Improved trustworthiness and weather-independence of conditional automated vehicles in mixed traffic scenarios

Reporting

Project Information

TrustVehicle

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Project website

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Project closed

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€ 4 998 903,75

Coordinated by
VIRTUAL VEHICLE RESEARCH GMBH
Austria

This project is featured in...

Periodic Reporting for period 2 - TrustVehicle (Improved trustworthiness and weather-independence of conditional automated vehicles in mixed traffic scenarios)

Reporting period: 2018-12-01 to 2020-10-31

Summary of the context and overall objectives of the project

Automated vehicles will be accepted by customers and society only when they will be deemed easy-to-use and fully reliable and safe regarding the planned manoeuvres and their execution. A key challenge is to ensure safe vehicles handling with reduced driver attention. Especially for level 3 automated driving systems, an effective interaction between the driver and the automated vehicle plays an important role. To act in harmony with driver expectations, these systems should be engineered following a user-centric approach. User acceptance is particularly important for the design of driver interfaces that will facilitate the transitions between human and automated driving. Moreover, the automated driving systems should be resilient to both system and driver failures and guarantee sufficient reliability and robustness in each and every situation in real world traffic.
The TrustVehicle project aimed to address these challenges with the following systematic approach:

TrustVehicle vision: Turning a vehicle into a TrustVehicle - a vehicle which the end user can trust.

TrustVehicle mission: Developing technologies that work reliably and predictably to gain the end-user’s trust.

TrustVehicle objectives:
• Objective 1: Systematic identification of critical road scenarios for the currently available Automated Driving (AD) systems, with special focus on the uncertainty associated with the behaviour of other road users and the sensor fusion system of the ego vehicle.
• Objective 2: Controllers and sensor fusion systems capable of dealing with complex, uncertain and variable road scenarios for enhanced road safety.
• Objective 3: Development and demonstration of intuitive human-machine interfaces (HMIs) for the safe management of the transition between fully automated driving (SAE Level 5) mode and human

driving taking into account user acceptance and gender-specific aspects.
• Objective 4: Development and demonstration of new tools for the cost- and time-effective assessment of vehicle and driver behaviour in complex mixed-traffic scenarios.
• Objective 5: Evaluation of L3AD functions and vehicle tailoring

Work performed from the beginning of the project to the end of the period covered by the report and main results achieved so far

The driver's impressions and feelings are crucial for L3AD driving since he/she should be able to resume vehicle control if needed. Therefore, they are taken into account in the whole development process of the different components that constitute the automated system. The analysis started with a traffic injury analysis. The research revealed considerable differences among countries in traffic road injuries, especially in relation with the gross-domestic-product (GDP) of the countries. The next step dealt with the analysis of user expectations. The aim was to explore what people think about automated vehicles and how comfortable they feel with this new technology. Therefore, a questionnaire was prepared and issued to volunteering participants. A broad overview of critical driving scenarios developed through the TrustVehicle project was compiled, where special focus was on the use cases represented by Ford Otosan's truck/trailer backing manoeuvres, Tofaş' LCV scenarios for narrow urban streets, Linkker's charging station use case, Volvo's sensor monitoring system, Valeo's self-cleaning sensors and IFAT's driver monitoring system. In addition, questionnaires and tests on the driver simulator were undertaken within TrustVehicle to assure this involvement of the user in the development process, either for planners and controllers, sensors and sensor monitoring or HMI. A modular co-simulation approach assured the flexibility needed within the development process.
Altogether TrustVehicle focused on 4 different vehicle classes (passenger car, bus, truck and light-commercial vehicle) within 6 different use cases.

Summarized the following results could be achieved:
• Driver Face Monitoring and Identification: Implementation of new time-of-flight camera-based sensor functionalities for driver monitoring and support
• Concept, Optimization and Testing of Sensors Cleaning Functions under Adverse Weather: Design of an AD system supervision for level 3 and 4 functions allowing to recover or maintain the sensors functionality.
• Sensor Monitoring and Self-Cleaning Sensors for a Passenger Vehicle: 3 developed methods for quantifying the availability of sensors during cleaning and in critical scenarios
• Heavy Truck-Trailer Reverse Parking Feature: Feature for completely autonomous smooth reverse parking manoeuvres demonstrated on an urban construction site and a truck docking station including driver HMI
• HMI for an Electric Bus Driving Automated under the Charging Station: Specially developed Bus Driver HMI to monitor when the electric bus is driven in automated driving mode safely and accurately under the charging station.
• Light Commercial Vehicle Sensor Fusion Development: Sensor fusion algorithms implemented for LIDAR, Camera and ultrasonic sensors for autonomous narrow street manoeuvring and reverse

parking and flexible HW platform suitable for sensor fusion to ensure the correct functioning of HW peripherals and interfaces.

The main exploitable results within TrustVehicle can be divided into two categories:
• commercial exploitation (new or advanced technologies): ranging from new technologies and knowledge when it comes to human machine interaction and driver monitoring via new reliable sense-plan act approaches to new concepts for verification and assessment.
• scientific exploitation: new knowledge
o via publications
o for academic teaching
o to feed results into future research activities
o for know-how transfer to industrial partners
o for further joint research activities.

In addition, almost 50 dissemination activities have been performed throughout the lifetime of the project, ranging from papers, conference presentations to dissertations, with the final public event and the Springer book as highlights on top.

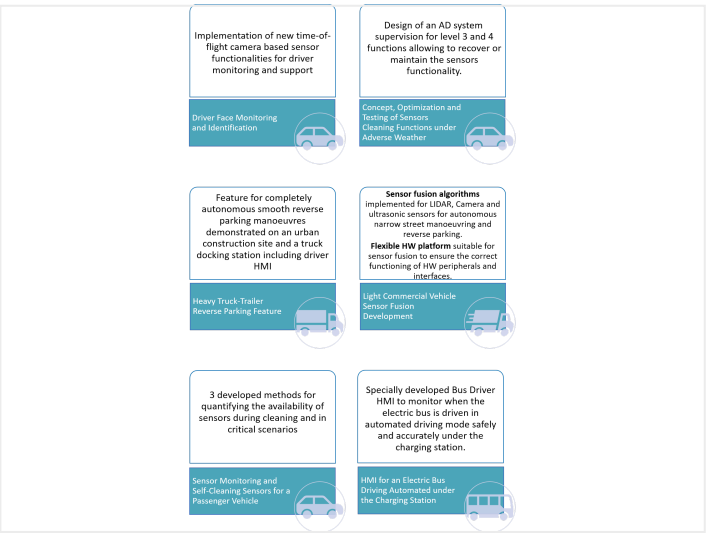
Progress beyond the state of the art and expected potential impact (including the socio-economic impact and the wider societal implications of the project so far)

Impact:
Via the consequent analysis of use requirements, expectations, and concerns by using interviews, questionnaires and focus groups, a user centric approach was the basis for the development and validation of level 3+ automated driving functions technologies within TrustVehicle. This approach led to increased trust and end-user acceptance as well as increased safety and reliability of L3AD. With L3AD being accepted and used widely, elderly person and person with special needs will be included into mobility. In addition, gender related questions and analysis done in questionnaires helped HMI and controller designs.
One of the main outputs of this process were 2 white papers: the catalogue of safety critical scenarios and the catalogue of assessment criteria that can be used as basis for the development of future human-centric reliable and safer L3AD technologies by scenario-based testing and validation.

Progress beyond the state of the art:
The following results reflect progress beyond state of the art:
• Driver Face Monitoring and Identification based on a Time-of-Flight-Camera
• Methodology to quantify sensor availability during cleaning and critical scenarios
• Sensor cleaning functions to guarantee sensor availability ruing harsh weather and environmental conditions (train, mud, etc.)
• Trajectory planning for autonomous reverse parking manouvres to be used for light commercial

vehicles and even heavy trucks including trailer

• New HMI concept for charging of electric busses



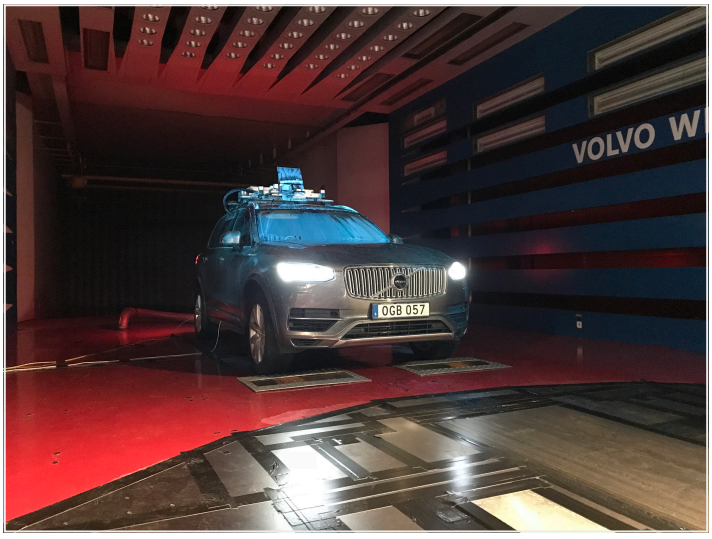
Results overview

Ford truck

Tofas LCV

Driving Simulator Study

LIN/VTT electric bus



Volvo passenger car

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