Road Infrastructure Requirements for Improved Performance of Lane Assistance Systems

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Road Infrastructure Requirements for Improved Performance of Lane Assistance Systems

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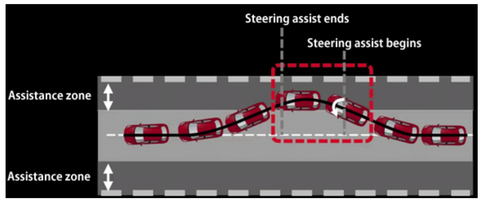
1. Introduction & Research Question

- The rapid advent of automated vehicles has raised a lot of interest in understanding their impacts on transportation;
- New EU regulation makes it mandatory from 2022 that all vehicles sold in the EU will have a set of automated safety systems including lane assistance systems;
- Road authorities need to take initiative towards understanding the implications of these systems on existing road infrastructure;

Main Research Question: What changes need to be made to the road infrastructure to increase the performance of Level 1 Automated Vehicles with Lane Assistance Systems?

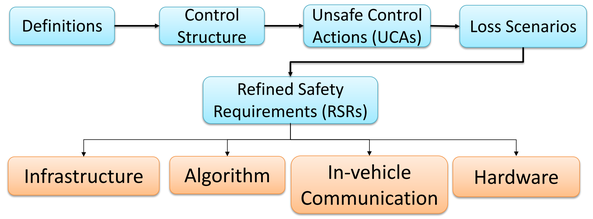
A typical provincial road



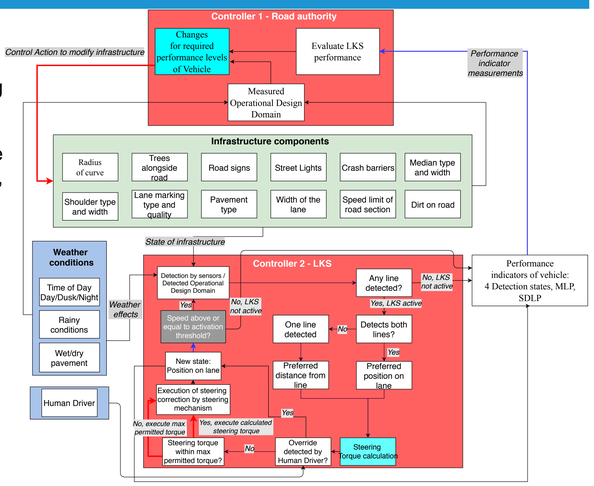
Working of a Lane Keeping System

2. STAMP model

- Useful for understanding a System containing several interacting components and sub-components;
- Analysis involves theoretic System description, and its extensive risk analysis using STPA (Systems-Theoretic Process Analysis), resulting in specific safety requirements;



The STPA analysis steps, based on the STAMP model



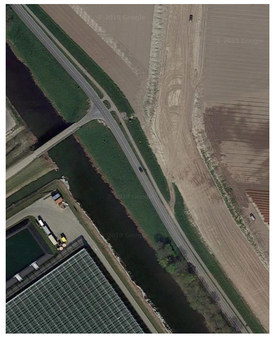
Depiction of the System as a Control Structure

3. Field test

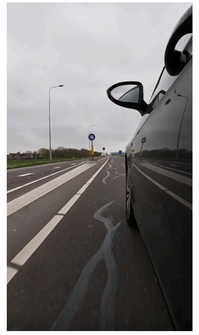
- 2 vehicles, equipped with a Lane Keeping System (LKS) and a Lane Departure Warning (LDW) system respectively, driven on about 600 km routes in different driving environments;

Routes covered in the field test

Median with crossings has too sharp curves

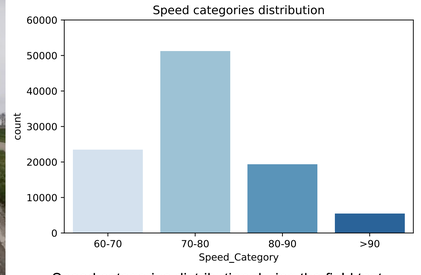


Reverse curves too sharp without enough transition section

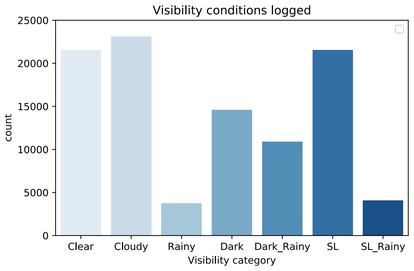


Asphalt repair patches

Speed reduction limit placed too late before a curve



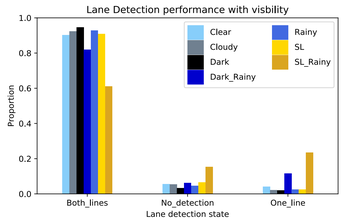
Speed categories distribution during the field test



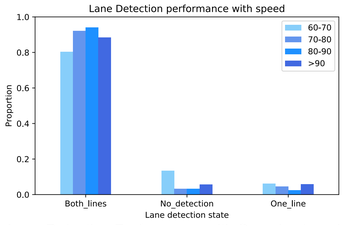
Visibility conditions distribution during the field test

4. Results

- Significant effect of Visibility conditions and Speed on Detection performance, and a significant effect of Lane width and Type of Curve on Lane Position;

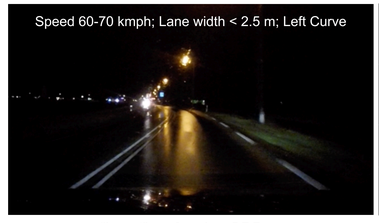


Lane Detection Performance with Visibility conditions

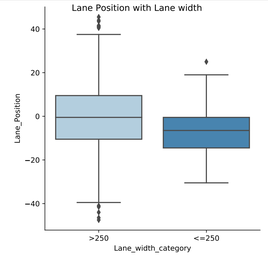


Lane Detection Performance with Speed categories

"Highest" performing ODD



"Least" performing ODD



Lane Position with Lane widths

ODD-Performance levels

	Visibility condition	Speed category (kmph)	Lane width	Type of curve
High Performance	Dark, Rainy, Cloudy, Clear	70-80, 80-90	≥ 2.5 m	Straight section, Right Curve
Medium Performance	Streetlights, Dark Rainy	>90	-	-
Low Performance	Streetlights Rainy	60-70	< 2.5 m	Left Curve

5. Conclusions

- Visibility conditions have a significant effect on detection performance, especially in rainy conditions under streetlights;
- On lane widths less than 2.5 m, and on Left curves, LKS positions the vehicle significantly to the left from the lane center;
- Road curvature must be considered in combination with the speed limit to safely accommodate LKS steering limitations;
- Infrastructure (re)design requires elimination of distracting "lines" in the driving environment (e.g. Asphalt repair patches);
- Close collaboration between road authorities and OEMs is crucial to expand the systems' Operational Design Domain (ODD);
- Drivers must be adequately informed about the limitations of these system by OEMs as well as authorities;

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