ADVANTAGES AND CHALLENGES USING AI FOR AUTONOMOUS DRIVING

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Bosch CR Hildesheim
About me

- Dr.-Ing. Niklas Beuter
- From 2003-2007 study about **information science and robotics**
  - Machine Learning
  - Computer Vision
  - Pattern Recognition
  - Intelligent Systems
- From 2008-2011 PhD in **intelligent systems**
  - Financed by Daimler
  - 3D Human Detection and Tracking on a Mobile Platform for Situation Awareness

CITEC
Cognitive Interaction Technology
Cluster of Excellence
Bielefeld University

- Started at CR@Bosch in 2011
  - Studies and projects around autonomous driving
  - Small project leads, driving innovation
- Changed to BU 2015
  - Product owner for parts of biggest video product
- Returned to CR in 2020
  - Senior Manager Computer Vision – Machine Learning

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Advantages and challenges using AI
Introduction

- Why using AI in your product?
- What are the changes and challenges in the general SW development using AI?
- What do you need to consider for validating your SW / system?
- What are the measures and methods for the verification of a safety critical AI function?

Advantages and challenges using AI
CR Hildesheim – Communication & Video competence for Bosch

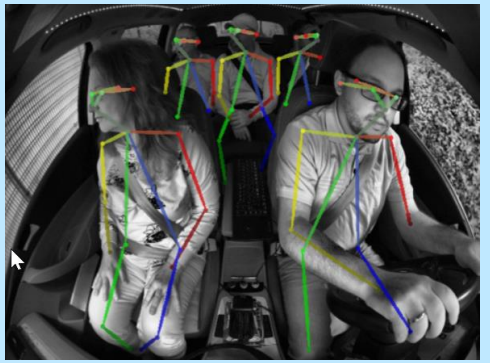
- Video is used in many domains @ Bosch: AD, ADAS, Interior Sensing, Security, Robotics, IoT, ...

Autonomous driving since 2013

Driver Assistance

Security

Body Pose



Scene understanding

Advantages and challenges using AI

Why using AI in your product?

https://youtu.be/lJscAeSh-RA?t=47

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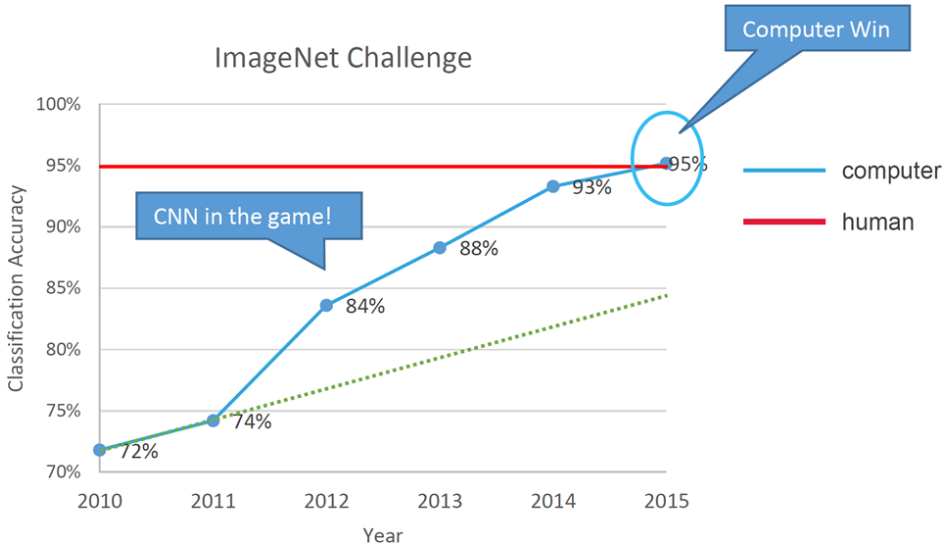
Advantages and challenges using AI

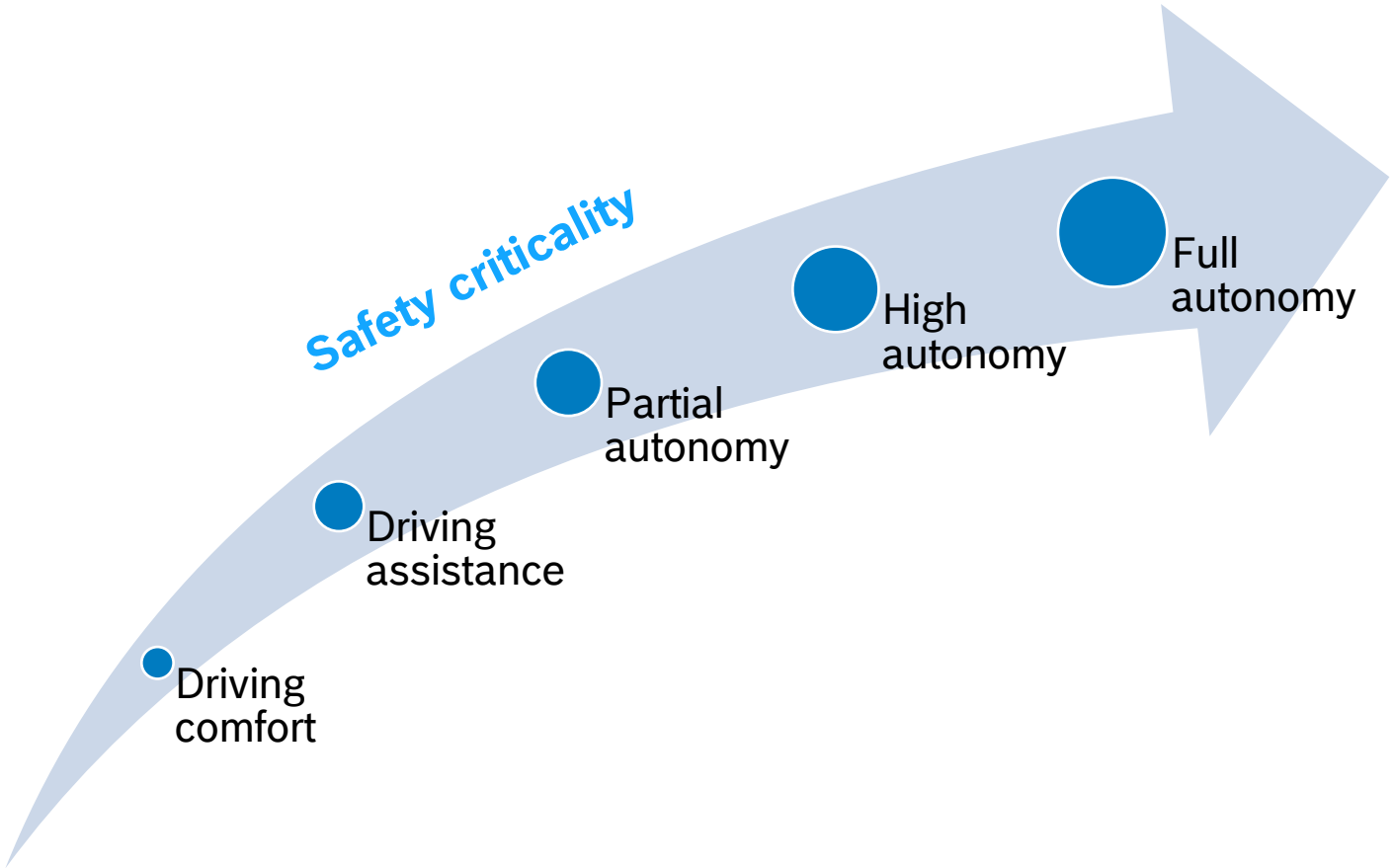
Why using AI in your product?

- Performance gain using AI
  - In the last years close to 100% of academia changes to deep neural networks in the computer vision object detection domain
  - Results are superior due to massive amount of available data and computation power
  - In many tasks the algorithmic solution is even better than humans
  - Hardware specifically designed for embedded AI is more and more available
  - Know how available to get algorithms small enough to fit them on a chip even with high performance



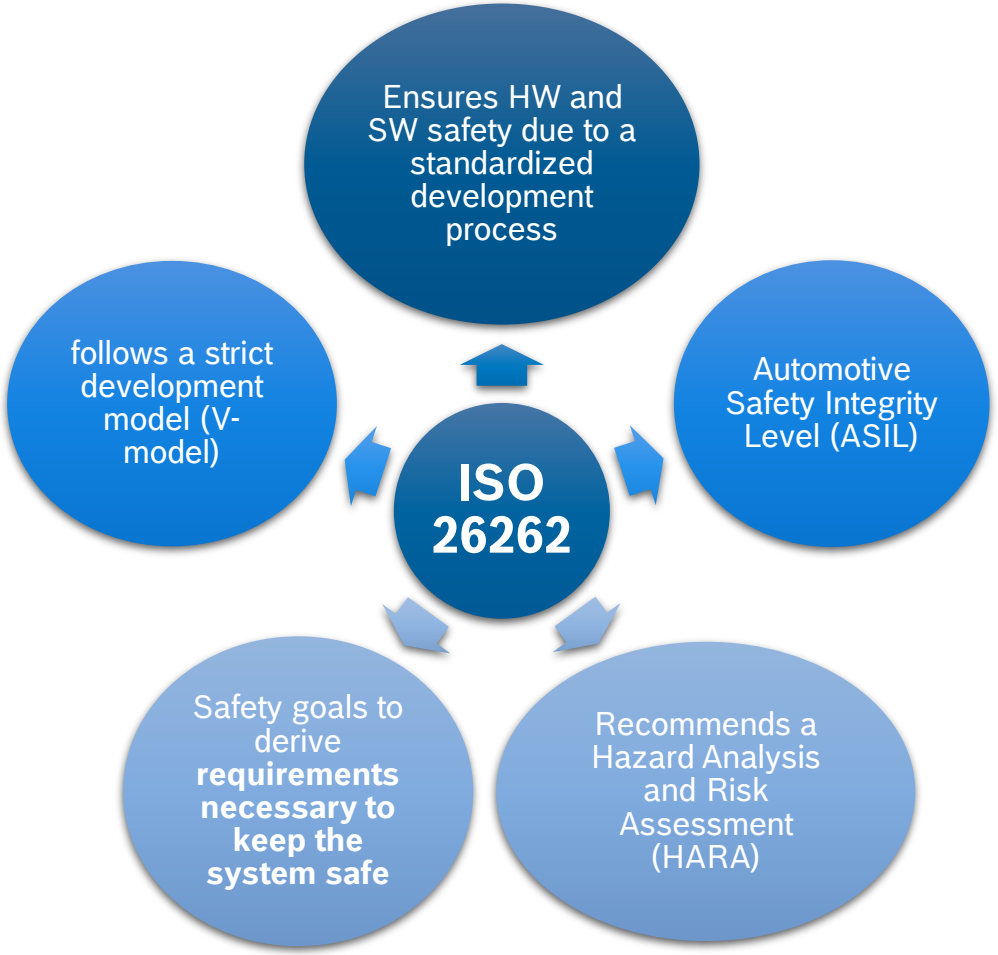
Task	Error (rate) human	Error (rate) machine
Face recognition	2,6 %	2,5 %
OCR (handwriting)	4,5 %	3,3 %
Geolocalization Photos	2.320 km	1.130 km
Date of photos taken	10,9 years	7,3 years

Advantages and challenges using AI
Safety critical development in automotive domain

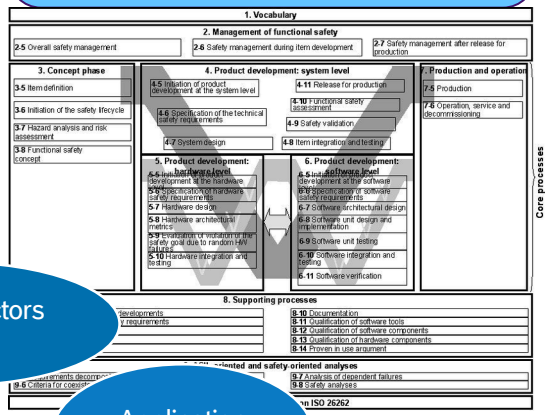


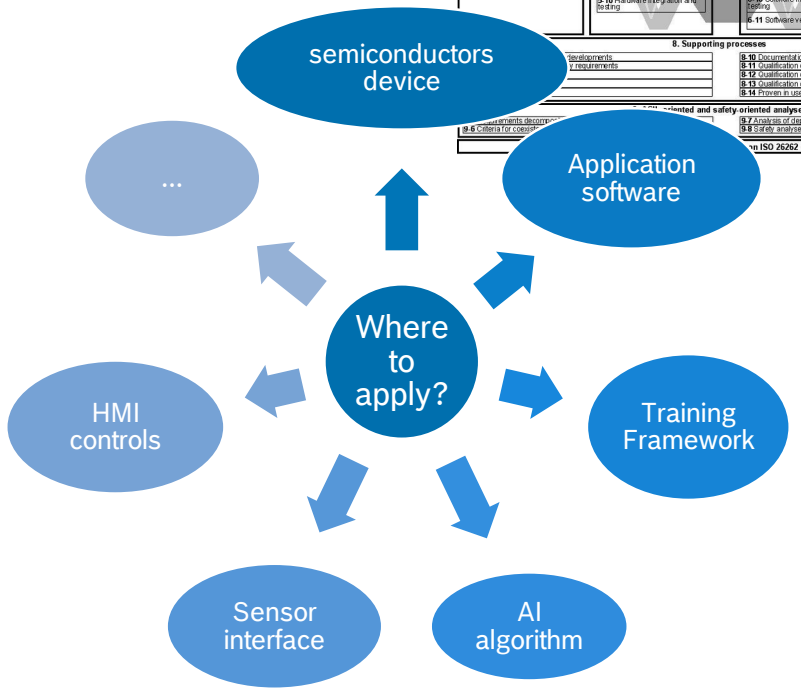
Advantages and challenges using AI

Safety critical development in automotive domain



ISO 26262
Road vehicles – Functional safety





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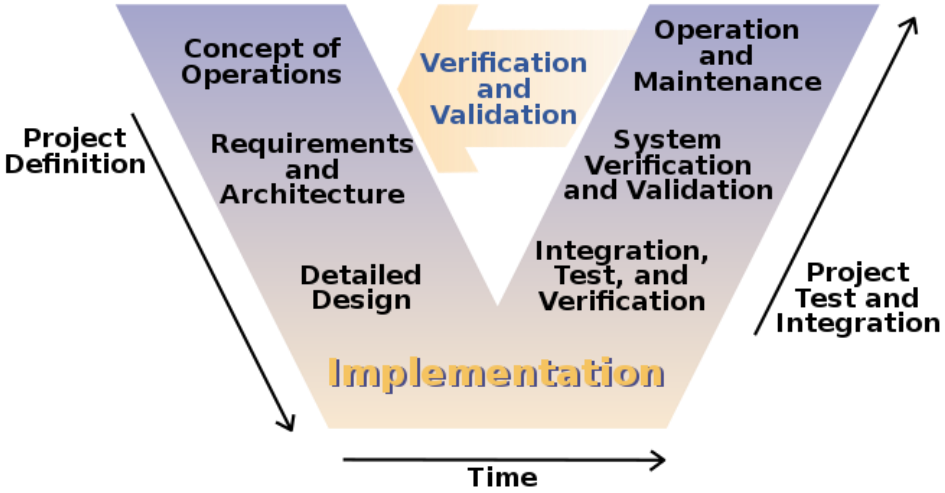
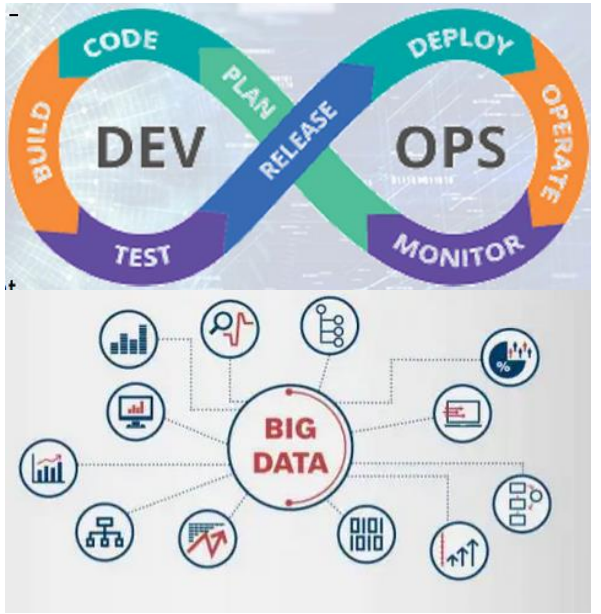
Advantages and challenges using AI

What are the changes and challenges in SW development with AI



* https://en.wikipedia.org/wiki/V-Model_(software_development)



AI SW development has the difficulty of the extreme high-dimensionality, also called "**black box**"

- We do not code the behavior, but **we present data**, which represents the feature space to learn. Using this data, the neural network "learns" the behavior.
- The network needs to generalize from the "seen" data
- The difficulty lies in the verification that the network has learned the right behavior / generalization

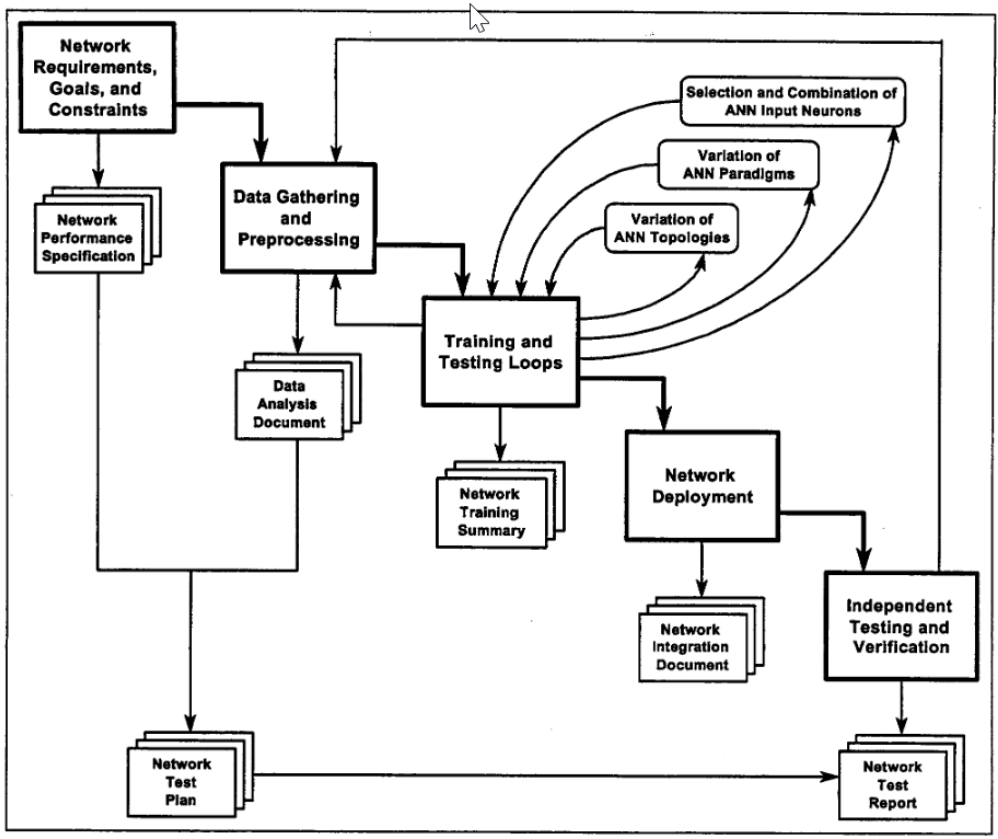
Advantages and challenges using AI

What are the changes and challenges in SW development with AI

In order to use AI you must change your way of coding!

→ AI is experimental and empirical

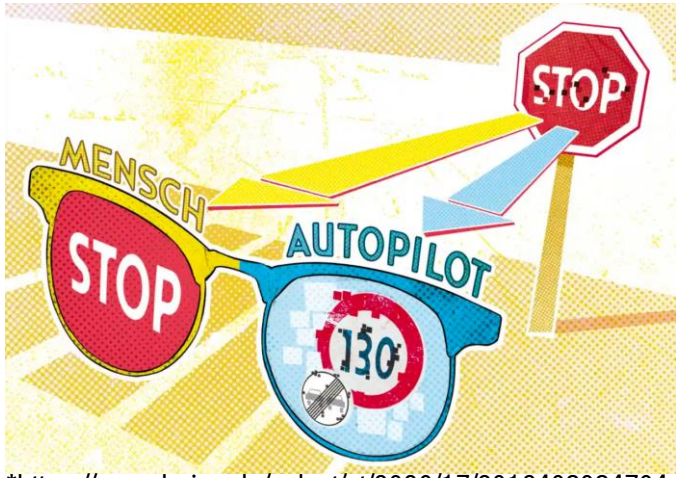
- Usually, following steps are necessary to embed AI in your SW:
  - 1) Formulation of requirements and goals
  - 2) Selection of training and test data sets
  - 3) Selection of the neural network architecture
  - 4) Training of the network
  - 5) Testing of the network
  - 6) Acceptance and use by the customer.
- Documentation!



*from: A Software Development Process Model for Artificial Neural Networks in Critical Applications

Advantages and challenges using AI
What are the changes and challenges in SW development with AI

- In addition to ISO 26262, **ISO/PAS 21448 SOTIF** (safety of the intended functionality) must be fulfilled.
  - SOTIF ensures the intended functionality and avoids misuse
    - Analyze possible hazards and verify and validate SOTIF
- SOTIF is very difficult to achieve with an AI system
  - Inadequateness in the AI enabled system for perception and safe drive operation
    - Wrong selection of algorithm or inadequate training data set
  - Unexpected situations / complex scenarios or even adversarial attacks
  - Image sensor problem due to out-of-calibration error or sensor performance limitation
- Write down the right **safety goals and formulate requirements**!



*https://www.heise.de/select/ct/2020/17/2016408084704769749

Advantages and challenges using AI

From safety requirements to ML properties

Generalization: Ability to accurately detect inputs outside of the training distribution

Robustness: Ability to detect transient effects and adversarial attacks

Architectural measures

Avoidance of systematic performance failures

Prediction certainty: provide monitoring with accurate inputs

Explainability: Increase confidence in absence of systematic faults

+/- 50 cm detection accuracy (e.g. based on IoU)

Ability to compensate for effects in the sensors (e.g. lens flare)

Robustness: Ability to react to noise and uncertainty in sensors

Example ML specific criteria

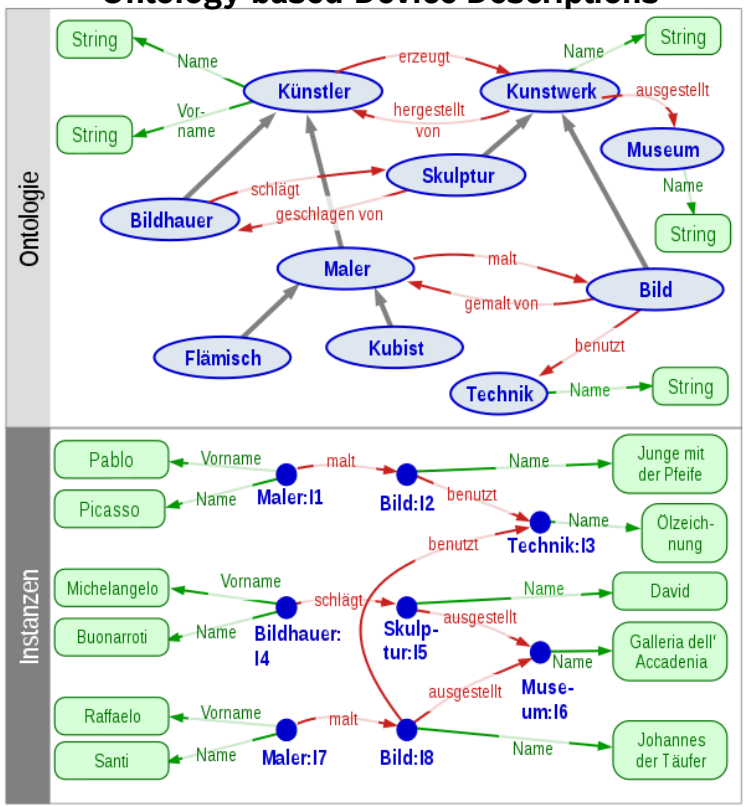
E.g.: Remaining Error Rate of 95% is achieved and the remaining 5% can be detected by the monitor. Target values must be iteratively derived based on an understanding of the performance limits of both the ML function and the architectural measures

Advantages and challenges using AI
Autonomous driving – Validation approach

https://venturebeat.com/2020/01/06/waymos-autonomous-cars-have-driven-20-million-miles-on-public-roads/

*[..] fully autonomous vehicles [..] would have to be driven 275 million failure-free miles. [..]this would take about 12.5 years.***

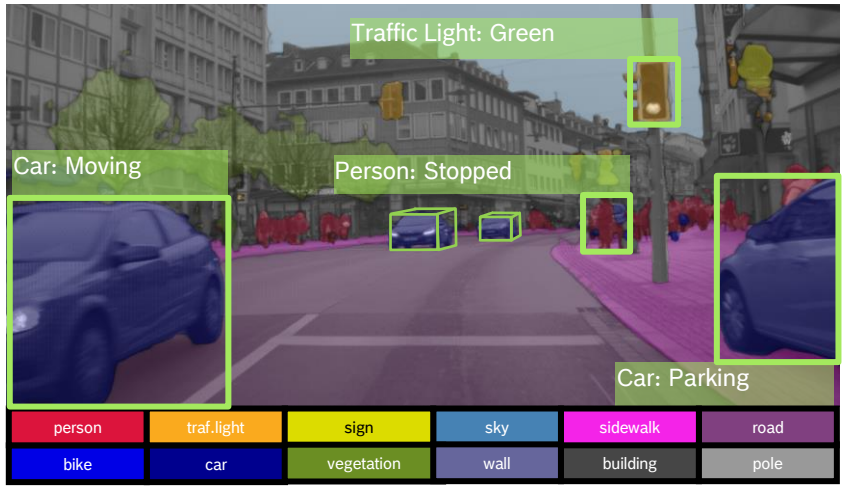
Ontology-based Device Descriptions



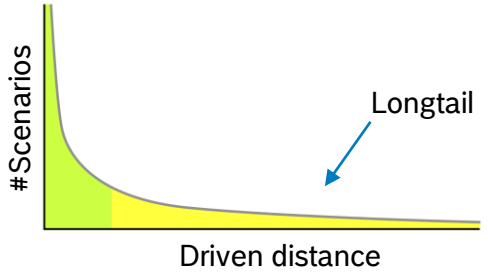
https://de.wikipedia.org/wiki/Ontologie_(Informatik)

**https://www.rand.org/content/dam/rand/pubs/research_reports/RR1400/RR1478/RAND_RR1478.pdf

Advantages and challenges using AI
Example for usage of ODD



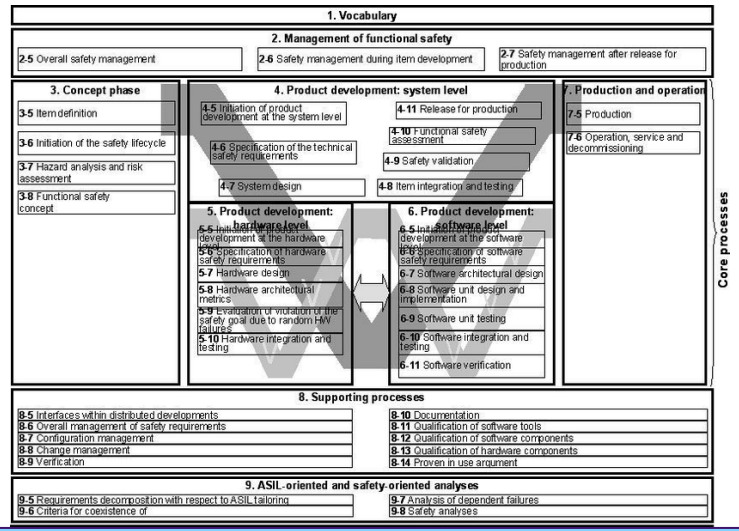
- Example of analysis:
  - Assumptions (A):
    - ODD: Size, distance, movement of relevant objects, level of occlusion, ...
    - System: Resolution, focus, noise camera, post processing
  - Guarantees (G):
    - Each pedestrian within a relevant distance and within the field of view is detected with an accuracy of +/50 cm
- It is important to go through the whole system and understand its limitations!
  - Scalable oversight: lack of data for extreme or corner cases, Distributional Shift over time: Change in distribution of data during operation, ...

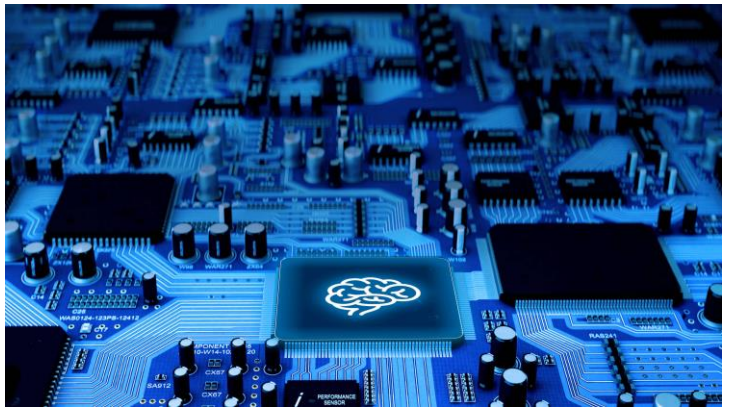


Advantages and challenges using AI

So, do we have a validation for autonomous vehicles ready?

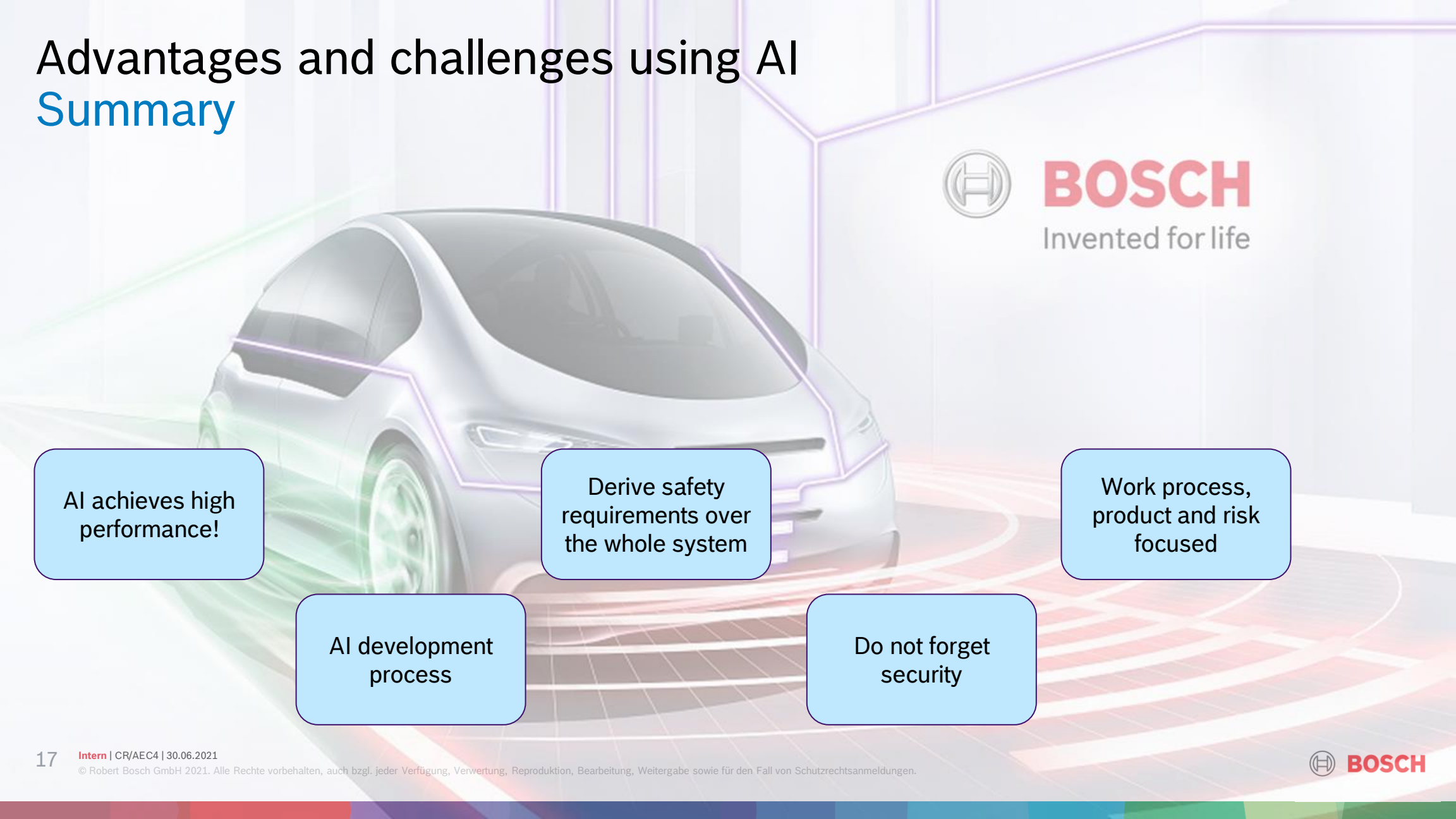
- Process focused:
  - “The system is safe because we followed the right process”
- Product focused:
  - “The system is safe because we have demonstrated the absence of faults
- Risk focused:
  - “The system is safe because we have demonstrated freedom of unacceptable risk”





All approaches are valid - But a combination is required to construct a robust assurance case

Advantages and challenges using AI
Summary



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AI achieves high performance!

Derive safety requirements over the whole system

Work process, product and risk focused

AI development process

Do not forget security