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EVO: Event-based 6-DOF Parallel Tracking and Mapping in Real-time

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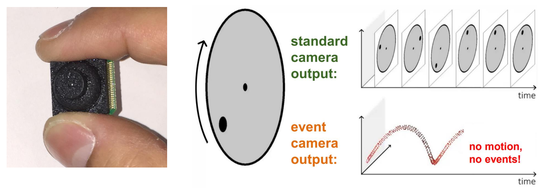
DEMO!

ROBOTICS & PERCEPTION GROUP

Motivation: Address **challenging SLAM scenarios** (high-speed, HDR, low latency).

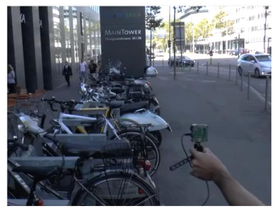
Goal: **Semi-dense SLAM with an event camera** in real time.

What is an event camera?



- Only transmits **brightness changes**.
- Output is a stream of **asynchronous events**.
- **Advantages**: low latency, no motion blur, HDR.

Watch video!



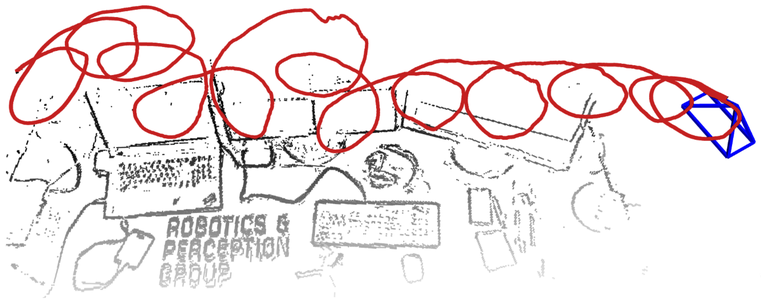
Scene

Input events

3D reconstruction

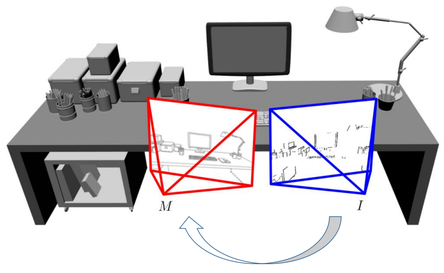
Key properties:

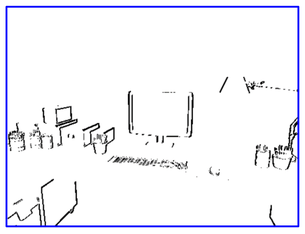
- **Semi-dense** 3D reconstruction and 6-DOF tracking.
- Works even in **high-speed** and **HDR** scenes, where standard cameras fail.
- **Real-time** on a **smartphone CPU**.
- **Intensity reconstruction** not needed, but available.



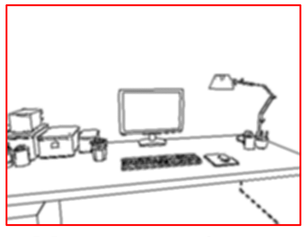
Event-based Vision Research

Tracking: edge-map alignment





I: Event Image



M: Projected Map

- **Event images** (~1000 events)
- **Minimize alignment error** between projected map and events:

$$\min_T \sum_{\boldsymbol{u}} \Big(M(\boldsymbol{u}) - I\big(\boldsymbol{W}(\boldsymbol{u};T)\big) \Big)^2$$

6-DOF warp: $\boldsymbol{W}(\boldsymbol{u};T) \coloneqq \pi(T \cdot \pi^{-1}(\boldsymbol{u}, d_{\boldsymbol{u}}))$

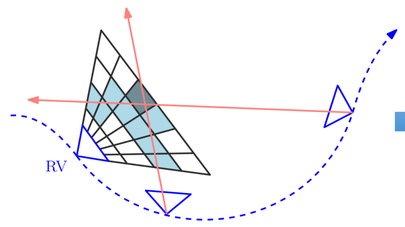
Camera pose

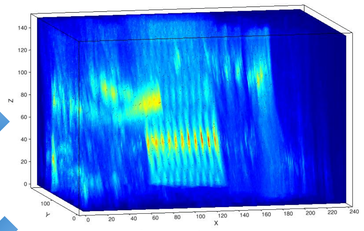
3D Map

Mapping: EMVS (IJCV'17) [2]

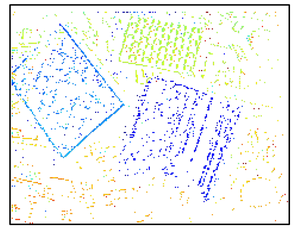
Event-Based Space-Sweep Method:

- **Back-project events** into space.
- Disparity Space Image (DSI) with **ray density.**
- Projective sampling of DSI + Adaptive thresholding.

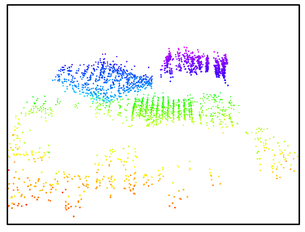




Ray density DSI



Semi-dense depth map



3D point cloud

References: [1] Rebecq et al, ***EVO***. IEEE Robot. and Autom. Letters, 2017
[2] Rebecq et al, ***EMVS***: *Event-based MultiView Stereo*. IJCV'17.