OpenDriveLab 浦驾

上海人工智能实验室
Shanghai Artificial Intelligence Laboratory

Leveraging Vision-Centric objects for 3D Object Detection

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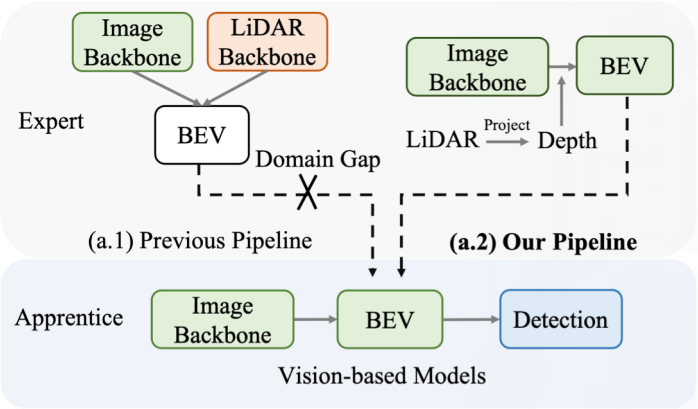
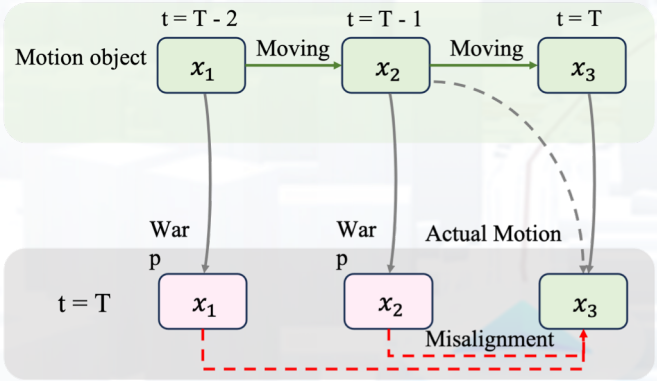
VCD

https://github.com/OpenDriveLab/Birds-eye-view-Perception

Comparison



Motion Misalignment



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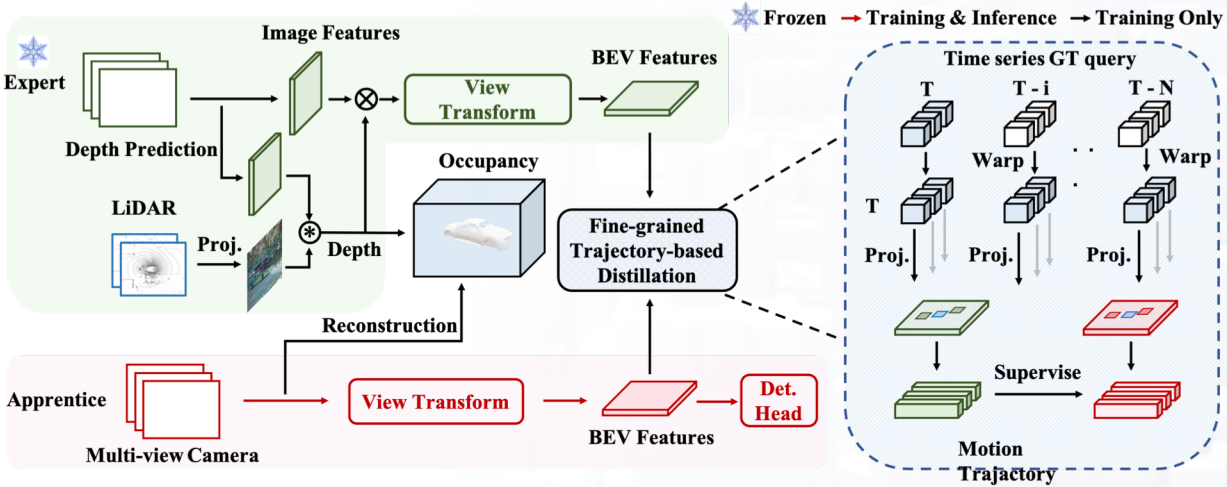
Overview



- Better Expert
- Occupancy Reconstruction
- Motion Trajectory Module

VCD

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Experiments

Methods	Backbone	Image Size	Frames	mAP↑	NDS↑	mATE↓	mASE↓	mAOE↓	mAVE↓	mAAE↓
BEVDet [23]	ResNet-50	256 × 704	1	0.298	0.379	0.725	0.279	0.589	0.860	0.245
PETR [39]	ResNet-50	384 × 1056	1	0.313	0.381	0.768	0.278	0.564	0.923	0.225
BEVDet4D [22]	ResNet-50	256 × 704	2	0.322	0.457	0.703	0.278	0.495	0.354	0.206
BEVDepth [35]	ResNet-50	256 × 704	2	0.351	0.475	0.639	0.267	0.479	0.428	0.198
BEVStereo [34]	ResNet-50	256 × 704	2	0.372	0.500	0.598	0.270	0.438	0.367	0.190
STS [54]	ResNet-50	256 × 704	2	0.377	0.489	0.601	0.275	0.450	0.446	0.212
VideoBEV [19]	ResNet-50	256 × 704	8	0.422	0.535	0.564	0.276	0.440	0.286	0.198
SOLOFusion [43]	ResNet-50	256 × 704	16+1	0.427	0.534	0.567	0.274	0.411	**0.252**	**0.188**
StreamPETR [51]	ResNet-50	256 × 704	8	0.432	0.540	0.581	0.272	0.413	0.295	0.195
Baseline*	ResNet-50	256 × 704	8+1	0.401	0.515	0.595	0.279	0.489	0.291	0.198
VCD-A	ResNet-50	256 × 704	8+1	0.426	0.540	0.547	0.271	0.433	0.268	0.207
Baseline*†	ResNet-50	256 × 704	8+1	0.418	0.542	0.522	0.267	0.428	0.262	**0.188**
VCD-A†	ResNet-50	256 × 704	8+1	**0.446**	**0.566**	**0.497**	**0.260**	**0.350**	0.257	0.203

Methods	Backbone	Image Size	mAP↑	NDS↑	mATE↓	mASE↓	mAOE↓	mAVE↓	mAAE↓
FCOS3D† [52]	R101-DCN	900 × 1600	0.358	0.428	0.690	0.249	0.452	1.434	0.124
DETR3D† [53]	V2-99	900 × 1600	0.412	0.479	0.641	0.255	0.394	0.845	0.133
UVTR [33]	V2-99	900 × 1600	0.472	0.551	0.577	0.253	0.391	0.508	0.123
BEVDet4D† [22]	Swin-B [41]	900 × 1600	0.451	0.569	0.511	**0.241**	0.386	0.301	0.121
BEVFormer [36]	V2-99	900 × 1600	0.481	0.569	0.582	0.256	0.375	0.378	0.126
PolarFormer [28]	V2-99	900 × 1600	0.493	0.572	0.556	0.256	0.364	0.439	0.127
BEVDistill [11]	ConvNeXt-B	900 × 1600	0.496	0.594	0.475	0.249	0.378	0.313	0.125
PETRv2 [40]	RevCol [4]	640 × 1600	0.512	0.592	0.547	0.242	0.360	0.367	0.126
BEVDepth [35]	ConvNeXt-B	640 × 1600	0.520	0.609	0.445	0.243	0.352	0.347	0.127
AeDet† [15]	ConvNeXt-B	640 × 1600	0.531	0.620	0.439	0.247	0.344	0.292	0.130
SOLOFusion [43]	ConvNeXt-B	640 × 1600	0.540	0.619	0.453	0.257	0.376	0.276	0.148
StreamPETR [51]	ConvNeXt-B	640 × 1600	**0.550**	**0.631**	0.493	**0.241**	**0.343**	**0.243**	0.123
Baseline*	ConvNeXt-B	640 × 1600	0.522	0.610	0.457	0.253	0.391	0.271	0.142
VCD-A	ConvNeXt-B	640 × 1600	0.548	**0.631**	**0.436**	0.244	**0.343**	0.290	**0.120**

- VCD-A Results on nuScenes val
- VCD-A Results on nuScenes test
- Consistency Improvement

VCD

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Experiments

Methods	Venue	Backbone	mAP↑	NDS↑	mATE↓	mASE↓	mAOE↓	mAVE↓	mAAE↓
BEVFusion [38]	NeurIPS 2022	LiDAR & Image	0.642	0.680	-	-	-	-	-
FUTR3D [10]	Arxiv 2022	LiDAR & Image	0.645	0.683	-	-	-	-	-
UVTR [33]	NeurIPS 2022	LiDAR & Image	0.654	0.702	0.332	0.258	**0.268**	0.212	**0.177**
CMT [57]	Arxiv 2023	LiDAR & Image	**0.679**	0.708	-	-	-	-	-
VCD-E	-	Image	0.677	**0.711**	**0.308**	**0.254**	0.317	**0.189**	0.201

Methods	Backbone	mAP	NDS
BEVFusion	ResNet-50	0.598	0.662
BEVFusion	ConvNext-B	0.597	0.665
VCD-E	ResNet-50	0.611	0.656
VCD-E	ConvNext-B	**0.664**	**0.693**

- VCD-E Results on nuScenes val
- Gains of different image backbone on multi-modal models

VCD

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Experiments

Expert	Paradigm	mAP	NDS
-	-	0.297	0.409
CenterPoint [60]	CM	0.281	0.420
Transfusion [2]	CM	0.292	0.435
BEVDepth [35]	UM	0.341	0.442
VCD-E	UM	**0.354**	**0.459**

Methods	mAP	NDS
Baseline [35]	0.297	0.409
FitNet [44]	0.318	0.421
CWD [46]	0.311	0.412
BEVDistill [11]	0.316	0.439
VCD-A	**0.354**	**0.459**

- The performance gains of the apprentice
- Effect of different distillation methods

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Experiments

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- The performance gains of the apprentice
- Effect of different distillation methods

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Experiments

Temporal Length	Distill	mAP (%)↑	NDS (%) ↑	mATE↓	mAOE↓	mAVE↓
1	✗	26.6	37.9	0.815	0.645	0.556
	✓	30.1 (+3.5)	41.5(+3.6)	0.732	0.629	0.476
2	✗	26.9	38.4	0.804	0.706	0.461
	✓	31.3 (+4.4)	43.2 (+4.8)	0.717	0.615	0.403
4	✗	28.4	39.8	0.748	0.739	0.432
	✓	33.0 (+4.6)	44.1 (+4.3)	0.707	0.632	0.389
8	✗	29.7	40.9	0.762	0.714	0.415
	✓	35.4 (+5.7)	45.9 (+5.0)	0.690	0.625	0.370

Trajectory Length	Distill	mAP (%)	NDS (%)
-	✗	29.7	40.9
0	✓	31.8	42.1
1	✓	33.1	44.5
3	✓	34.6	45.6
5	✓	**35.4**	**45.9**
9	✓	33.9	44.7

- The performance gains on different temporal lengths
- The performance gains of different trajectory length

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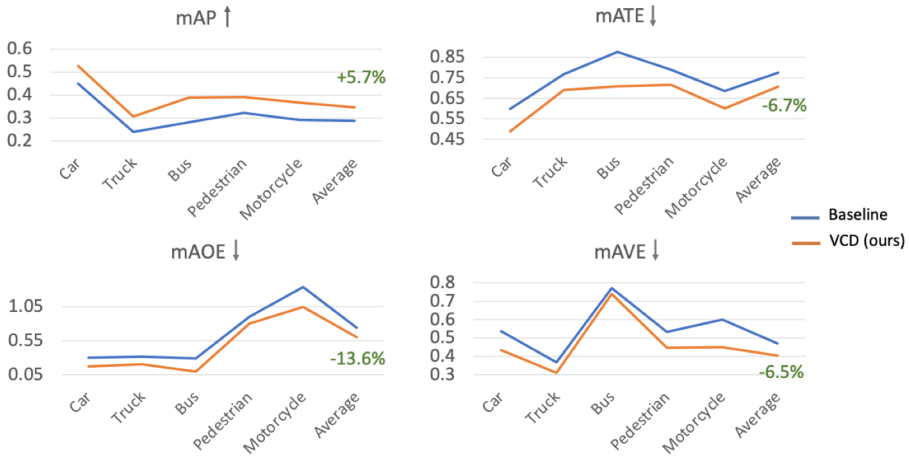
Experiments



- **The Effects of VCD on Movable Objects**

VCD

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Visualization

- Visualization of the Predictions

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Thanks

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