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3 May 2023

Timing is everything: model-based and learning-based reconstruction methods for event-driven cameras

Pier Luigi Dragotti

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Motivation

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Motivation (cont'd)

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Outline

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Bio-Inspired Energy Efficient Sensing

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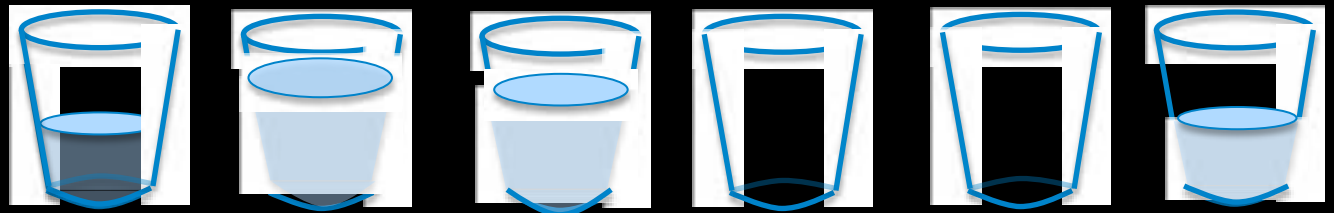

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Bio-Inspired Energy Efficient Sensing

Approach 2

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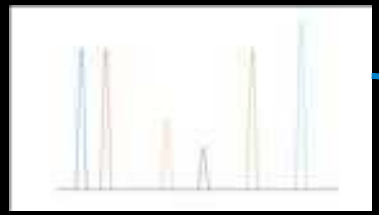
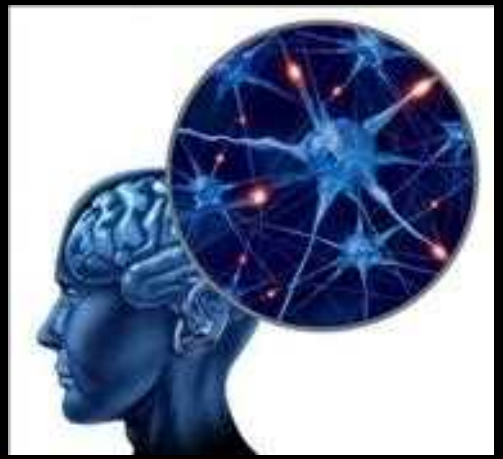
Bio-Inspired Energy Efficient Sensing

Approach 2
integrate-and-fire neurons

Time encoding appears in nature

very efficiently





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Time-Encoding Machines

Integrate-and-fire System

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Reconstruction from time-encoded information

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Reconstruction from time-encoded information

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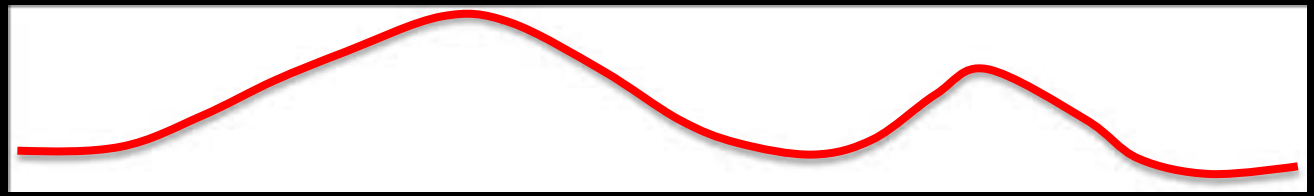
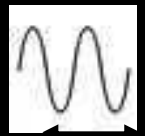
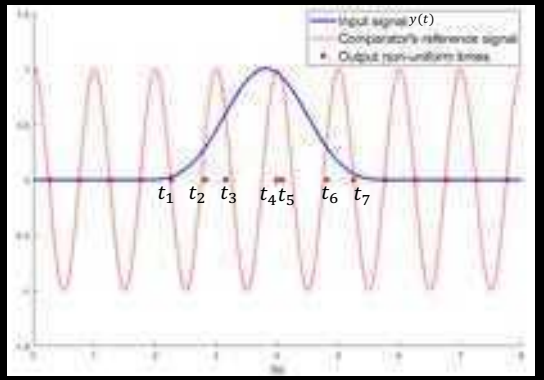


Time-Encoding Machines

Comparator System





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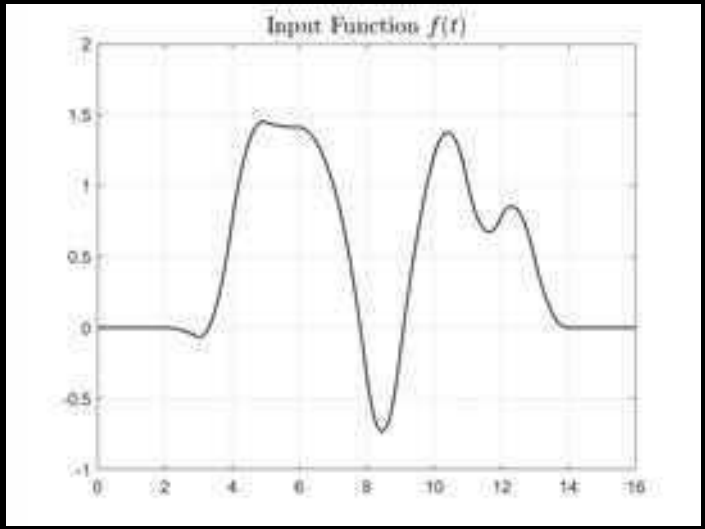
Reconstruction from time-encoded information



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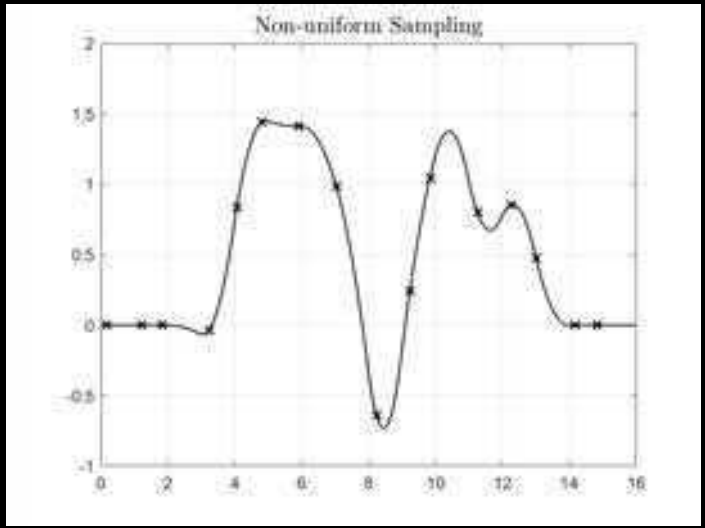

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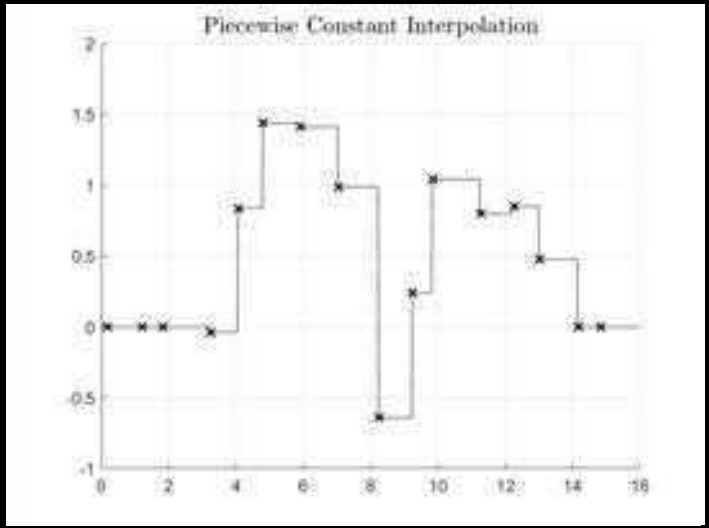

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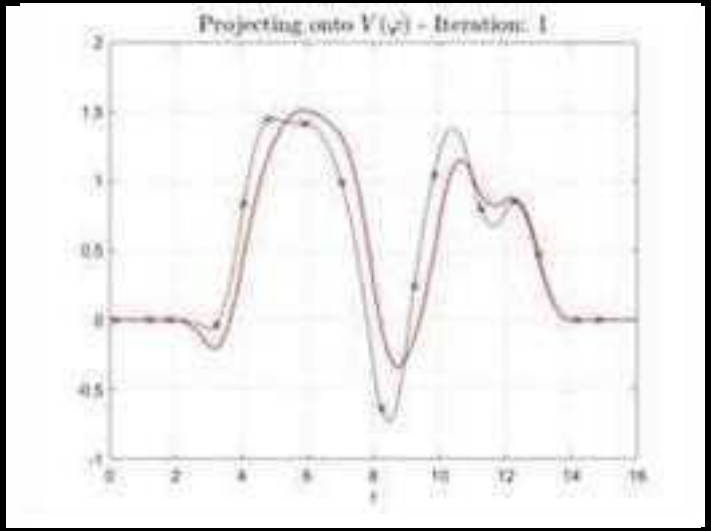

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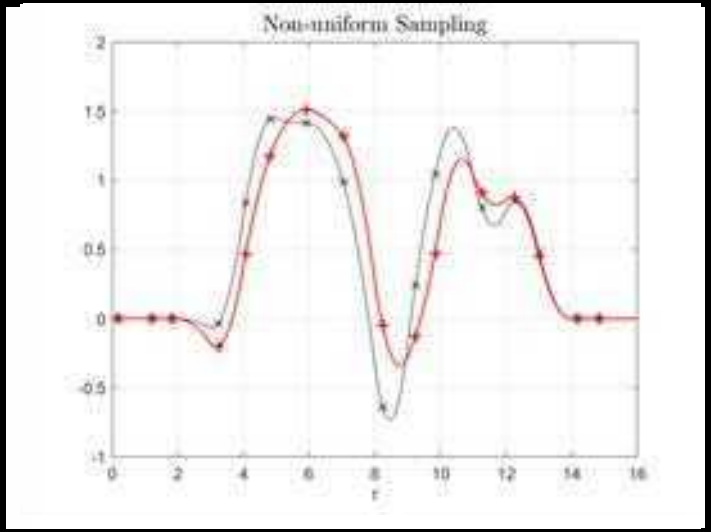

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Reconstruction from time-encoded information

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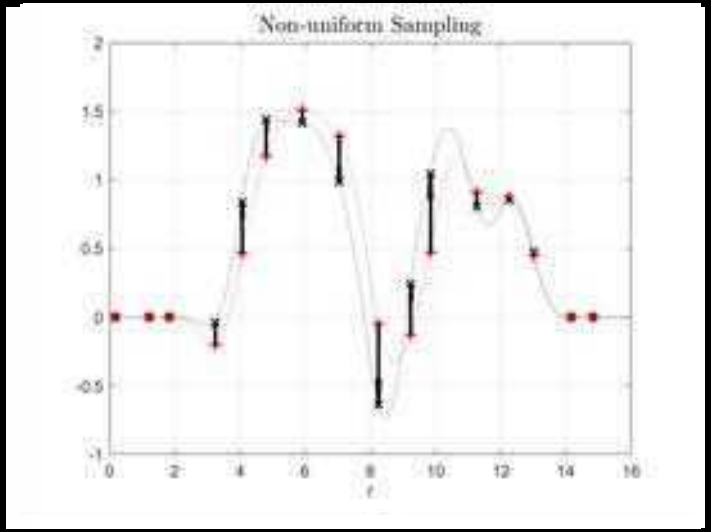

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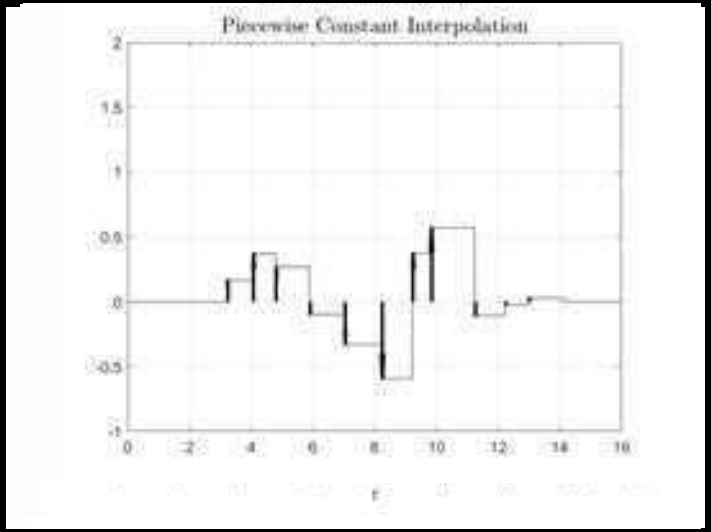

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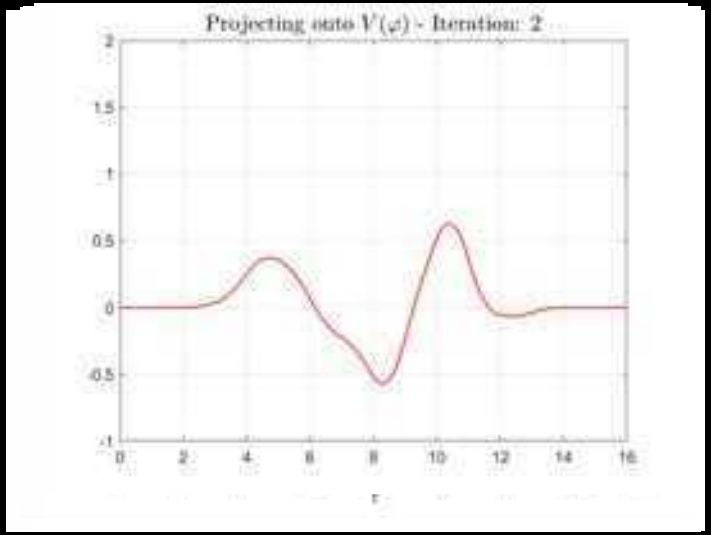

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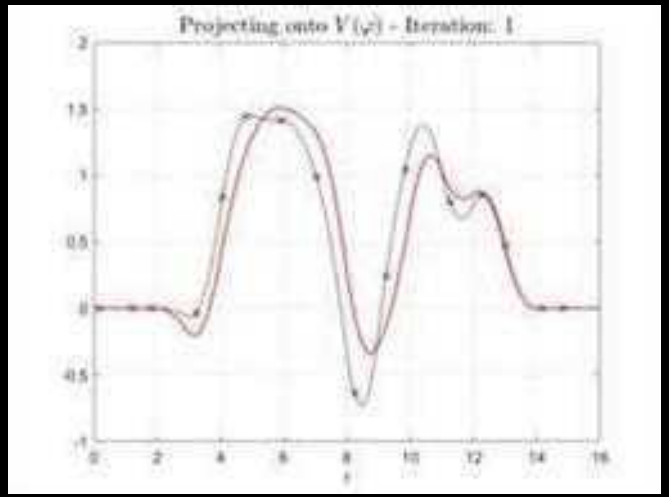

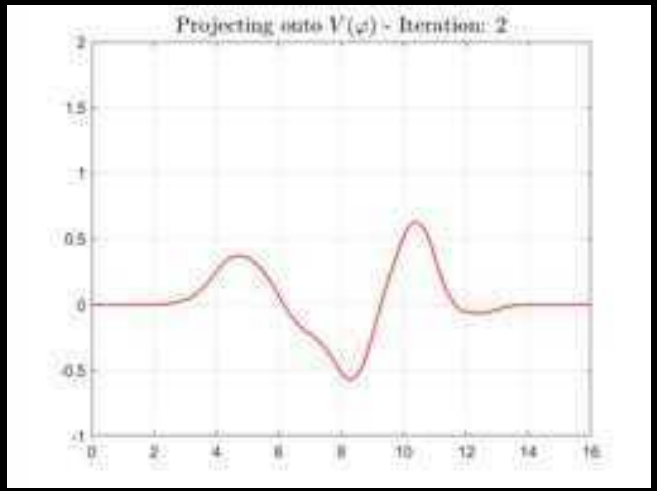

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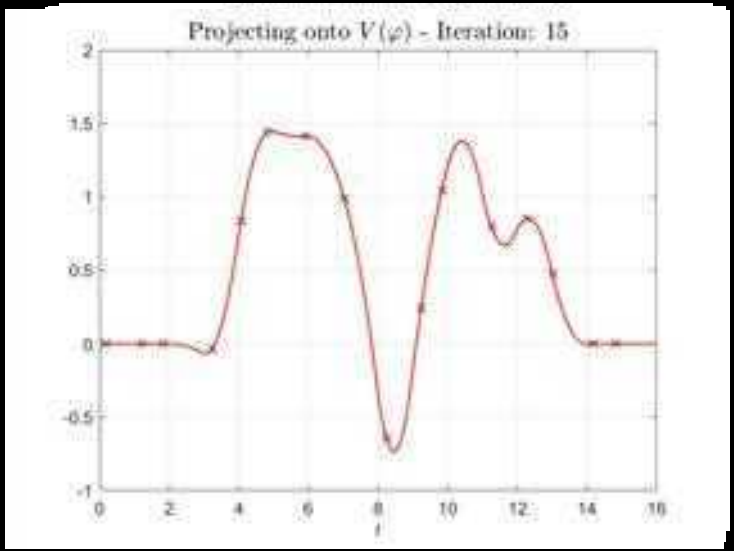

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Reconstruction from time-encoded information

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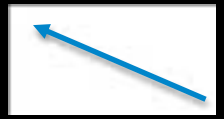
Reconstruction from time-encoded information



Time-based Sampling of Sparse Signals

Signals:

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Sensing Systems:

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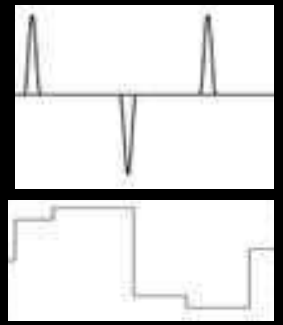

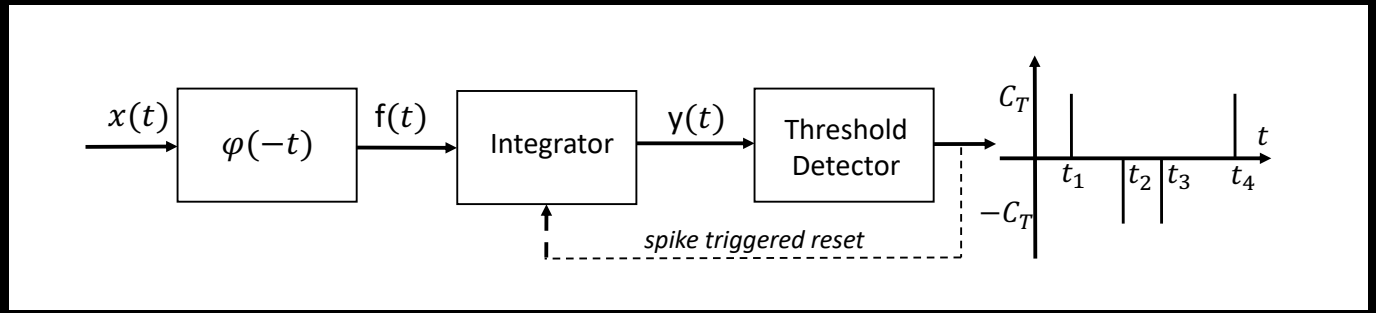

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Our approach for time decoding of signals

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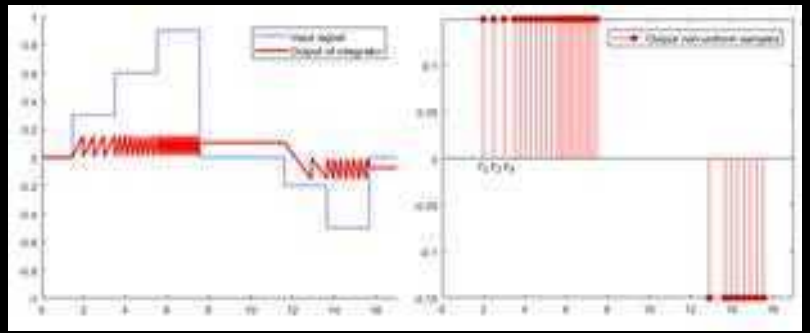
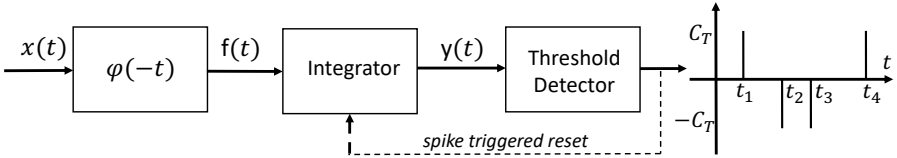
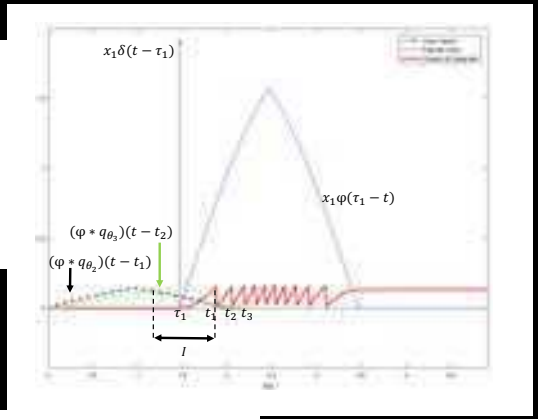


Integrate and Fire TEM



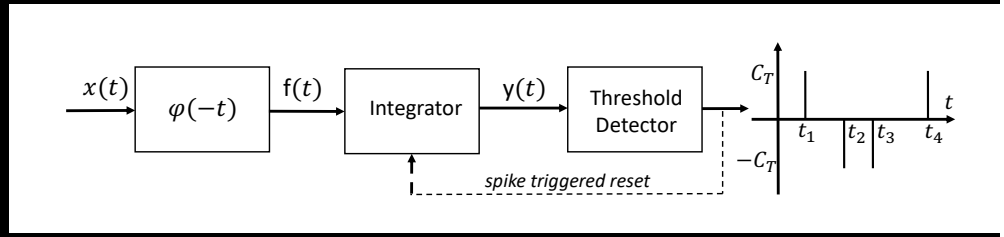


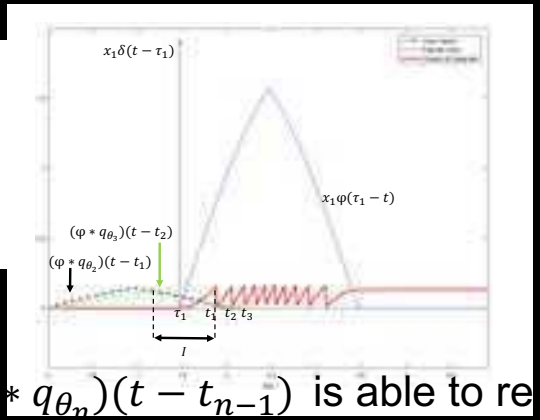
$$y(t_n) = \langle x(t), (\varphi * q_{\theta_n})(t - t_{n-1}) \rangle,$$

where $\theta_n = t_n - t_{n-1}$ and $q_{\theta_n}(t)$ is defined as:

$$q_{\theta_n}(t) = \begin{cases} 1, & 0 \leq t \leq \theta_n, \\ 0, & \textit{otherwise}. \end{cases}$$

Integrate and Fire TEM





$* q_{\theta_n})(t - t_{n-1})$ is able to re

- *Proposition:*

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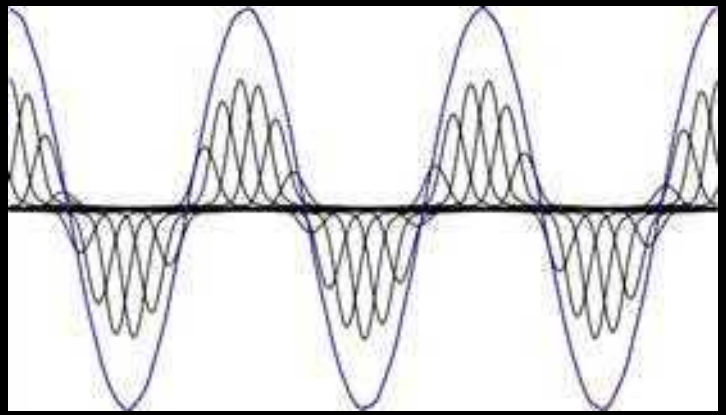
Reproduction of Exponentials



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Reproduction of Exponentials

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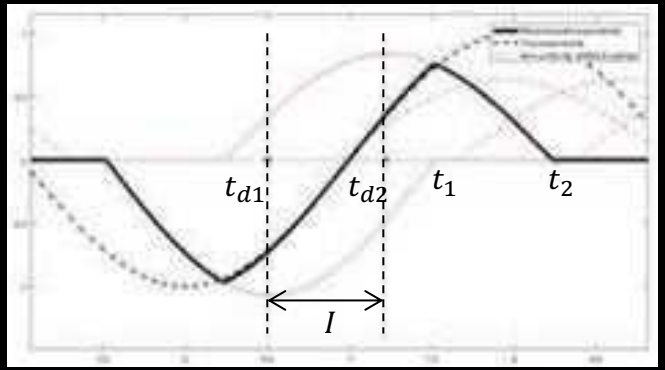

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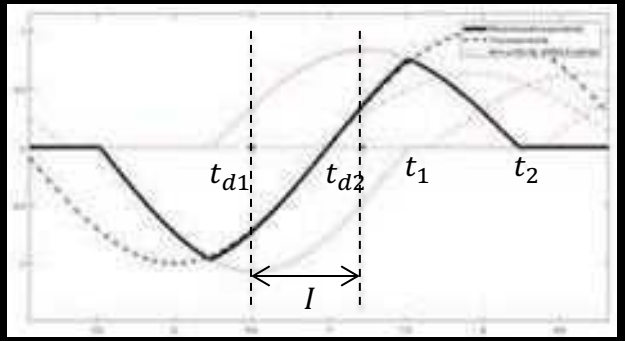
Reconstruction of an input Dirac from time-encoded information



- x_1 τ_1
- c_1 c_2 d_1 d_2

  c_1 c_2

  d_1 d_2
- c_1 c_2 x_1 c_1 τ_1 c_2 τ_1 x_1 τ_1

  d_1 d_2 x_1 d_1 τ_1 d_2 τ_1 x_1 τ_1

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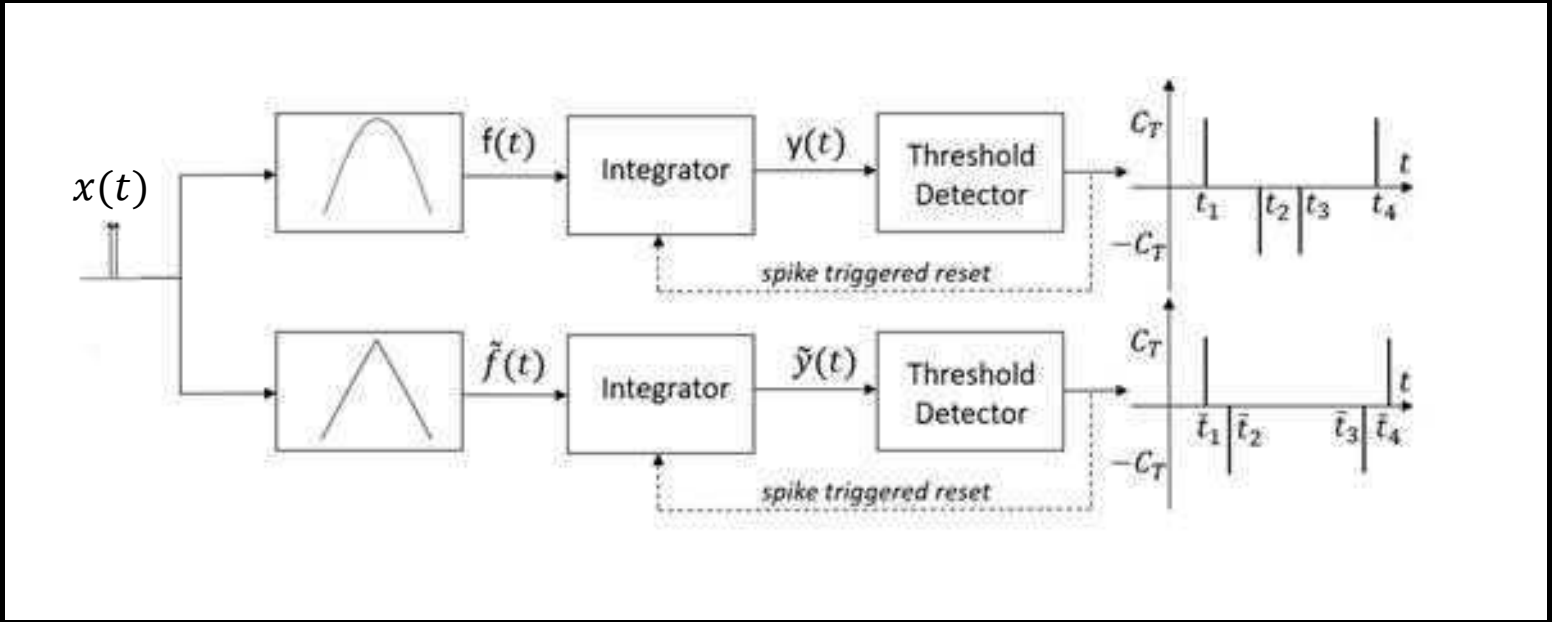
Reconstruction of close pulses



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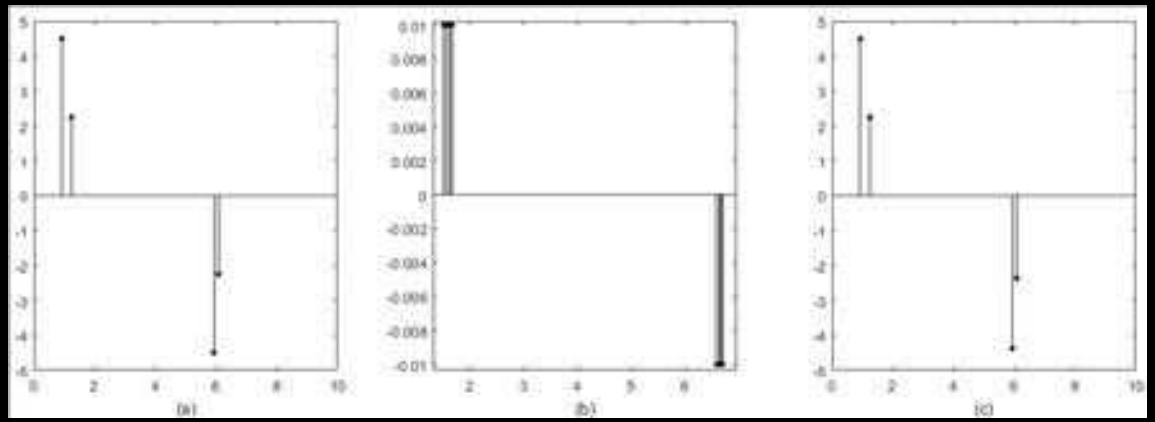
Integrate and Fire – Reconstruction of Pulses



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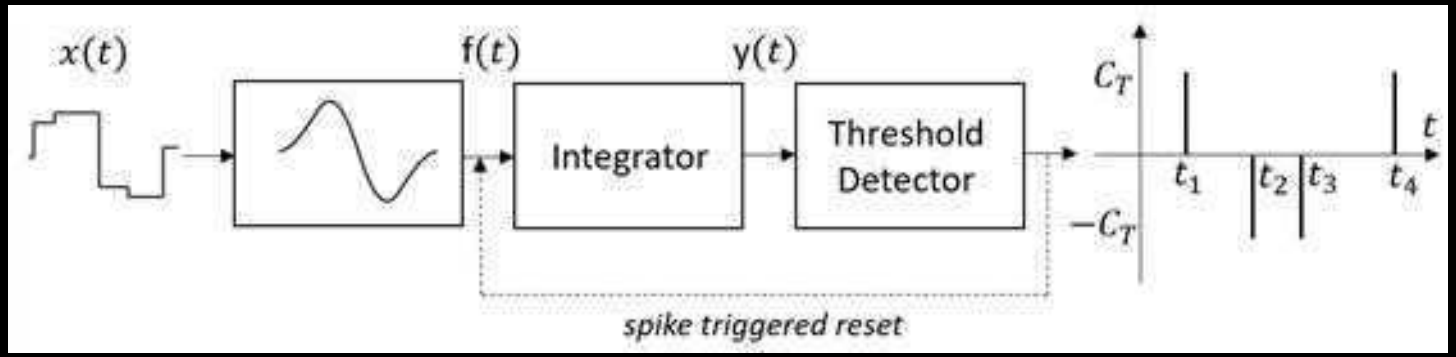
Integrate and Fire – Piecewise Constant Signals



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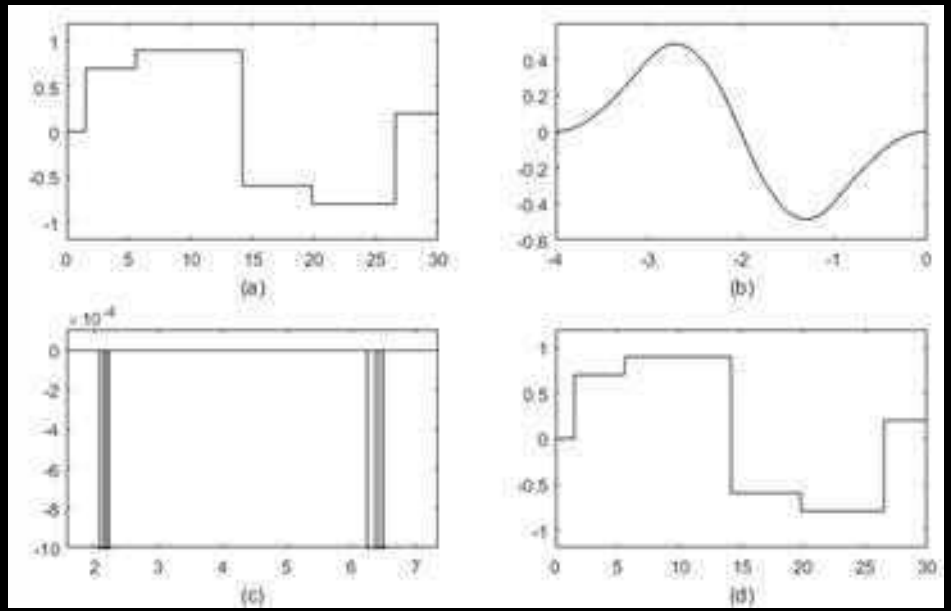
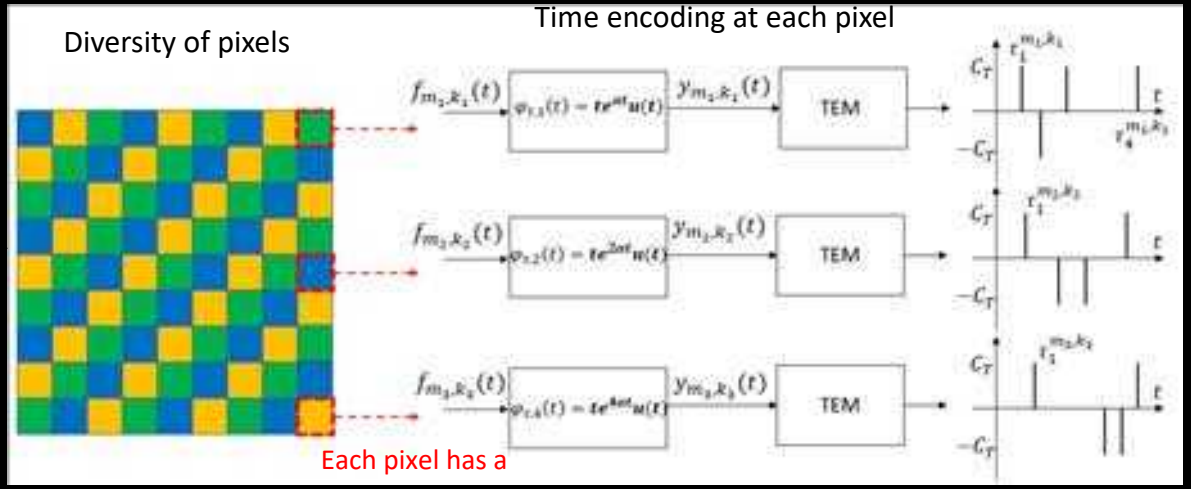
Energy Efficient Sampling -Results

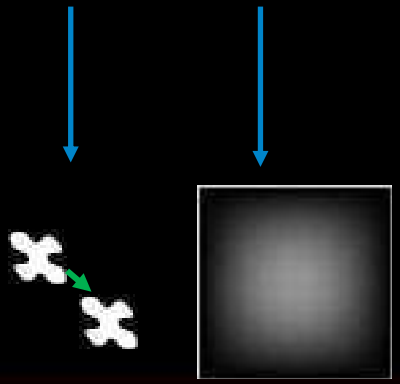


more efficient

Integrate and Fire and Neuromorphic Cameras



Each pixel has a different temporal filter



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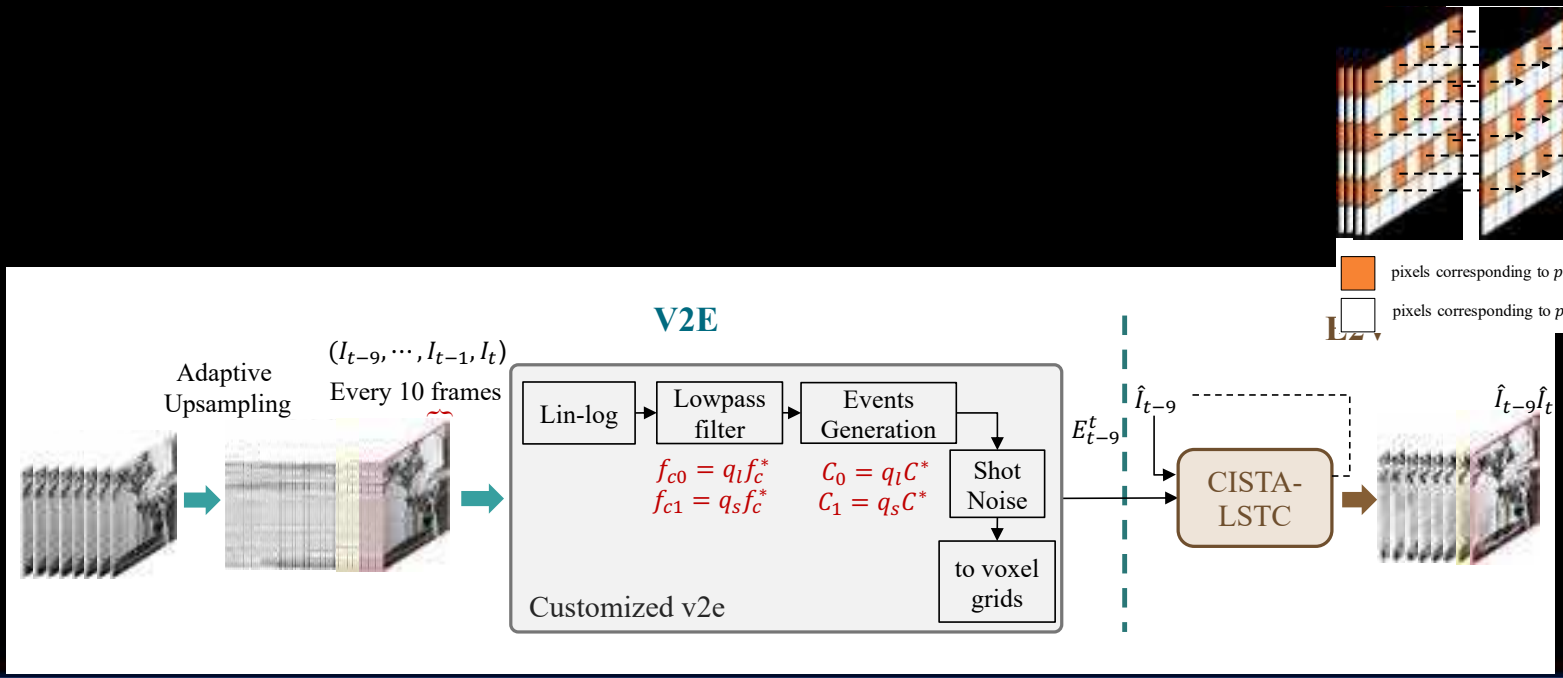
Sensing Diversity for Neuromorphic Cameras



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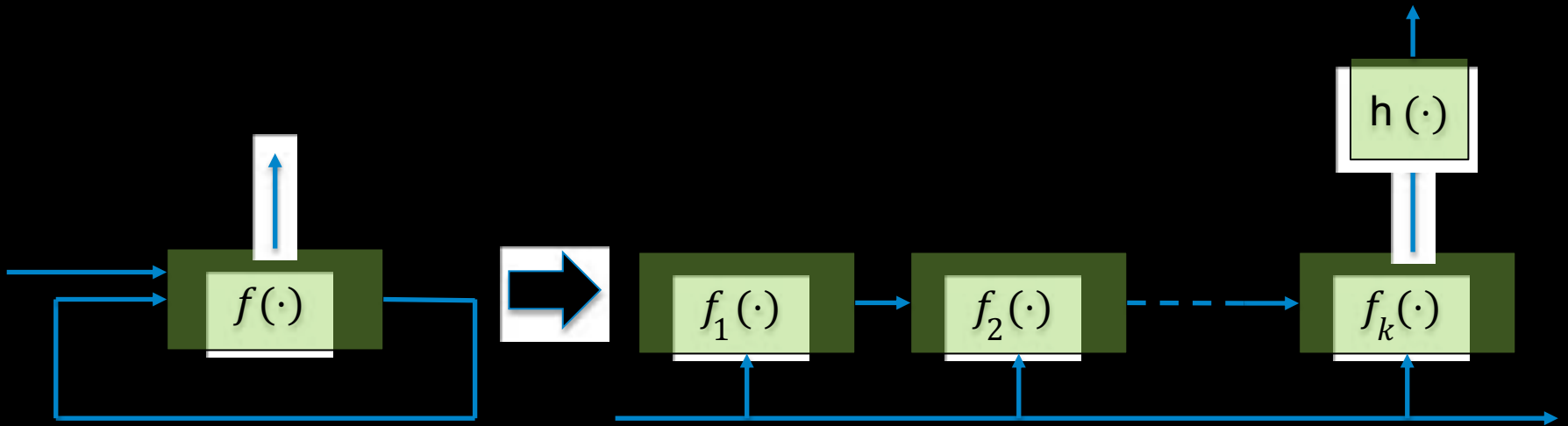
Deep Unfolding Strategy



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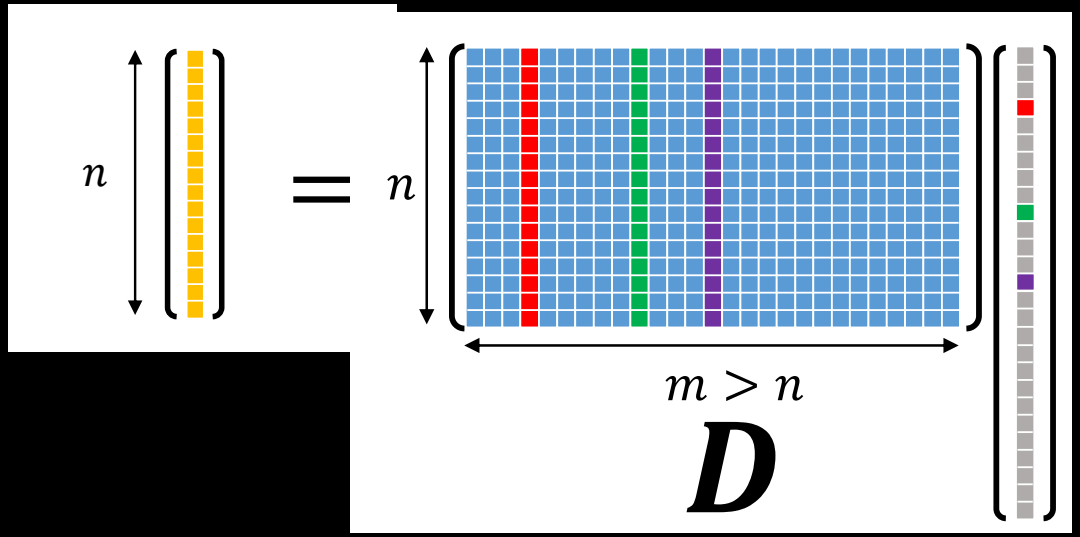
Dictionary Learning



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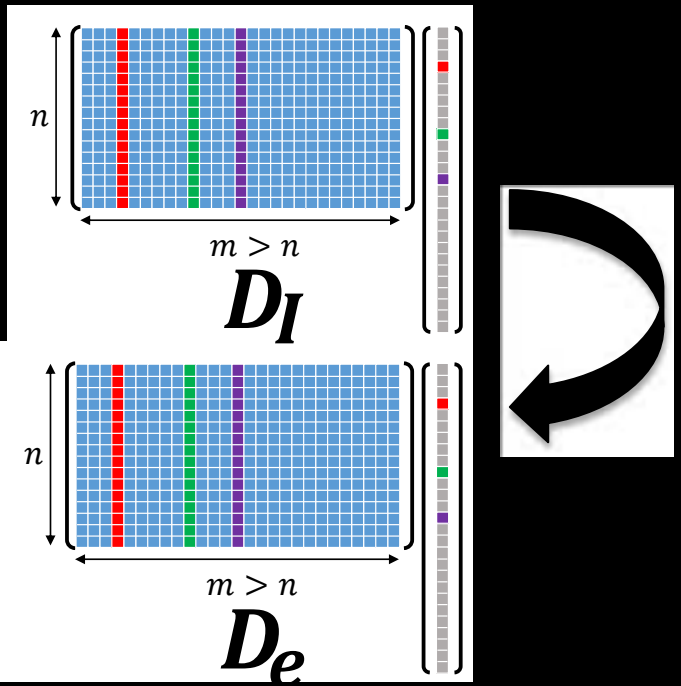
Model of dependency between intensity and events



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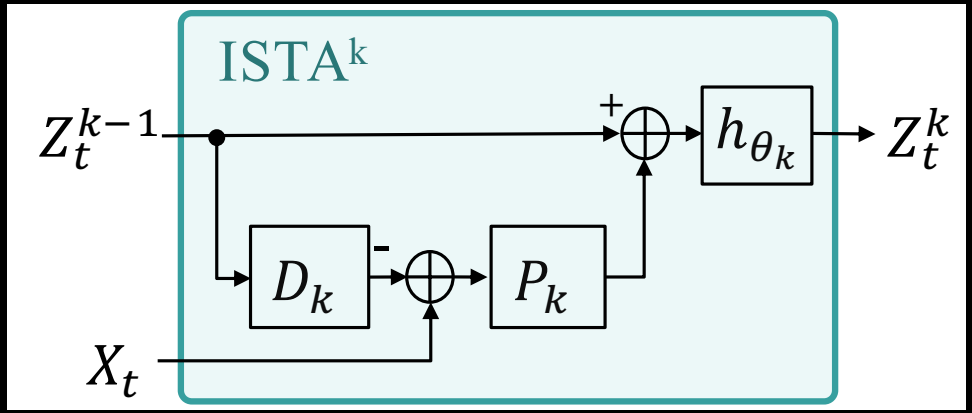
Deep Unfolding Strategy



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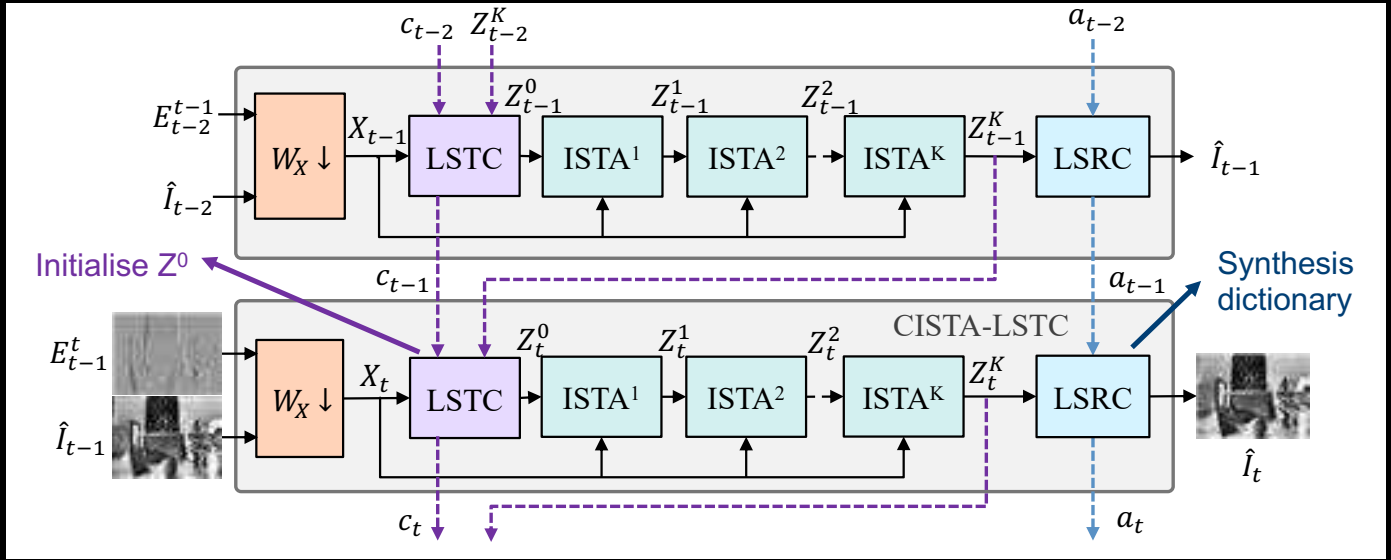
Model-based reconstruction from events



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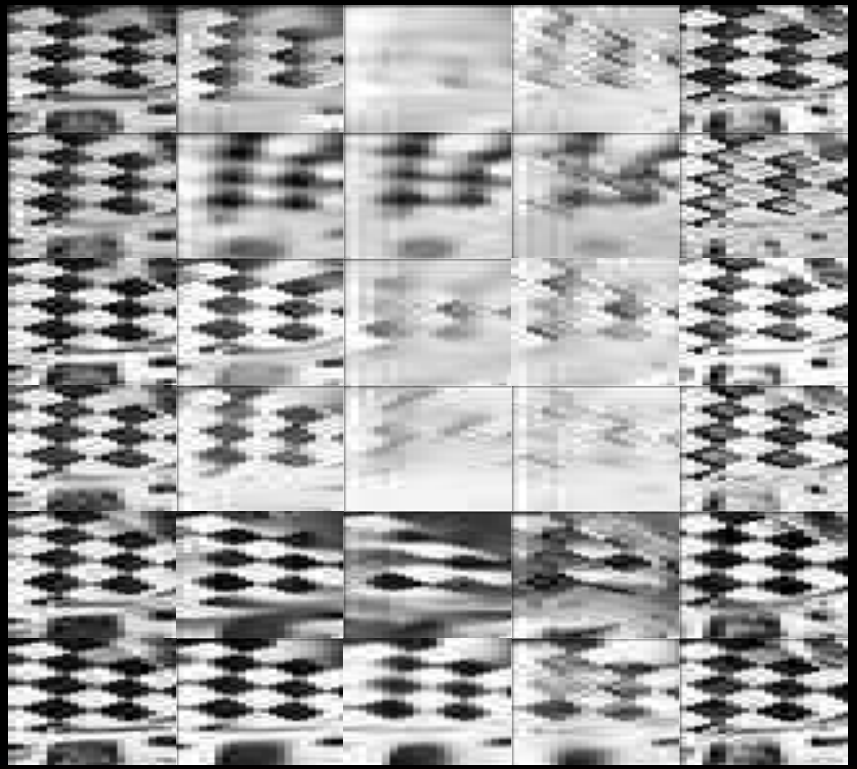

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Conclusions

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Thank you!

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References

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