

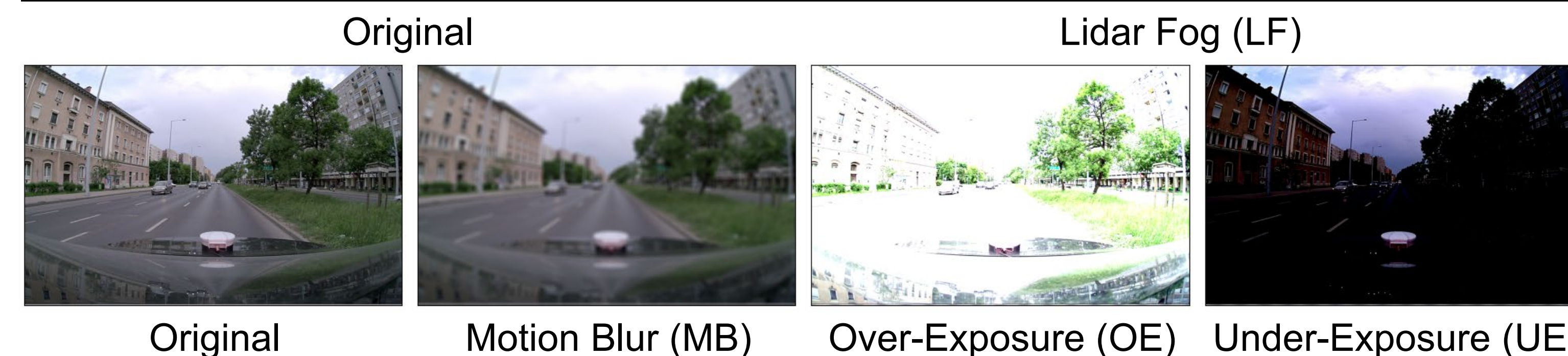


Hyperdimensional Uncertainty Quantification for Multimodal Uncertainty Fusion in Autonomous Vehicles Perception

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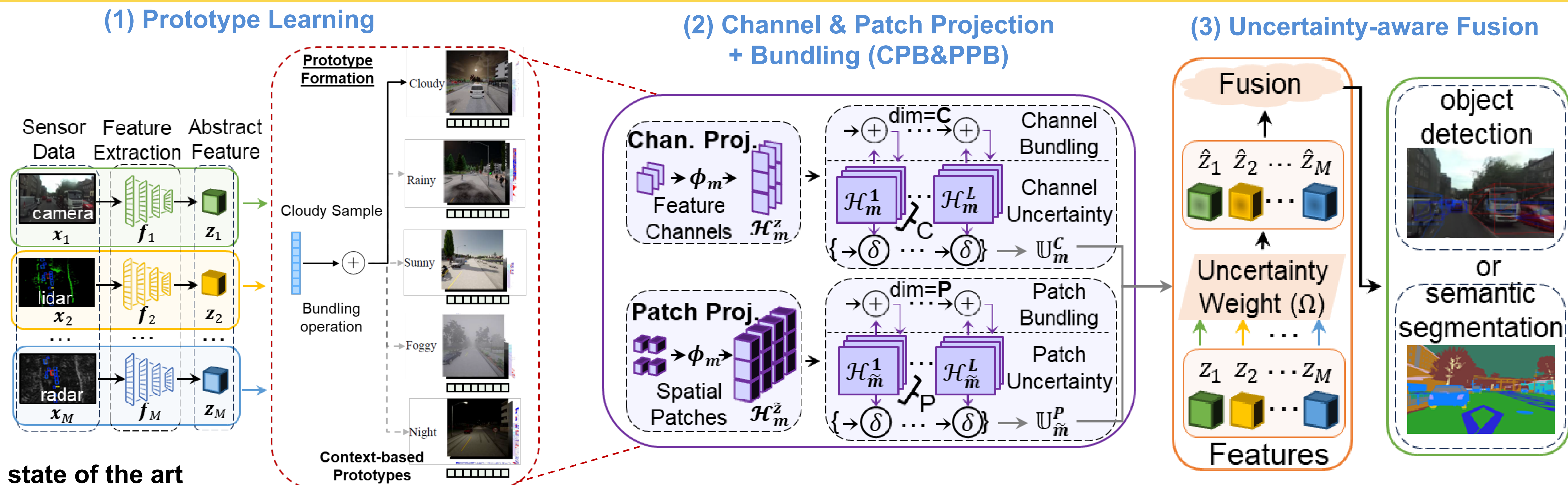
Motivation & Contribution



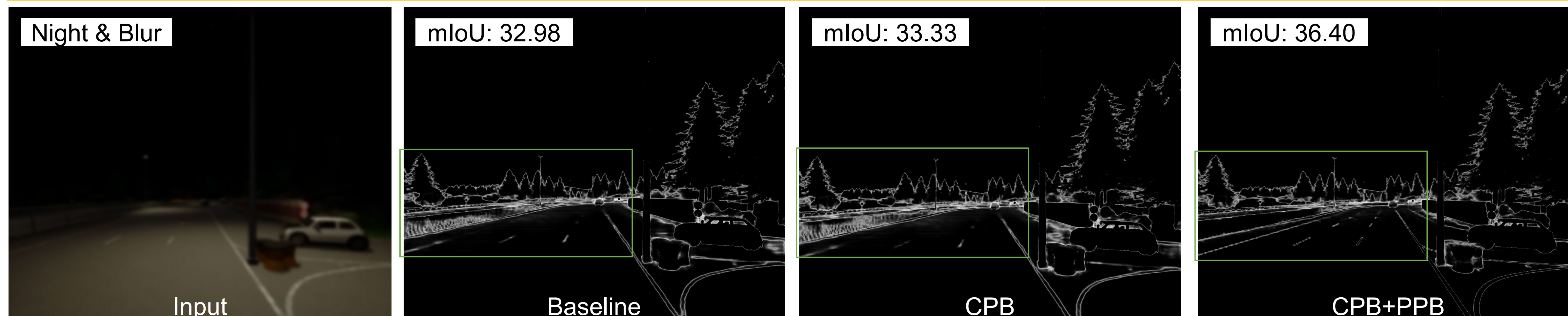
Efficient & Effective Multimodal Uncertainty Fusion

- Novel Hyperdimensional Deterministic Uncertainty Method (HyperDUM)
- Multimodal Channel & Spatial feature-level uncertainty-aware fusion
- Up to 2.36x less Floating-Point Operations and 38.30x less parameters vs. state of the art

Methodology: *HyperDUM*



Experimental Results



- CPB captures course-grain uncertainties, while PPB captures fine-grain uncertainties.
- Ablation studies reveal quantitative impact of CPB & PPB respectively.

Dataset Metric	aiMotive all-point AP/11-point AP \uparrow	DeLiVER mIoU \uparrow
<i>HyperDUM</i>	66.70/66.00 (Mean Δ)	67.59 (Mean Δ)
- w/o Patch (4x) Proj.	65.67/65.23 (-1.03/-0.77)	67.18 (-0.41)
- w/o Chan Proj.	64.43/64.25 (-1.24/-0.98)	66.63 (-0.55)

UQ Method	MB	OE	UE	LF	Mean
BEVFusion [33]	64.10/63.69	62.40/59.26	63.57/63.25	65.07/65.08	63.79/62.75
InfMCD [34]	62.00/61.99	64.47/64.28	63.25/63.49	64.27/63.81	63.50/63.39
InfNoise [34]	62.61/62.61	64.94/64.72	63.18/60.07	65.19/64.99	63.98/63.10
PostNet [5]	60.42/58.90	63.12/59.99	60.20/59.25	64.13/60.60	61.97/59.69
LDU [10]	62.06/62.22	65.07/64.85	62.87/60.02	65.47/65.10	63.87/63.05
<i>HyperDUM</i>	64.39/63.99	66.16/65.39	64.18/63.91	65.89/65.22	65.16/64.62

aiMotive 3D Object Detection (AP \uparrow)

Scenarios	UQ Methods (Metrics: mIoU \uparrow)						
	CMNeXt [58]	InfMCD [34]	InfNoise [34]	PostNet [5]	LDU [10]	Gemini [21]	<i>HyperDUM</i> (Ours)
MB	62.91	63.61	63.55	63.55	63.16	-	64.28 ^{+1.37}
OE	64.59	65.39	65.17	65.06	64.73	-	65.67 ^{+1.08}
UE	60.00	60.38	60.42	60.27	60.29	-	61.20 ^{+1.20}
LJ	65.92	66.12	66.25	66.33	66.40	-	66.93 ^{+1.01}
EL	65.48	66.05	66.17	66.06	65.89	-	66.80 ^{+1.32}
Mean	66.30	66.90	66.86	66.77	66.60	66.90	67.59 ^{+1.29}

DeLiVER Semantic Segmentation (mIoU \uparrow)

Dataset UQ Method	aiMotive		DeLiVER	
	FLOPs	#Params	FLOPs	#Params
InfMCD [34]	990.90M	4.05K	1.84G	20.19K
InfNoise [34]	990.90M	4.05K	1.84G	20.19K
LDU [10]	264.24M	44.04M	613.42M	102.24M
<i>HyperDUM</i>	111.84M	1.15M	338.40M	38.85M
- w/o Patch (4x) Proj.	84.00M	1.13M	256.00M	38.78M
- w/o Chan Proj.	6.96M	3.38K	20.60M	16.83K

Performance (4 Patch) Performance (16 Patch) Performance (64 Patch)
FLOPs (4 patch) FLOPs (16 patch) FLOPs (64 patch)

