IMAGE RECONSTRUCTION FROM DVS

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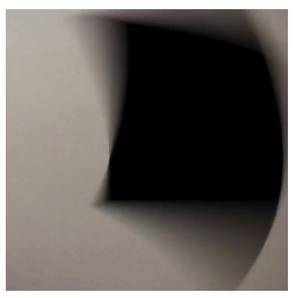
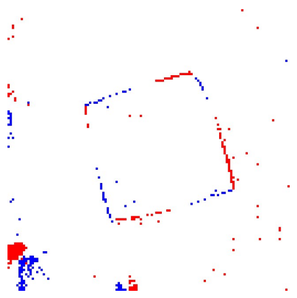
1. DYNAMIC VISION SENSOR



normal camera



event camera (DVS)

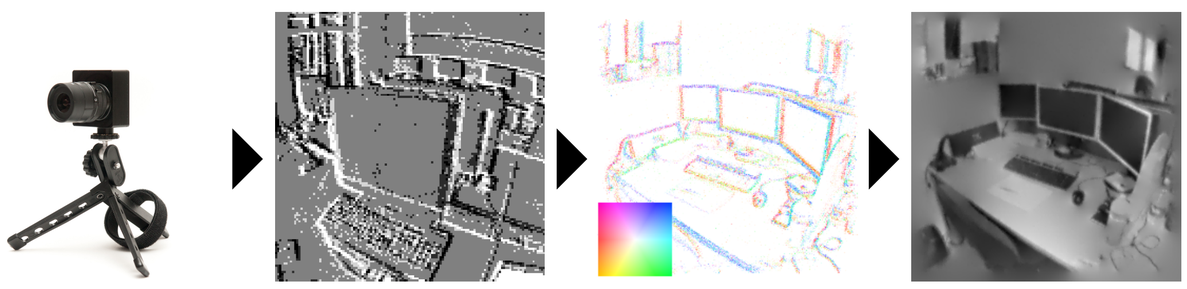
images by [3]

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

2. 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

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 gradient (intensity change) at event pixel.

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

ASSUMPTIONS

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

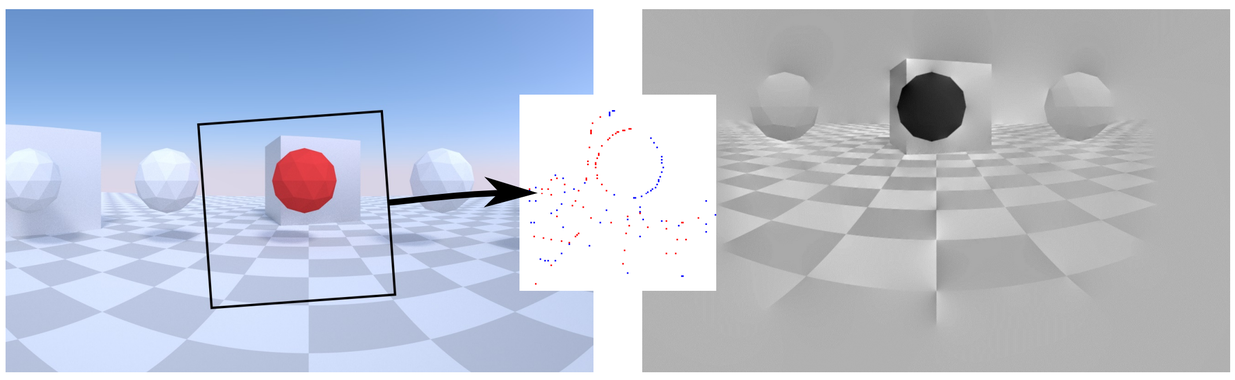
MOVEMENT TRACKING

- 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:

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

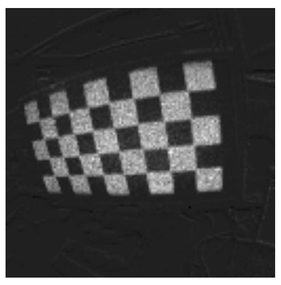
the closer the intensity change to the camera's threshold the more likely is the proposed movement

4. SIMULATION



5. REAL DATA

CALIBRATION



- flickering display of normal checkerboard pattern
- standard camera calibration toolbox

INITIALIZATION

- integrate events when removing a dark cover gives an initial image patch

6. CONCLUSION

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

7. REFERENCES

[1] H. Kim, A. Handa, R. Benosman, S. Ieng, A. Davison, 2014
"Simultaneous Mosaicing and Tracking with an Event Camera"

[2] D. Weikersdorfer, D. Adrian, D. Cremers, Jörg Conradt, ICRA 2014
"Event-based 3D SLAM with a depth-augmented dynamic vision sensor"

[3] E. Mueggler, B. Huber, D. Scaramuzza, IROS 2014
"Event-based, 6-DOF Pose Tracking for High-Speed Maneuvers"

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