IMAGE RECONSTRUCTION FROM DVS

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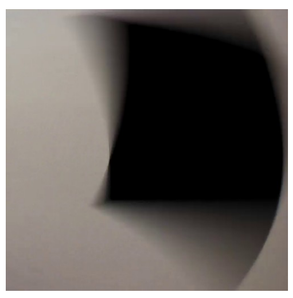
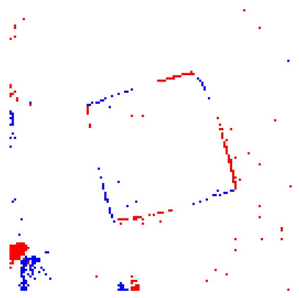
1. DYNAMIC VISION SENSOR



normal camera



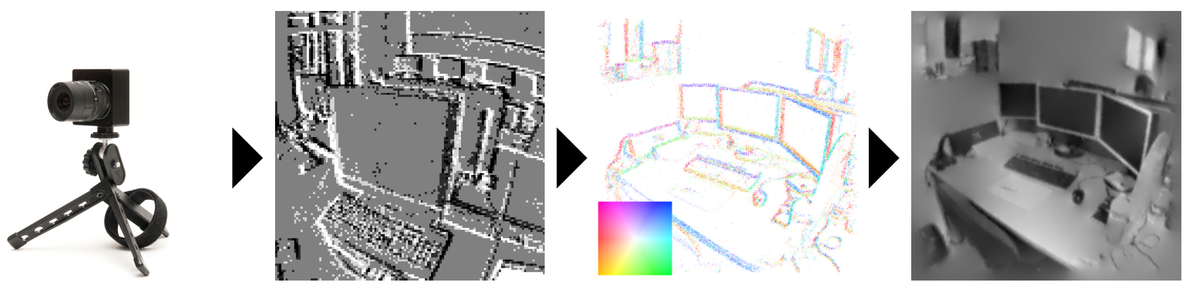
event camera (DVS)

- 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.

ASSUMPTIONS

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

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.

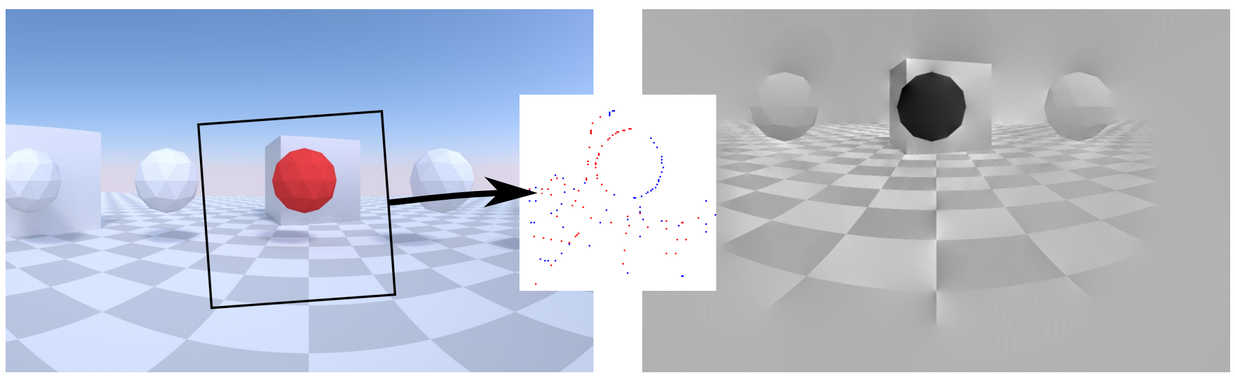
MOVEMENT TRACKING

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

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

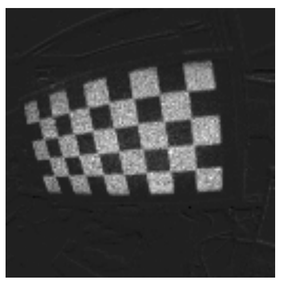
the closer the intensity change to the camera's threshold the more likely is the proposed movement

4. SIMULATION



5. REAL DATA

CALIBRATION



- flickering display of normal checker-board 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 easily real-time capable, especially when combined with other sensors, such as an IMU.

7. REFERENCES

[1] H. Kim, A. Handa, R. Benosman, S. Ieng, A. Davison, 2014
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[3] E. Mueggler, B. Huber, D. Scaramuzza, IROS 2014
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