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Temporal Binary Representation for Event-Based Action Recognition

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Introduction

- Event cameras capture illumination changes at extremely fast rates, generating an asynchronous stream of polarized events for each pixel.
- In order to use standard frame-based machine learning approaches, such as Convolutional Neural Networks, events must be aggregated into synchronous frames.

- Most event aggragation strategies lead to a loss of information by temporally quantizing the signal.
- We propose Temporal Binary Representation, a memory efficient event aggregation strategy, lossless up to a configurable temporal scale.

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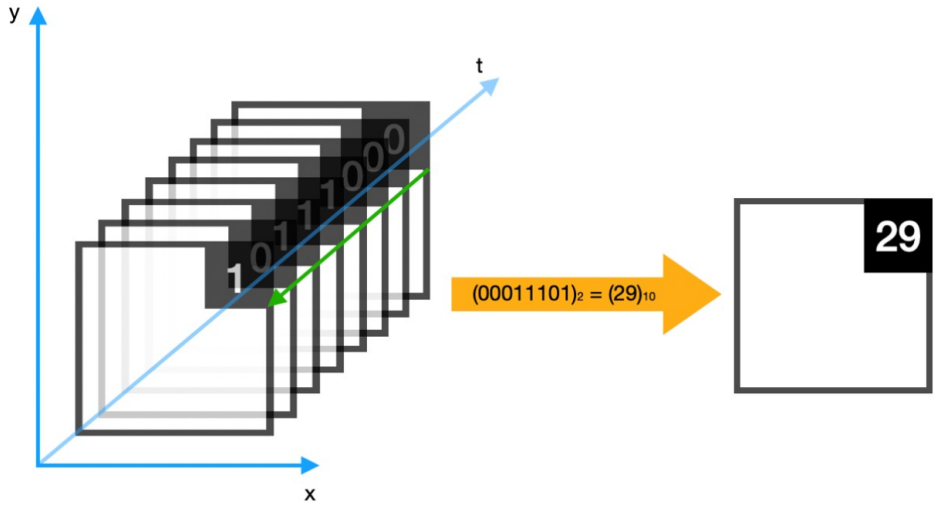
Temporal Binary Representation

- Given an arbitrarily small accumulation time Δt, we build an intermediate binary representation b^i by checking the presence or absence of an event for each pixel.
- Stacking N temporally consecutive binary representations, each pixel can be considered as a binary string of N digits $[b^0_{x,y} \;\; b^1_{x,y} \;\; \dots \;\; b^{N-1}_{x,y}]$
- We convert the binary string into a decimal number and normalize it dividing it by N



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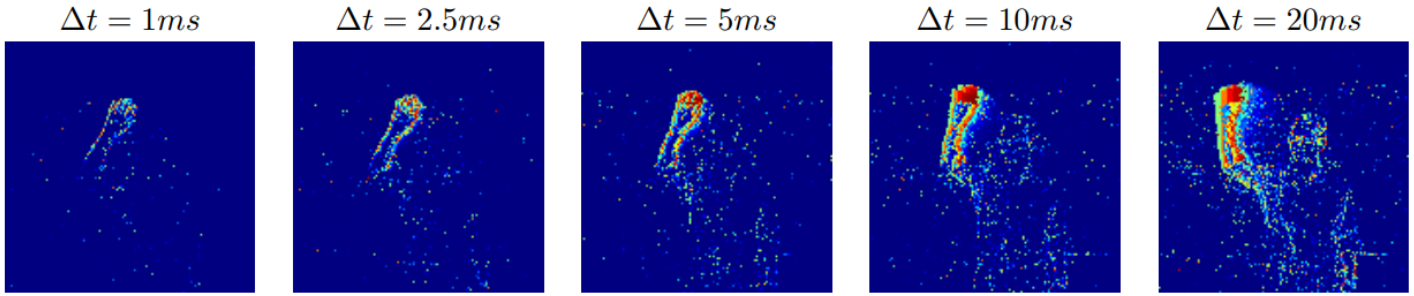
Properties of Temporal Binary Representation

- Each frame covers a timespan of $\mathrm{N} * \Delta t$
- Memory efficient
  - N separate representations are encoded into a single frame preserving all information
  - Less data to be processed by a Neural Network
- Movement direction directly encoded in the image
  - Recent events have higher values
  - No need to encode event polarity
- Lossless representation up to Δt, which can be chosen arbitrarily small



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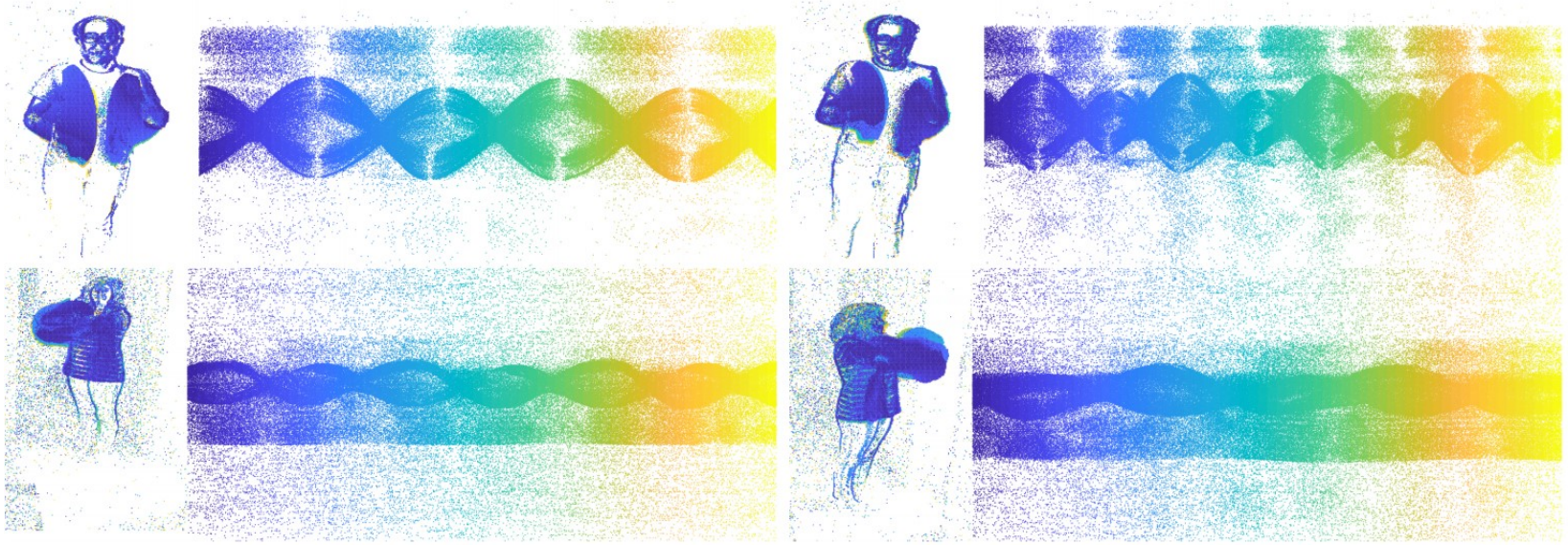
Action Recognition with Temporal Binary Representation

- We evaluate our approach on the DVS128 Gesture Dataset by training two different models
  - Inception 3D
  - AlexNet + LSTM
- We collect the MICC-EVENT Gesture Dataset to increase the variability of DVS128
  - 640x480 resolution
  - Multiple speed
  - Different scales
  - Different camera orientations
  - Uneven illumination



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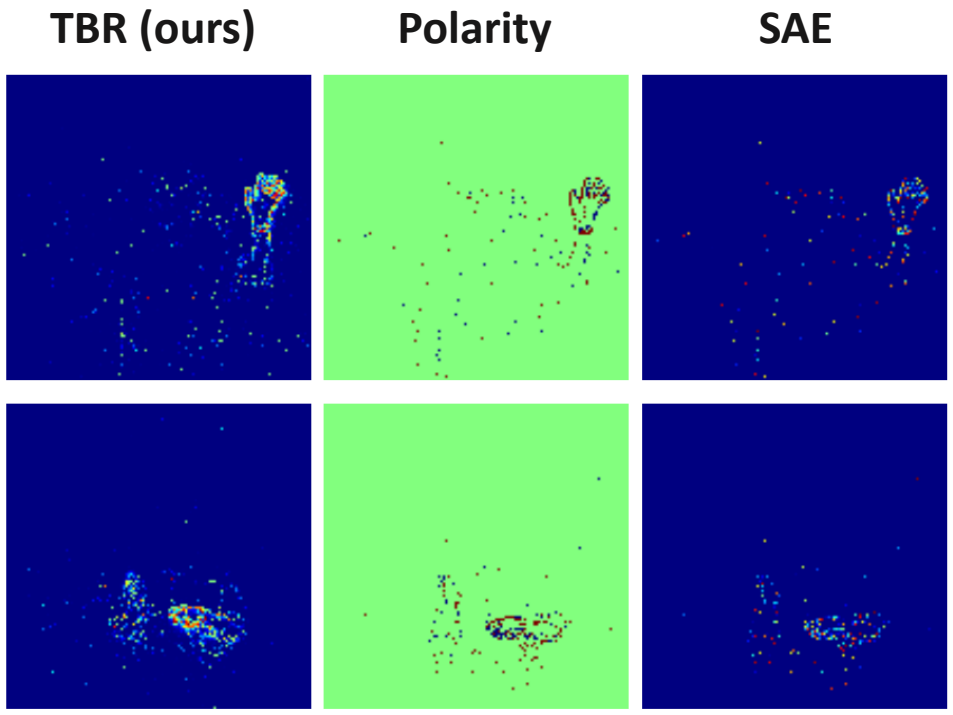
Results

RESULTS ON THE DVS128 GESTURE DATASET.

	10 classes	11 classes
Time-surfaces [25]	96.59	90.62
SNN eRBP[26]	-	92.70
Slayer [27]	-	93.64
CNN [6]	96.49	94.59
Space-time clouds [28]	97.08	95.32
DECOLLE [29]	-	95.54
Spatiotemporal filt. [3]	-	97.75
RG-CNN [30]	-	97.20
Ours - AlexNet+LSTM	97.50	97.73
Ours - Inception3D	**99.58**	**99.62**

RESULTS ON THE DVS128 GESTURE DATASET AND THE MICC-EVENT GESTURE DATASET FOR INCEPTION 3D TRAINED WITH THREE DIFFERENT AGGREGATION STRATEGIES: TBR (OURS), POLARITY [1] AND SAE [36].

	TBR (ours)	Polarity	SAE
DVS128 Gesture Dataset	**99.62**	98.86	98.11
MICC-Event Gesture Dataset	**73.16**	68.40	70.13



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Conclusions

- TBR is a simple, yet effective, aggregation strategy for event data based on binary intermediate representations.
- Since we losslessly aggregate several multiple representation, we lower the memory footprint while generating more informative representations compared to standard approaches
- State of the art results on the DVS128 Gesture Dataset
- New MICC-EVENT Gesture Dataset collected

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