Simulation-based Development of ADAS and Automated Driving with the Help of Machine Learning

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Fields of Competence

- Artificial Intelligence
- Data Mining
- Big Data Analytics
- Modeling and simulation
- Predictive Model based Control
- Distributed Control
- Signal Classification
- Swarm Intelligence
- (Embedded) Software
- Decision Support Systems
- Robustness and Complexity Management

Big Data Analytics & AI & Simulation

Failure prediction

Anomalies and Incident Detection

Data driven development process

Automotive safety

Vehicle and traffic automation

Industry 4.0, Digitalization

(Mobile) Robotics Automated Guided Vehicle

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Advanced Driver Assistant Systems and Automated Driving

Avoiding collisions by informing, warning, braking, steering, automated manoeuvres

- Which sensors are necessary for valid decisions in automated driving?
- What sensefull functions can be carried out with a given set of sensors?
Problem Statement

• Number, diversity and complexity of safety systems increases steadily
• Do we still underestimate the complexity of integral safety systems?
• What is the minimum/best set of test cases to sufficiently describe/specify/evaluate the system behaviour?
• How can we be sure?
Sources of Complexity

- Human beings are part of the control loop now!
- Systems have to anticipate the anticipation of other traffic participants
- It’s about the difference between subjective and objective danger rather than about objective danger only
Sources of Complexity

- The problem is of stochastic nature!
- There are a lot of possibilities how a given situation can evolve
  - Action/reaction of driver/pedestrian
  - Scatter of environmental conditions
  - Uncertain vehicle conditions
  - There is not one single certain Time to Collision (TTC)
  - Time to Collision is a stochastic random variable
  - Conditional probabilities: Bayes!
Sources of Complexity

• The problem is mathematically instable!
  ➢ Even small changes in the initial/boundary conditions may lead to completely different collision conditions
Sources of Complexity

• Conflicting requirements
• Incomplete information
Consequences

- Taking a **probabilistic/stochastic** point of view
- Consequent **Top-Down** instead of Bottom-Up **system development**
- Analysis of **field effectiveness** instead of test effectiveness
- Increasing integration of **simulation** based development (scenario based approach)
- Broad application of **data driven** approaches (Big Data Analytics and Artificial Intelligence)

- Combined into **Integral Development Process**
- Almost completely carried out in MATLAB
The Core Principle for Algorithm Development

- Example based representation of functional requirements

Sensor signals

Desired action

Time window

Algorithm

Field of Effect

Sensors

Algo

Action

Effect! > Visible to customer

Market driven > Requirements/Spec

Neural Networks, Machine Learning

Functional requirement for algorithm:
- Which action to take when
- in which situations
- based on which sensors/information

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Example Based Representation of Functional Requirements

Situation_1

Situation_2

Situation_n
Data Acquisitions from Fleet Data
Scenario - Management and Development/Approval of Actions

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Action Specification Based on „Decision Points“ with „Big Data Analytics“
Folding Various Decision Variables (e.g. collision probabilities)
Effectiveness Rating von Different System Variants
What is a requirements conflict for a control algorithm?

- In different situations, which induce the same sensor image, different actions are desired!
Problem description
• Model based predictive control of traffic flows

Solution approach
• Scenario- & data based specification of function
• Functional algorithms with Artificial Intelligence
• Multi-level, stochastic simulation
• System-Engineering
• Pattern recognition
• Machine Learning
• Virtual sensors
• Effectiveness rating
• …

Tools
• MATLAB
• Neural Networks Toolbox
• Statistics and Machine Learning Toolbox
• Div. ANDATA Toolboxes für MATLAB
Problem description
• Development of control algorithms for mobile robots in industrial environments

Solution approach
• Scenario based approaches
• Sensor signal modeling
• Kinematic simulation
• „Intelligent“ algorithms for mapping, localization, path planning

Tools
• MATLAB, Simulink/Stateflow
• Neural Networks Toolbox
• Statistics and Machine Learning Toolbox
• MATLAB Compiler, MATLAB Coder
• var. ANDATA Toolboxes for MATLAB
ANDATA Software and Tools

**STIPULATOR**
- Data collection, preparation and normalization
- Data cleaning
- Sensor models
- Signal preparation
- Requirements definition ("labelling", etc.)

**BRAINER**
- Data analysis
- Training, adaption and evaluation of Machine Learning models
- Meta modelling, feature selection, etc.

**SCENE INSPECTOR**
- Scenario management
- Multilevel stochastic simulation
- Execution of distributed simulations

**EXPECTATOR**
- Data plausibilization
- Anomalies and incident detection
Summary

- Scenario Management
- Operational Requirements Management
  - Conflict analysis
  - Proof of feasibility of the requirements
- Sensor concept evaluation and rating
- Effectiveness rating of system concept
- Design of experiments (What is the minimum test set to assure safe system functionality?)
- Virtual sensors, e.g. for estimation of collision probabilities
- Fast prototypical implementation
- Conform separation between specification and implementation
- Anomalies detection as quality assurance for simulation
- ...

➢ Extreme Development Procedures
  ➢ Extremely quick, efficient, effective

➢ Uniform, integral product development process for traffic automation

➢ Carried out completely in MATLAB

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Conclusion

Extreme product development procedures with Big Data Analytics and Artificial Intelligence are not research anymore!

- Just do it! Tools are available for decades now
- MATLAB / Simulink / Neural Networks Toolbox
Thanks, for listening!

The singularity is near, let’s be prepared!