AI in Future Automation: The “Adaptation” Edge
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01  Who We Are

02  AI: Adaptation

03  Big Picture
Siemens Milestones – Across 170 Years Of History

1816-1892  
Company founder, visionary and inventor

1866  
Dynamo

1847  
Pointer telegraph

1925  
Electrification of Ireland with hydropower

1959  
SIMATIC controller

1975  
High-voltage direct-current (HVDC) transmission

1983  
Magnetic resonance tomograph

2010  
TIA Portal for automation

2012  
Field testing of world's largest rotor at an offshore wind farm

2016  
MindSphere introduced as the digitalization platform for all industries

Werner von Siemens

Siemens innovations over 168 years
Who We Are

Research and Development at Siemens

€5.2 billion
Expenditures for R&D in fiscal 2017

40,000
R&D employees¹

Inventions and patents – securing our future

7,500
inventions¹

3,600
patent applications¹

University cooperation – our knowledge edge

9
CKI universities²

16
Principal partner universities

Corporate Technology – Our competence center for innovation and business excellence³

8,000
employees worldwide

5,400
software developers

1,600
researchers

400
patent experts

¹ In fiscal 2017
² Centers of Knowledge Interchange
³ Employee figures: As of September 30, 2017
Corporate Technology – Innovating Globally

A worldwide presence is the heart of the Siemens brand – and that goes for us as well. This presence enables us to quickly offer targeted solutions that are tailored to regional requirements.

Corporate Technology – worldwide locations

- Germany
- Switzerland
- Austria
- Hungary
- Romania
- Denmark
- Czech Republic
- Slovakia
- Russia
- United Kingdom
- Turkey
- Qatar
- China
- U.S.

>500 employees
100–500 employees
<100 employees

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Justinian Rosca

Corporate Technology
Our Focus in Digitalization and Automation – Securing and Extending Technology Leadership

Connectivity and Edge Devices
Devices become intelligent and connected

Data Analytics, Artificial Intelligence
Making automated decisions

Software Systems and Processes
Managing the SW Life-cycle

Simulation and Digital Twin
Expanding the Digital Twin

Future of Automation
From automated towards autonomous systems

Connected (e)Mobility
Mobility is electric, connected, autonomous

Autonomous Robotics
Controlling pervasive robotics

Block-chain Applications
Managing Transactions

Cyber Security
Enabling Digitalization

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PHM Vision – Intelligent Machines

Machine Intelligence … Intelligent Edge

- Edge: Where the action is! Control, computing, communication…

- Present paradigm: cloud computing accumulates and processes data in the data center

- The “edge computing” paradigm: Perform data processing near the source of the data at the edge of the network

Vision: Intelligent edge implements and executes high-level task specifications without detailed programming, are self-sufficient assistants to other machines and humans
Present vs. Future Automation

- Optimal Control
- Digitalization
- Big Data, Cloud, AI

• Autonomy
• Common Sense
• General AI

Information Retrieval
Level 3-4 Automation
Image Analysis

Agile and Dexterous Robots
Level 5 Autonomous Cars/AGVs
Machines with Common Sense
Present and Future Automation

- Optimal Control
- Digitalization
- Big Data, AI

- Autonomy
- Common Sense
- General AI

• Learn and generalize beyond the data used for training, outside experience space
• Problem solve quickly: diagnose something about to happen (predict), prevent, keep the line going!

DexNet 2.0
99% Precision Grasping

[ DexNet 2.0: Mahler et al. RSS 2017 ]
Digitalization - The Digital Twin

Siemens Tecnomatix Plant Simulation - Simulate Digital Factory Representation in Real-Time

Optimize amount, position, sequence of production resources:
- System operation
- Plant layout
- Control Logic
- Dimensioning, etc.

Investigate system behavior with analysis tools (Sankey diagram)

Time to market, productivity, reduce energy costs
Can create corner cases, dangerous situations rarely met in practice
Augmented Reality / Virtual Reality Enablers for Smart Factory

Fully digitalized factory model representing production system

- Can additionally generate realistic data about machine, human/environment, and interaction between human/environment and machine, accidents, etc.

- Connected through sensors/SCADA PLC/automation devices to product lifecycle management (PLM) data repository

- Sensors (simulated by advanced physics-based models, e.g. cameras, vibration, radar, lidar, temperature, etc.)

Can create corner cases, dangerous situations rarely met in practice

Bring AI in the Edge - PHM Edge Intelligence

- (Deep) Perception, Reasoning, Prediction

- Business enablers:
  - **Digital Twin**: domain engineering knowledge captured by “digital twin” (Siemens Tecnomatix, Teamcenter, NX)
  - **Programming**: software that evolves over lifecycle of the product, its verification and validation
  - **Reusable runtime stacks**: software deployable on a variety of hardware platforms

- “Plumbing” (or “hidden technical debt”) makes it all possible:
  - **Sensors and edge devices**, connectivity, networking (install/reuse)
  - **Data management**: acquisition, storage, historization of high resolution high dimensional data
  - **Software**: infrastructure, configuration, machine, process, preparation, monitoring, analysis and visualization management
  - **Cloud services**: Siemens Mindsphere
Autonomous System Use Case:

- Processes interact; an error or failure – a missing piece of inventory or stumble on the automation line can cause extremely costly slowdowns and interruptions
- Automation control intelligence / intelligent machine: predicts course; safely shutdown; rectifies; resumes
- Intelligent edge components: perceive, analyze, diagnose, correct the quality of the product immediately, automatically feeding the results back into the production process
Additional Challenges

Beyond cost and methods for edge intelligence: human aspects

**Trusted decisions, transparency, safety, collaboration, fun!**

- Trust, transparency - capabilities for autonomous systems to explain their actions
- Safety – From Safety Integrity Level (SIL) for failsafe operation to Machine Learning software run-time assurances - strong (run-time) verification methods

*Small or Large Manufacturing: road to autonomy, self sufficiency, is to integrate adaptation and prediction capabilities exploiting both simulation and real data*