

Automated Drive Analysis of Naturalistic Driving Studies with Looking-out Video

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Ultimate Goal

Develop computer vision algorithms and machine learning techniques to automate the analysis of NDS data to understand driver behaviors and situational awareness for intelligent vehicle applications.



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Approach

- ❑ Configurable vehicle testbed to replicate NDS platforms
- ❑ Algorithm development on multi-perspective views
- ❑ Testing and validation on large scale NDS datasets

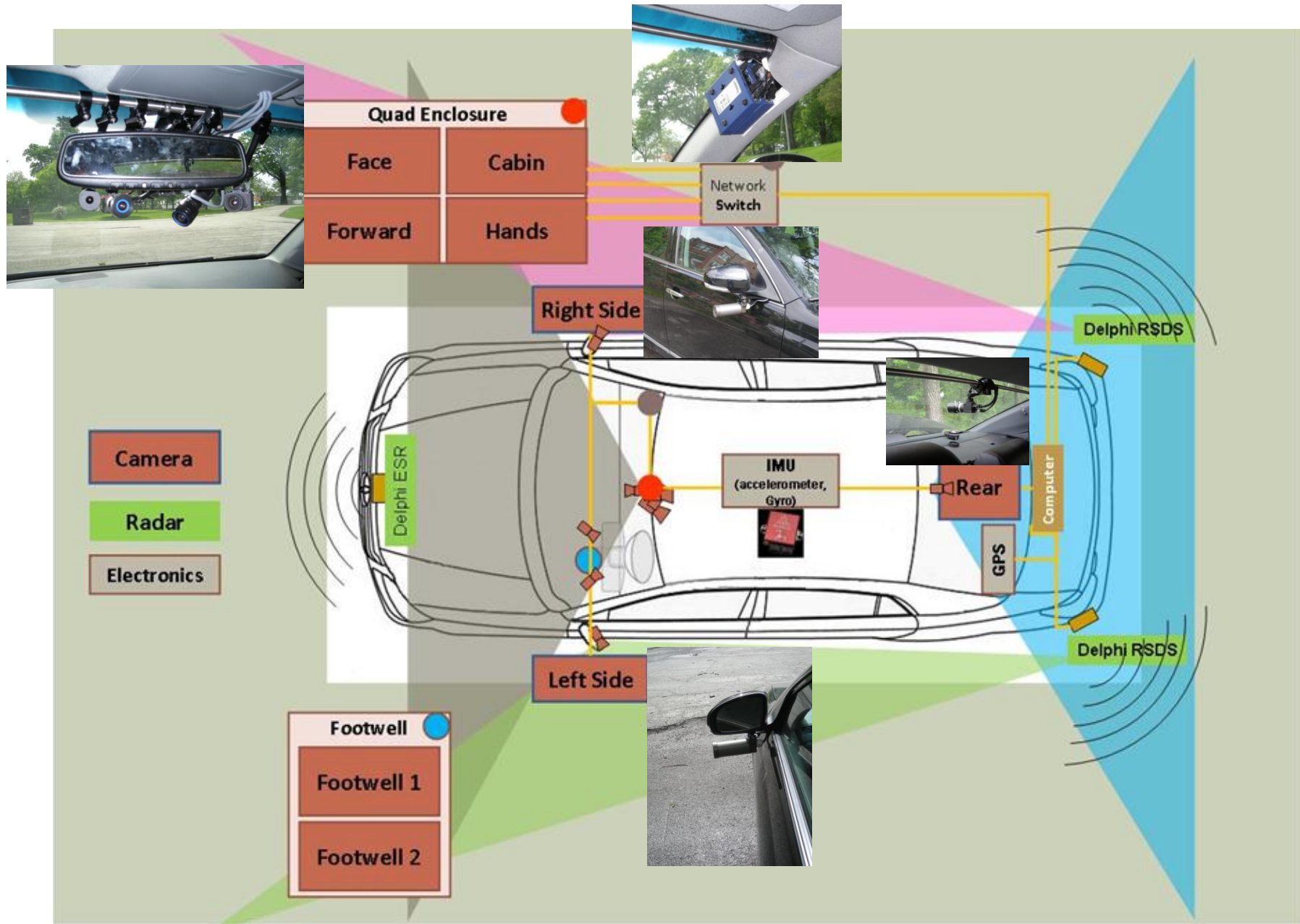


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Instrumented Vehicle Testbed



Simulated SHRP2 Views



+ SHRP2 identical vehicle sensors

Face view

Cabin view (MY11UM)

Hands view (MY125M)

Forward view



SHRP2 Compatible Combined view

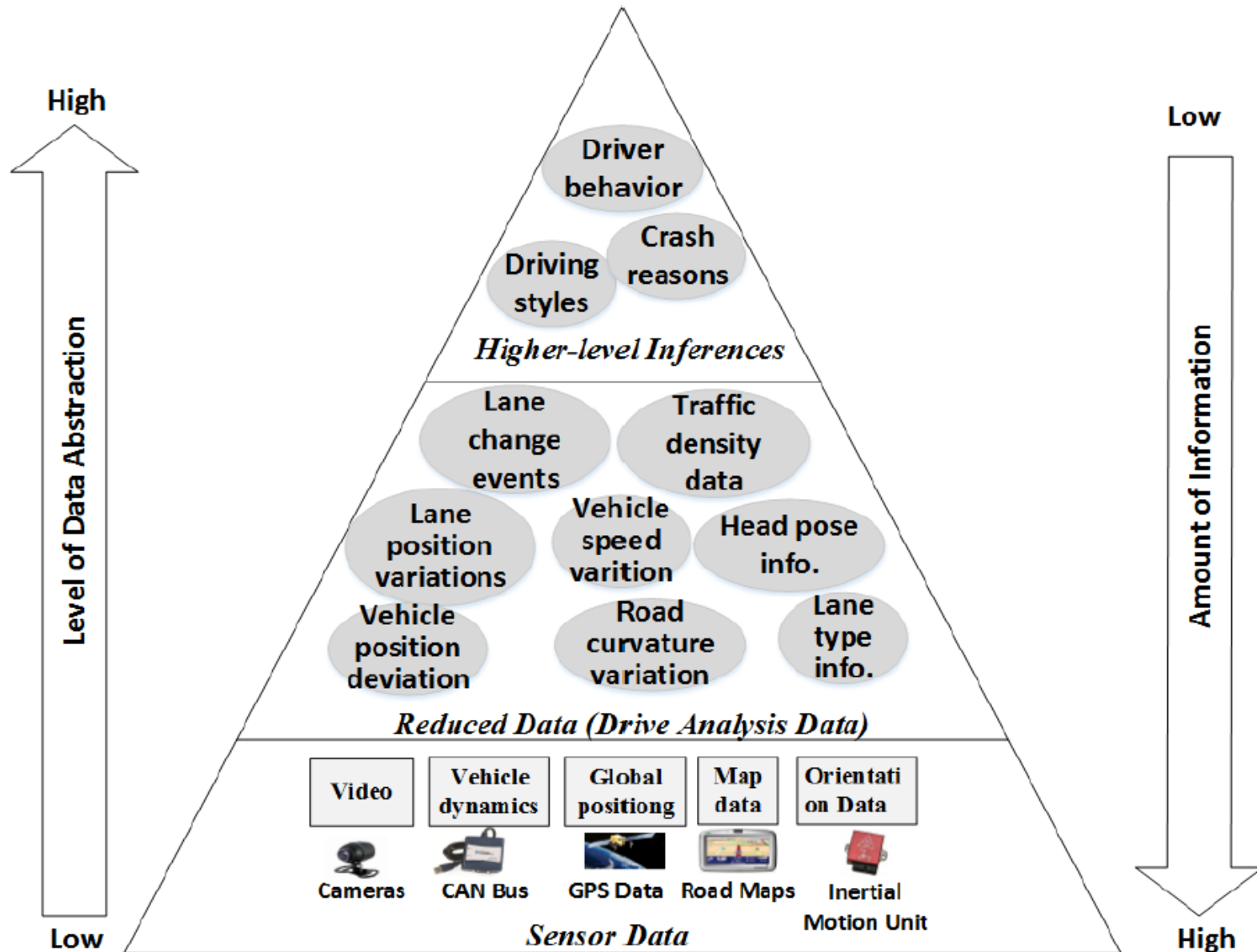


Drive Analysis on NDS Data

- ❑ Introduction: Hierarchical view of Drive Analysis
- ❑ Lane analysis for data reduction
- ❑ Lane detection - LAsSeR
- ❑ Lane drift analysis
- ❑ Lane position detection evaluation
- ❑ Drive Analysis
- ❑ Future Work

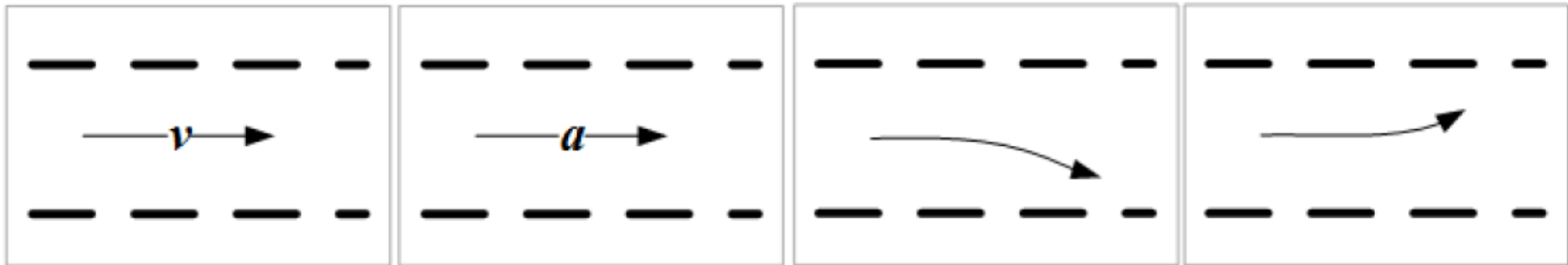


Hierarchical view of Drive Analysis



Lane Analysis

- ❑ Extraction of lane drift related events from naturalistic driving data
- ❑ Data reduction events in “Researcher Dictionary for Video Reduction Data” (ver2.1, Dec.3, 2010)
 - Moving straight with constant velocity
 - Moving straight with acceleration
 - Drifting right
 - Drifting left



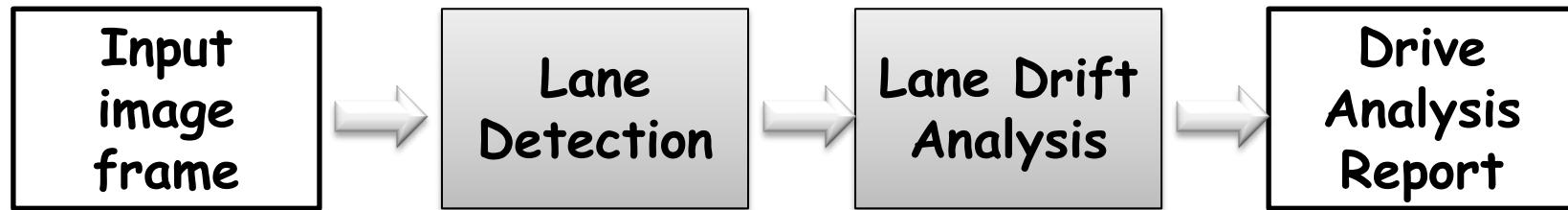
No drift with constant velocity

No drift with constant acceleration

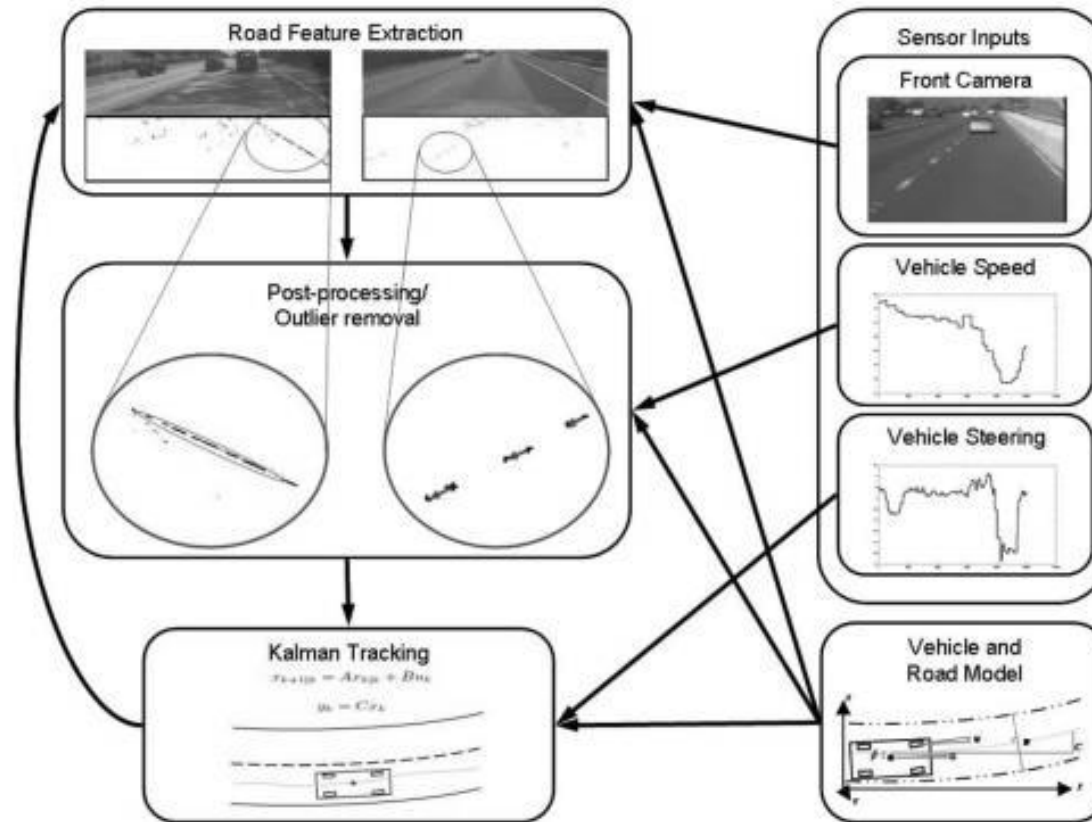
Right lane drift

Left lane drift

Lane Drift Analysis

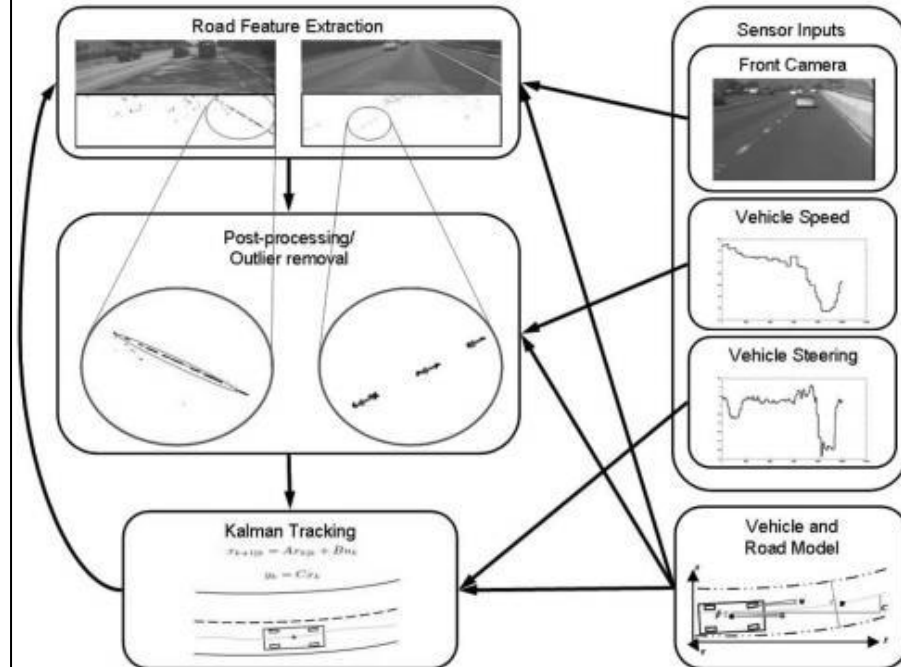
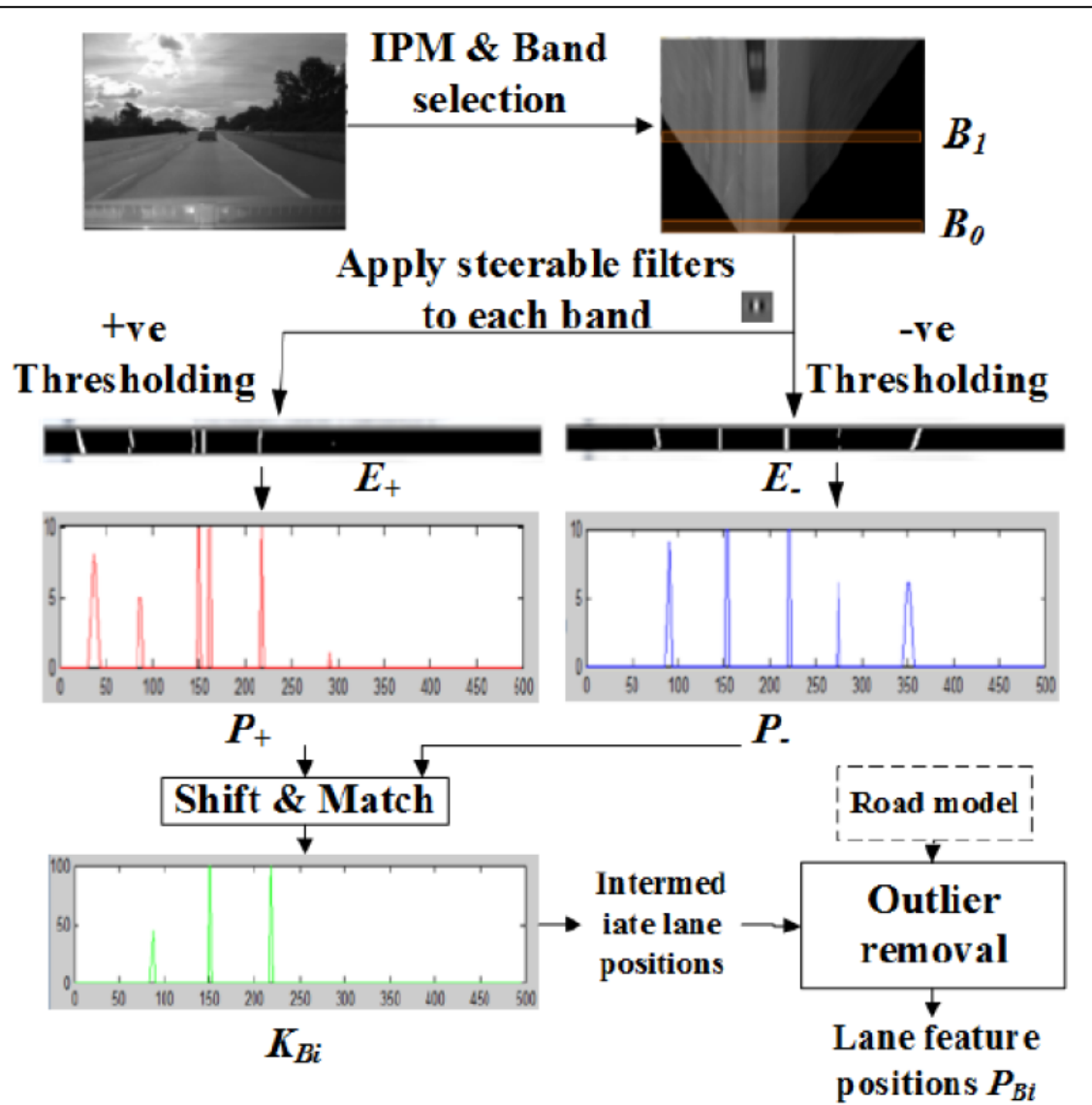


Lane Detection



Lane Detection: LAsER

LAsER-Lane Analysis using Selective Regions



Sample Results: Lane Detection



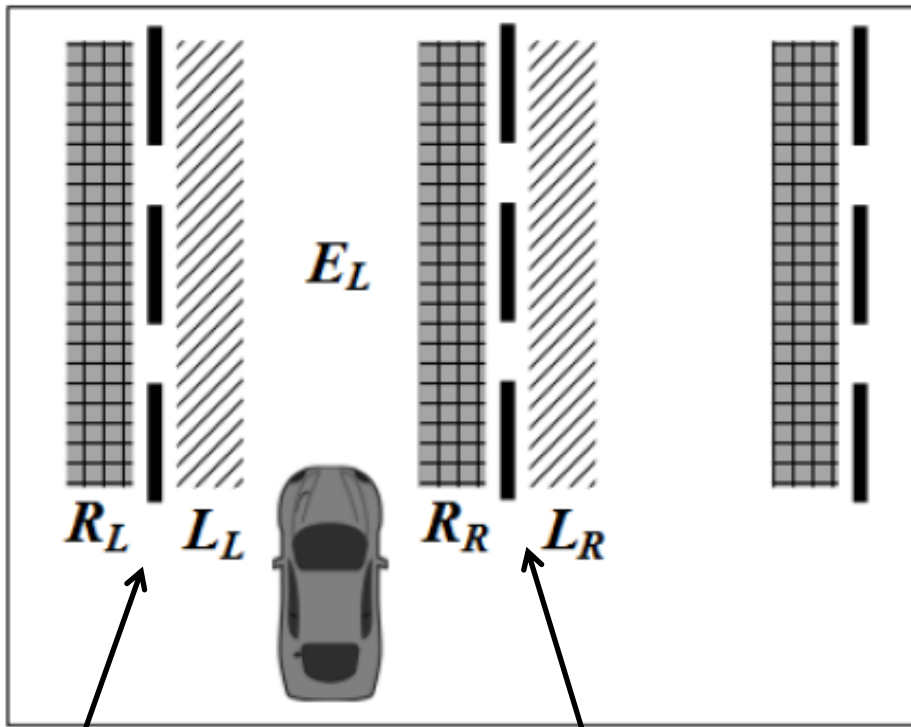
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Lane Drift Analysis

- ❑ Drift regions are defined where lane markings would be perceived to drift during a vehicle drift
- ❑ Positions of lane markings are determined → if found in the drift regions, lane drift is detected



Left lane
marking

Right lane
marking

$$event = left_drift \text{ if } \begin{cases} \forall x_{Lj} : L_L^- < x_{Lj} < L_L^+ \\ \forall x_{Rj} : L_R^- < x_{Rj} < L_R^+ \end{cases}$$

$$event = right_drift \text{ if } \begin{cases} \forall x_{Lj} : R_L^- < x_{Lj} < R_L^+ \\ \forall x_{Rj} : R_R^- < x_{Rj} < R_R^+ \end{cases}$$

$$event = in_lane \text{ if } \begin{cases} \forall x_{Lj} : R_L^+ < x_{Lj} < L_L^- \\ \forall x_{Rj} : R_R^+ < x_{Rj} < L_R^- \end{cases}$$

Sample Drift Analysis on TRB SHRP2 Video Data



Constant right drift



Left drift in Passing a truck



Rainy day

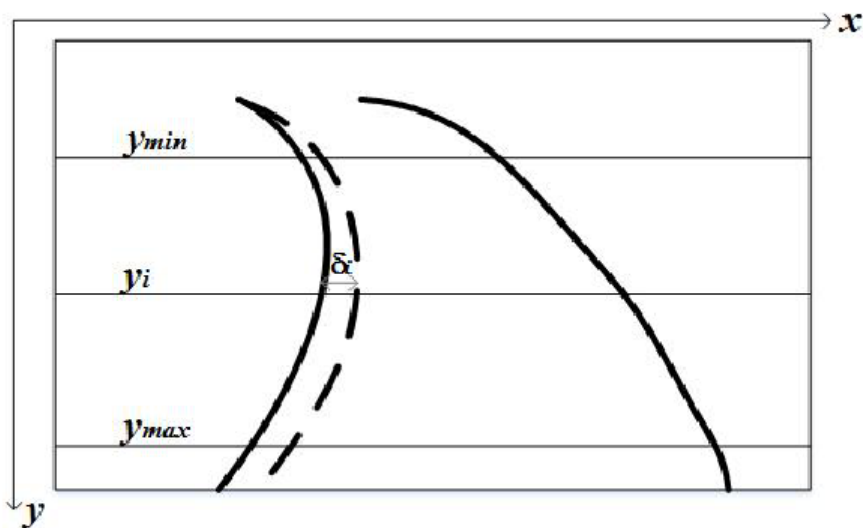


Lane Detection Evaluation: Lane Position Deviation (LPD)

- Determines accuracy of lane position in the front view of the ego-vehicle

$$\delta_{LPD} = \frac{1}{y_{max} - y_{min}} \sum_{i=y_{min}}^{y_{max}} \delta_i$$

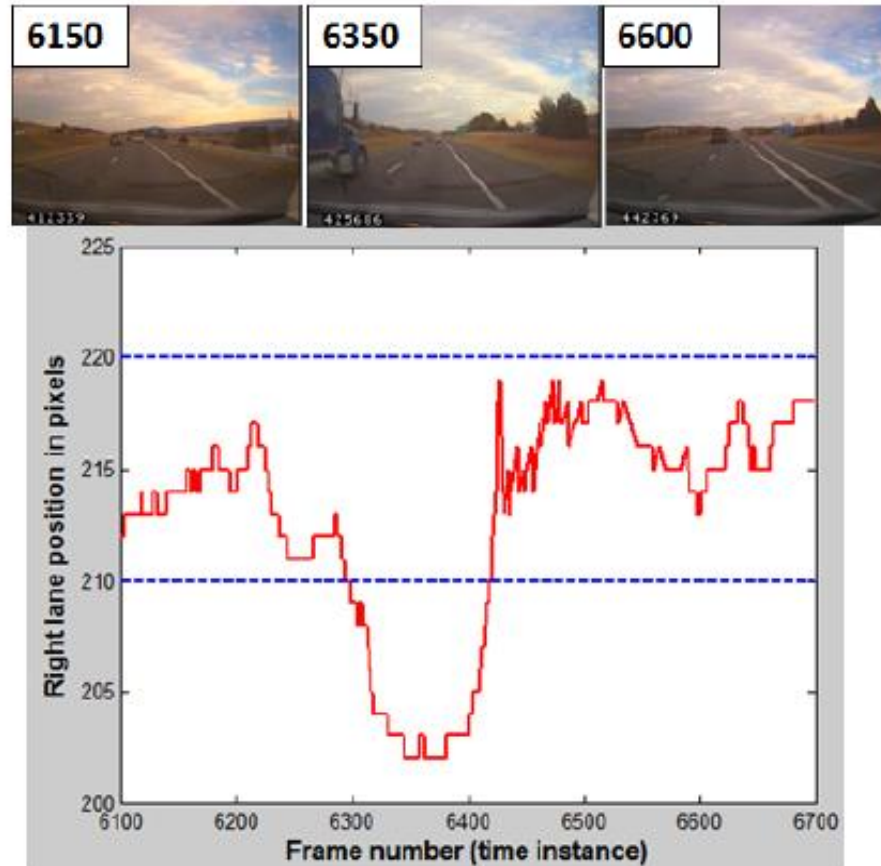
- Mean LPD was less than 8cm.



h_B	Dataset	$N_B = 16$		$N_B = 8$	
		μ_{LPD}	σ_{LPD}	μ_{LPD}	σ_{LPD}
10	LISA S_1	5.33	4.53	6.05	4.53
	LISA S_2	8.09	3.54	8.38	3.51
	LISA S_3	7.12	3.81	9.73	5.12
	LISA S_4	7.30	3.59	7.83	3.71
	LISA S_5	5.71	3.69	5.7	3.19
5	LISA S_1	5.01	3.36	5.38	3.72
	LISA S_2	7.11	3.33	6.36	2.80
	LISA S_3	6.11	3.62	9.14	5.28
	LISA S_4	7.72	3.77	7.35	4.01
	LISA S_5	6.18	5.08	7.51	5

Drift Analysis Evaluation

- ❑ Validated on SHRP2 sample data and TTC experiment data.
- ❑ Drift is estimated when vehicle moves $> 50\text{cm}$ from the center of the lane
- ❑ Detected with more than 90% accuracy (on SHRP2 sample data)



Drive Analysis Report

- ❑ After analyzing the entire drive, a drive analysis report is generated

Looking-out Drive Analysis

Laboratory for Intelligent and Safe Automobiles (LISA),
UCSD

Toyota Collaborative Safety Research Center (CSRC)



Conclusions & Future Work

- ❑ We presented a preliminary work on lane drift analysis for NDS data.
- ❑ Evaluation on sample SHRP2 datasets, LISA and TTC datasets (similar to SHRP2 perspectives) shows high accuracy rates.
- ❑ Currently work is going on to characterize lane drifts further based on surroundings of the ego-vehicle.



Contributions

- ❑ R. K. Satzoda and M. M. Trivedi, "Drive Analysis using Vehicle Dynamics and Visual Lane Semantics", IEEE Trans. On Intelligent Transportation Systems, Aug. 2014.
- ❑ Ravi Kumar Satzoda and Mohan M. Trivedi, "Selective Salient Feature Based Lane Analysis," 16th IEEE Intelligent Transportation Systems Conference, (ITSC2013), Oct. 2013.
- ❑ Ravi Kumar Satzoda and Mohan M. Trivedi, "Vision-based Lane Analysis: Exploration of Issues and Approaches for Embedded Realization," Advances in Embedded Computer Vision, Springer, 2014.
- ❑ R. K. Satzoda, P. Gunaratne, M. Trivedi, "Drive Analysis using Lane Semantics for Data Reduction in NDS", IV 2014.
- ❑ Ravi Kumar Satzoda and Mohan M. Trivedi, "On Performance Evaluation Metrics for Lane Estimation," *International Conference on Pattern Recognition (ICPR2014)*, August 2014.
- ❑ R. K. Satzoda, P. Gunaratne, M. Trivedi, "Drive Analysis using Lane Semantics for Data Reduction in NDS", IV 2014.
- ❑ R. K. Satzoda, Sujitha M., Minh Van Ly, Pujitha G. and Mohan M. Trivedi, "Towards Automated Drive Analysis: A Multimodal Synergistic Approach", 2013 IEEE Annual Conference on Intelligent Transportation Systems, pp. 1912-1916, Oct. 2013.



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Thank You!



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