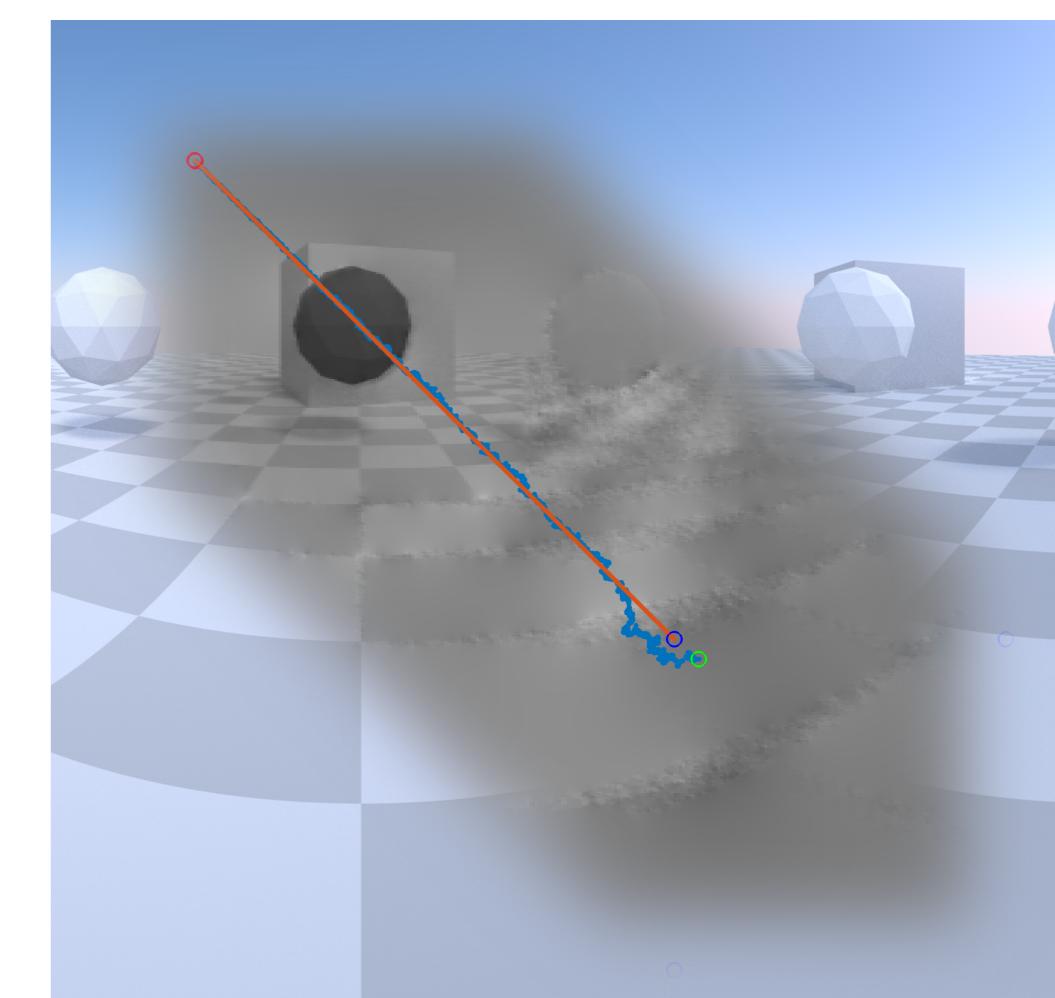
The full system is implemented in simulation. Tracking and image reconstruction can both work with either ground truth or results from the other component.

TRACKING



- sensitive to motion parameters
⇒ suggests better motion model
- no way of detecting or correcting lost tracking
- probabilistic = locally noisy
(+/- a pixel) ⇒ many events necessary

COMBINED



INITIALIZATION



- removing a dark cover results in an initial image patch
- 2nd generation DVS is able to take full pictures

6. CONCLUSION

A dynamic vision sensor is a feasible option for rotational motion tracking. With some optimizations the system is conceivable real-time capable - especially when combined with other sensors such as an IMU. This might even lead to full 3D-SLAM with a dynamic vision sensor.

From our point of view, the next important points are parameter tuning, runtime optimization and the usage of a more sophisticated motion model (eg. constant velocity or acceleration).

7. REFERENCES

- [1] H. Kim, A. Handa, R. Benosman, S. Ieng, A. Davison, 2014 "Simultaneous Mosaicing and Tracking with an Event Camera"
- [2] E. Mueggler, B. Huber, D. Scaramuzza, IROS 2014 "Event-based, 6-DOF Pose Tracking for High-Speed Maneuvers"