Process automation

Smart Factory

BS UNI studies, Fall semester 2025/2026

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Framework

- Accelerated adoption of new concepts for the optimization of production processes.
- The concept of the "Smart Factory" integrates into the broader framework of the Fourth Industrial Revolution, which was initiated as the German government’s Industrie 4.0 initiative.

> *"We are at the brink of a revolution that will fundamentally alter our way of life, work, and mutual understanding. What I understand as the Fourth Industrial Revolution, in its scale, scope, and complexity, is unlike anything humanity has experienced before.”*
>
> *- Klaus Schwab (2016)*

A brief history of industrial revolutions

First – Original

- *1760–1840, Europe (started in the UK), USA*
- **Triggers**: Invention of the steam engine
- **Characteristics**:
  - Transition to machine production: machines replaced human and animal power
  - Initially in the textile industry, then in iron, agriculture, and mining

Second – Technological

- *1871–1914*
- **Triggers**: Electricity, assembly lines, railways, telegraph
- **Characteristics**: Mass production

Third – Digital

- *1960–2000*
- **Triggers**: Semiconductor technology, computers, internet (1990s)
- **Characteristics**: Automation

Additional Insights

- Approximately 17% of the world (1.3 billion people) still lacks access to electricity
- Half of the world's population (4 billion people) still lacks internet access today

4th Industrial Revolution

- **Start**: Began in the 21st century (the term "Industrie 4.0" was first used in 2010 at the Hannover Fair)
- **Triggers**: Ubiquitous (mobile) internet, cheaper and more accessible sensors, artificial intelligence (AI)
- **Involves the fusion of other technologies**: Gene sequencing, nanotechnology, quantum computing
- **Blends physical, digital, and biological domains**: Cyber-physical systems
- **New business models**: Mass production of user-customized products
- **”Artificial intelligence is the new electricity"** - Andrew Ng
- **Why do we talk about the 4th Industrial Revolution and not the continuation of the third?**
  - **Speed of change**: The pace is exponential due to synergy and interconnectedness rather than linear.
  - **Depth of change**: It alters our core values, not just how we work or what we do.
  - **Impact on society**: It affects the entire social system, including businesses, industries, and governments.

4th Industrial Revolution – Slovenia

- **Slovenian Strategy for Smart Specialization (2016)**:
  - Creation of 9 strategic research-innovation partnerships (SRIP), which unite representatives from businesses, knowledge institutions, and the government in targeted areas:
    - Materials as final products
    - Sustainable food production
    - Sustainable tourism
    - Networks for transition to a circular economy
    - Smart cities and communities
    - Smart buildings and homes
    - **Factories of the future**
    - Health – medicine
    - Mobility
- **Faculty of Mechanical Engineering, University of Ljubljana**:
  - Demonstration center "Smart Factory" (2019)

Smart factory

Challenges:

- Aging population → shortage of human labor
- Environmental pollution → climate change
- Customer demands for highly customizable products in small series

- **Definition**: A smart factory is an adaptable system that self-optimizes, adjusts, and learns from new conditions in real time, autonomously driving the entire production process.

Smart Factory – Technologies and Trends

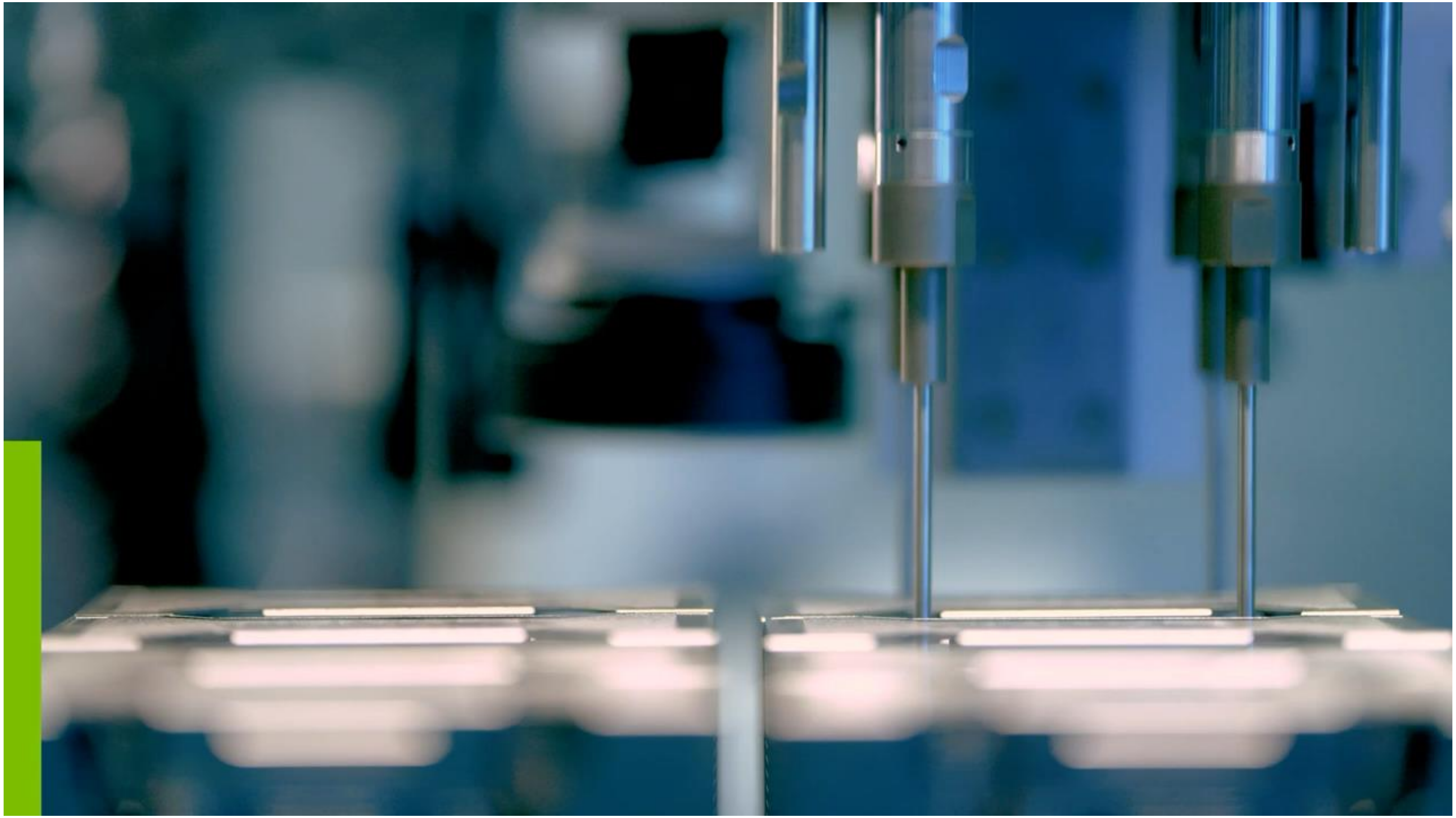
- Industrial Internet of Things (IIoT)
- Smart sensors
- Cloud services, edge computing
- Virtual / Augmented / Mixed Reality (VR, AR, MR)
- Simulation and visualization
- Big data collection and processing
- Artificial intelligence, predictive maintenance
- 3D printing (plastic, metal, concrete, biological tissues)
- Increased demand for cybersecurity

Digital twins

Digital twin

- "The innovation backbone of the future" (Siemens statement)
- A digital replica of a physical product, process, asset, or service.
- **Virtual representation of components and dynamics**:
  - A digital model serves to display and analyze behavior under different conditions—simulating environments like wind, fluids, or temperature. This allows for improved product characteristics and the prevention of errors or issues even in the design phase.
  - The concept of the digital twin doesn't end at simulation—the model is continuously updated based on real-world measurements, allowing comparison with simulations and the prediction of critical deviations.
- **Primary goal**: Business process optimization.
- Facilitates product development and maintenance throughout its entire life cycle.
- **Example: Turning Robots**
  - Due to significant forces during turning, the cutting head may deviate from its ideal path.
  - Modeling and simulation allow for pre-calculation of such deviations and their compensation in real-world operations.

Example: Factory Digital Twin From Wistron



Digital twin vs. SCADA

Aspect	SCADA (Supervisory Control and Data Acquisition)	Digital Twin (Smart Factory)
Purpose	Primarily focuses on monitoring and controlling physical processes in real-time.	Provides a real-time simulation and predictive modeling of systems.
Scope	Displays current system state; limited in predictive capabilities.	Offers deep insights, future predictions, and simulations.
Integration	Relies on traditional sensors and PLCs for data acquisition.	Integrates data from IoT devices, AI, machine learning, and external systems.
Analytics	SCADA presents raw or basic processed data.	Digital twins enable advanced analytics, such as predictive maintenance and scenario testing.
Visualization	Provides a **static dashboard** with real-time process visuals.	Creates **interactive, 3D virtual models** of physical systems with dynamic behaviors.
Decision Support	Supports manual decision-making based on system feedback.	Suggests or automates decisions using AI and simulation tools.
Historical Data	Archives data for future use but lacks forward-looking insights.	Leverages historical and live data for **forecasting and optimization**.

Example:

- **SCADA** might show the real-time status of a machine (e.g., running, idle, fault) and allow an operator to intervene if an issue arises.
- A **digital twin**, however, would predict the machine's failure before it happens, suggest corrective actions, and even simulate how adjusting settings could improve production.

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