>> A Short 4.0 Round Trip << :

From AI, Digital Natives and Innovation Cultures towards to Future of Work, Life, and Society

Wenn Roboter Steuern zahlen – Umverteilung
in Zeiten von Automatisierung und Digitalisierung
Managerkreis derFriedrich Ebert Stiftung

Munich, February 9th, 2017

Univ.-Prof. Dr. rer. nat. Sabina Jeschke

Cybernetics Lab IMA/ZLW & IfU
Faculty of Mechanical Engineering
RWTH Aachen University

Outline

Breakthroughs - A new era of artificial intelligence

Communication technology
bandwidth and computational power

Embedded systems
miniaturization

Semantic technologies
information integration

Artificial intelligence
behavior and decision support

Watson 2011

Google Car 2012

→ **Systems of "human-like" complexity**

1st dimension: complexity level

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Breakthroughs - Everybody and everything is networked

Communication technology
bandwidth and computational power

Embedded systems
miniaturization

Semantic technologies
information integration

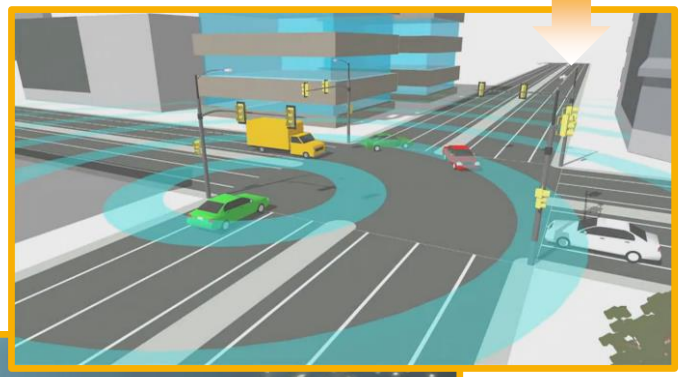
Artificial intelligence
behavior and decision support

2nd dimension: network level

Swarm Robotics

Team Robotics

Car2Infra-structure

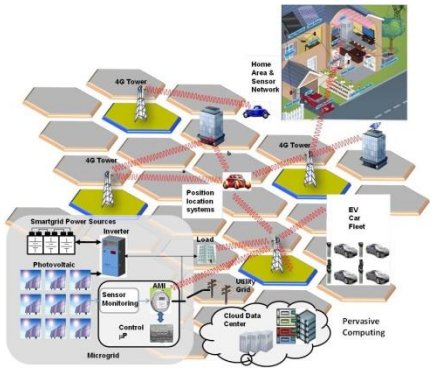


Smart Grid

Smart Factory

"Information Revolution"

Everybody and everything is networked. - Big Data & Cyber-Physical Systems



Vision of Wireless Next Generation System (WiNGS) Lab at the University of Texas at San Antonio, Dr. Kelley

> "Internet of Things & Services, M2M or Cyber Physical Systems are much more than just buzzwords for the outlook of connecting 50 billions devices by 2015."
>
> **Dr. Stefan Ferber, Bosch (2011)**

Weidmüller, Vission 2020 - Industrial Revolution 4.0
Intelligently networked, self-controlling manufacturing systems)

„local" to **„global"**

„local" to **„global"**

around 1750

1st industrial revolution
Mechanical production systematically using the power of water and steam

around 1900

Power revolution
Centralized electric power infrastructure; mass production by division of labor

around 1970

Digital revolution
Digital computing and communication technology, enhancing systems' intelligence

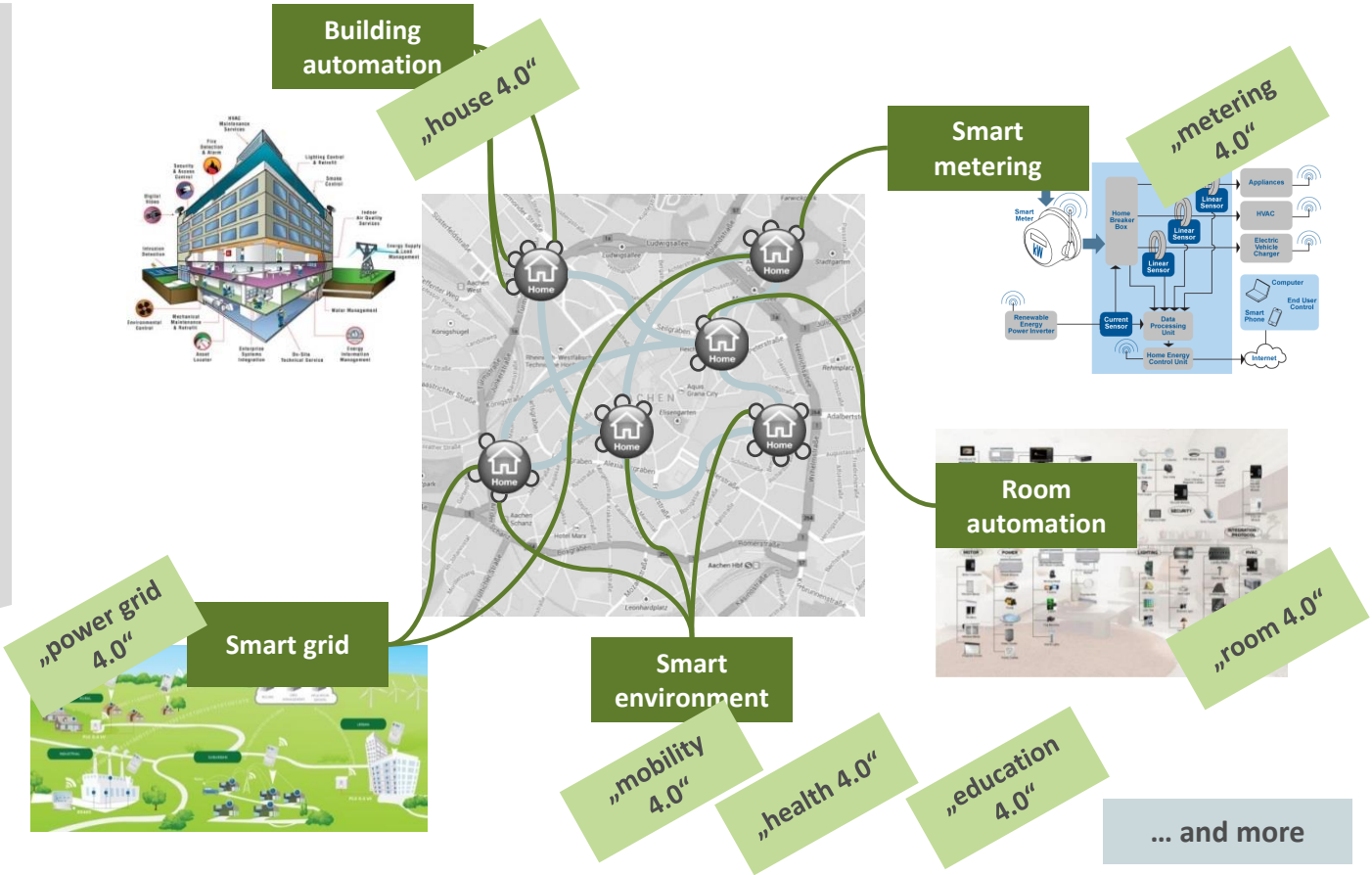
today

Information revolution
Everybody and everything is networked – networked information as a "huge brain"

“Information Revolution” – not reduced to Industry 4.0

“Industry 4.0 will address and solve some of the challenges facing the world today such as resource and **energy efficiency, urban production** and **demographic change.“**

Henning Kagermann et.al., acatech, 2013



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And how do these systems work?

Communication technology
bandwidth and computational power

Embedded systems
miniaturization

Semantic technologies
information integration

?? Steering - Controlling ??

Towards intelligent and (partly-) autonomous systems AND systems of systems

around 1750	around 1900	around 1970	today
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Outline

The vendor change around „cars“

Characteristics of Industrial Revolutions:
The vendor change

Latest version of Google's self driving car (Huffington Post, 28.5.2014)

Sony announced autonomous car in 2015, based on their experience in visual sensors

SONY

Ford 021C concept car 2012, designed by Newson now at Apple (1999)

Apple Inc.

Google: First autonomic car with street license, 2012

Google

Car specialists? – No.

- **Connectivity & data specialists.**
- **Energy & sensor specialists.**

TESLA

Tesla X 2015, other Teslas since 2006; Forbes: "most innovative enterprise"

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An autonomous car is more like a computer on wheels than a car which includes one or many computers.

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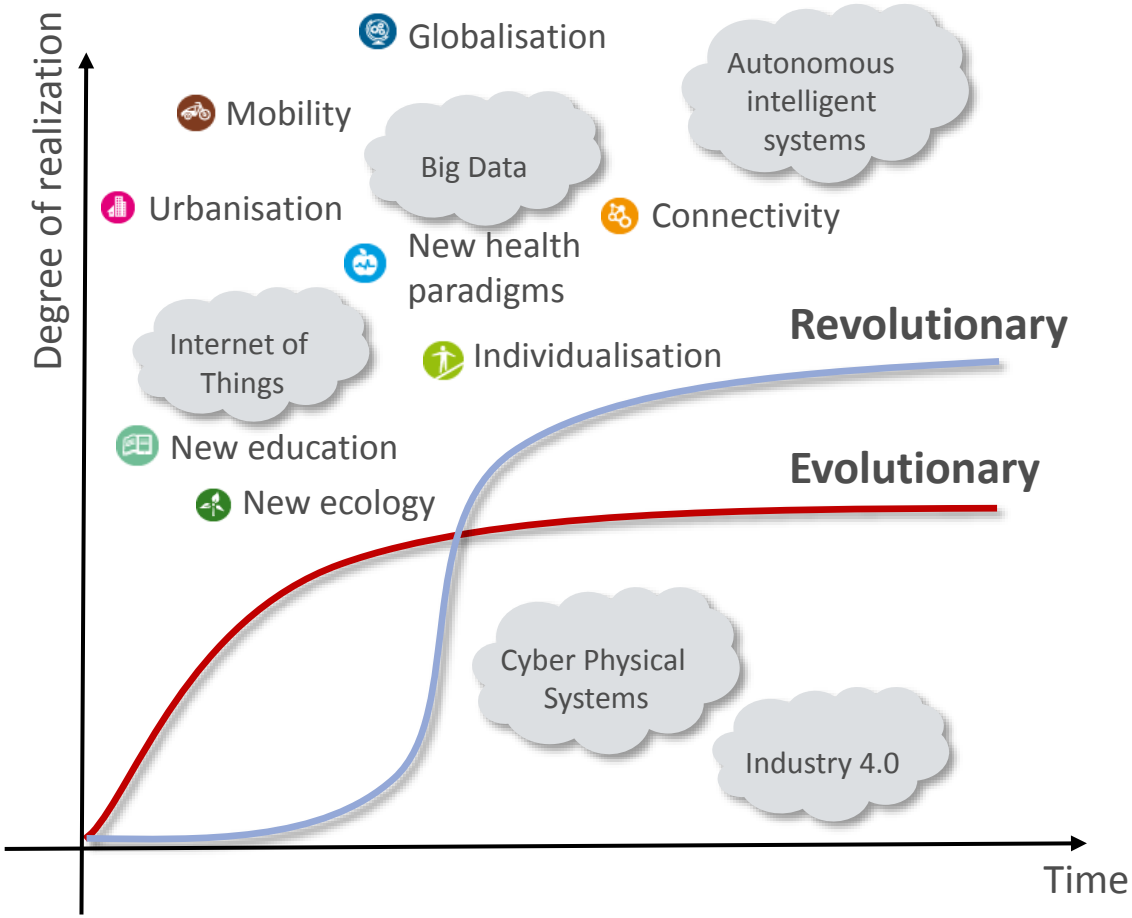
The two ways of innovation



BusinessDictionary.com
Over 20,000 Terms. Clear. Concise. Comprehensive.

"Innovations are divided into **two categories**:

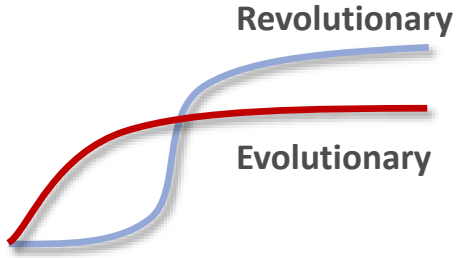
- **Evolutionary innovations** (continuous or dynamic evolutionary innovation) that are brought about by many incremental advances in technology or processes and
- **Revolutionary innovations** (also called discontinuous innovations) which are often disruptive and new."

!

IMPORTANT:

- In times of Industrial Revolutions, the revolutionary innovations dominate.
- In the times between, the evolutionary innovations dominate.

The innovators' dilemma

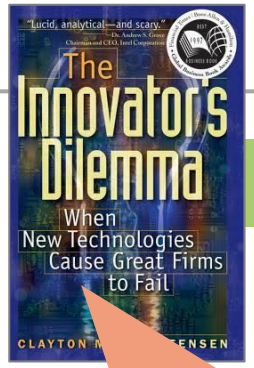


Evolutionary innovations:

- Improvement and optimization of an already existing product or process
- Changes ‚locally'
- **Mainly carried out by established players**

Revolutionary innovations:

- Something „really new"
- Characterized by categorial changes and with strong consequences for the society, ‚globally'
- **Mainly carried out by market newcomers**



By C. M. Christensen, 1997
new edition 2015

- The more professional organization are, the stronger they tend to remain in their traditions since…
  - … management structure is organized in such a way that it „reproduces" itself
  - … clients' sugestions always address traditional ways
  - … self-affirmation feedback…
- Standard management methods as TQM, CIP(KVP), Kaizen, standards, lean management, etc. address evolutionary processes

➢ **… hampering categorial changes, system changes and disruptive changes**

Innovation – A question of culture?!

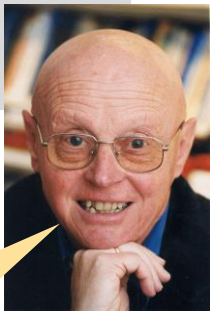
→ **Since the 1960s:**

- **research on organizational cultures in respect to innovation, "innovation culture"**

Breakthrough of the "culture concept" in the 1980s

Hofstede's "cultural dimensions theory" (1980)

- 5 cultural dimensions
- Still most cited European social scientist
- Critics addresses mainly the particular dimensions and the measurement process, but not the general approach.



Hofstede (1991):
Culture is the collective programming of the mind which distinguishes the members of one group from another.

! **Organizational culture…**

- … transfers the concept of culture from cultural anthropology (national cultures) to organisations.
- … represents the collective values, beliefs and principles of organizational members.
- … is a product of such factors as history, product, market, technology, and strategy, type of employees, management style, and national culture.

[Wikipedia, 2015]

! **Innovation culture:**

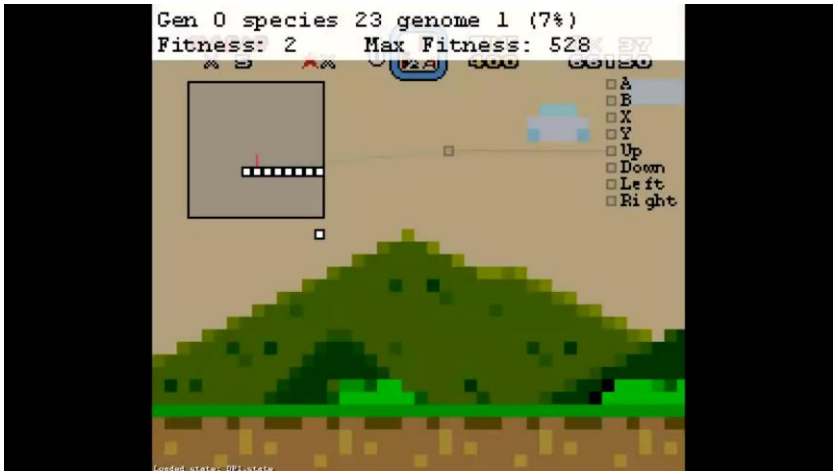
Innovation culture describes a specific type of organisational culture adressing the generation of innovation in the organisation.

[Wikipedia, 2015]

Outline

Reinforcement learning: Using rewards to learn actions

? Remember Mario: What if the machine could learn, how to solve a level?
Why not use some kind of intelligent trial-and-error?



[SethBling, 2015]

Neuroevolution of augmenting topologies (NEAT)

[Stanley, 2002]

- **Genetic algorithms on top of neural networks**
- At each **state** the system decides what **action** to perform
- Actions are **rewarded** if Mario does not die in return
- Level progress by **evolving** neural networks

Human factor is "very small"

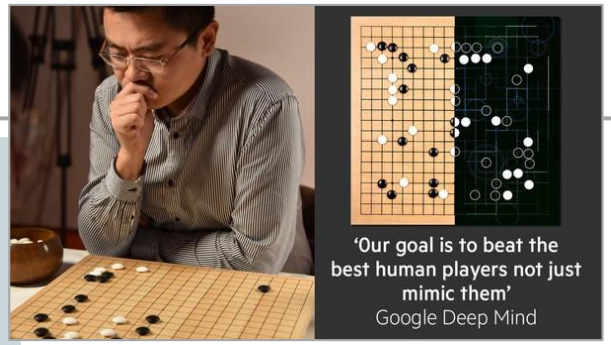
- reduced to very general, mainly formal specifications of the neural network…
- However, humans still influences the underlying representation model

Reinforcement learning (R-learning)
is inspired by behaviorist psychology – maximizing the expected return by applying a sequence of actions at a current state.

➔ can be applied to broad variety of problems

However again, I have no clue WHAT exactly this system is learning, and WHEN, and…

Where the Story Goes: AlphaGo



! Go originated in China more than 2,500 years ago. Confucius wrote about it. As simple as the rules are, Go is a game of profound complexity. This complexity is what makes Go hard for computers to play, and an irresistible challenge to artificial intelligence (AI) researchers. [adapted from Hassabis, 2016]

→ The problem: **2.57×10^{210} possible positions** - that is more than the number of atoms in the universe, and more than a googol times (10^{100}) larger than chess.

➔ Bringing it all together!

Data-driven learning

Training set
30 million moves recorded from games played by humans experts

Creating deep neural networks
12 network layers with millions of neuron-like connections

Predicting the human move
(57% of time)

Reinforcement learning

Learning non-human strategies
AlphaGo designed by **Google DeepMind**, played against itself in thousands of games and evolved its neural networks; Monte Carlo tree search

March 2016:
Beating Lee Se-dol (World Champion)
AlphaGo won 4 games to 1.
(5 years before time)

! Achieving one of the grand challenges of AI

[Hassabis, 2016]

Microsoft Visual Storytelling (SIS): machines becoming creative

! "**Creativity** is a phenomenon whereby **something new** … is formed. The created item may be intangible (such as an idea, a scientific theory, a musical composition or a joke) or a physical object (such as an invention, a literary work or a painting)." [adapted from Wikipedia, last visited 5/3/2016]

- **DII (descriptions for images in isolation):** Traditional storytelling software
- **SIS (stories for images in sequence):** new approach towards storytelling, including
  - Based on SIND - Sequential Image Narrative Dataset: 81,743 unique photos in 20,211 sequences, aligned to both descriptive (caption) and story language.
  - [Margaret Mitchell / Microsoft, 04/2016, together with colleagues from Facebook]

			
DII	A group of people that are sitting next to each other.	Adult male wearing sunglasses lying down on black pavement.	The sun is setting over the ocean and mountains.
SIS	Having a good time bonding and talking.	[M] got exhausted by the heat.	Sky illuminated with a brilliance of gold and orange hues.

Visual-Storytelling by Microsoft
based on deep neural networks (convolutional neural networks)

Google DeepDream: machines becoming creative

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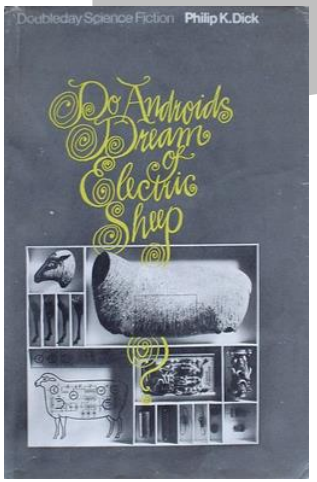
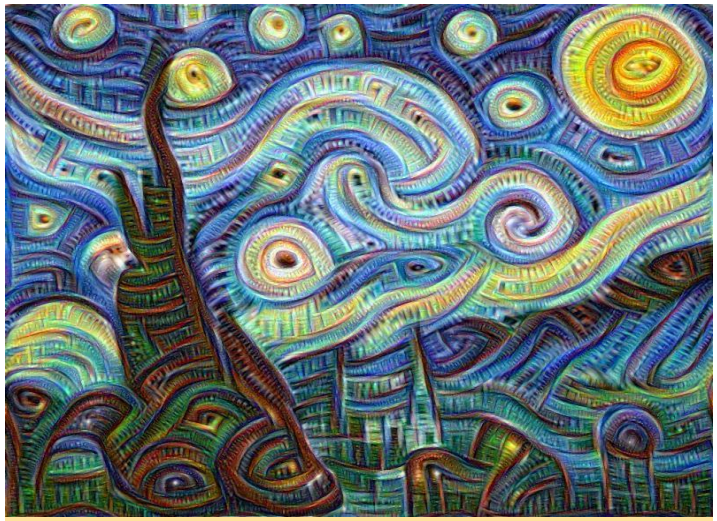
"Do Androids Dream of Electric Sheep?"

(science fiction novel by American writer Philip K. Dick, published in 1968)



➔ **Computational creativity (artificial creativity)** … is a multidisciplinary endeavour that is located at the intersection of the fields of artificial intelligence, cognitive psychology, philosophy, and the arts. [adapted from Wikipedia, last visited 5/3/2016]

„Can machines be creative?" by Iamus, a computer cluster composing classical music by genetic algorithms, concert for Turings 100th birthday [youtube]



Van Gogh's Starry Night interpreted by Google DeepDream based on deep neural networks

Outline

Industry 4.0 does not only change the "routine" jobs

→ **The typical assumption…**

… that job changes in 4.0 are mainly addressing blue collar jobs and/or routine jobs does not hold true.

→ **From „blue collar – low qualified" to „white collar – middle class"…**

but probably, this is just a transition phenomenon

High qualified jobs

… as e.g. health professionals face already the taking over through AI in certain fields by IBM Watson, Google Flu, etc.

White collar jobs

… are under massive change due to the enhancement in AI, here the impact often hits "**middle class jobs**"

Decentralized platforms

… with automated consensus models (e.g. blockchain) take over complex administrative tasks e.g. in **judiciaries**

Social robots

… will become capable of taking over even complex tasks with personal presence as in **health or home care**

Virtual and augmented environments

… allowing **for new international players**, even in tasks requiring humans and presence

Autonomous systems

… as autonomous cars and more envanced production technology will **change the blue collar** – low qualified as well

… in five steps!

4th Industrial Revolution

We are right in the middle of a 4th Industrial Revolution.

4.0 – a revolution of a distributed artificial intelligence

- IT driven
- Characterized by "everything/body is connected to everything/body anywhere anytime".
- Rediscovery of cybernetics
- Decentralized control paradigms
- The rise of cognitive computing

Society 4.0 – „sandwiched" between 4.0 and other revolutions

- Digital natives entering the scene
- The "fall" of the expert
- Shared economy
- The "as a service" paradig
- Meeting demographic and migration challenges

Innovation 4.0 – a question of culture

- The vendor change
- Difference between evolutionary and revolutionary innovations
- The new Innovators
- Globalization has its additional effects on speed and plurality

Work 4.0 – everything under change

- Not restricted to specific jobs or fields
- New service models demand for new competences
- The creativity of technology

4.0 – an era of "new" cooperations

- In science: interdisciplinary perspectives
- In organizations: strong participation of all groups
- In society: strong integration of the plural perspectives resulting from the heterogenous demands

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Thank you!

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2011 – 2016	**Vice Dean** of the Department of **Mechanical Engineering**, RWTH **Aachen** University
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since 05/2015	**Supervisory Board of Körber AG**, Hamburg