EE Summer School | 11 July 2025

High-Dynamic-Range Imaging

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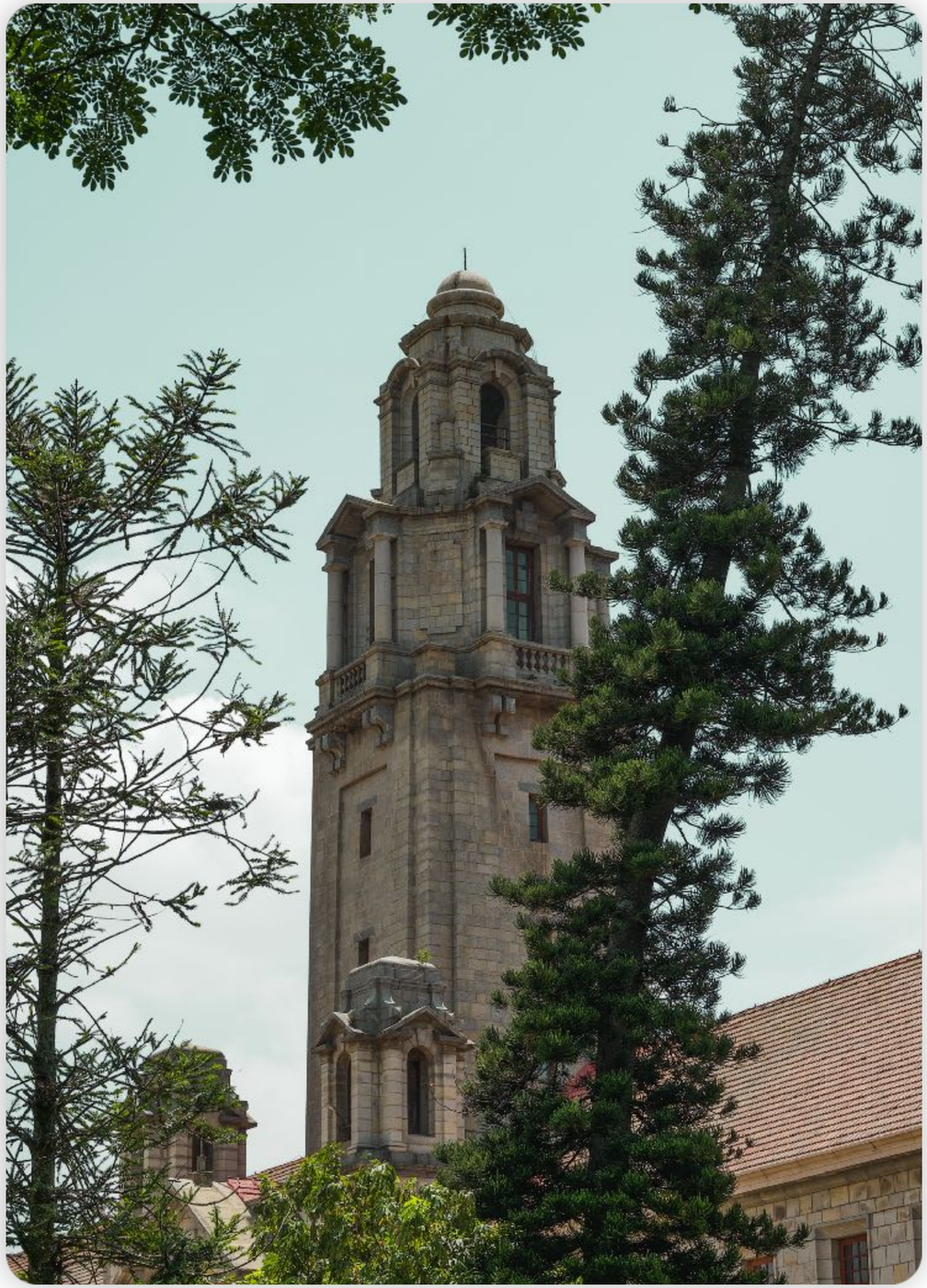
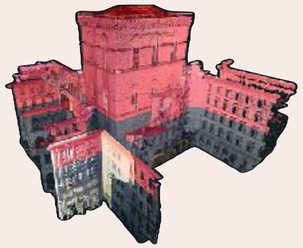
SPECTRUM LAB



Spectrum Lab

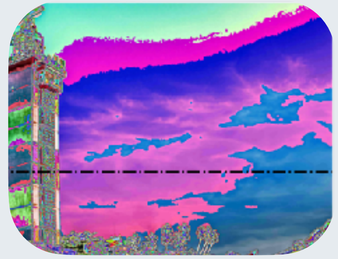
synthetic aperture radar



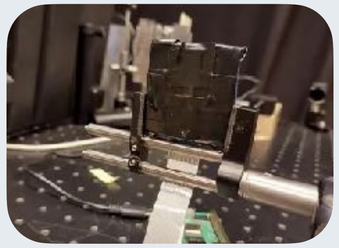
3d reconstruction

IMAGING

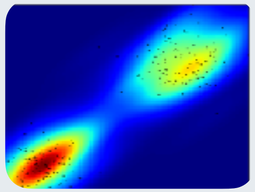
seismic imaging



event-driven imaging

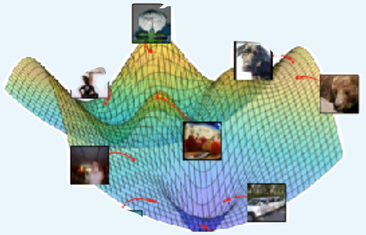


lensless imaging

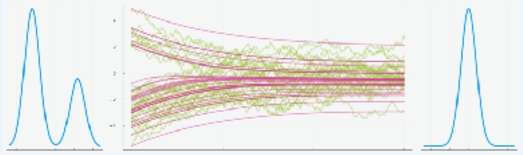


adversarial regularisation

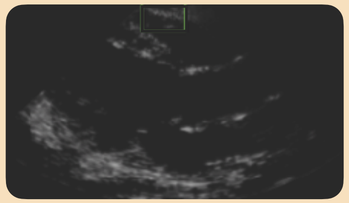
GENERATIVE MODELS



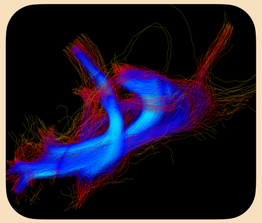
accelerated training



accelerated sampling



super-resolution ultrasound imaging



accelerated mri

wireless capsule endoscopy

eye care

HEALTHCARE

Why HDR?

HDR SENSOR

STANDARD SENSOR

Video credits: LUCID Vision Labs

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STANDARD SENSOR

Video credits: LUCID Vision Labs

HDR Photography: Multi-Exposure Capture

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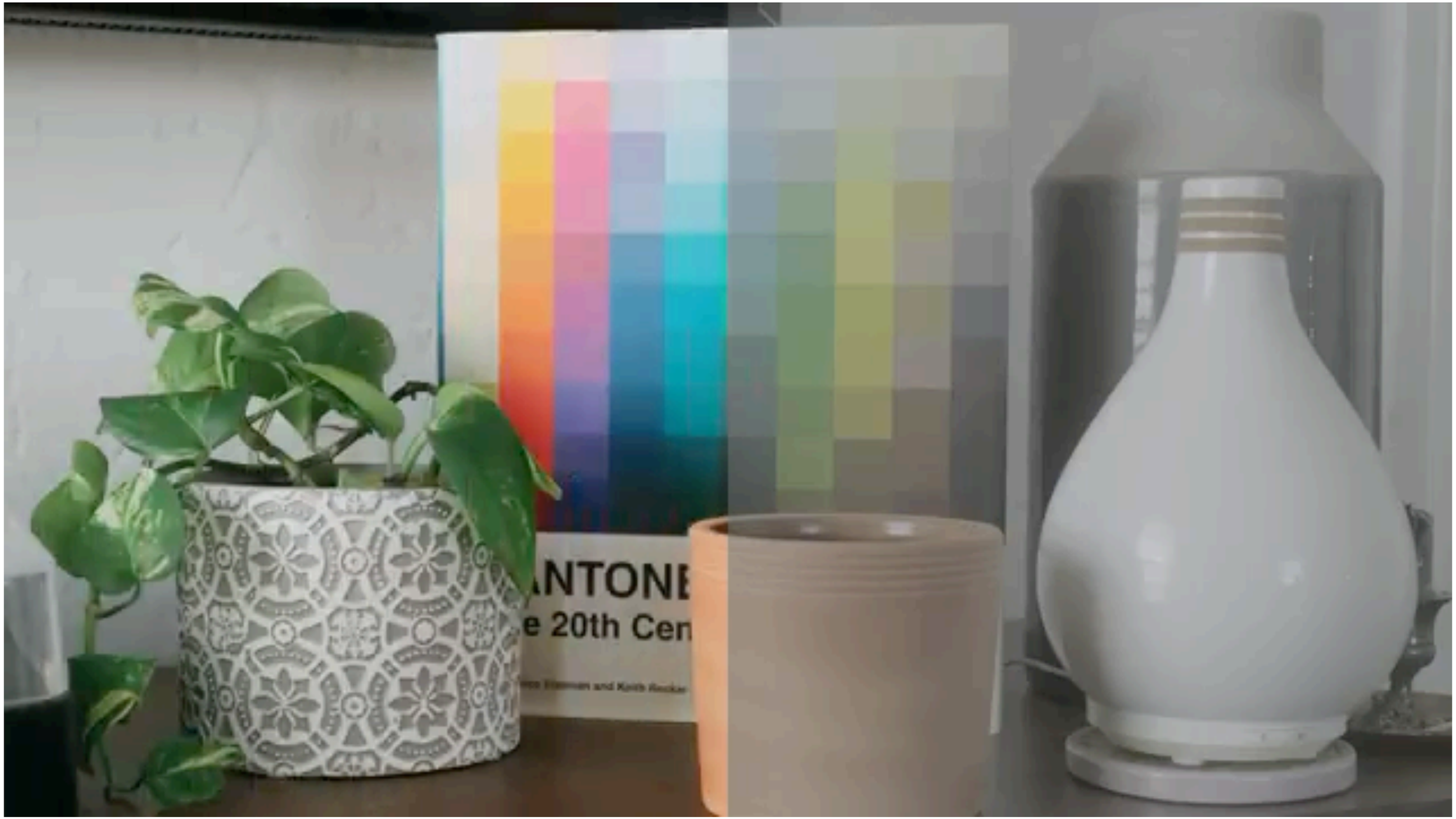
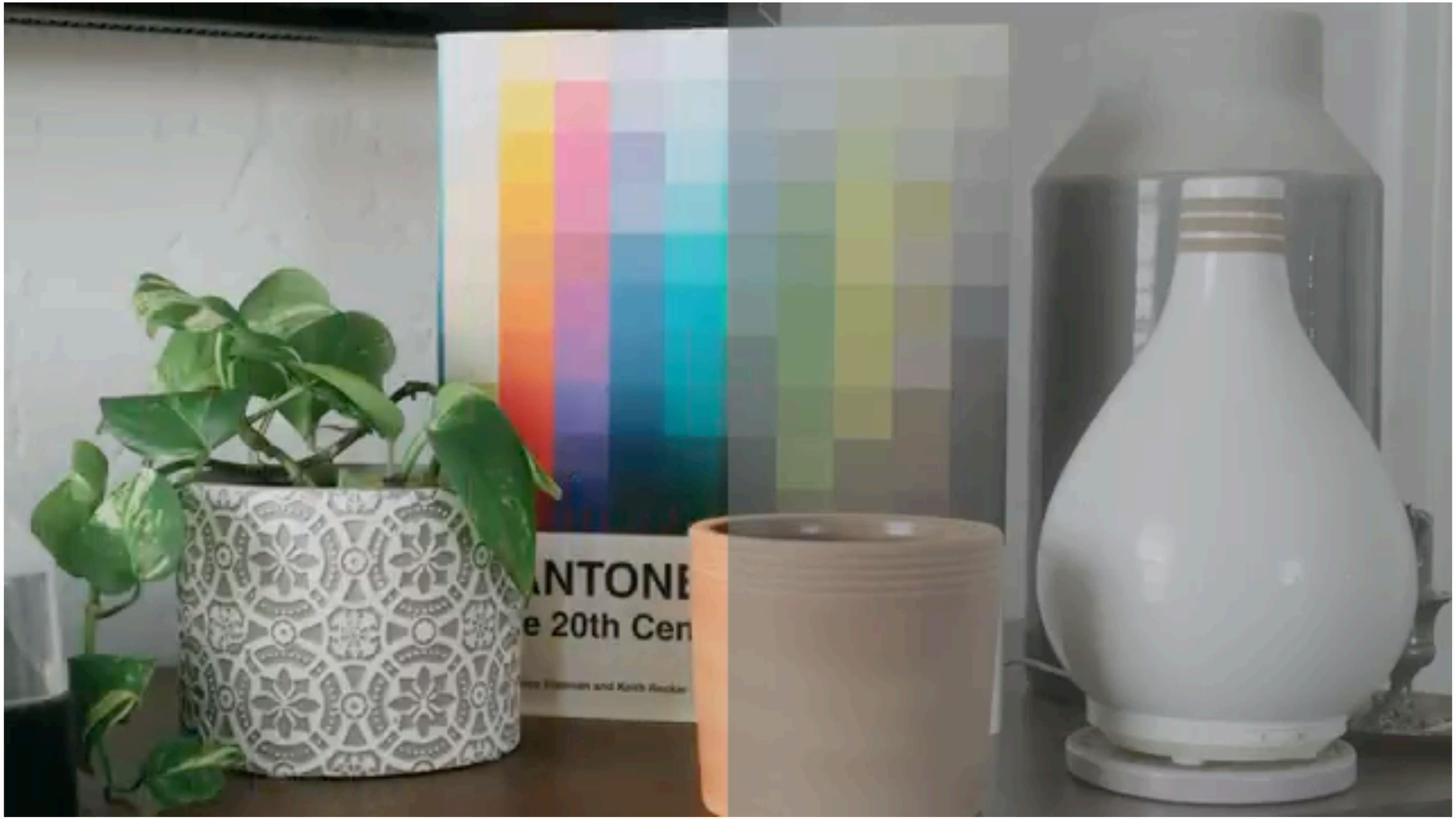
Debevec and Malik, *SIGGRAPH* 1997

HDR Videography: Logarithmic Profile



Video credits: Evan Schneider @ YouTube

HDR Videography: Logarithmic Profile



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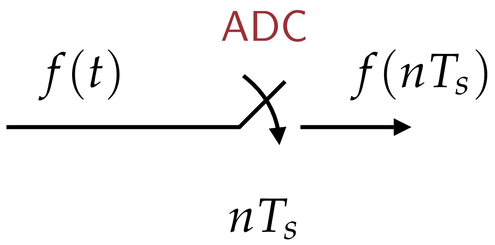
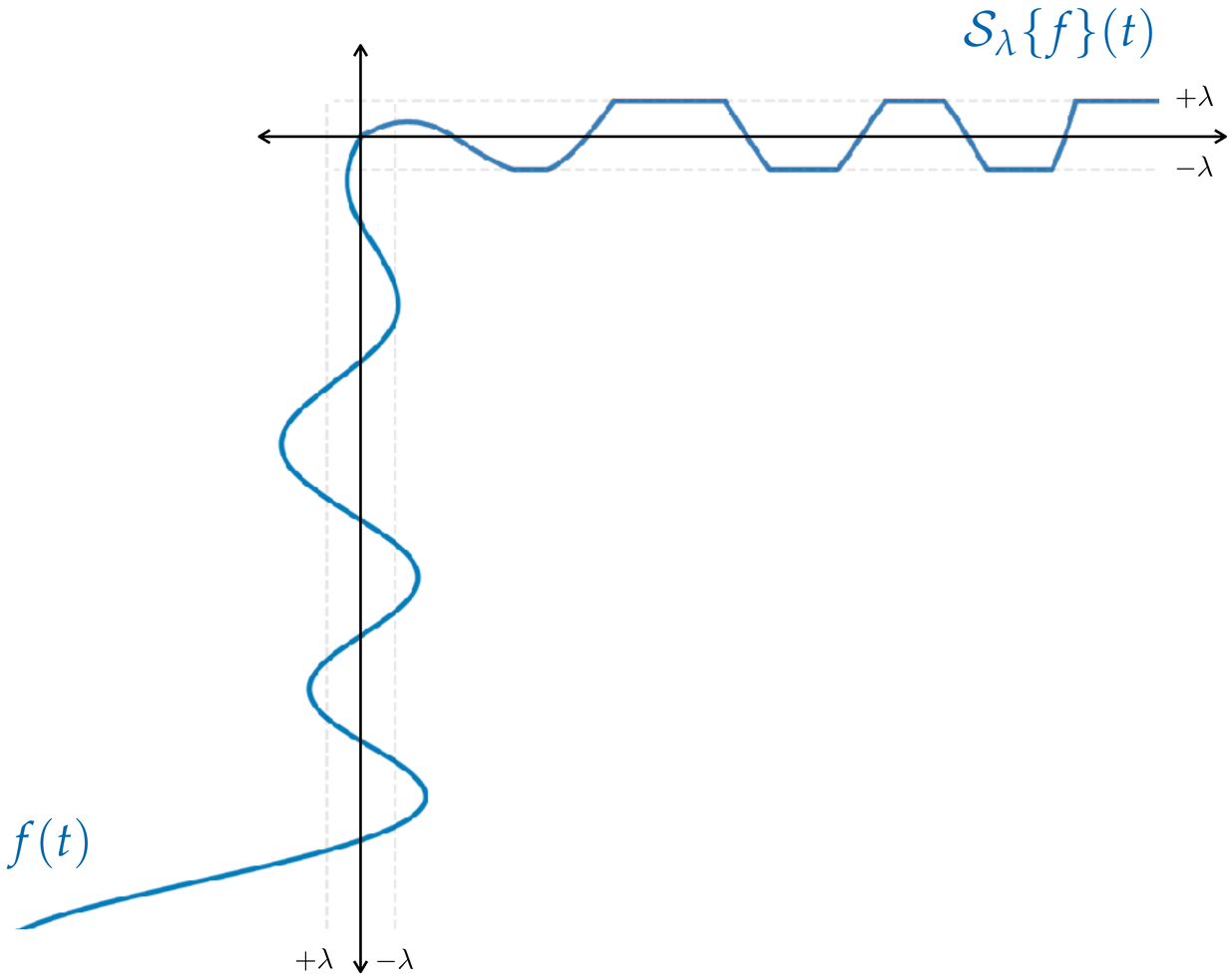
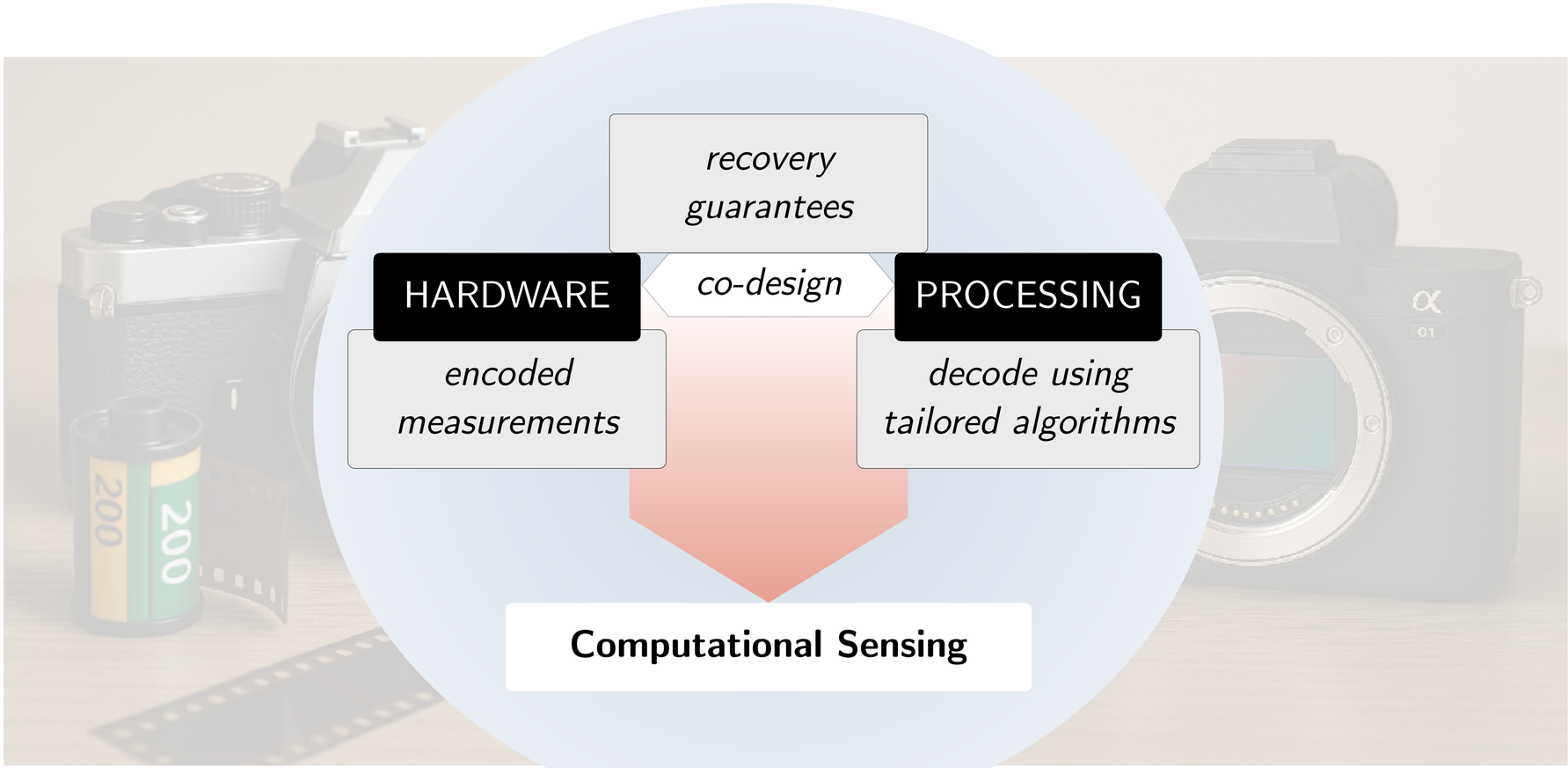
Modelling High-Dynamic Range

- Standard ADCs
  - Finite dynamic range $[-\lambda, +\lambda]$
    Beyond $[-\lambda, +\lambda]$, signal saturates
  - Fixed bit resolution
    Beyond which $\rightsquigarrow$ incur quantization noise
- *High-dynamic range (HDR)* information is lost

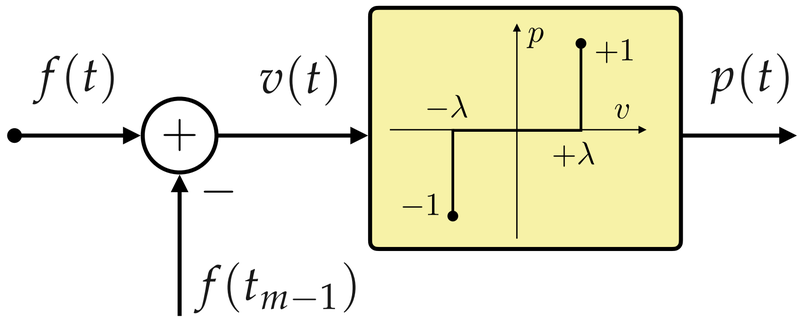


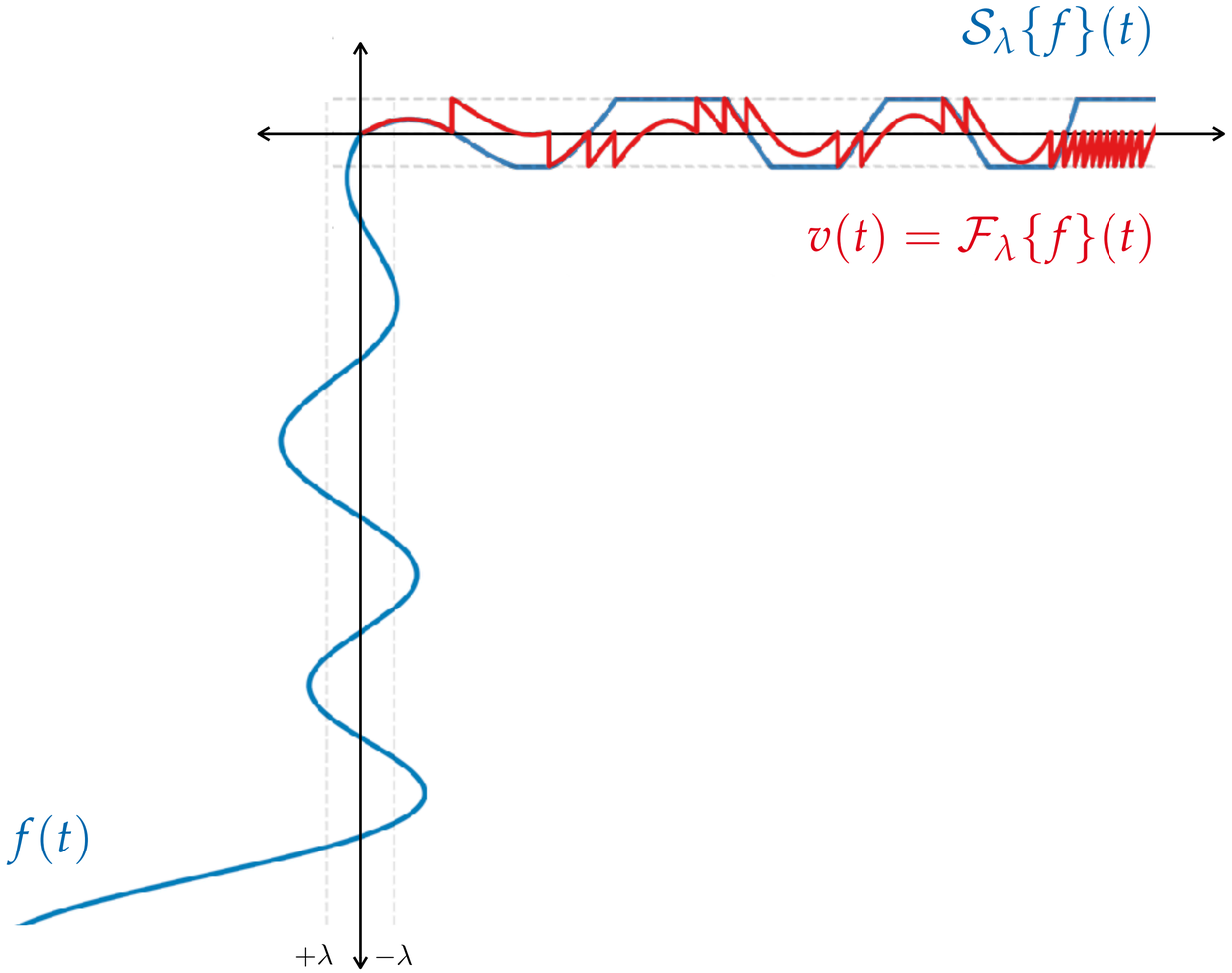


Is it possible to acquire ***unlimited*** dynamic range?



Neuromorphic Unlimited Sampling (NeUS)





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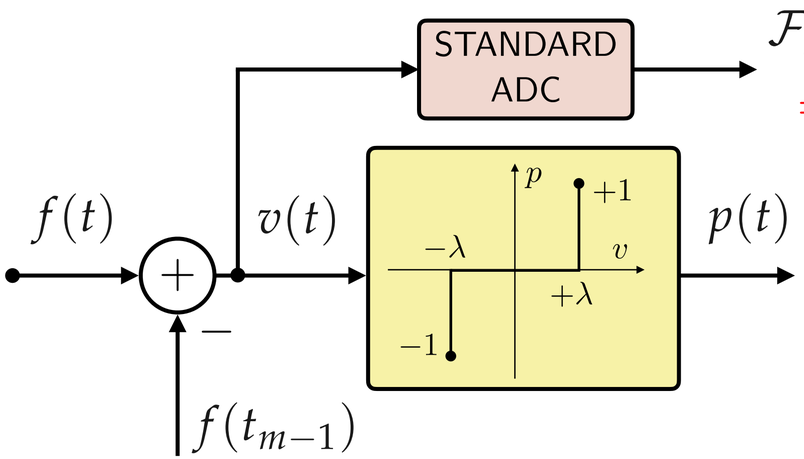
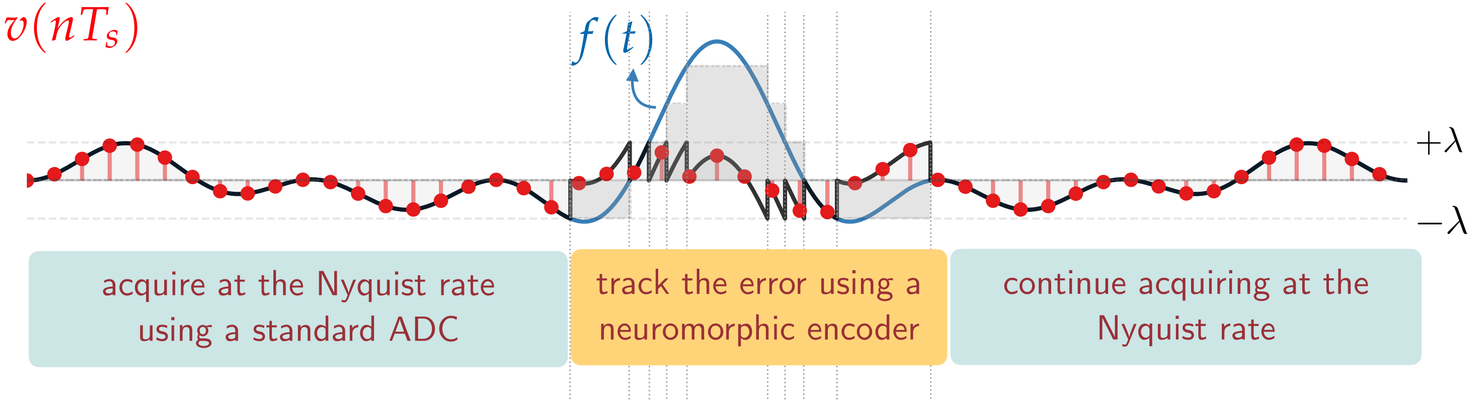


$\mathcal{F}_\lambda\{f\}(nT_s)$
$= v(nT_s)$



Signal Reconstruction

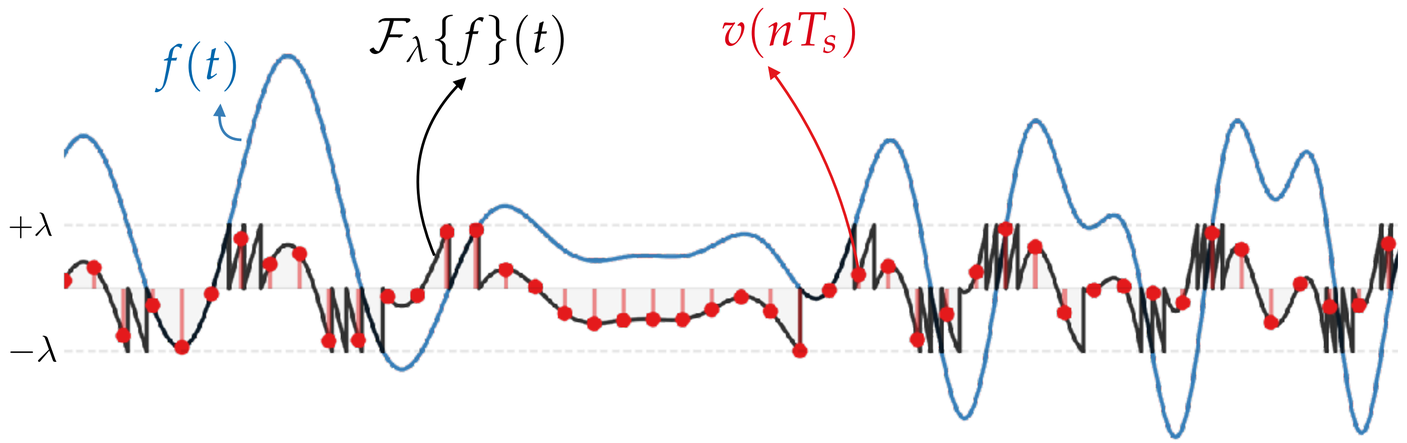
- The error signal:

$$\begin{aligned}\eta_f(t) &= f(t) - \mathcal{F}_\lambda\{f\}(t) \\ &= \sum_m \alpha_m \mathbb{1}_{[t_m, t_{m+1}[}(t)\end{aligned}$$

- Amplitude shifts $\alpha_m = \lambda \sum_{k=0}^{m} p_k$

- Reconstruction:

$$\check{f}(nT_s) = v(nT_s) + \eta_f(nT_s)$$



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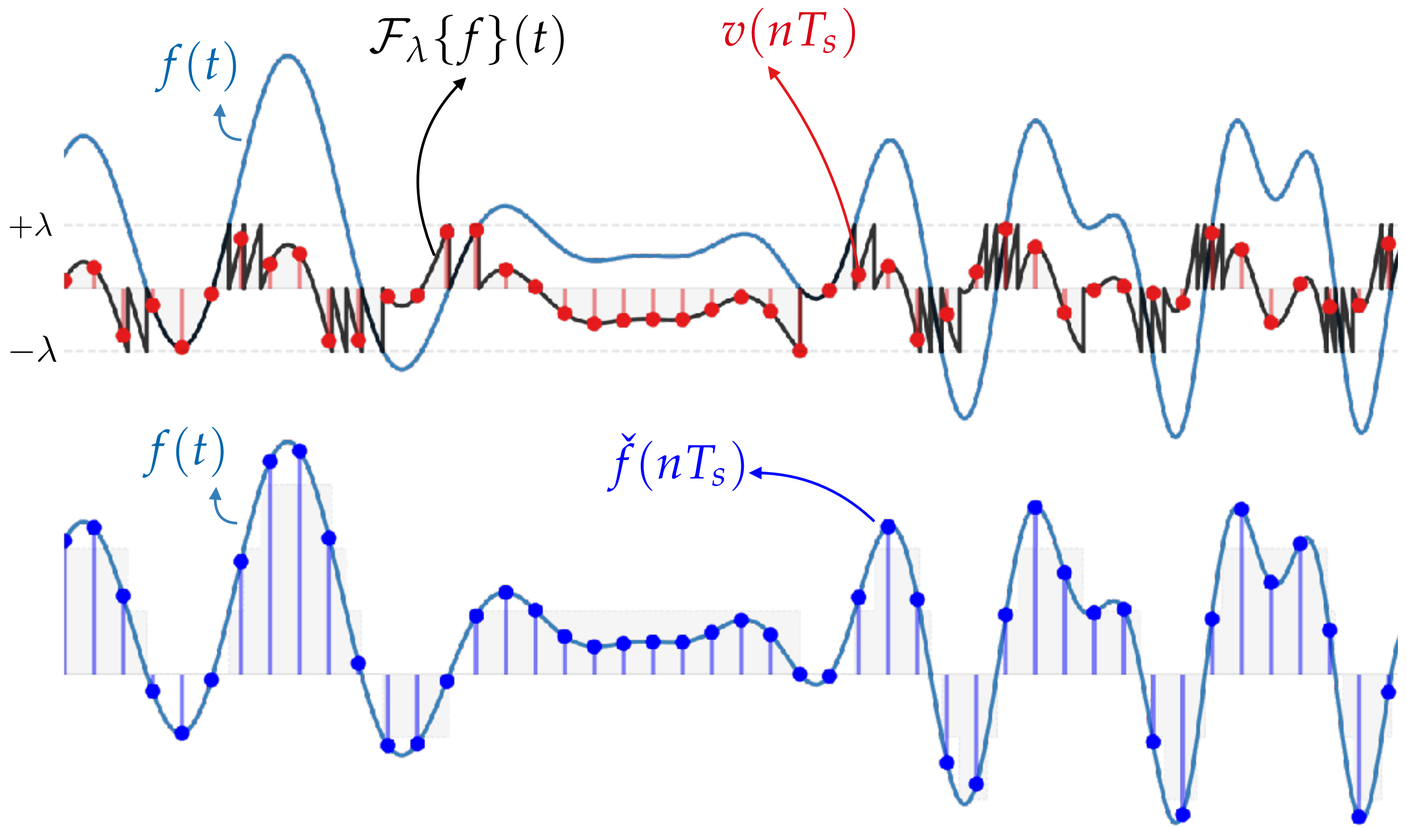
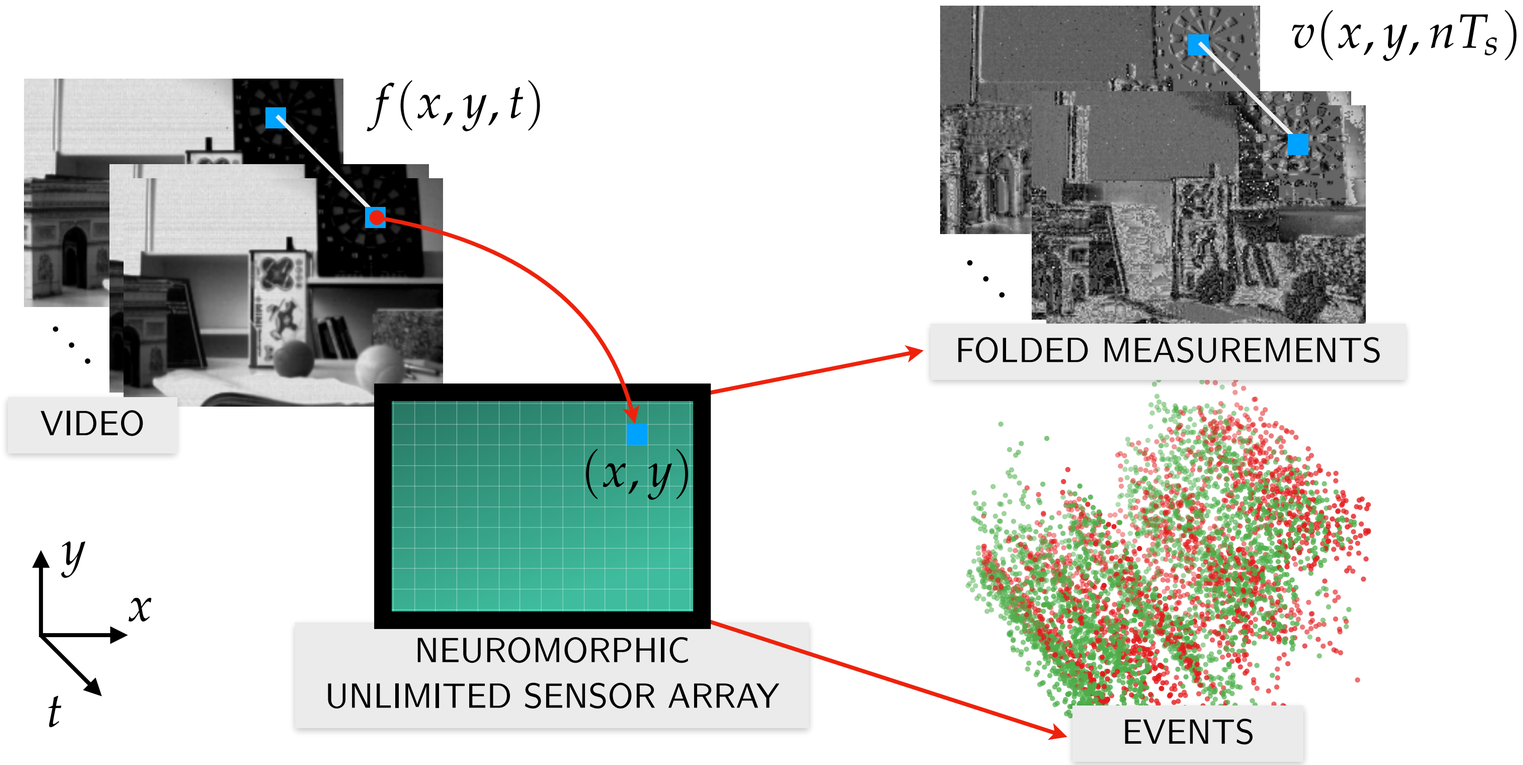
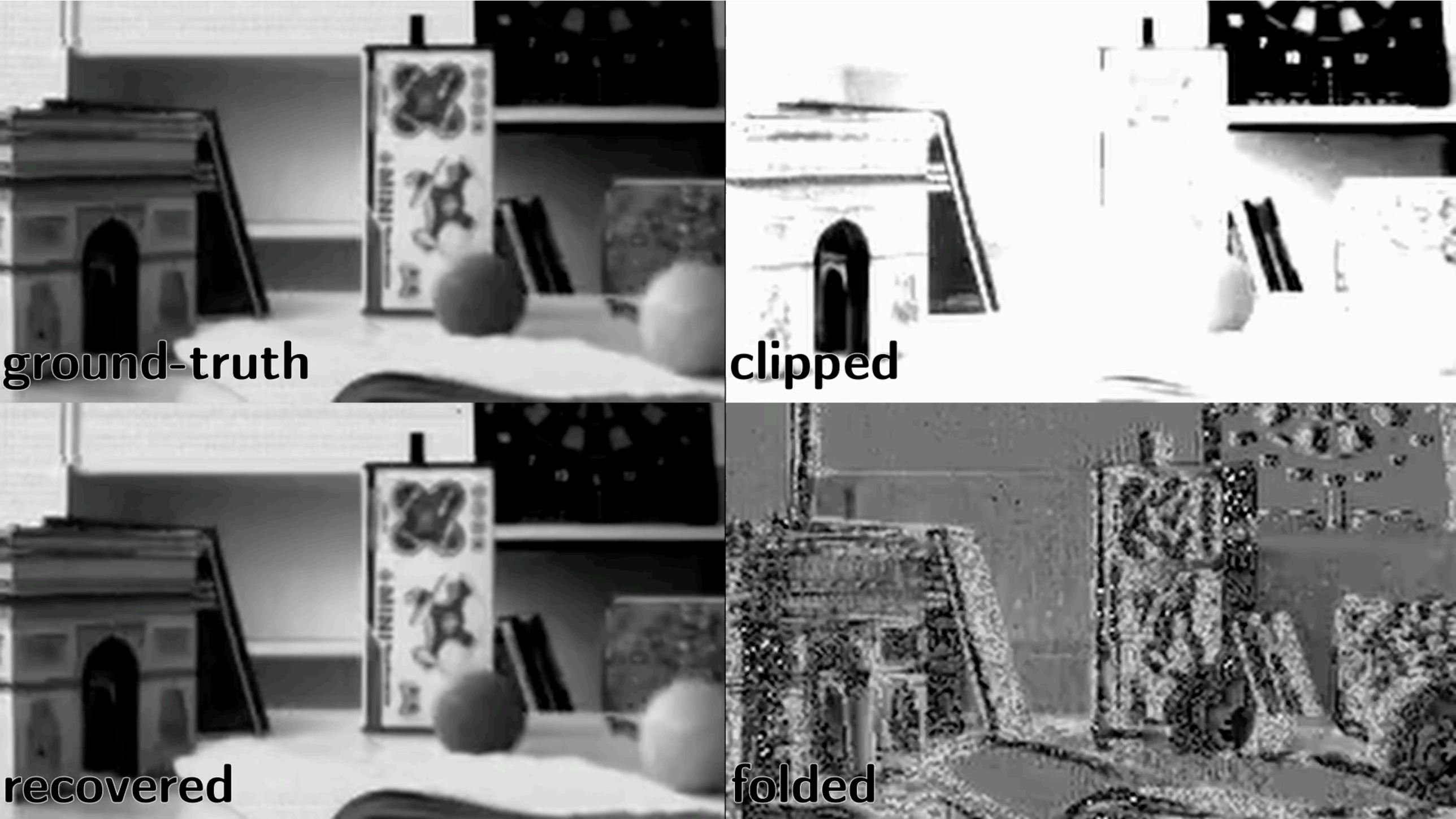
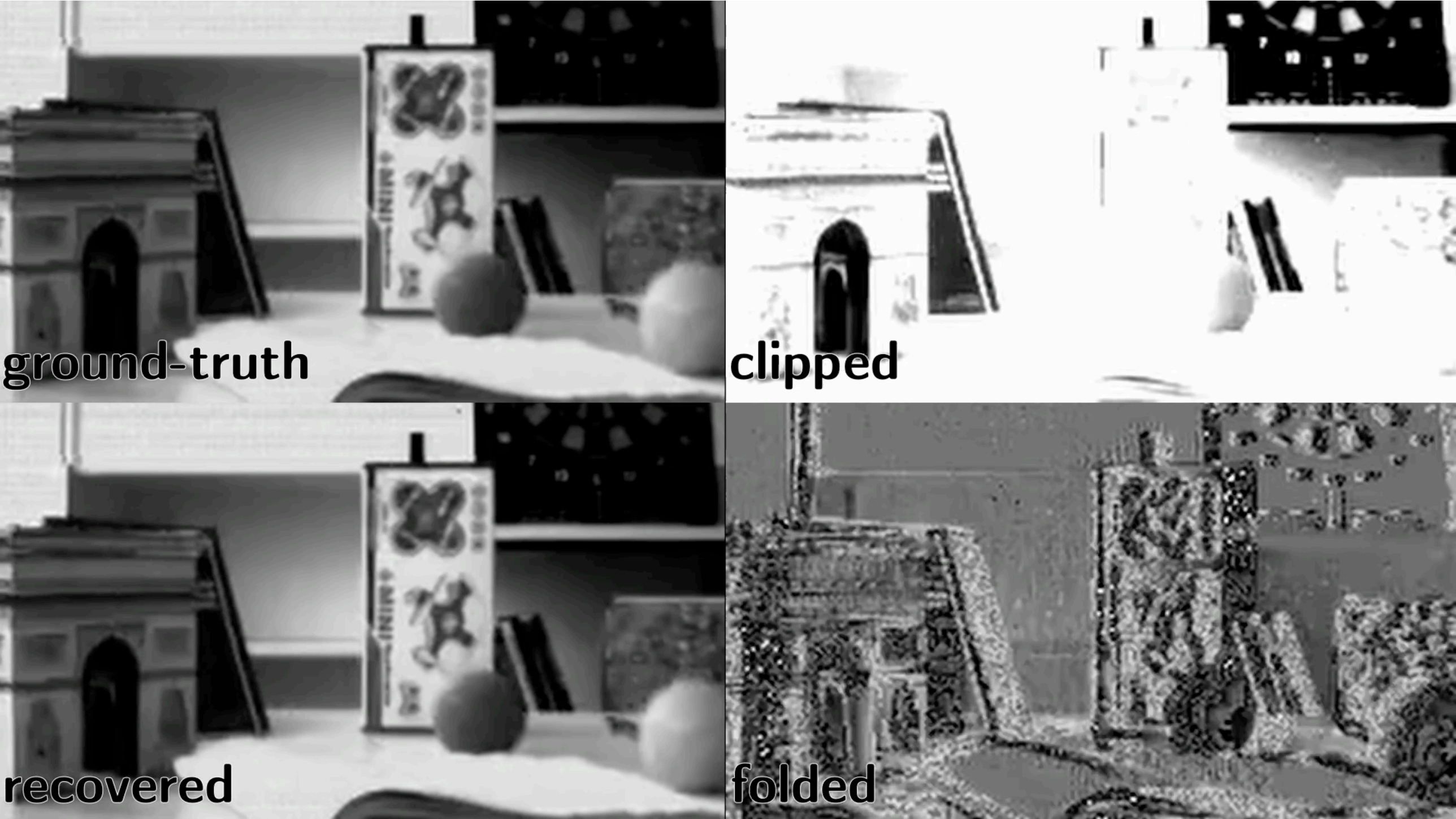


NeUS on a Pixel Array




ground-truth
clipped
recovered
folded


ground-truth
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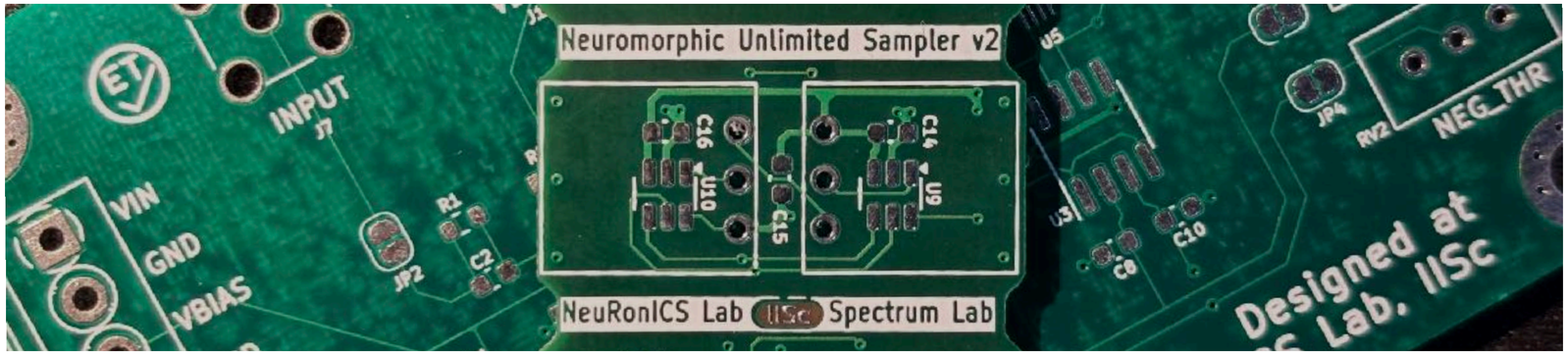
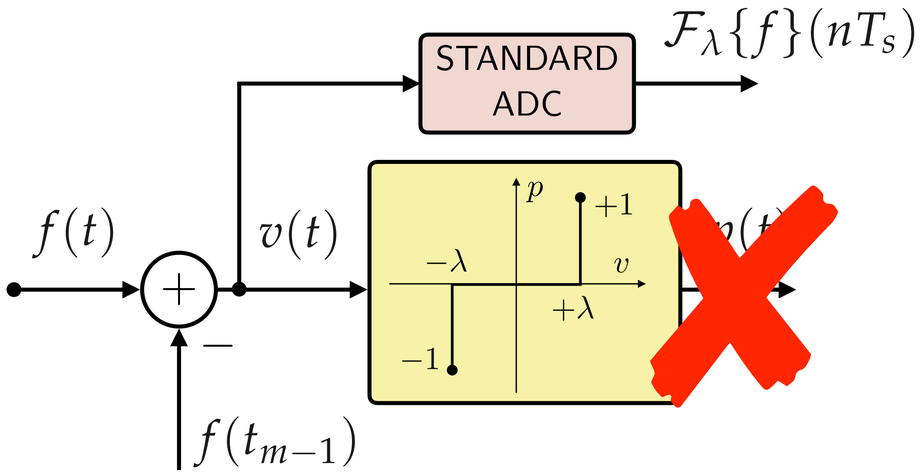
measurements


measurements

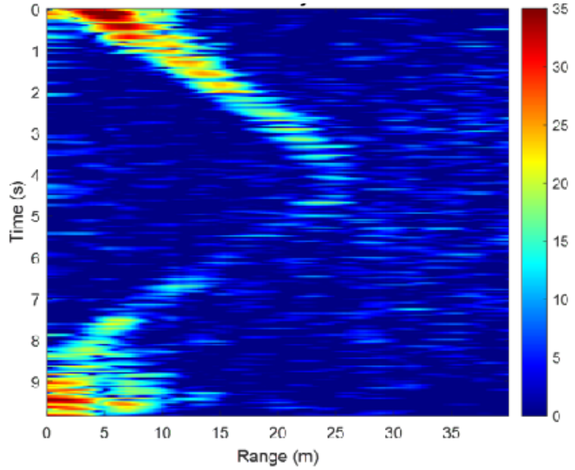
Outlook



hardware design



recovery without events



applications

Thank You!

project

slides

$$\sigma_x \sigma_p$$