Creating a Reference for Automated Driving – The Approach followed by PEGASUS

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Creating a Reference for Automated Driving

Outline

I. Challenges on Automated Driving
II. Development & Evaluation Process
III. Establishing a Reference
IV. Required Methodologies
V. Summary
I. Challenges on Automated Driving
Challenges + interdependencies are depicted by 5 Layer-Model

Societal Layer

Legal Layer

Economics Layer

Human factors Layer

Technical Layer

DRIVER
VEHICLE
ENVIRONMENT
I. Challenges on Automated Driving

On the technical Layer all requirements need to be addressed

- Functional transition
  - Fade-out of automated driving
  - Driver assistance after TOR

- Environment detection
  - Sensor range
  - Redundancy

- Understanding the environment
  - Traffic situation
  - Anticipation, prognosis

- HMI concept
  - Information presentation
  - Logics & timing & escalation

- Driver monitoring
  - Actual use of system
  - TOR = f (driver state)

- Driver monitoring
  - TOR = f (driver state)

Technical Layer

Societal Layer

Legal Layer

Economics Layer

Human factors Layer
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II. Development & Evaluation Process
Successful Automated Driving requires a Holistic Tool Chain

1. Assess the Driver Experience before Technology exists
2. Develop & Calculate virtual Effectiveness
3. Experience & Optimize as Expert in-the-Loop
4. Validate Acceptance & Effectiveness
5. Assess Controllability of Failures
6. Validate Functionality & Controllability
7. Evaluate & sign-off Functionality & Acceptance
8. Monitor and Learn offboard
9. Check improvements and update functionality

Multi-scale Simulation
rika Driving Simulator
Vehicle Platforms
ATC Intelligent Proving Ground

Concept Experience
Concept Evaluation & Optimisation
Function Validation
Field operational tests
Real traffic

Idea
“Time-Machine”
Validation Tool
Expert Tool
Specification
Software in-the-Loop
Hardware in-the-Loop
Component Development
Traffic Situations with Connectivity
Functional Tests
SOP
II. Development & Evaluation Process

Tool Chain forms fundament for “circle of relevant scenarios”

- Relevant Traffic Scenarios
  - Assignment
  - Generation of Scenarios
  - Determination of criteria
  - Relevance
  - Reference

- Continuous Completion with Scenarios & Criteria
  - Frequency + Type of incidents
  - Traffic Situations with Connectivity

- Field operational tests
  - Functional Tests
  - Traffic Situations with Connectivity

- Real traffic

- Database
  - Relevant Traffic Scenarios

- Concept Experience
  - Idea

- Concept Evaluation & Optimisation
  - Concept Validation
  - Software in-the-Loop
  - Hardware in-the-Loop
  - Functional Tests

- Component Development
  - Component Tests

- Multi-scale Traffic Simulation
  - "Time-Machine" Expert Tool Validation Tool

- Driving Simulators
  - "Time-Machine"

- Research Vehicles
  - Intelligent Proving Ground

- Intelligent Proving Ground
  - "Time-Machine"
  - Expert Tool Validation Tool

- Field operational tests
  - Functional Tests
  - Traffic Situations with Connectivity
II. Development & Evaluation Process
PEGASUS project addresses methodology for AD on Motorways

WHAT
needs to be shown?

HOW
can it be shown?

Relevant Traffic Scenarios

Assignment

A1

A2

Continuous Completion with Scenarios & Criteria

S1
Determination of criteria

Generation of Scenarios

S2
Criteria

Exact description of Scenarios

S3
Relevance

Frequency + Type of incidents

S4
Reference

Accident Scenarios

WHAT

needs to be shown?

HOW
can it be shown?

Idea

Concept Experience

Concept Evaluation & Optimisation

A3
Concept Validation

Software in-the-Loop

Component Development

Function Validation

Hardware in-the-Loop

Field operational tests

Real traffic

SOP

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#150· Prof. Dr. Lutz Eckstein
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Creating a Reference for Automated Driving

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I. Challenges on Automated Driving
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III. Establishing a Reference
Database comprising Scenario Description + Relevance + Reference

WHAT needs to be shown?

1. Scenario Description
   - Comprises Static environment (open drive) + dynamic environment / traffic and wheather (open scenario)
   - Parametric, relational description of Scenarios in order to systematically depict the infinite number of traffic situations
   - Compatible format to SiL, Driving Simulators, HiL and test-tracks

2. Scenario Relevance
   - Takes into account frequency of relevant traffic scenarios and severity
   - Facilitates prioritization of development effort, possibly balancing of safety benefits

3. Scenario Reference
   - Reference is the performance of human drivers, systematically captured by suitable experiments
   - Formulation as driver models depicting also the variance of driver performance
III. Establishing a Reference
Database forming State of the Art requires collaboration

WHAT needs to be shown?

1. Who should contribute?
   - Description: Industry + Road Authorities + Universities
   - Relevance: Authorities + Industry + Universities
   - Reference: Universities + Road Authorities + Industry

2. Who could drive the process?
   - A neutral player balancing interests of different stakeholders
   - In Germany, fka is moderating this process with BASt and VDA
I. Challenges on Automated Driving

II. Development & Evaluation Process

III. Establishing a Reference

IV. Required Methodologies

V. Summary
IV. Required Methodologies

Simulation plays a crucial role on different scales

- Traffic Server
- Traffic Parameters
- Vehicles x Functions
- Map Data
- Traffic Flow Simulation
- Relevance of traffic scenarios (type, frequency, characteristics)
- Simulation of Function Y in relevant Scenarios
- V Vehicles with Function Y
- Traffic Performance, e.g. traffic flow
- Vehicle Performance
- Requirements on system performance

**On this level, modelling of sensors & systems may be simplified**
IV. Required Methodologies

Simulation plays a crucial role on different scales

- Traffic Flow Simulation
- Map Data
- Traffic Performance, e.g., traffic flow
- Relevance of traffic scenarios (type, frequency, characteristics)
- Simulation of Function Y in relevant Scenarios
- Vehicle Performance

Traffic Server

Scenario Database (PEGASUS ff)

xD – Scenario Generator (highly detailed)

Traffic Parameters

Vehicles x Functions

Scenario Parameters

Vehicle with Function Y

Perception

Recognition & Anticipation

Decision Making & Trajectory Planning

Actuation & Vehicle Control

System Multi-scale Simulation

Components

Sensor A

Sensor B

Sensor C

Perception Performance

Reliability Requirements

Performance Requirements

Scenario Understanding

Security Requirements

Communication wire / wireless

Software Components

Hardware

CPU, GPU...

Drive train

Steering System

Brakes

Vehicle Dynamics
Creating a Reference for Automated Driving

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V. Summary
Safe Automated Driving requires International Collaboration

- Automated driving constitutes an interdisciplinary challenge, ranging from a technical layer via a human factors layer, an economic and a legal layer to a societal layer.

- The human factors layer plays a central role, not only for automated systems requiring or allowing for interaction between vehicles and human beings. This results in requirements on the technical level directly or legal requirements, which again cause technical requirements.

- Defining, **WHAT** an automated system needs to comply with, should be done by an international community of industry, authorities and universities, in order to establish a commonly accepted state of the art – continuously!

- **HOW** to prove, that an automated system complies with the relevant scenarios, is not a solved problem – new methodologies are required, incorporating a powerful multi-scale simulation. PEGASUS will contribute, additional projects are already being prepared.
Contact

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Breakout Session 17: Safety Assurance

Sub-Session 1: Technical Approaches on Safety Assurance

• *Creating a reference for Automated Driving – the approach followed by PEGASUS*
  • Lutz ECKSTEIN, RWTH Aachen University, Chair of ika and Director of the board of fka, Germany

• *Software-defined intra-vehicular networking for autonomy*
  • Edward R. GRIFFOR, Associate Director, Smart Grid and Cyber Physical Systems, NIST

• *Validation of AV software by simulation*
  • Chad PARTRIDGE, CEO of Metamoto, Inc.

• *Proving Ground Testing*
  • John MADDOX, American Center of Mobility
Breakout Session 17: Safety Assurance

Sub-Session 2: Societal Perspectives on Safety Assurance

• Customer Expectation of AV
  • Ryan HARRINGTON, Exponent, Inc.

• A new age in public sector safety assurance
  • Shawn KIMMEL, Ph.D., Lead Engineering, Booz Allen Hamilton;

• Dan BARTZ, FCA
  • SAE V&V committee
Breakout Session 17: Safety Assurance

Summary of Key Findings/Lessons Learned/Issues:

• Database with relevant traffic scenarios is a (the?) key component for the validation & development process.
• It is not possible to evaluate the AV software by physical cases “completely.”
• Simulation plays a crucial role on different scales.
• Virtual Software-Defined Networking (SDN) for physical resource management is an innovative way of addressing the problem.
• Safe validation must include a structured combination of three methodologies (simulation, proving ground testing, on-road testing)
• Cyber security is a concern that needs to be progressively addressed
Breakout Session 17: Safety Assurance

Summary of Key Findings/Lessons Learned/Issues (cont’d):

- Cooperation by all stakeholders will be beneficial, but how to encourage and implement “sharing”
- Customers perception of benefits and consumer understanding of functionalities sometimes are not aligned with reality.
- How to avoid a full verification when a new functional component is added when the lower levels of components are already verified?
- Over-The-Air upgrade may present some challenges
- Potential confusion in case of functional changes by update
Breakout Session 17: Safety Assurance

Recommended Action Items:

• Better understanding about the challenge of safety assurance
• Needing researchers and stakeholders to face this challenge
• Maintain the momentum of the current gathering of interested parties and stakeholders
• Sharing driving scenarios/database