Collaborative Research: CPS: Medium: Spatio-Temporal Logics for Analyzing and Querying Perception Systems

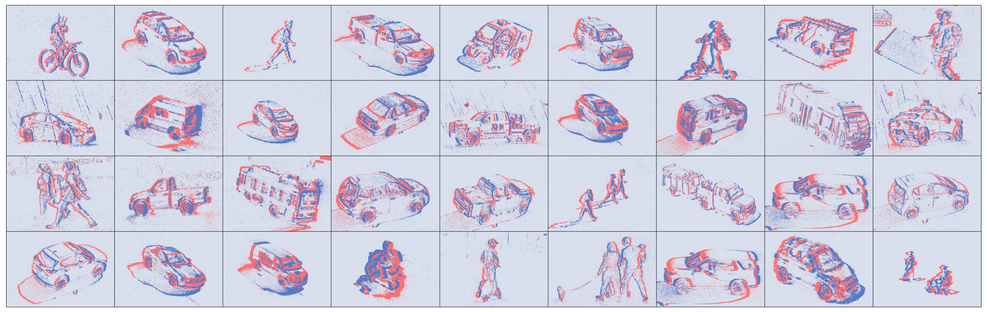
'YZ' Yezhou Yang, Arizona State University
Jyotirmoy Vinay Deshmukh, University of Southern California

Abstract

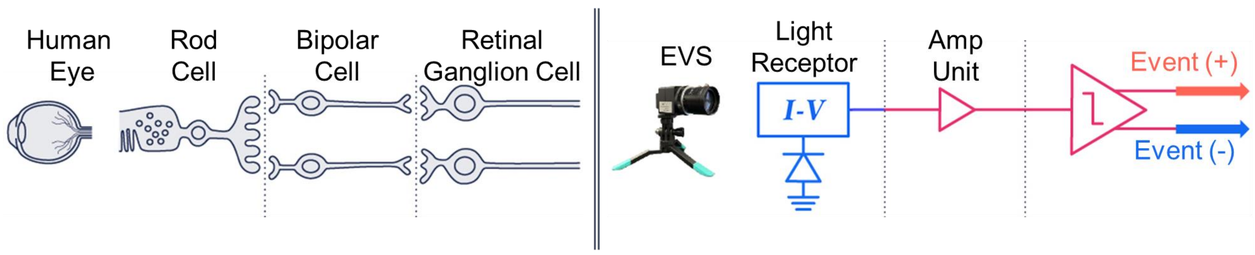
- Development of formal languages for evaluating the quality & robustness of perception sub-systems within ADS & ADAS.
- A novel spatio-temporal logic enabling temporal & spatial reasoning about streaming perception data.
- Educational curricula to train engineers & engage the public in understanding ADS challenges.
- Open-source software tools for testing perception systems & establishing standardized requirements languages.

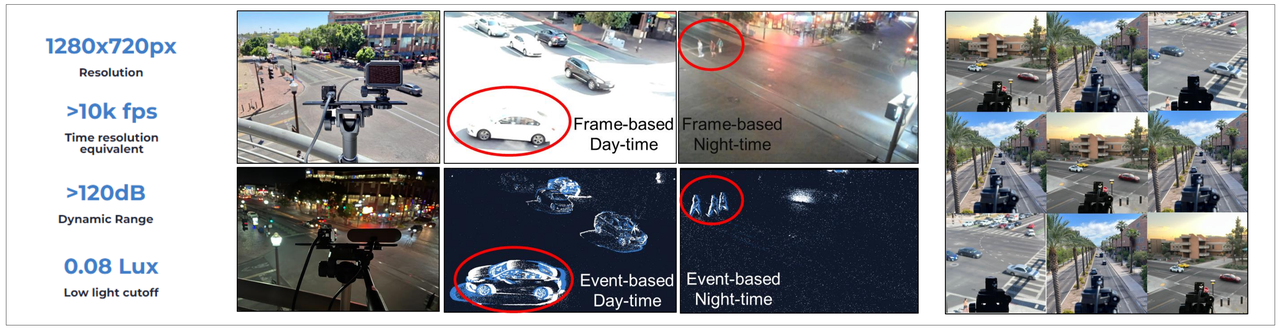
Neuromorphic Vision Unveiling Spatio-Temporal Traffic Insights: Enhancing ADAS Perception in High Dynamic Scenes

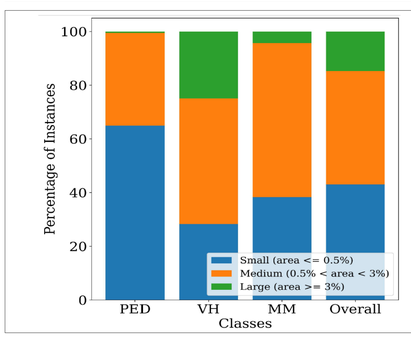
- Exploring the integration of neuromorphic vision systems with spatio-temporal reasoning for fixed traffic monitoring, leveraging event-based cameras' high temporal resolution & dynamic range
- ***eTraM**** - the first fully event-based fixed traffic monitoring dataset, providing comprehensive insights into real-world traffic dynamics featuring 2M annotations across 8 distinct traffic participant classes across a variety of scenes & lighting scenarios.

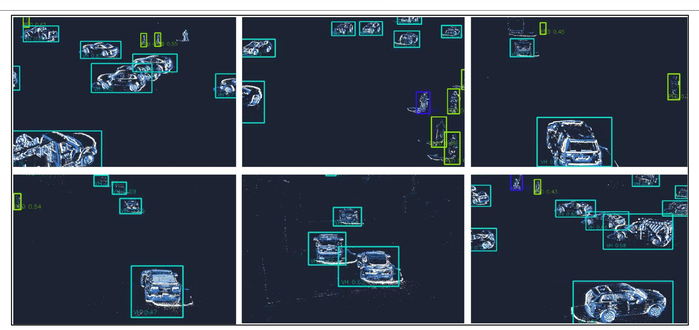


Event-based Vision Systems Capturing Movements like Human Eye









Traffic Site	Lighting	RVT				RED				YOLO			
		PED	VH	MM	all	PED	VH	MM	all	PED	VH	MM	all
Intersections	Daytime	**0.460**	0.813	0.315	**0.722**	**0.395**	0.593	0.284	0.545	0.167	0.293	0.111	0.190
Roadways		0.430	0.733	0.070	0.627	0.347	0.590	0.055	**0.551**	**0.173**	0.290	0.004	0.156
Local Street		0.196	**0.938**	**0.586**	0.316	0.208	**0.875**	**0.695**	0.351	0.124	**0.559**	**0.204**	**0.296**
Overall		0.304	0.781	0.403	0.572	0.302	0.656	0.251	0.497	0.142	0.309	0.112	0.188
Intersections	Nighttime	0.161	0.465	-	0.262	0.149	0.425	-	0.242	0.071	0.375	-	0.149
Roadways		0.310	0.827	-	0.739	0.362	0.782	-	0.726	0.004	0.229	-	0.117
Local Street		**0.739**	**0.868**	0.097	**0.829**	**0.722**	**0.831**	0.145	**0.817**	**0.198**	**0.486**	0.030	**0.239**
Overall		0.317	0.674	0.064	0.523	0.303	0.660	0.083	0.504	0.123	0.322	0.013	0.153
Overall		0.309	0.717	0.313	0.539	0.303	0.649	0.197	0.491	0.134	0.314	0.086	0.178

Broader Impact on Society - Who Will Care

- Policymakers, regulators, & automotive stakeholders will prioritize advancements in perception systems to enhance road safety & improve autonomous vehicle reliability.
- Improved ADS & ADAS technologies will offer enhanced mobility options for individuals with disabilities, contributing to societal inclusivity.
- Society will benefit from reduced accidents & fatalities on roads, leading to safer communities & improved quality of life.
- Manufacturers & suppliers will value perception systems that optimize the performance of autonomous vehicles

Broader Impact – Education & Outreach

- Engineering students will gain essential skills through educational curricula focused on perception system development.
- Public awareness initiatives will highlight the importance of perception technologies in road safety & autonomous vehicle development.
- Summer internships for undergraduate women will promote diversity & encourage participation in autonomous vehicle research.
- Open-source datasets & software tools will facilitate collaboration & knowledge sharing among engineers & governmental agencies.

Potential Impact

- Enhanced perception systems can significantly reduce accidents & fatalities, leading to human life & economic savings.
- Formal languages & metrics can streamline testing processes, expediting the deployment of safer autonomous vehicles.
- Integration of neuromorphic vision technology in traffic management can mitigate congestion, improving transportation efficiency.
- Inclusion initiatives can foster innovation & diversity in autonomous vehicle technology, benefiting society & advancing technology.

Award ID: 2038666

eTraM: Event-based Traffic Monitoring Dataset [**CVPR 2024**]

Aayush Atul Verma, Bharatesh Chakravarthi, Arpitsinh Vaghela, Hua Wei, 'YZ' Yezhou Yang
Arizona State University