Design and Implementation of a Compute-Efficient Event-Based 2D MIMO OCC system

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1. Introduction

- As wireless communication demand grows, Optical Camera Communication (OCC) emerges as a cost-effective and straightforward complement to existing systems. It has been proposed for future applications such as 6G networks and the Internet of Things (IoT). However, OCC suffers from low data rates and restrictive parameters [1]. Event cameras, with high temporal resolution, enable adaptive strategies that enhance data transmission and system efficiency.
- This research aims to design a methodology better suited for DVS sensors, using artificial frames only for detection.

2. Methodology

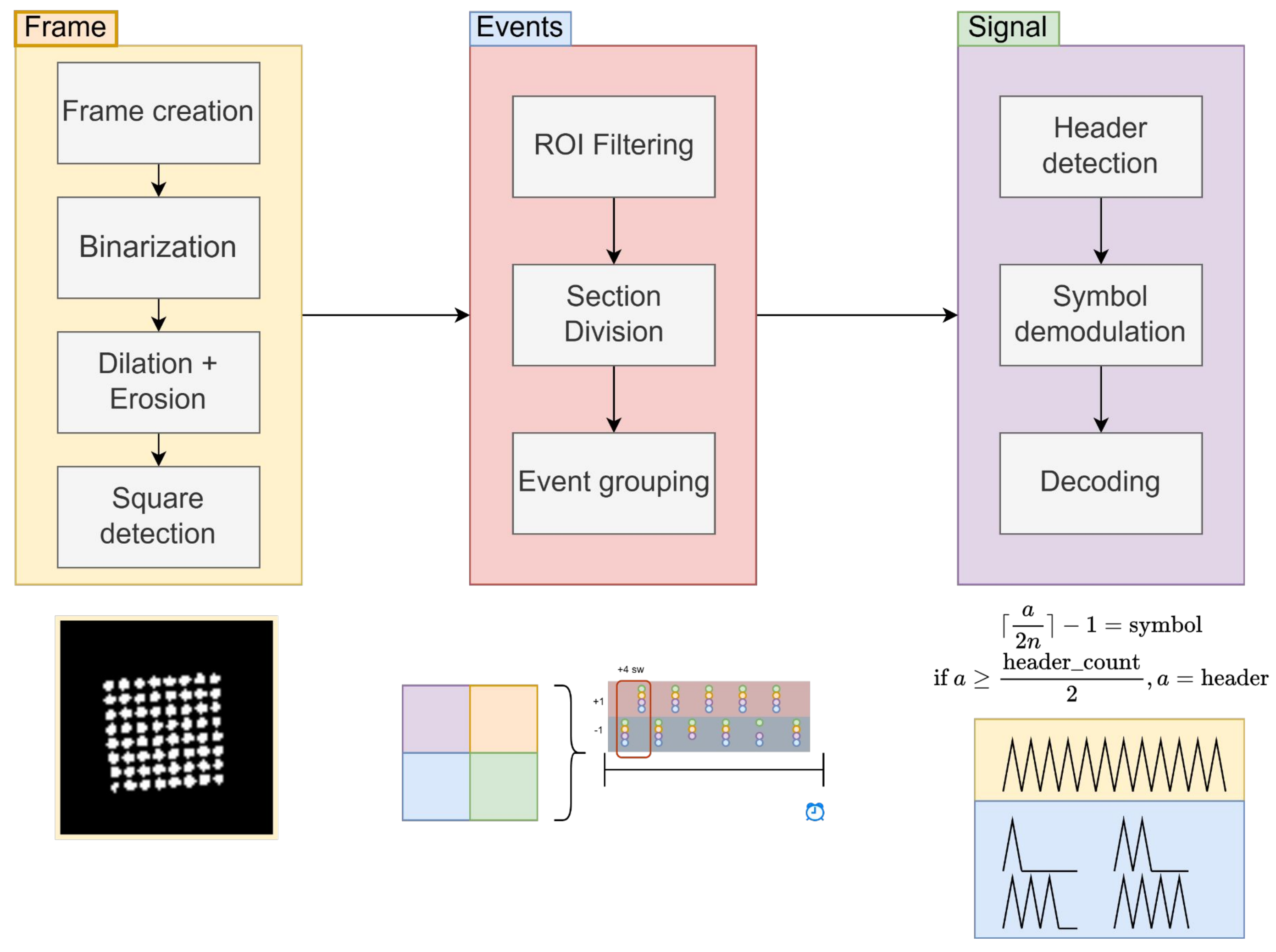

Fig. 1 - Block diagram of the system divided by sections.

2.1 Transmitter Implementation

- The transmitter used is a 8x8 WS2812B array, it uses N-Pulse modulation [2] and the modulation complexity is determined by grouping LEDs.

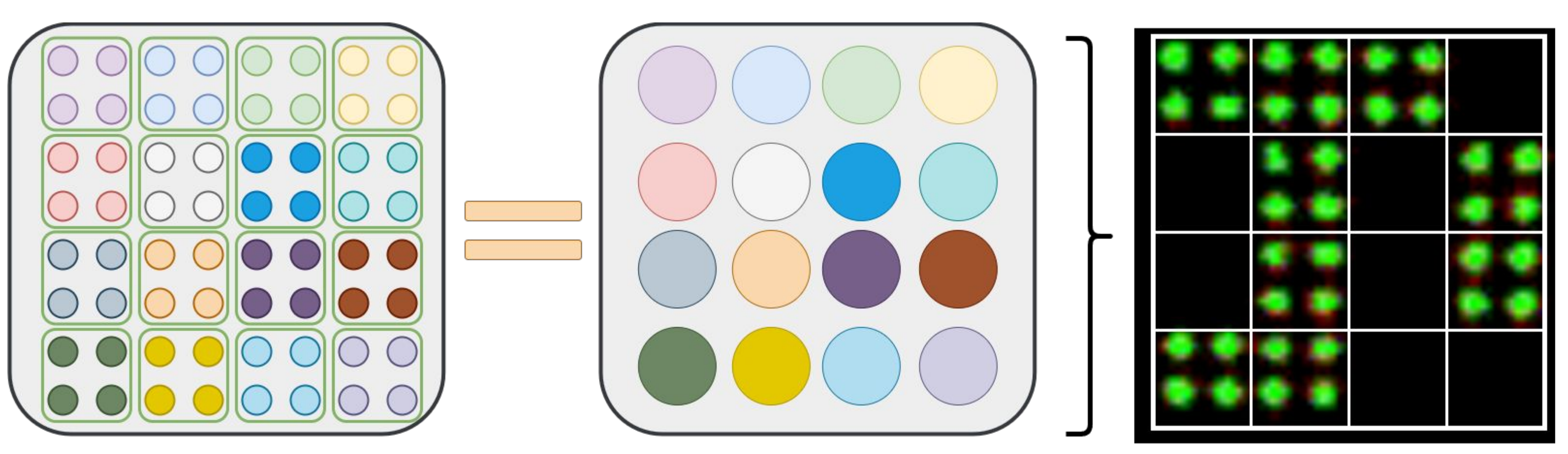

Fig. 2 - Led Grouping. The right image is an artificial frame from events.

2.2 Receiver

- Using a *DAVIS346* camera, a series of events recording were done in distances ranging from 40 to 120 cm using different modulation complexities under natural light (≈680 flux).
- Artificial frames are used for detection, after that events are divided by sections and decoded by counting the amount of transitions in time windows.

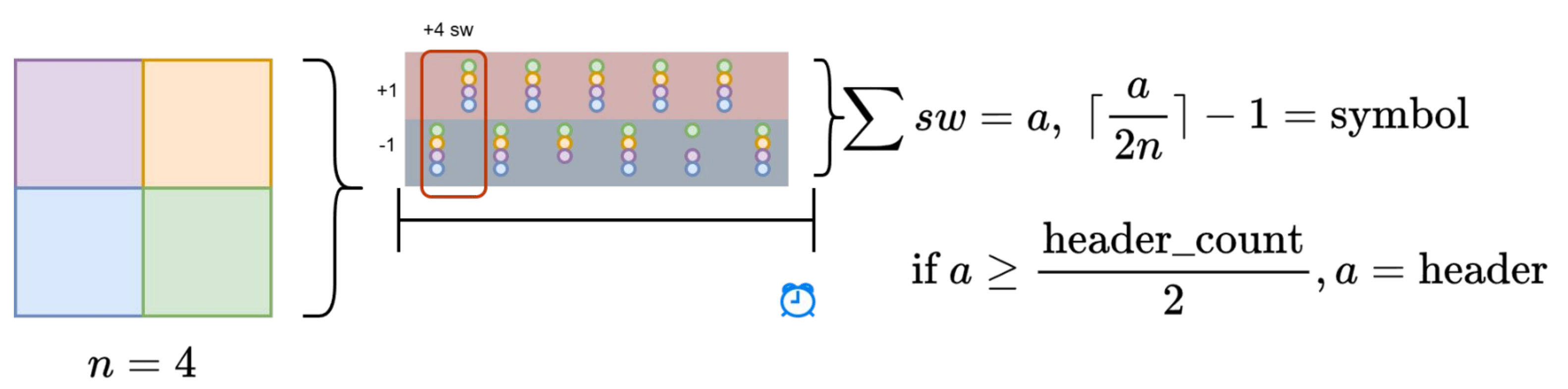

Fig. 3 -Simplified scheme of demodulation.

3. Preliminary Results

- Detection works in all distances, regardless of the modulation complexity.
- Division on the other hand, fails if the complexity is too high for longer distances due to a lack of enough pixels, resulting in high BER rates.

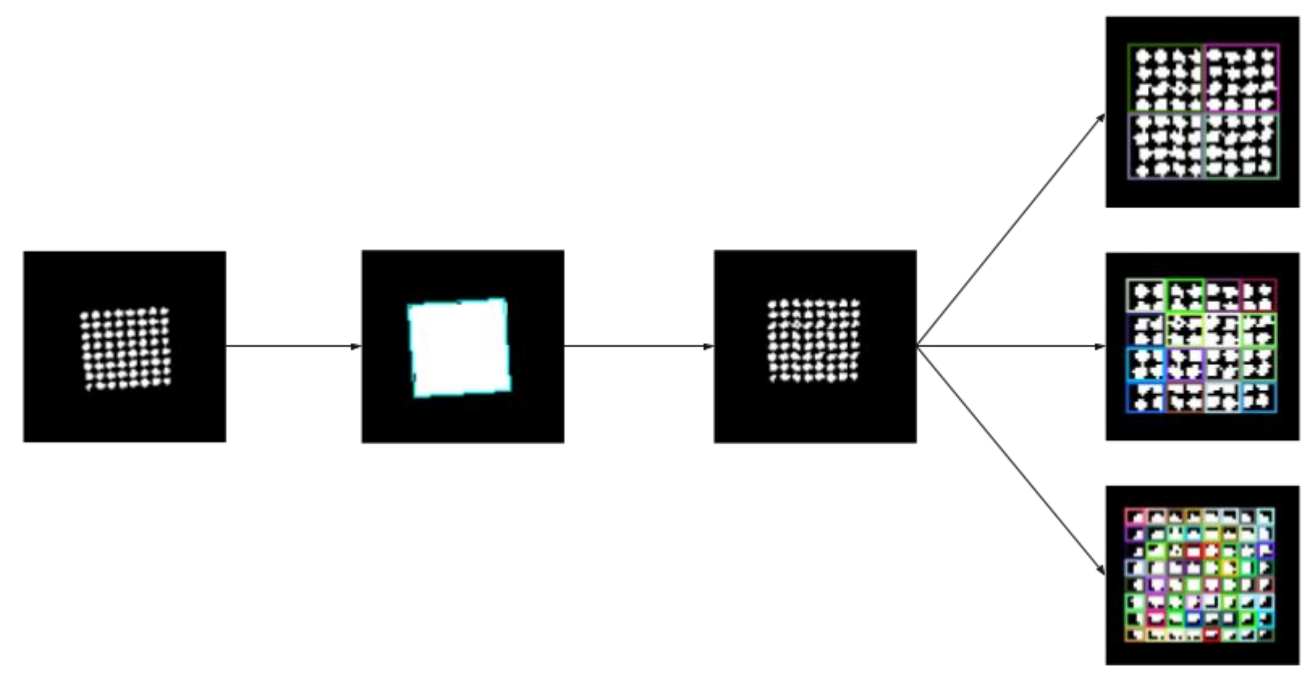

Fig. 4- Example of the steps applied over real data.

- In terms of transmission, the highest data rate obtained so far with BER around the <10^{-3} mark is 810 bps, and under certain distances, all modulation complexities obtain at least one BER around or below the <10^{-3} mark.

BER	Symbol period [ms]		100			
	Distance [cm]		40	65	90	120
	Modulation complexity	64	2.42×10^{-3}	6.11×10^{-2}	1.40×10^{-1}	1.36×10^{-1}
		16	$< 10^{-5}$	4.10×10^{-4}	1.02×10^{-3}	6.11×10^{-3}

BER	Symbol period [ms]		50			
	Distance [cm]		40	65	90	120
	Modulation complexity	64	6.74×10^{-3}	6.44×10^{-2}	1.29×10^{-1}	1.83×10^{-1}
		16	1.38×10^{-3}	1.72×10^{-3}	7.51×10^{-3}	7.74×10^{-3}

Fig. 4 - BER table of different modulation complexities and distances, The array brightness was set to 20, corresponding to a normalized intensity value on a scale of 0 to 255.

Conclusions

- A 2D MIMO OCC system was developed using N-Pulse modulation, said system was tested under natural light and showed good BER metrics (≈10^{-3}), although there still is room for improvement and optimizations.
- In future work, a notification of the modulation complexity will be added, as well as a checksum in order to implement a adaptive system.

Bibliography

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[2] J. Aranda, V. Yánez, J. Rabadan, and R. Pérez-JIménez, 'Enhancing Computational Efficiency in Event-Based Optical Camera Communication Using N-Pulse Modulation', Electronics, vol. 13, p. 1047, 2024.