Technische Universität Berlin

EINSTEIN CENTER Digital Future

Event-based Robot Vision

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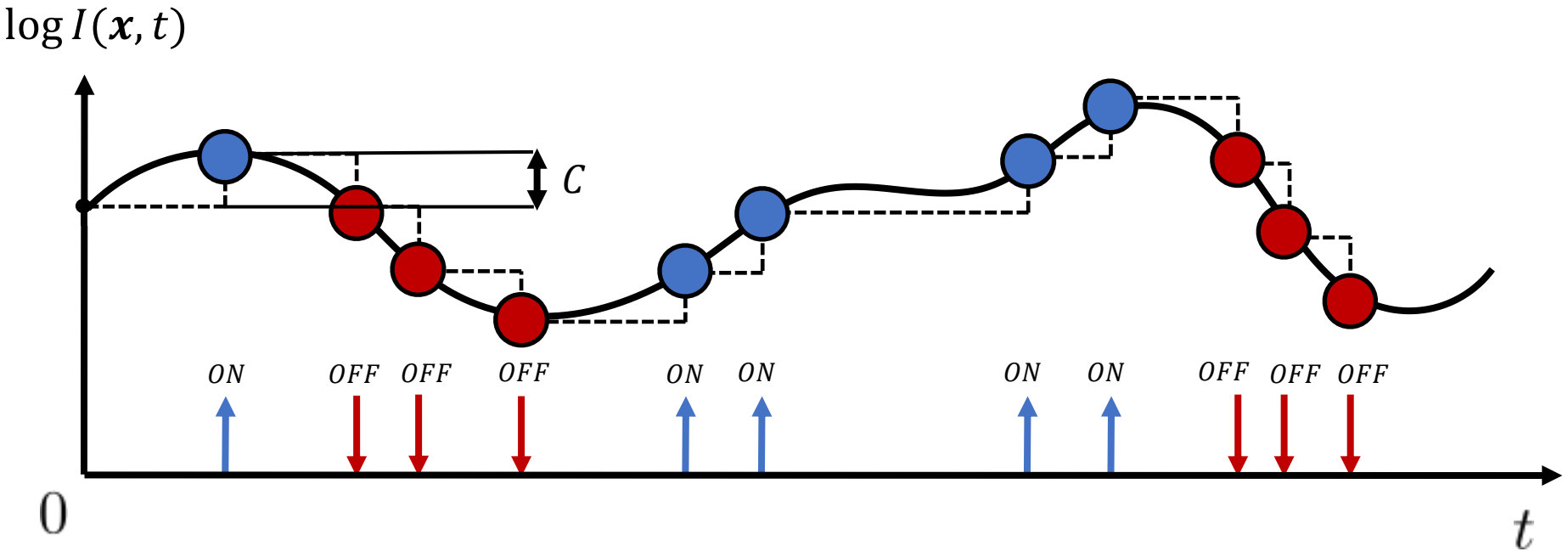
Image (intensity) Reconstruction

Recall the Event Generation Model

$$\log I(\boldsymbol{x}, t) - \log I(\boldsymbol{x}, t - \Delta t) = \pm C$$

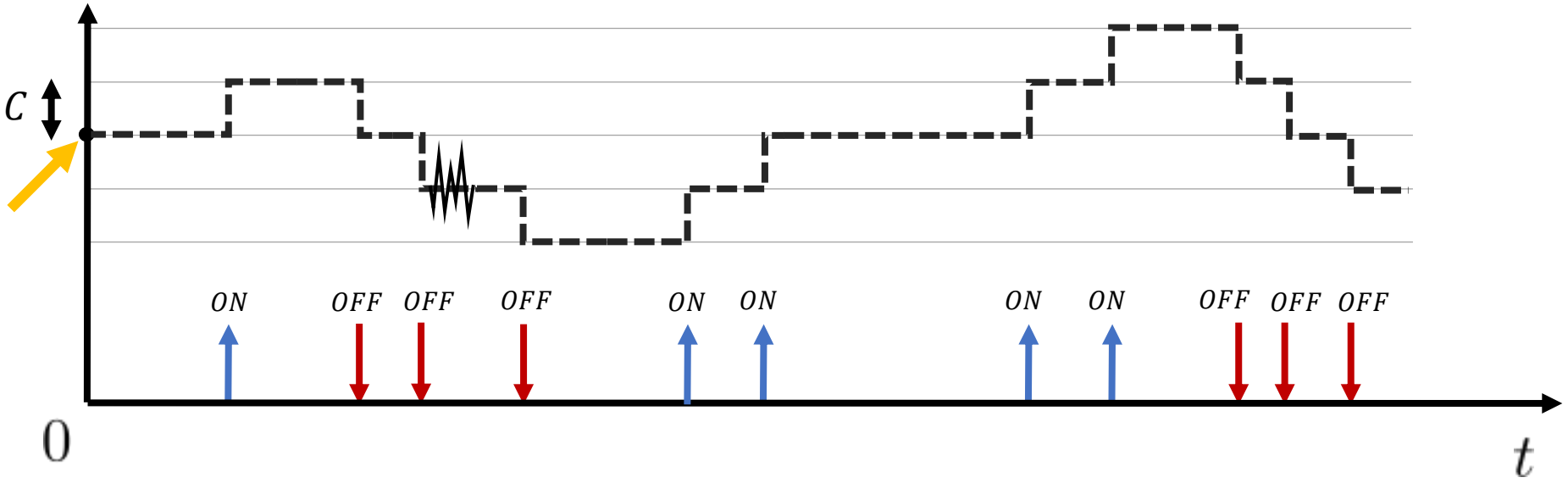


Light (log *I*) has been transduced into asynchronous events…

Given the events, can we recover the absolute intensity?

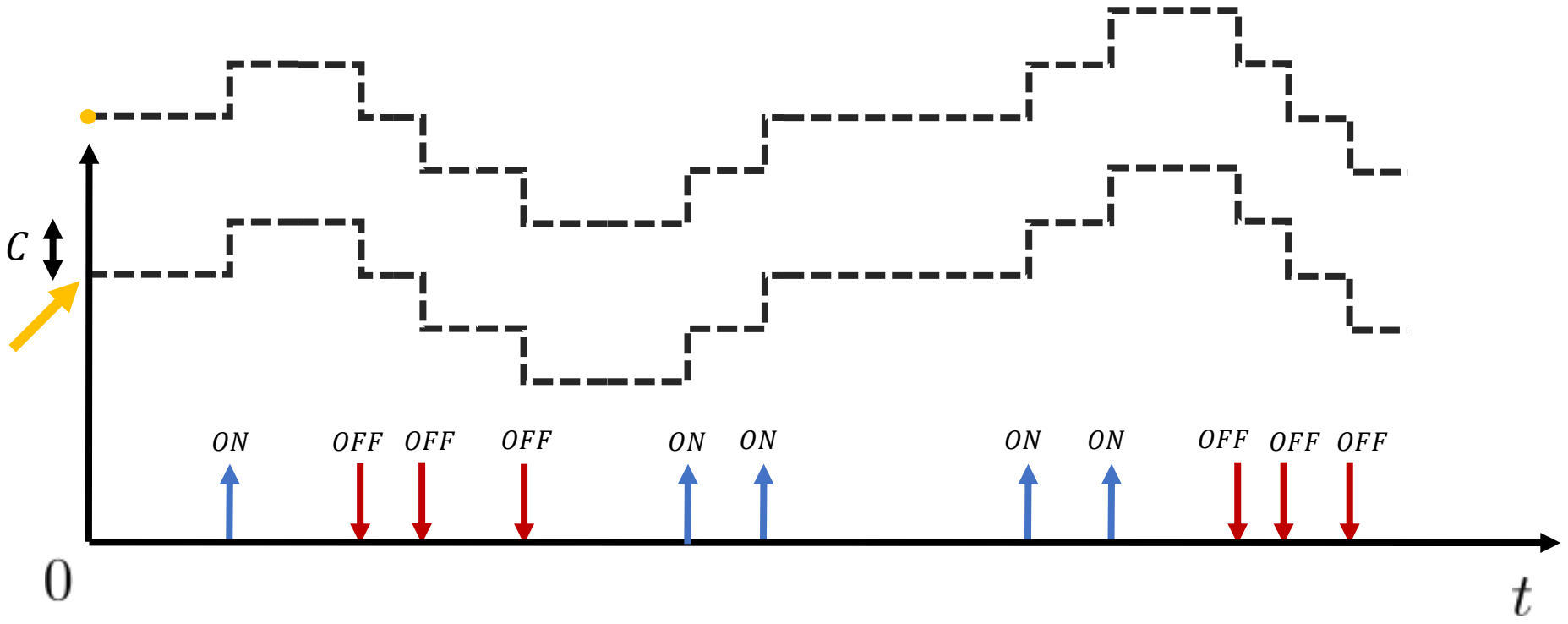
Let's try to recover the pixel's intensity

- Events represent **intensity changes** ⇒ **Integration** should provide absolute intensity



- The recovered signal approximates the original one
- And we cannot see oscillations within the step C (quantization error)
- Additionally, the offset (at $t = 0$) is typically unknown…

Let's try to recover the pixel's intensity



- Typically the offset (at $t = 0$) is unknown…
- That's what happens at 1 pixel… and we need offsets on all image pixels to make a good (coherent) image

Event Integration

- Estimated intensity. Intuition:

$$L(t) = L(0) + \int_0^t \frac{dL}{dt}(\tau)\,d\tau$$

Increment $\Delta L \coloneqq L(t) - L(0)$

$$\log \hat{I}(\boldsymbol{x}, t) = \log I(\boldsymbol{x}, 0) + \sum_{0<t_k\leq t} p_k\, C\, \delta(\boldsymbol{x} - \boldsymbol{x}_k)\delta(t - t_k)$$

pixel

polarity

Kronecker delta (discrete variable)

Dirac delta (continuous variable)

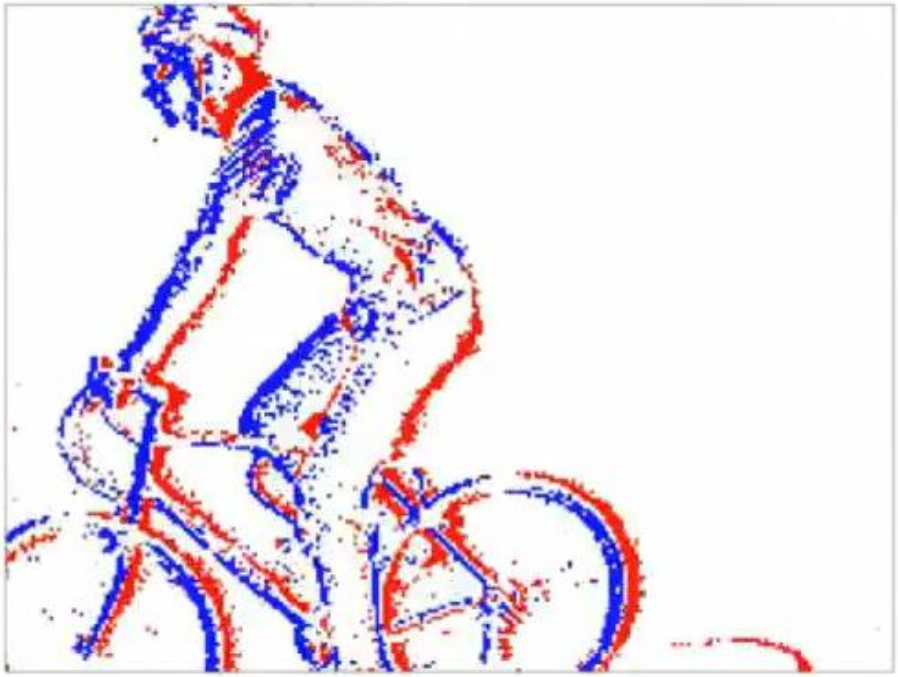
Intensity at $t = 0$ (offset)

Intensity increment $\Delta \log I$

Mueggler et al., *The Event Camera Dataset and Simulator: Event-based Data for Pose Estimation, Visual Odometry, and SLAM*, IJRR 2017.

Image Reconstruction sneak peek

- Isn't it magic? We can reconstruct some intensity **starting from zero offset** (initial condition), i.e., without knowing $\log I(\boldsymbol{x}, 0)$



- Did we notice how intensity (i.e., grayscale) information **appears as edges move** through the scene and then it fades away?
- Did we notice the background trees as "after image" while fading?

References

Reading:

- E. Mueggler et al., *The Event-Camera Dataset and Simulator*, IJRR 2017, page 3.