Simulationbased Development of ADAS and Automated Driving with the Help of Machine Learning

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ANDATA

MathWorks®

MATLAB EXPO 2017 DEUTSCHLAND

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

ANDATA ARTIFICIAL INTELLIGENCE LABS

MathWorks Partner

Big Data Analytics & AI & Simulation

Data driven development process

Failure prediction

Anomalies and Incident Detection

Industry 4.0, Digitalization

(Mobile) Robotics *Automated Guided Vehicle*

Vehicle and traffic automation

Automotive safety

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Advanced Driver Assistant Systems and Automated Driving

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

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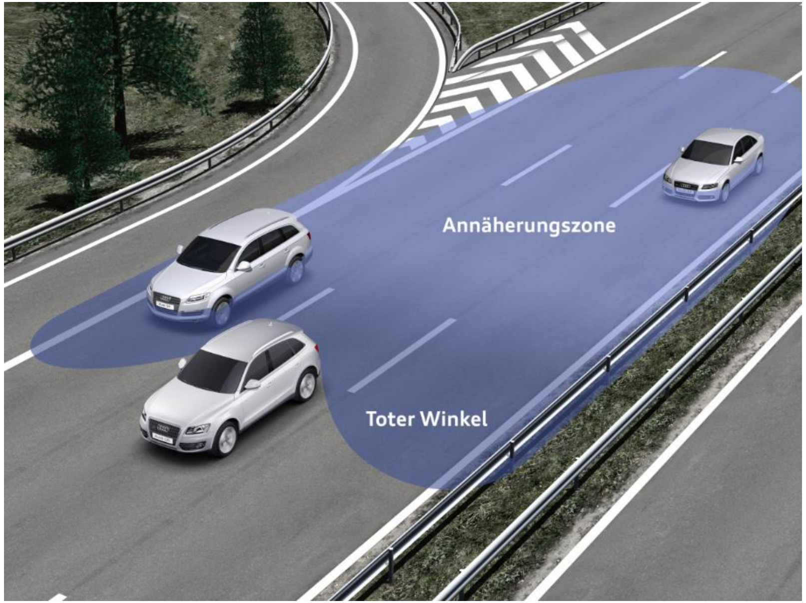
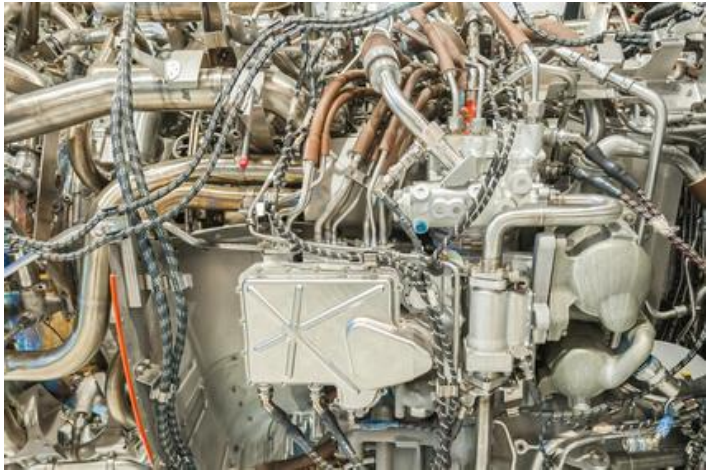


- ➢ Which sensors are necessary for valid decisions in automated driving?
- ➢ What sensefull functions can be carried out with a given set of sensors?

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?

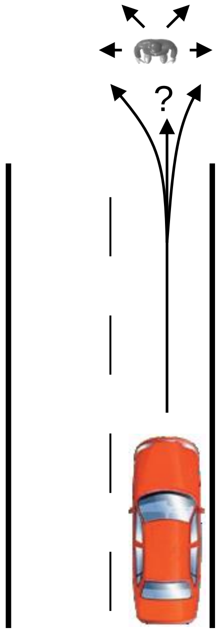


Sources of Complexity

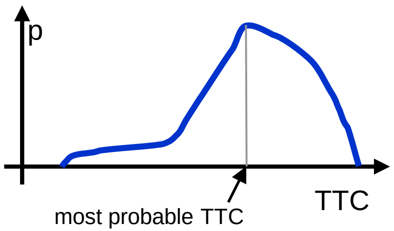
- Human beings are part of the control loop now!
- ➢ Systems have to anticipate the anticipation of other traffic participants
- ➢ It's about the difference between **subjective** and **objective danger** rather than about objective danger only

Sources of Complexity

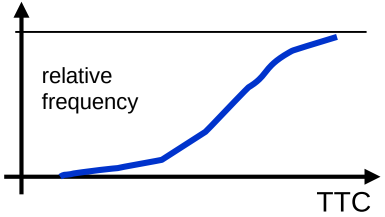
- The problem is of stochastic nature!
- ➢ There are a lot of possibilities how a given situation can evolve



- Action/reaction of driver/pedestrian
- Scatter of environmental conditions
- Uncertain vehicle conditions



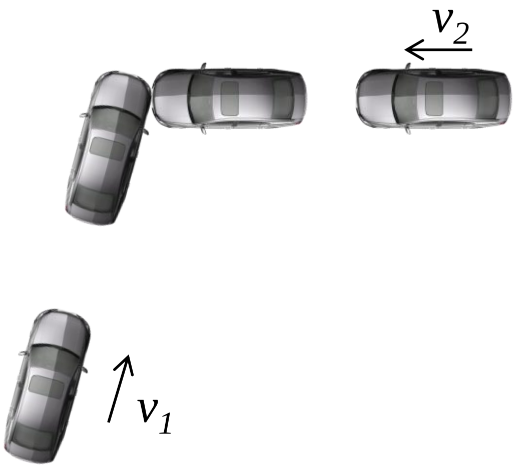
- ➢ There is not one single certain Time to Collision (TTC)
- ➢ Time to Collision is a stochastic random variable
- ➢ Conditional probabilities: Bayes!

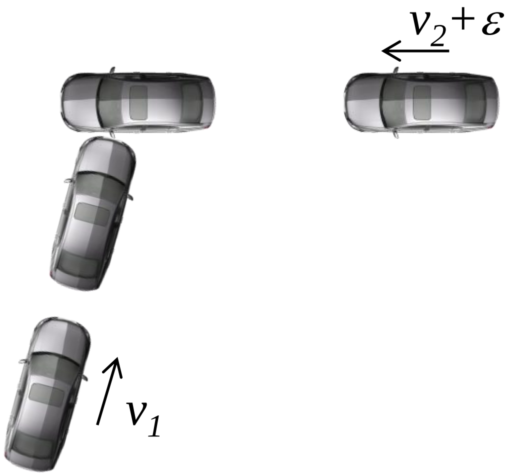


Sources of Complexity

- The problem is mathematically instable!

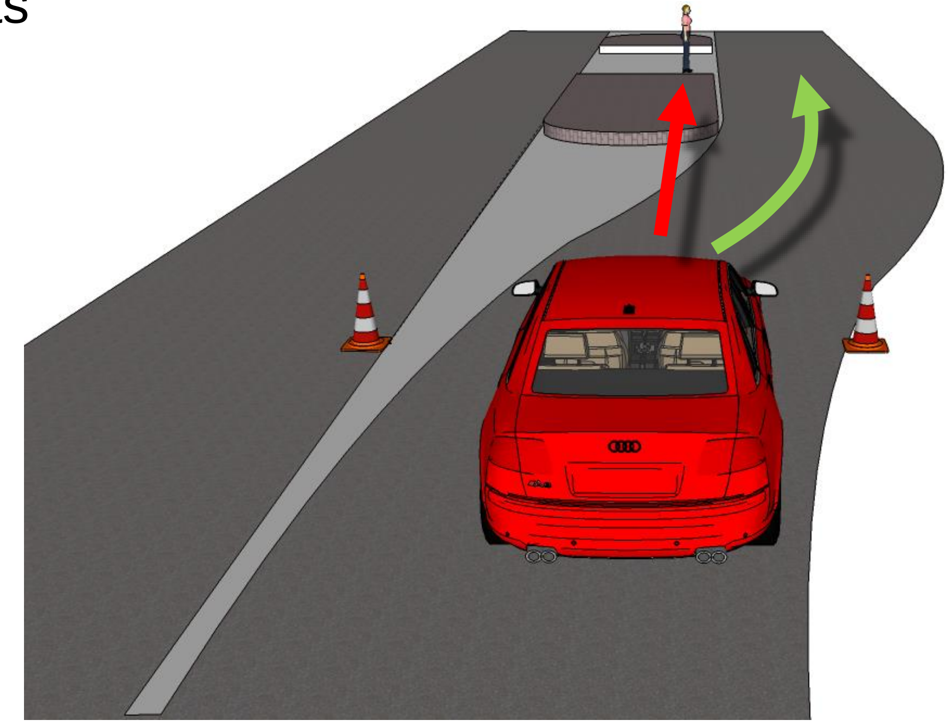
➢ Even small changes in the initial/boundary conditions may lead to completely different collision conditions





Sources of Complexity

- Conflicting requirements
- Incomplete information



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Consequences

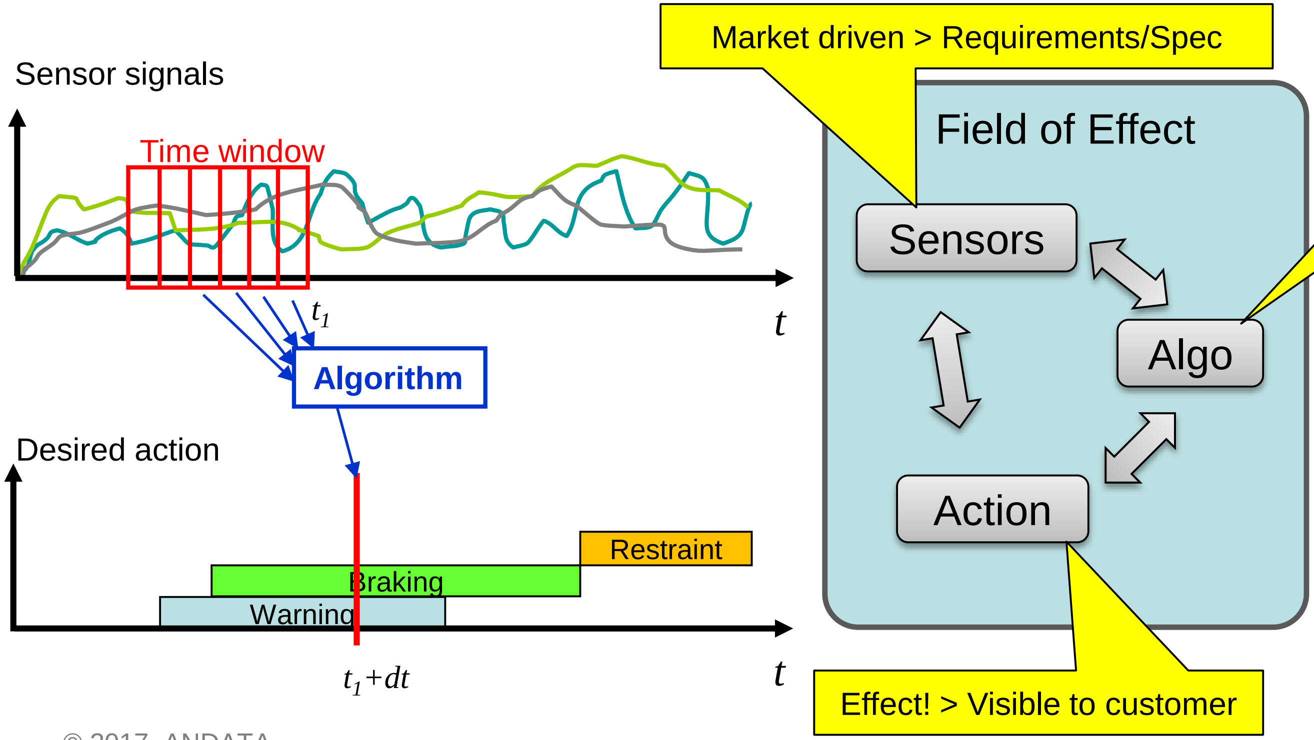
- Taking a **probabilistic/stochastic** point of view
- Consequent **Top-Down** instead of Bottom-Up **system development**
- Analysis of **field effectiveness** instead of test effectiveness
- Increasing integration of **simulation** based development (scenario based approach)
- Broad application of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

➢ Combined into **Integral Development Process**

➢ Almost completely carried out in MATLAB

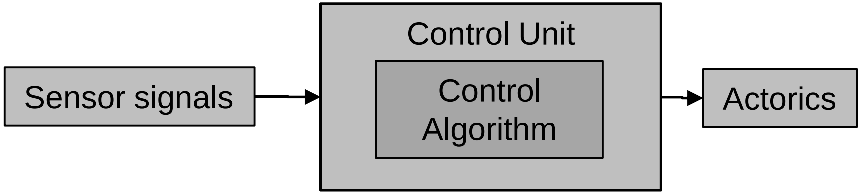
The Core Principle for Algorithm Development

- Example based represenation of functional requirements

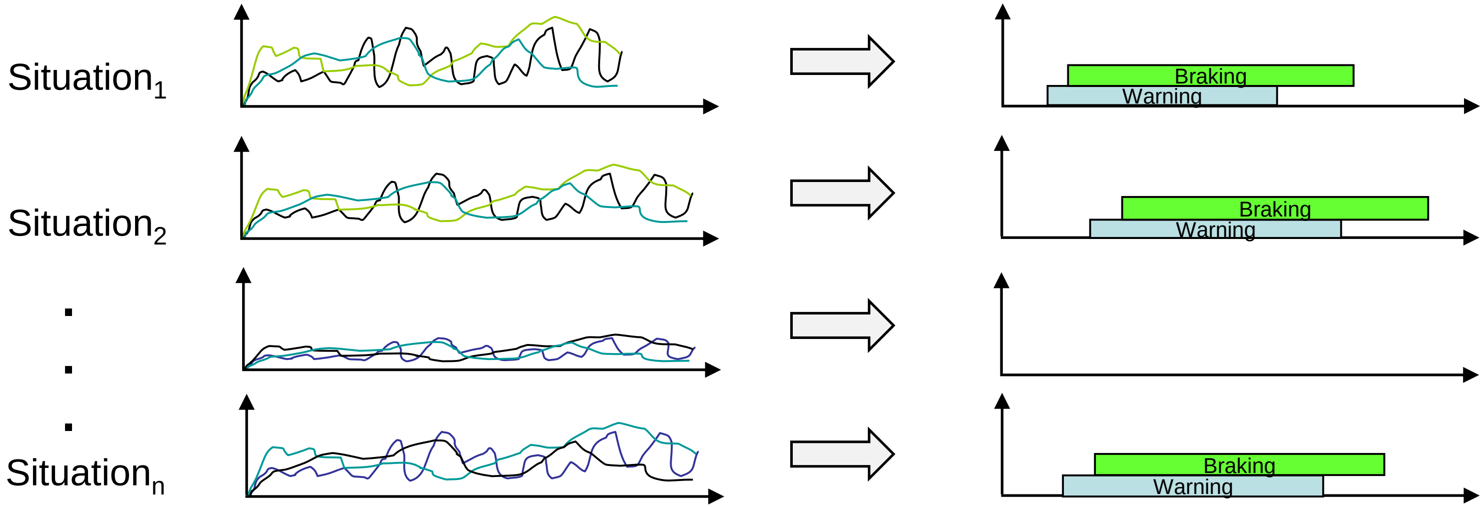


Functional requirement for algorithm:
- Which action to take when
- in which situations
- based on which sensors/information

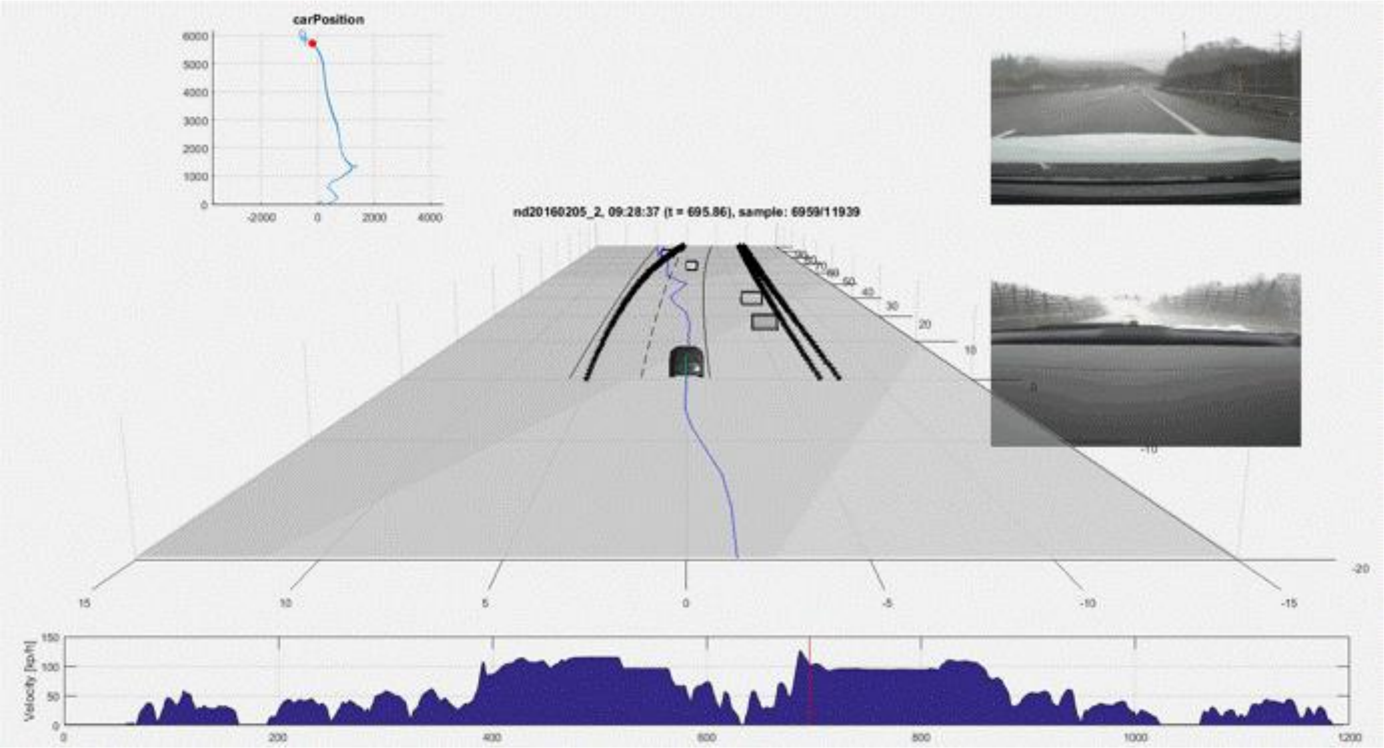
Example Based Representation of Functional Requirements



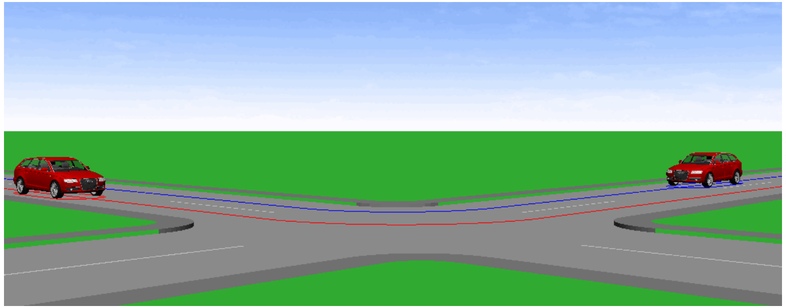
STIPULATOR

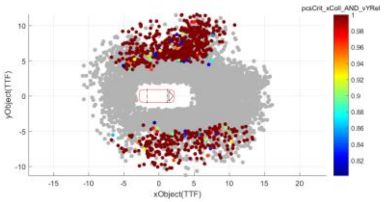


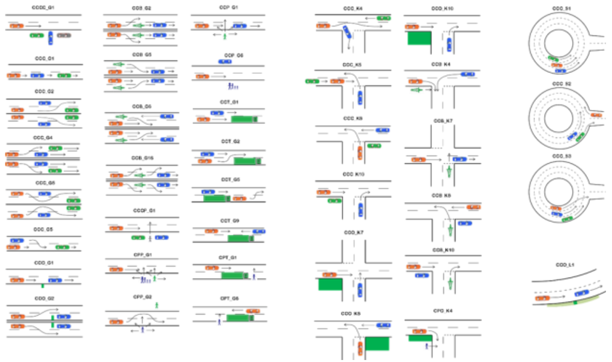
Data Acquisitions from Fleet Data

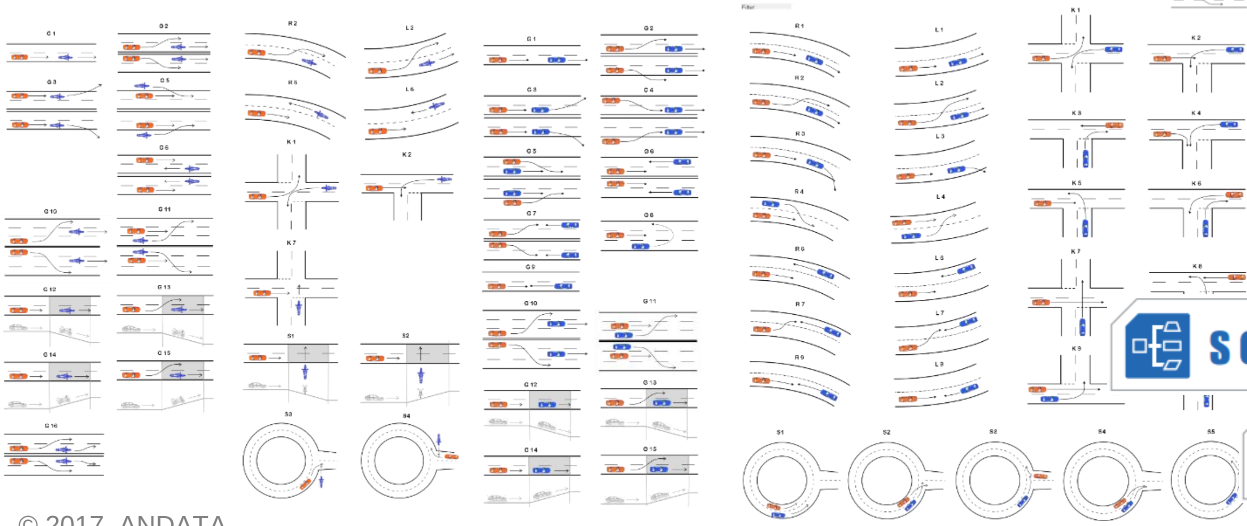


Scenario-Management and Development/Approval of Actions







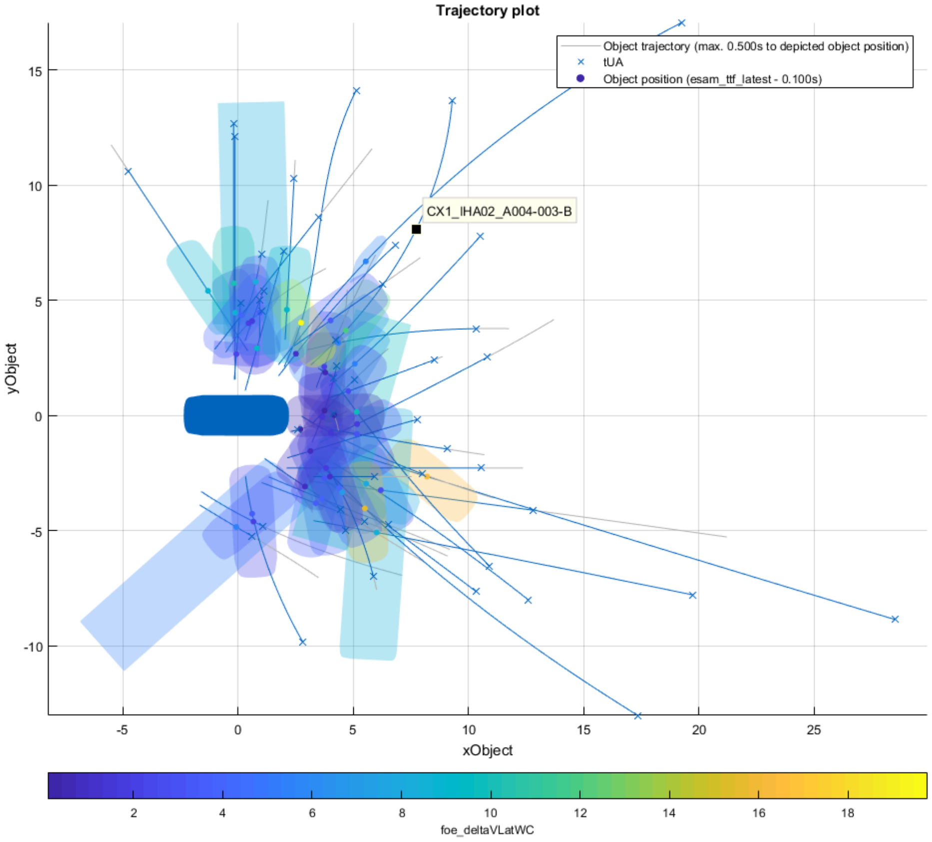


SCENE INSPECTOR

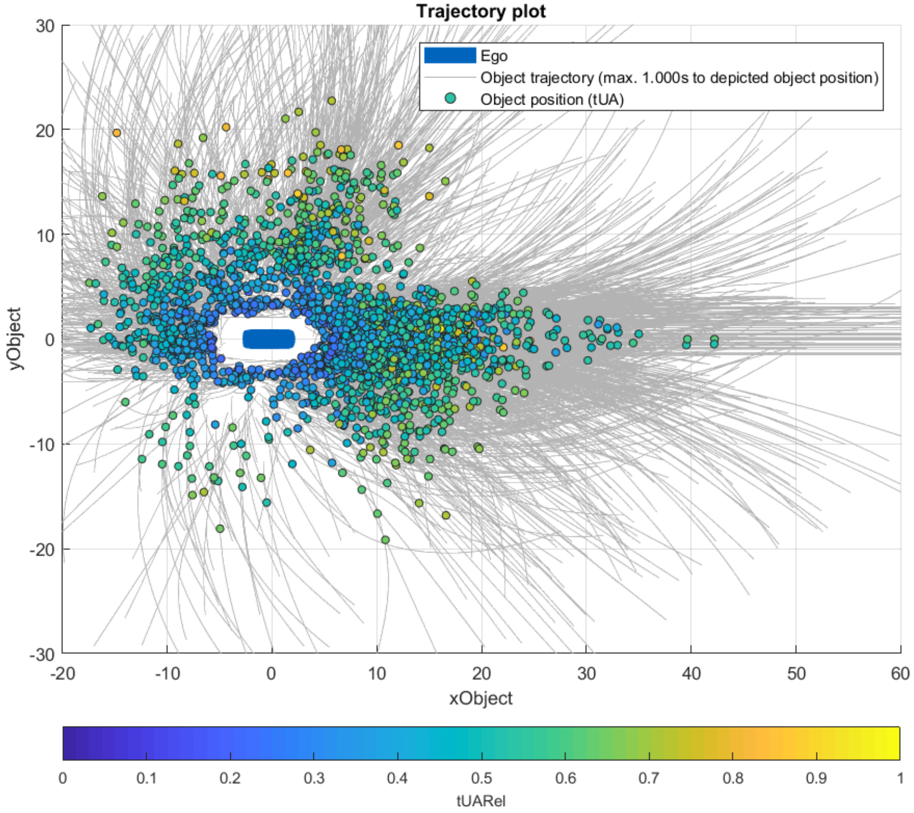
EXPECTATOR

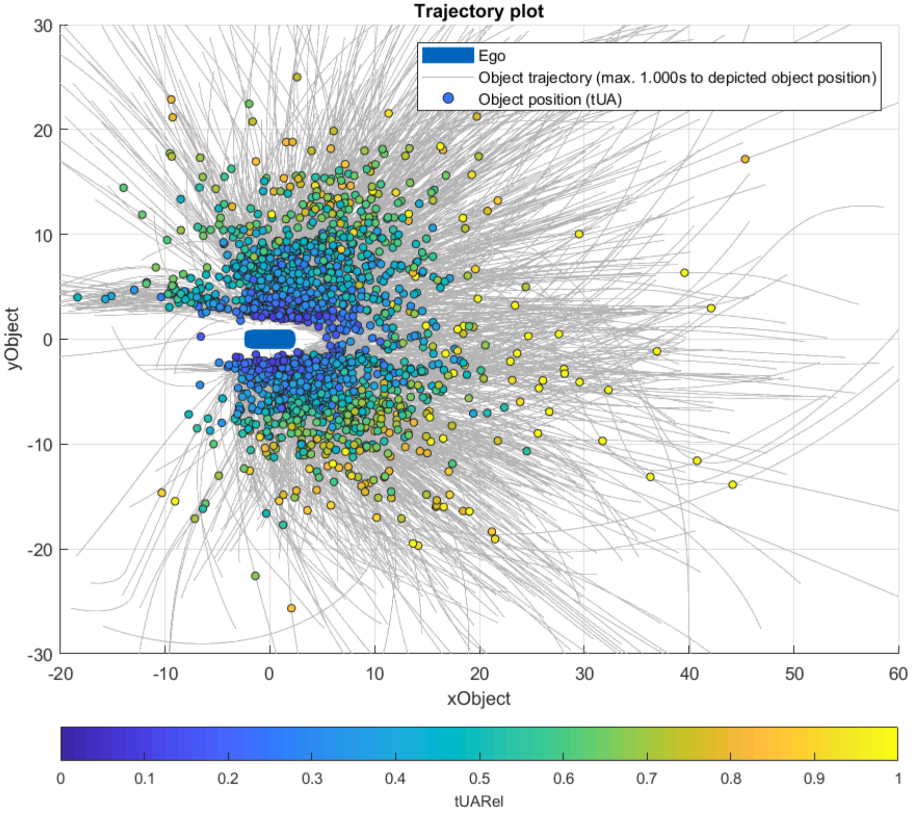
VEHICLE CONTROL

Action Specification Based on „Decision Points“ with „Big Data Analytics“

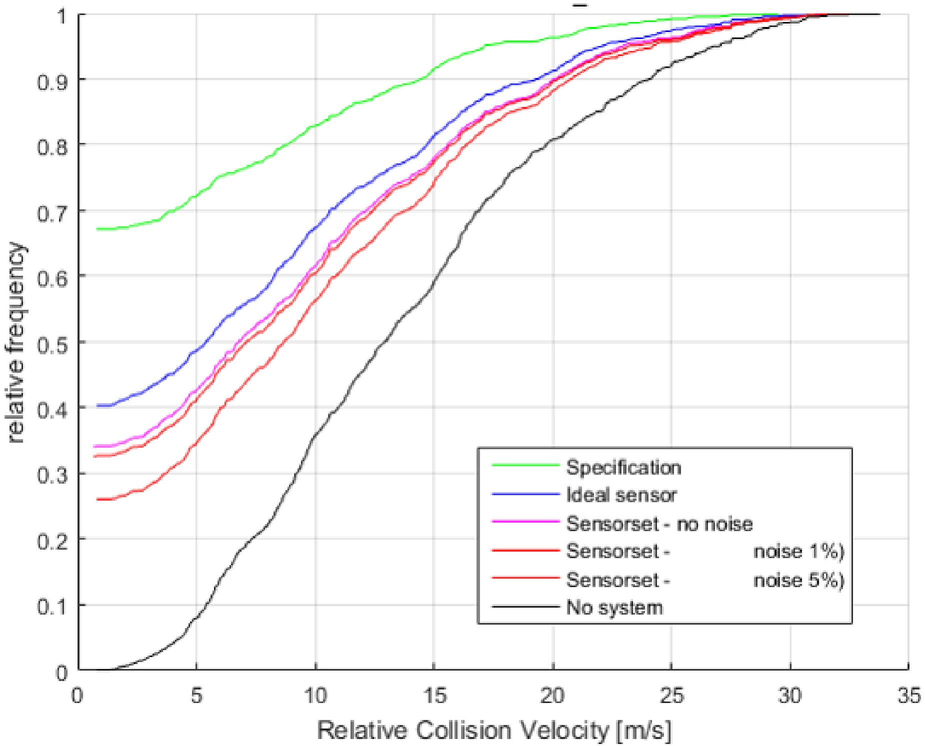


Folding Various Decision Variables (e.g. collision probabilities)





Effectiveness Rating von Different System Variants

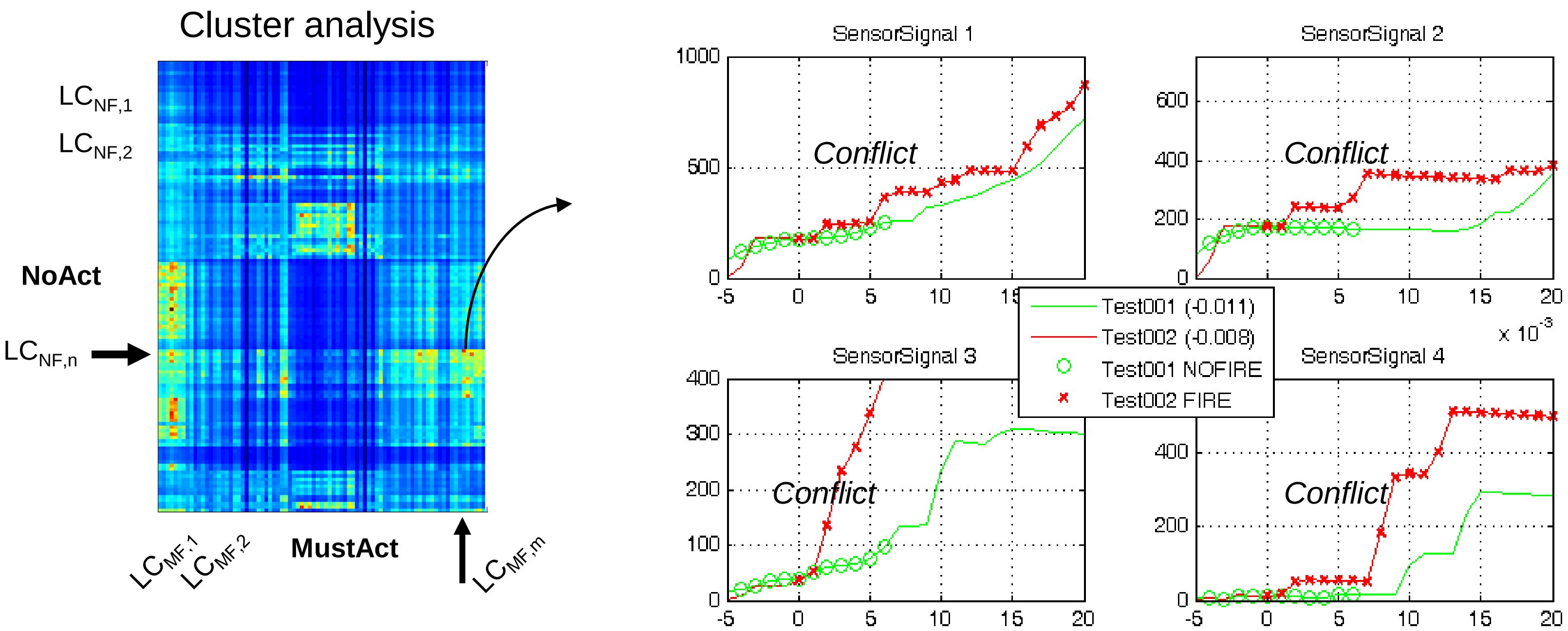


SYSTEM RATING

Numerical Conflict Analysis

What is a requirements conflict for a control algorithm?

- In different situations, which induce the same sensor image, different actions are desired!



ANDATA Solution Traffic Control

Problem description

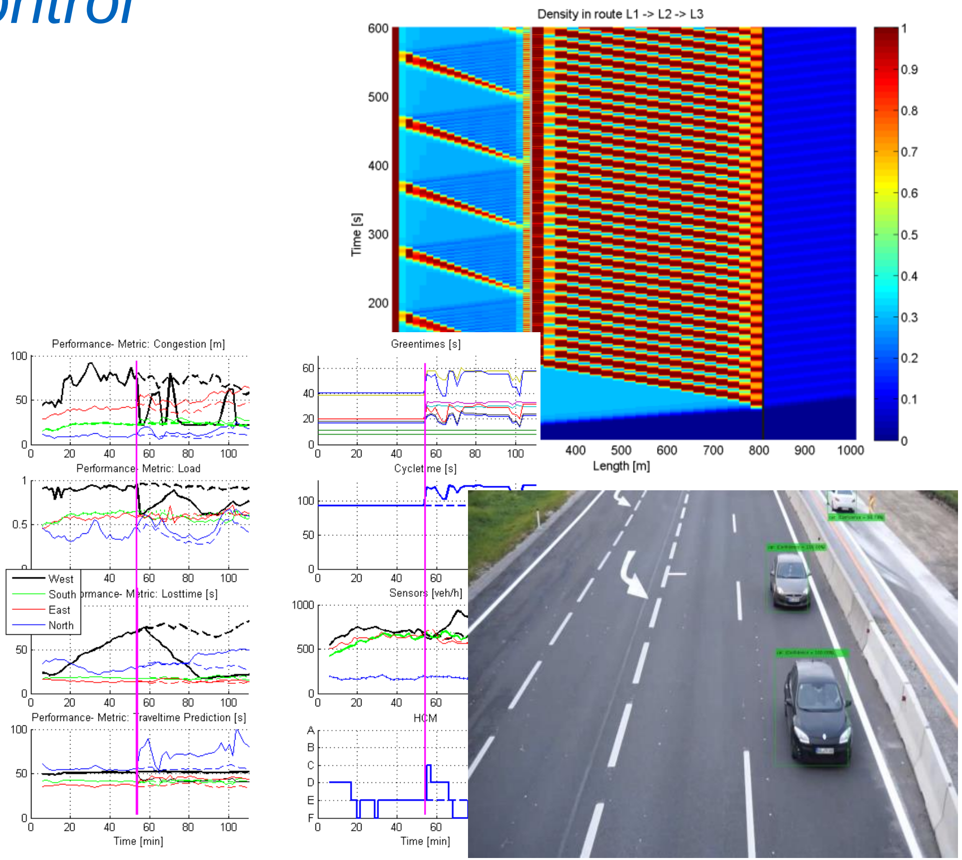
- Model based predictive control of traffic flows

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
- Effectivness rating
- …

Tools

- MATLAB
- Neural Networks Toolbox
- Statistics and Machine Learning Toolbox
- Div. ANDATA Toolboxen für MATLAB

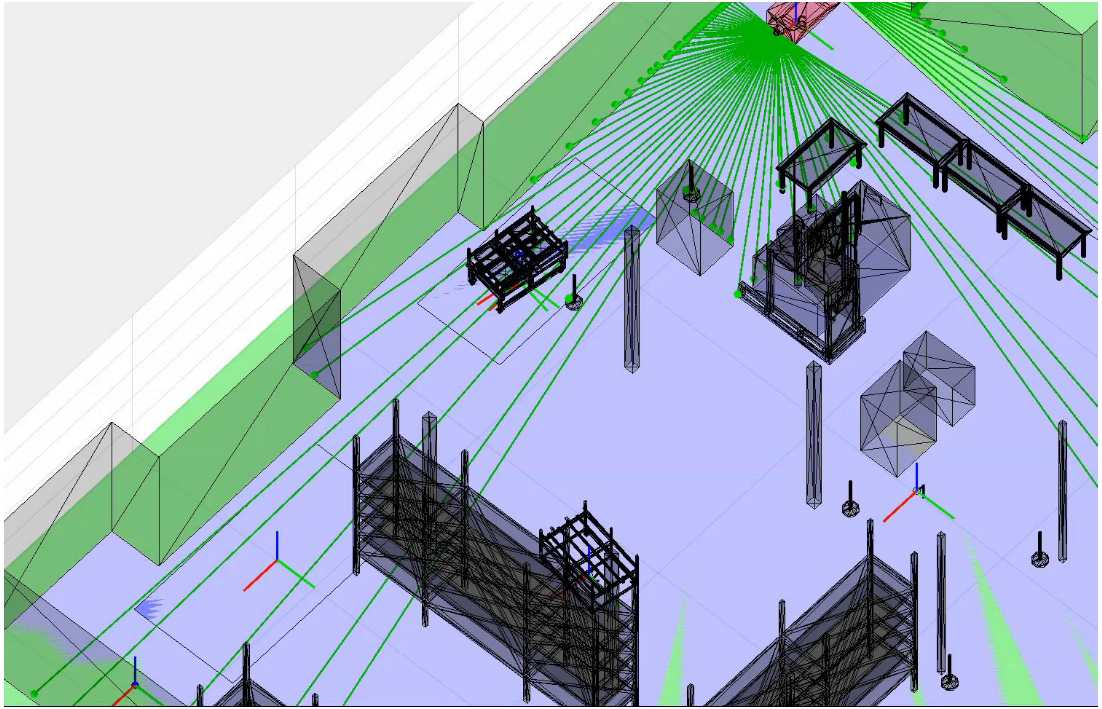


ANDATA Solution Robotics, Production and Assembly

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

MathWorks Partner

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
- …

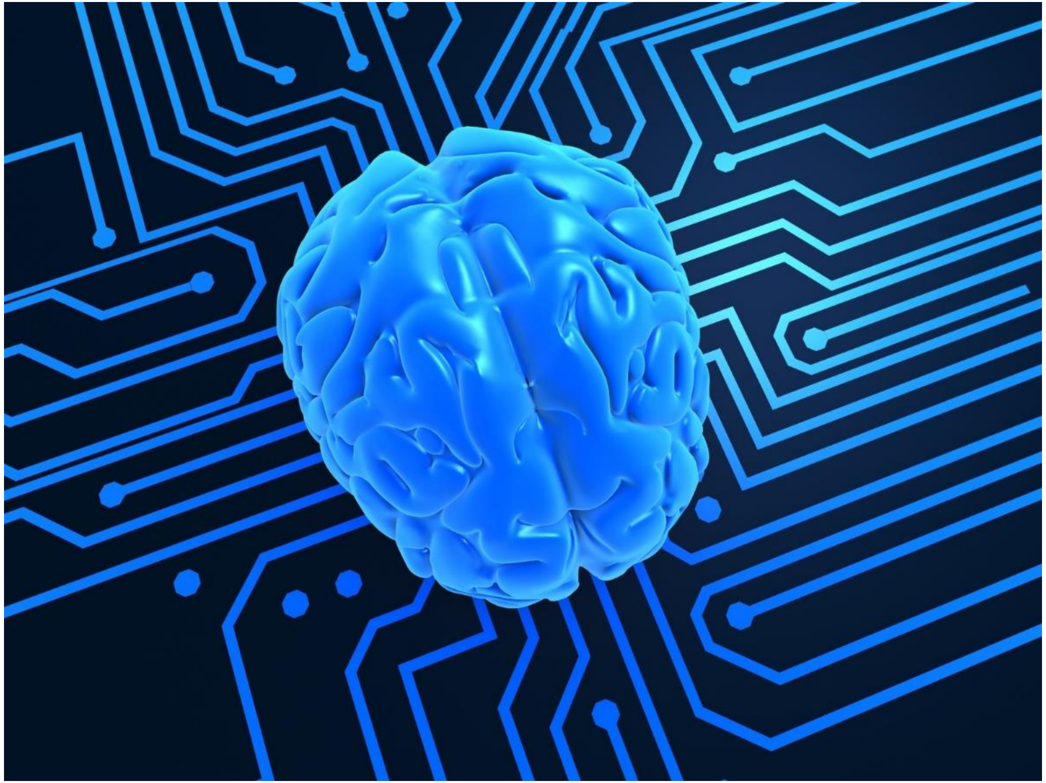
➢ Extreme Development Procedures
  ➢ Extremely quick, efficient, effective

➢ **Uniform, integral product development process for traffic automation**

➢ **Carried out completely in MATLAB**

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!

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