University of Zurich[UZH] | ETH zürich
Institute of Informatics – Institute of Neuroinformatics
Technische Universität Berlin
ROBOTICS & PERCEPTION GROUP
Event-based Vision Research

ESL: Event-based Structured Light

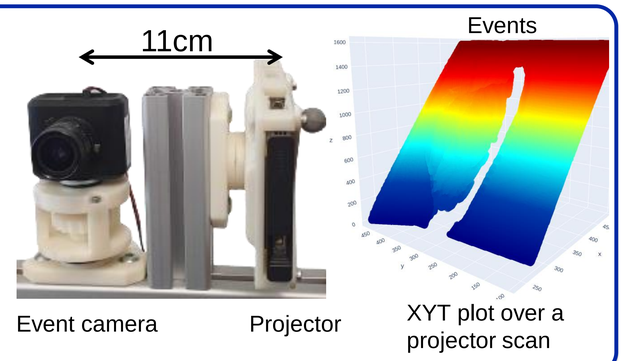
Manasi Muglikar, Guillermo Gallego, Davide Scaramuzza

Motivation: Structured Light (SL) using standard cameras is not robust to motion blur and HDR. They suffer from accuracy versus speed trade-off.

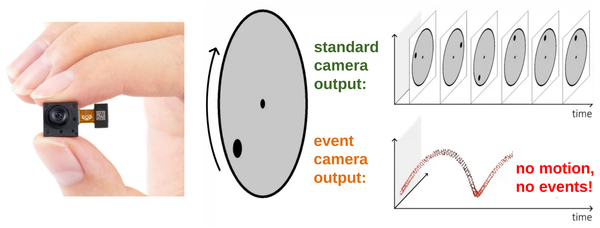
Goal: Novel structured light system using an event camera for accurate and high-speed depth sensing

Key Properties:

- **Dense scene reconstruction** with an event camera and laser point projector
- Model the projector as an **inverse event camera**
- Estimate the depth by **minimizing spatio-temporal consistency**
- **More accurate and robust to noise** in event timestamps than state-of-the-art
- Works in **high-speed and HDR scenes** where standard frame-based SL fails

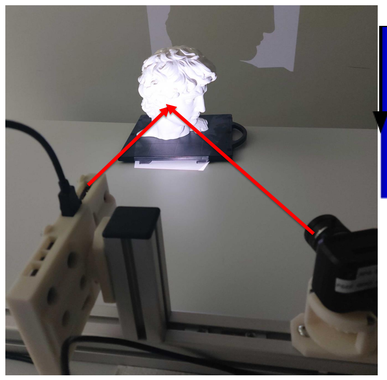


What is an Event Camera?

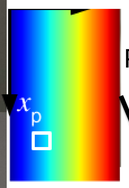


- Only transmits **brightness changes**
- Output is a stream of **asynchronous events**
- **Advantages:** low latency, no motion blur, HDR

Approach



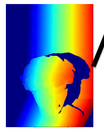
Model the projector as an "**inverse event camera**"



Projector time-map (τ_p)

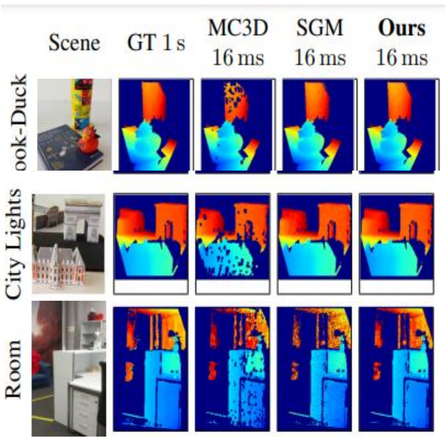
Minimize spatio-temporal consistency

$$C(x_1 z) = \left\| \tau_c(x_c, w) - \tau_p(x_P, w) \right\|^2_{L^2(w \times w)}$$



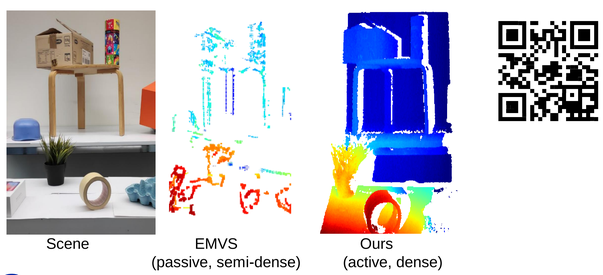
Event time-map (τ_c)

Dense 3D reconstruction



Static scene reconstruction

Watch Video!

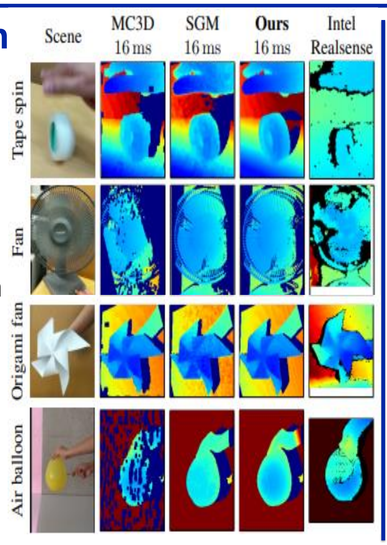


Sponsors

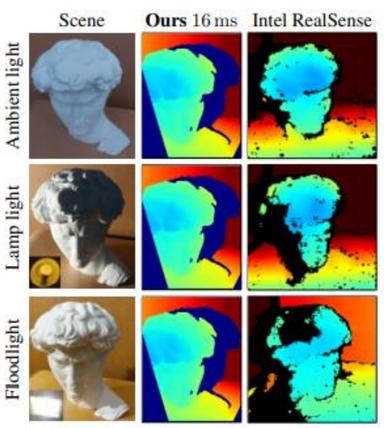
FNSNF Swiss National Science Foundation
SONY
robotics Swiss National Centre of Competence in Research

High-Speed Depth

- Evaluation on static scene shows **83% improvement** over SOTA in RMSE
- Qualitative comparison on **dynamic scenes** shows our method produces **smoother** depth and is **better** than commercial frame-based SL



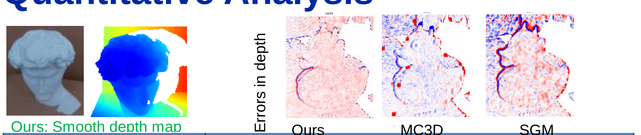
HDR Scenes



Depth even in bright light!

Quantitative Analysis

NEW DATASET!



Scene (Mean depth)	RMSE [cm]		
	Ours	MC3D	SGM
David (50cm)	**0.46**	14.81	1.08
Heart (50cm)	**0.55**	14.99	0.54
Book-Duck (49cm)	**1.40**	20.33	7.30
Plant (70cm)	**1.97**	24.73	5.21
City of light (90cm)	**1.17**	26.93	6.76
Cycle (90cm)	**1.15**	25.28	16.31
Room (394cm)	**161.3**	192.2	195.5
Desk-chair (171cm)	**33.79**	96.56	33.79
Desk-Book (151cm)	**5.15**	93.78	7.30