

Mind the Hitch: Dynamic Calibration and Articulated Perception for Autonomous Trucks

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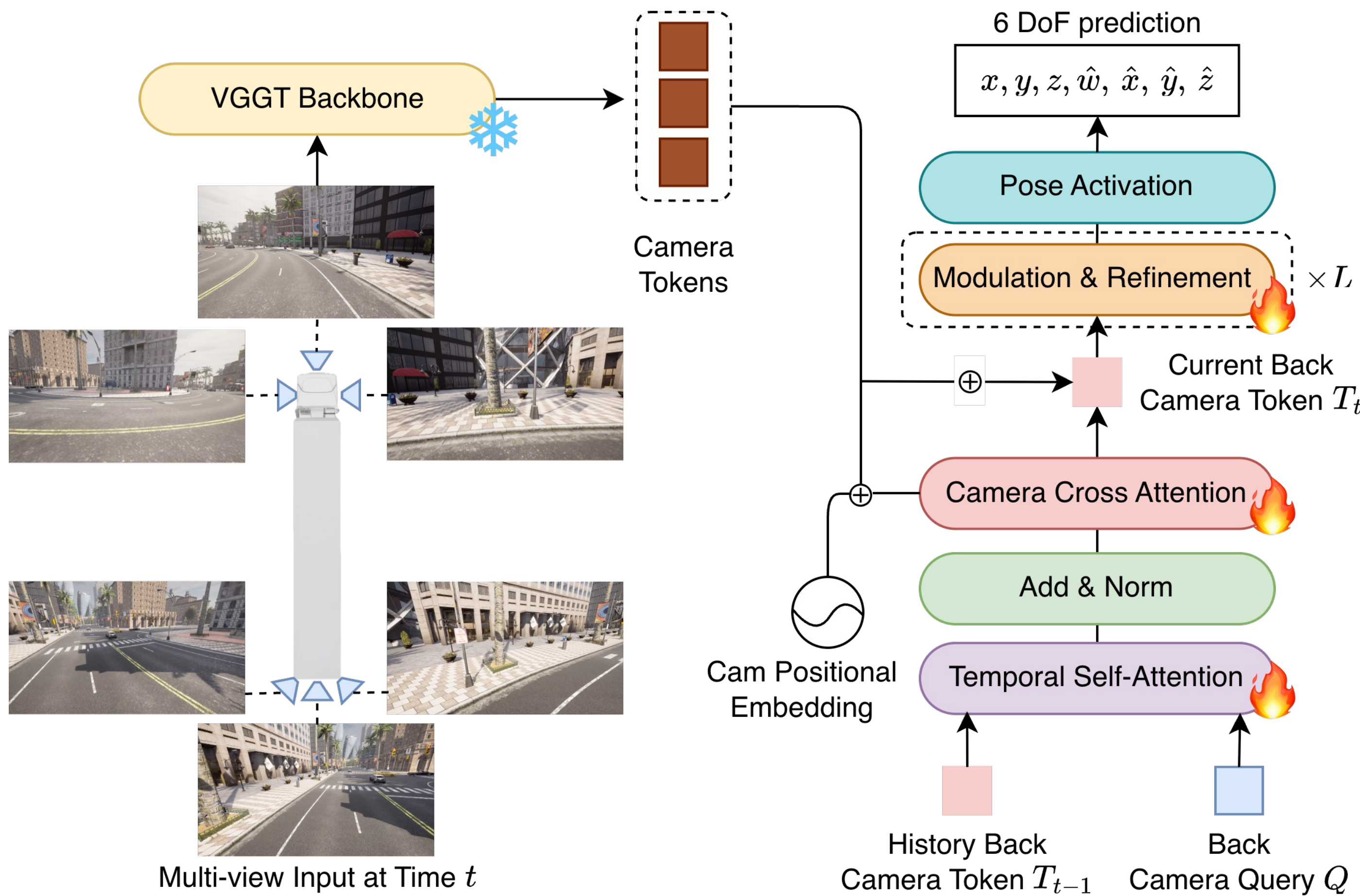


GitHub repository:
<https://github.com/zhumorui/dCAP>

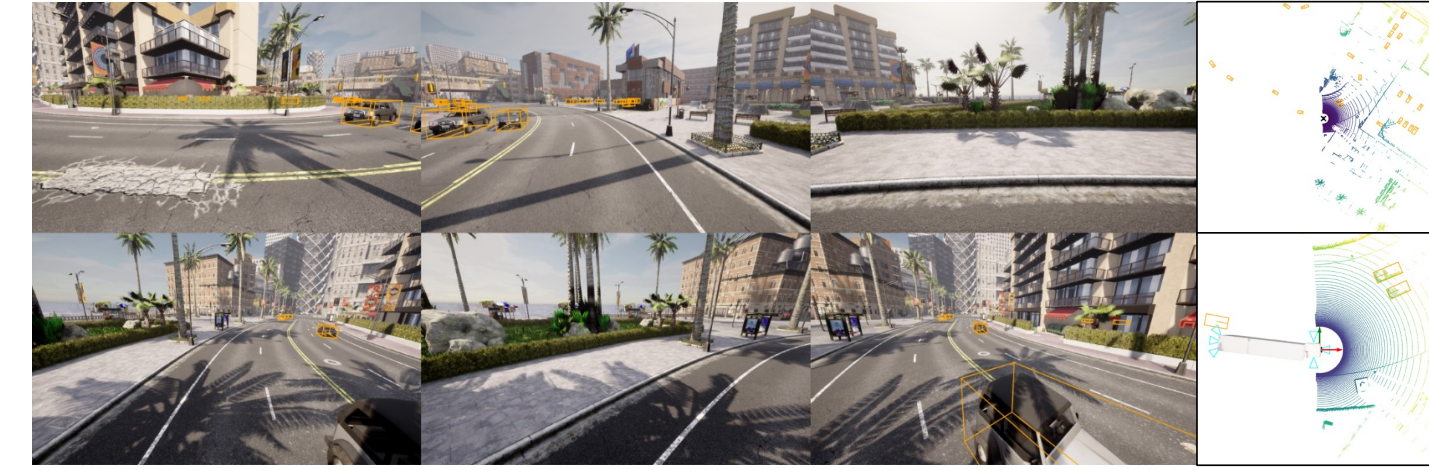
Abstract

- **Dynamic calibration** for articulated tractor-trailer systems.
- **STT4AT**, a CARLA-based benchmark for articulated trucking.
- **dCAP** (dynamic Calibration and Articulated Perception), a vision-based framework that continuously estimates the relative pose between tractor and trailer cameras, enabling accurate 3D object detection.
- **Robust** under U-turns and other high-articulation maneuvers.

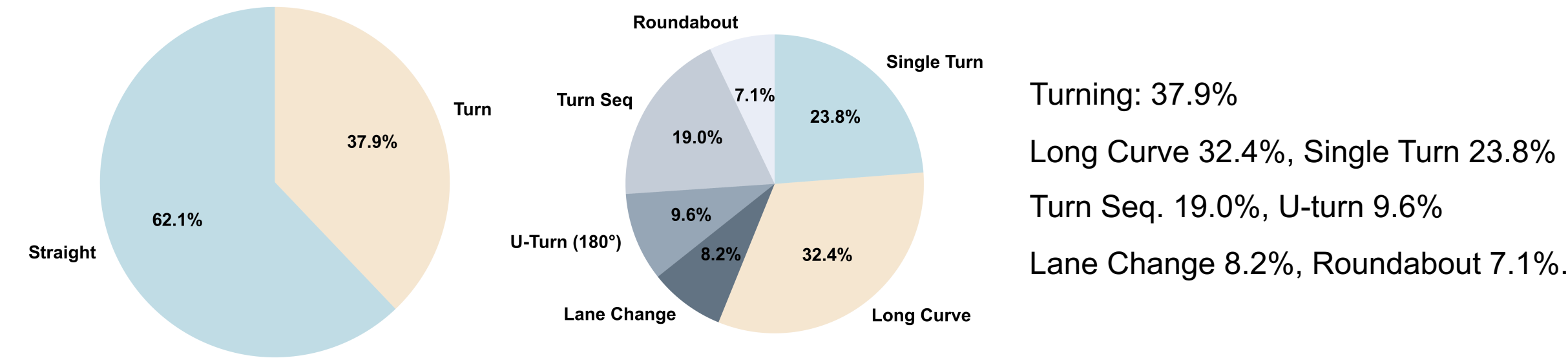
Framework



STT4AT Benchmark



- 87 scenes from 8 CARLA towns
- Sensor setup: 6 RGB cameras, 1 LiDAR, 2 GPS, 2 IMU
- Camera resolution: 1600×900, 110° FOV



Representative Scenarios



Quantitative Comparison with Pose Estimation

Method	$\Delta_T \downarrow$	$\Delta_x \downarrow$	$\Delta_y \downarrow$	$\Delta_z \downarrow$	RRA $\downarrow$
Static Calibration	1.284	0.210	1.120	0.356	0.148
COLMAP [23] [†]	-	-	-	-	-
VGGT [30]	6.040	2.761	3.082	3.634	0.309
DUST3R [31]	8.625	4.664	5.080	2.953	0.578
GNSS-IMU (Kalman Filter)	1.379	0.309	1.116	0.431	0.129
dCAP (w/o CCA, w/o CTA)	0.632	0.076	0.600	0.087	0.073
dCAP (w/ CCA, w/o CTA)	<u>0.505</u>	<u>0.069</u>	0.475	0.074	<u>0.048</u>
dCAP (w/o CCA, w/ CTA)	0.452	0.125	0.395	0.090	0.058
dCAP (w/ CCA, w/ CTA)	0.452	0.061	<u>0.421</u>	<u>0.085</u>	0.042

Quantitative Comparison with 3D Object Detection

Method	AP $\uparrow$	NDS $\uparrow$	ATE $\downarrow$	ASE $\downarrow$	AOE $\downarrow$	AVE $\downarrow$	AAE $\downarrow$
Static Calibration	0.058	0.033	0.734	0.176	0.153	2.419	0.237
COLMAP [23] [†]	-	-	-	-	-	-	-
Tractor only	0.049	0.032	0.705	0.183	0.198	2.572	0.267
VGGT [30]	0.033	0.031	0.671	0.181	0.202	2.619	0.251
DUST3R [31]	0.034	0.031	0.711	0.182	0.219	2.682	0.256
dCAP (w/o CCA, w/o CTA)	0.084	0.034	0.710	0.172	0.132	<u>2.328</u>	0.222
dCAP (w/ CCA, w/o CTA)	<u>0.102</u>	0.036	0.657	<u>0.170</u>	<u>0.118</u>	2.330	<u>0.212</u>
dCAP (w/o CCA, w/ CTA)	0.094	0.035	0.697	<u>0.170</u>	0.122	2.349	0.211
dCAP (w/ CCA, w/ CTA)	0.103	0.036	<u>0.675</u>	0.169	0.116	2.312	<u>0.212</u>
GT (upper bound)	0.129	0.039	0.513	0.168	0.105	2.258	0.209

Qualitative Comparison

