Density Invariant Contrast Maximization for Neuromorphic Earth Observations

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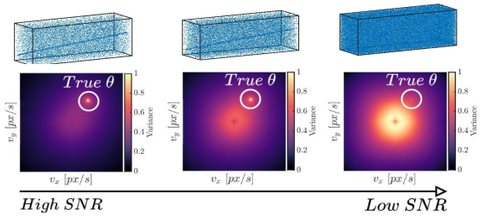
Introduction

- Project Falcon Neuro was a collaboration between WSU and USAFA that placed an event camera on the ISS for earth imaging, representing the first of its kind in such an environment
- Data from the ISS are extremely dense and noisy
- To enable Neuromorphic Earth Observations we propose an analytical solution to the contrast maximization (CMax) algorithm to handle highly dense scenes

Problem

- CMax is noise-intolerant: multiple extrema appear on the loss surface

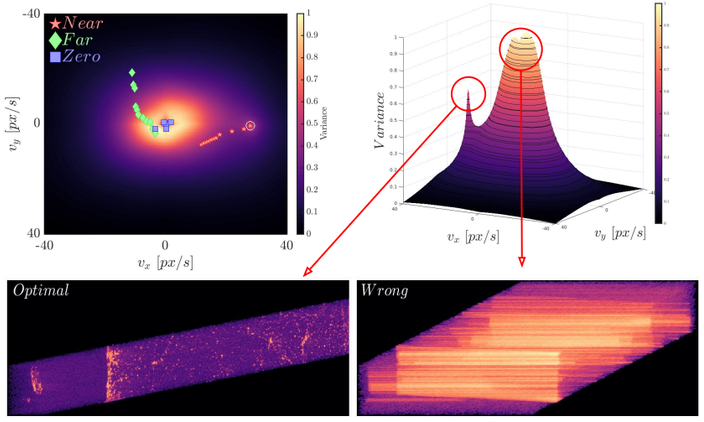


Question

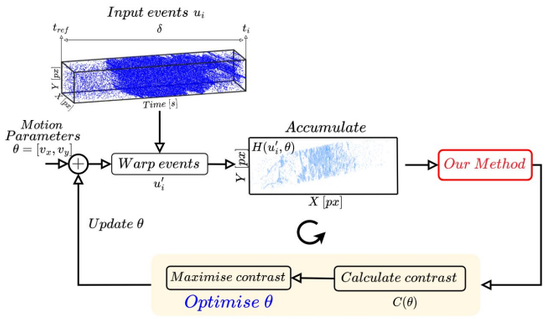
How to make CMax invariant to high event density?

High variance does not always indicate a high level of contrast

The optimizer is likely to converge to an incorrect solution



Method



CMax aims at estimating the camera's motion parameters by aligning the events to a candidate point trajectories that give the maximum image contrast. Gallego et al. CVPR'18

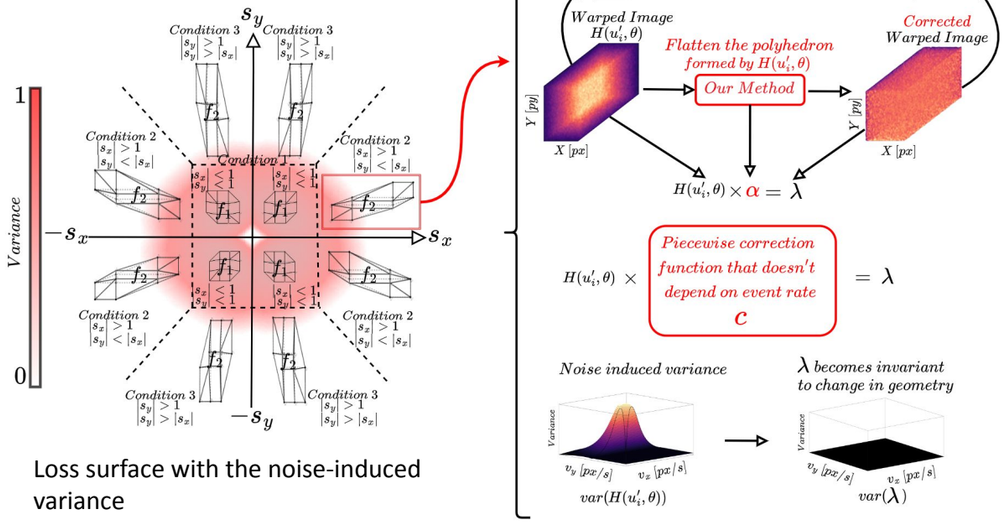
Assumptions:

- Constant-speed linear motion
- Time window can be arbitrary large
- No prior about events rate

Contribution: Making CMax invariant to the density of events, analytically

Analytical Piecewise Correction Functions

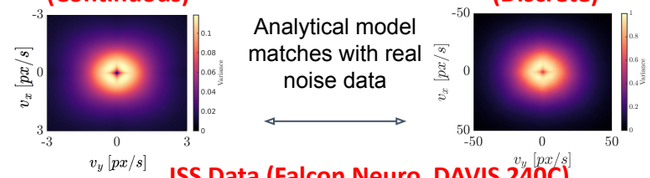
Correct the warped image with a multiplicative weight function to analytically cancel the noise-induced variance



Loss surface with the noise-induced variance

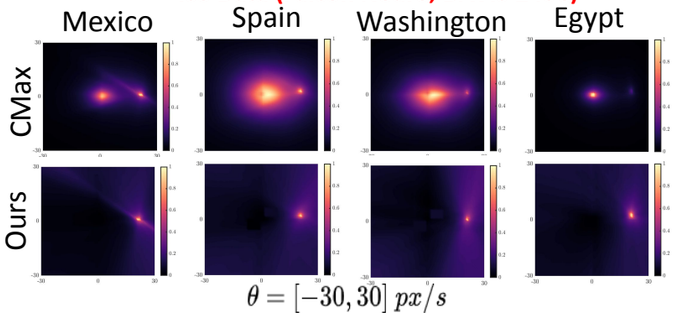
Results

Analytical Model (Continuous) — **Real noise (Discrete)**



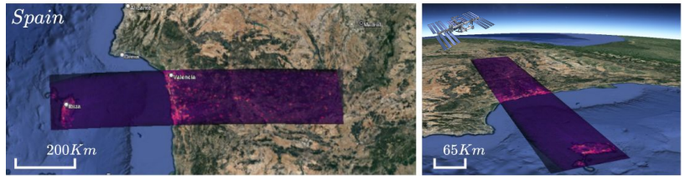
Analytical model matches with real noise data

ISS Data (Falcon Neuro, DAVIS 240C)



	CMax [8]		Ours	
	RMS	$RoC\%$	RMS	$RoC\%$
EL Salvador	14.47	2.55	**0.61**	**75.57**
Houston	13.74	2.62	**0.55**	**81.48**
Brittany	0.08	83.13	**0.01**	**83.57**
Mexico	14.13	1.16	**0.09**	**80.50**
Washington	14.19	2.87	**0.11**	**74.10**
Spain	13.77	2.45	**0.14**	**80.82**
Sumatra	13.41	1.62	**0.22**	**81.60**
UK	12.84	2.02	**0.28**	**82.89**
Egypt	13.53	1.95	**0.01**	**76.51**
Panama	14.50	2.72	**0.04**	**70.61**

Neuromorphic Earth Observations



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