Industry 4.0 - Introduction

A seminar about what we are doing and learning in this course

**Course code:** PPU213  
**ECTS:** 5 (33% ~12-13 hours/week)  
**Level:** First cycle

Mats Ahlskog, Researcher at MDH and course responsible
Outline

- Background
- About the course
- Some examples from the different areas/lectures covered in the course
- Additional information
Background: Industry 4.0 Introduction

- This course provides basic knowledge of industry 4.0. The course gives insight and understanding of the 4th Industrial revolution and how it will impact on the industry and humans. The aim is to give a conceptual understanding of how an industry 4.0 system can be built up and run, as well as an overall understanding of which technologies can be included.

- The course includes the following parts
  - Introduction to Industry 4.0
  - Introduction to the main technologies in Industry 4.0
  - The economic drivers for implementing Industry 4.0 technology
  - The production and development engineer’s role in development of future production system
  - The impact of digitization on industry and human beings

The main target group is people in need of understanding the principles of Industry 4.0. The focus is production but anyone from another functions can take this course.
Background

- This a new course that is given for the first time
- This course was supposed to be held with a combination of meetings at MDH and online

https://www.mdh.se/samverkan/fortbildning-och-kompetensutveckling-for-yrkesverksamma/kompetensutveckling-med-premium
Areas covered

- Overview industry 4.0
- Human perspective
- Historical perspective
- IoT & Cloud & AI & Data analytics
- Cyber security
- Augmented reality & Virtual reality
- Additive manufacturing
A combination of broad and narrow focus is needed.

<table>
<thead>
<tr>
<th>Broad focus</th>
<th>Technology focus</th>
<th>Technology focus</th>
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<tbody>
<tr>
<td><strong>Module 1</strong></td>
<td><strong>Module 2</strong></td>
<td><strong>Module 3</strong></td>
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<tr>
<td>Book chapter + reports</td>
<td>Book chapter + reports</td>
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</tr>
<tr>
<td>• Historical perspective</td>
<td>• IoT &amp; Cloud</td>
<td>• Augmented reality</td>
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<tr>
<td>• Overview industry 4.0</td>
<td>• AI &amp; Data analytics</td>
<td>• Virtual reality</td>
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<tr>
<td>• Human perspective</td>
<td>• Cyber security</td>
<td>• Additive manufacturing</td>
</tr>
<tr>
<td><strong>Discussion on the module topics</strong></td>
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<td><strong>Discussion on the module topics</strong></td>
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<tr>
<td><strong>INL1a</strong></td>
<td><strong>INL1b</strong></td>
<td><strong>INL1c</strong></td>
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</table>

All material in the course is digital.
# Course assignments

<table>
<thead>
<tr>
<th>Assignments</th>
<th>What</th>
<th>When</th>
<th>How</th>
<th>Why</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>INL1</strong></td>
<td>Three written assignments based on the modules in this course</td>
<td>After each module</td>
<td>Individual</td>
<td>Check knowledge and way of thinking</td>
</tr>
<tr>
<td><strong>Canceled due to Covid-19 LAB</strong></td>
<td>FESTO equipment at MITC AR &amp; VR</td>
<td>One day</td>
<td>Individual</td>
<td>Increase knowledge about digital technologies and relationships</td>
</tr>
<tr>
<td><strong>Replacement for the LAB INL2</strong></td>
<td>Identification of challenges and possibilities - from a report</td>
<td>During the course – final seminar in the end of the course</td>
<td>Individual or group</td>
<td>Increase knowledge about challenges and possibilities</td>
</tr>
<tr>
<td><strong>PRO1</strong></td>
<td>Assessment of your companies maturity level – predefined frameworks</td>
<td>During the course – final presentation in the end of the course</td>
<td>Individual or group</td>
<td>Reflection Bring something back to the company</td>
</tr>
</tbody>
</table>
### Teachers

<table>
<thead>
<tr>
<th>Namn</th>
<th>Roll</th>
<th>E-post</th>
<th>Area</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mats Ahlskog</td>
<td>Examiner, Teacher</td>
<td><a href="mailto:mats.ahlskog@mdh.se">mats.ahlskog@mdh.se</a></td>
<td>Historical perspective</td>
</tr>
<tr>
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<td>Assistant Teacher</td>
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<td></td>
</tr>
<tr>
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<td>Teacher</td>
<td><a href="mailto:alessio.bucaioni@mdh.se">alessio.bucaioni@mdh.se</a></td>
<td>Introduction to Ind 4.0</td>
</tr>
<tr>
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<td><a href="mailto:rachael.tripney.berglund@mdh.se">rachael.tripney.berglund@mdh.se</a></td>
<td>Human perspective</td>
</tr>
<tr>
<td>Moris Benham</td>
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<td><a href="mailto:moris.behnam@mdh.se">moris.behnam@mdh.se</a></td>
<td>IoT &amp; Cloud</td>
</tr>
<tr>
<td>Markus Bohlin</td>
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</tr>
<tr>
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<td>Cybersecurity</td>
</tr>
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<td>Additive Manufacturing</td>
</tr>
<tr>
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<td><a href="mailto:barrett.sauter@mdh.se">barrett.sauter@mdh.se</a></td>
<td>AR &amp; VR</td>
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</tbody>
</table>

I wanted to include as many as possible different knowledge domains and perspectives in this course.
Introduction to the main technologies and terminology
Module 1 – Broad focus

- Historical perspective - Mats Ahlskog
  - mats.ahlskog@mdh.se

- Overview industry 4.0 - Alessio Bucaioni
  - alessio.bucaioni@mdh.se

- Human perspective - Rachel Tripny Berglund
  - rachael.tripney.berglund@mdh.se

- I have borrowed some slides from their lecturers
Module 1 – Broad focus

- What is Industry 4.0?
- That is something we discuss during the course
- Industry 4.0, was first declared by German government during Hannover Fair in 2011 as the beginning of the 4th industrial revolution.
Where started the first industrial revolution?
The first industrial revolution is generally said starting in the beginning of the 1700’s England who is the cradle of modern industry (Bellgran and Säfsten, 2010; Marks, 2002).

Why England?

Communication

- 1764 - Spinning Jenny
- 1830 – The first railway in the world was built between Manchester and Liverpool
- 1844 - Baltimore and Washington shared the world’s first telegraph line and by using this innovation, news could be sent faster

Transportation of people and material

- 1733 The flying shuttle
- 1800

Textile industry
Module 1 – Timeline 3rd Ind. revolution

3rd Industrial revolution

4th Industrial revolution

Connectivity

Advancement of several technologies

1940-2000

1945 ENIAC

1947 Transistor

1958 - The invention of the integrated circuit

1968 – 1971
Programmable controllers and Programmable Logic Controller (PLC)

1973 ASEA IRB6

1976-77 - Entry of Radio Shack, Apple, and Commodore into the market.

1991 The World Wide Web

1993 The first Web browser

As late as 1990, only 22 percent of U.S. households had a computer

2000-2040

2007 Apple iPhone launched

Hannover Fair in 2011 - German concept “Industry 4.0

Today 2020

1940 - 2000

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Hannover Fair in 2011 - German concept “Industry 4.0

Today 2020

Computerization and automation
Module 1

- Based on the past – what will happen?
- How will this digital transformation affect us as humans?

I4.0 FUTURE WORKFORCE
Module 1

- Change management (digitalization) from a human perspective
- Work environment
Module 1

Do no harm

<table>
<thead>
<tr>
<th>Orsak</th>
<th>Antalet dödsfall om året</th>
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</thead>
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<td>Stress</td>
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<td>Skiftarbete</td>
<td>728</td>
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<td>Motoravgaser</td>
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<td>Damm, Kol</td>
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<td>Asbes</td>
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<td>Passivrökning</td>
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<tr>
<td>Kvarts damm</td>
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<tr>
<td>Svetsrök</td>
<td>71</td>
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<tr>
<td>Olyckor</td>
<td>37</td>
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</table>
Module 1 – Some examples from follow-up seminar

- People will lose their jobs in some areas
- Lifelong learning
- Laws & Regulations
- More work from home
  - Less social interaction
  - Difficult to separate work and private life
- Less distinction between white and blue collars
- Bigger gap between specialists and generalists/workers
  - Prevalence and domination of AI and robotics in offices and workspace
Module 2 – Technology focus

1. IoT & Cloud – Professor Moris Benham
   moris.behnam@mdh.se

2. AI & Data analytics – Professor Markus Bohlin
   markus.bohlin@mdh.se

3. Cybersecurity – Professor Francesco Flammini
   francesco.flammini@mdh.se

• I have borrowed some slides from their lecturers
Module 2 – IoT & Cloud

Industry 4.0
The Fourth Industrial Revolution

First Industrial Revolution
- Introduction of mechanical production tools

Second Industrial Revolution
- Labor organization, mass production, use of electricity

Third Industrial Revolution
- First step regarding automation, with electronics and computer science entering companies

Fourth Industrial Revolution
- Interconnected products and services thanks to the new digital technologies

1780: First loom powered by steam
1870: First assembly line
1970: First PLCs
2011: First appearance of "Industry 4.0"

Cyber physical systems
Module 2 – IoT & Cloud

Cyber-physical systems CPS

• CPS: It is the integration of Cyber world, computation & network, and physical processes.
• Its purpose is to control a physical process and adapt itself in real-time to new conditions in order to optimize the performance.
• It allows creation of autonomous and cooperative elements and sub-systems, with the purpose of optimization production processes.
• CPSs can be considered as Digital Twins DT
• CPS academia, DT industry
Module 2 – IoT & Cloud

Industry 4.0 technologies
Module 2 – IoT & Cloud

Traditional automation in manufacturing

- The automation pyramid provides a hierarchical structure that allows the various technologies and systems used for planning, managing, and assessing the value creation process to be assigned to various levels of the company.

In practice, the lines between the levels are often blurred, and the individual levels can rarely be clearly identified.
Module 2 – IoT & Cloud

IoT Architecture

- Sensors: used to measure the environment, actuators are taking actions to change the environment
- Computers: read the sensor measurements and transfer it to the internet
- Edges: connect the computers to the internet
- Internet: transferring the data to the Cloud
- Cloud: provides storage and computation power for the analysis and decision making
- Different data communication technologies are used between levels

Cloud

Internet

Edge

Computer devices

Sensors and actuators
Module 2 – IoT & Cloud

What’s in the cloud?
Module 2 – IoT & Cloud

Service models

1- Cloud Software as a Service (SaaS)
2- Cloud Platform as a Service (PaaS)
3- Cloud Infrastructure as a Service (IaaS)
Module 2 – AI & Data analytics

What is A.I.?

“Our intelligence is what makes us human, and AI is an extension of that quality.” – Yann LeCun, Professor, New York University
Module 2 – AI & Data analytics

AI: Past, Present and Future

The Turing test

“I propose to consider the question, ‘Can machines think?’” (A. Turing, 1950)

An interrogator asks questions to an (unseen) person A. If A is replaced by an AI, can the interrogator detect this or not?

1st AI Winter: 1974-1980
Golden years: 1957-1974
Symbolic AI, search algorithms, neural nets, industrial robots, etc.

2nd AI Winter: 1987-1993
Rule-based, logical systems
Selection of components based on customer requirements
5th gen project (Japan)
Neural networks, backprop.

Goals fulfilled: 1993-2011

Deep Blue (1997)
Victory of the “neats” (2003)
DARPA Grand Challenge (2005)
AI untold successes in data mining, robotics, logistics, speech recognition, search engines

Deep learning, big data and general AI: 2011-present
Access to large amounts of data
Faster computers
Deep learning drives progress in image and video processing, text analysis, speech recognition
Google DeepMind defeats world champion in Go (2016)
Widespread discussions around Strong AI: superhuman intelligence
Module 2 – AI & Data analytics

● Basic introduction to:
  ● Different challenges within A.I.
  ● The Industrial A.I. stack
  ● Data cleaning and preparation
  ● Optimization in artificial intelligence
  ● Some problems in Machine Learning
     ● Overtraining
Module 2 – AI & Data analytics

The Industrial A.I. stack in reality

- Data collection and cleaning
- Representation
- “Solving the problem”
- Validation
- Deployment, maintenance and support

Often 80% of total effort

First step: take PPU433 Cloud and Analytics course!

Foundations of value creation (20% of effort)

End-user value
Module 2 – Cybersecurity

Definition of cybersecurity

Complex concept, no single definition!

Cybersecurity is the art of protecting networks, devices, and data from unauthorized access or criminal use and the practice of ensuring confidentiality, integrity, and availability of information. (https://www.us-cert.gov/ncas/tips/ST04-001)
Module 2 – Cybersecurity

Holistic vision of cybersecurity

- Focus on:
  - People – education, awareness, etc.
  - Process – procedures, regulations, etc.
  - Technology – intrusion detection systems, antivirus, etc.
Module 2 – Cybersecurity

- Importance of cybersecurity
- Cybersecurity in Industry 4.0
- Cyber-physical systems (CPS) security
- Security threats to intelligent systems
- Vulnerability Assessment
- Examples of some classic cyberattacks (STUXNET, Denial of Service (DoS) attacks
- Etc.
Module 3

- Augmented reality & Virtual reality - Barrett Sauter
  - barrett.sauter@mdh.se

- Additional lectures - Not covered in this presentation
  - FESTO-Overview Leo Hatvani
  - leo.hatvani@mdh.se

- Special lecture – From theory to practice – how to implement Ind 4.0 – Mats Ahlskog

- Not covered in this presentation – lecture next week
  - Additive manufacturing - Christopher Gustafsson
  - christopher.gustafsson@mdh.se

- I have borrowed some slides from their lecturers
Module 3 - Augmented reality

Agenda

- What are eXtended Realities?
- Augmented Reality (AR)
  - AR examples
  - Industrial AR applications
  - Case studies
  - Industrial AR challenges
- Virtual Reality (VR)
  - VR examples
  - Industrial VR applications
  - Case studies
  - Industrial VR challenges
Module 3 - Augmented reality

eXtended Reality: a range of technologies. Includes virtual & augmented reality environments

Virtual reality (VR)

- User sees full digital world through headset
- Creator has much control, can show viewer exactly what they want
- Relatively high resources needed to produce

Augmented reality (AR)

- User sees digital information overlayed on the real world
- Content needs to be integrated with real world objects
- Relatively lower resources needed to produce
Module 3 - Augmented reality

eXtended Realities

Virtual Reality (VR)

Augmented Reality (AR)
Module 3 - Augmented reality

Case Studies

- Remote maintenance

Ex: Toyota

What: remote assistance and communication while adhering to strict privacy regulations

Use: Chalk is used to connect experts with workers both inside and outside of their organization via mobile or tablet. Chalk combines live video, audio and ability for both participants to draw digital annotations on the live shared view.

Results: Subcontractors are able to tackle complex or unfamiliar challenges with the help of an expert when and where they need it. Company has adopted Chalk because of its security control functions.

Module 3 - Augmented reality & Virtual reality

Why are these tools important?

The real world is 3D. Most data is trapped on 2D screen and pages.

XR speeds up our ability to understand the problem and act on it.
Module 3 - Virtual reality

**General VR Uses**

- Entire digital environments
- Training simulations
- Distance work collaboration
- Product development
Module 3 - Virtual reality

Industrial VR applications

- Product design & virtual prototyping
- Virtual factory
  - Planning, simulation & training
- Assembly & service
  - Training
  - Quality assurance
- Fault diagnosis

Module 3 - Virtual reality

Case Study

- Virtual factory

Ex: Automotive supplier

**What:** Virtually validated assembly

**Use:** Virtual tool used for design and validation of elements such as space, human-factors and maintenance validation. CAD drawings or mock-ups previously used.

**Results:** Virtual build allowed for inspectors to walk around 1:1, inspect, interact, even operate the new sub-assembly long before first parts were made. Able to identify undesirable or dangerous conditions in time.

Module 3 - Virtual reality

Industrial VR advantages

- Visualization
  - VR makes it easier to view the effects of complex data and interactions in models
  - Additional views and navigation of a model not viewable with 2-D and in some cases difficult to see with screen-based 3-D presentations are possible with VR

- Understanding
  - Ability to capture and compare the virtual and physical state of objects

- Communication
  - Aids in communicating changes to both internal and external organizations

Additional information
Lifelong Learning at Mälardalen University

- Courses for professionals
- Developed in close cooperation with industry
- Gives university credits
- Free-of-charge for employees in Sweden and EU/EEA and Swiss citizens

Production Engineering
- Industry 4.0
- Lean Production
- Simulation

Software Engineering
- Dependable Software
- Internet-of-Things
- Software Test

Applied AI
- Big Data
- Machine Learning
- Predictive Analytics

Environmental and Energy Engineering
- Circular Economy
- Climate Change
- Sustainable Development

Innovation Management
- Trendspotting and scenariodesign
- Innovation Management

mdh.se/en/malardalen-university/education/further-training
# Seminar series Industry 4.0

<table>
<thead>
<tr>
<th>Date</th>
<th>Title</th>
<th>Teacher</th>
</tr>
</thead>
<tbody>
<tr>
<td>May 15</td>
<td>Industrial Internet of Things and the Opportunities in Manufacturing</td>
<td>Mohammad Ashjaei &amp; Moris Behnam</td>
</tr>
<tr>
<td>May 29</td>
<td>Artificial Intelligence</td>
<td>Markus Bohlin</td>
</tr>
<tr>
<td>June 5</td>
<td>Simulation for evaluation and improvement of production systems</td>
<td>Ioanna Aslanidou</td>
</tr>
<tr>
<td>June 12</td>
<td>Introduction to industrial cybersecurity</td>
<td>Francesco Flammini</td>
</tr>
<tr>
<td>June 26</td>
<td>AR and VR for Industry 4.0: From Development to Maintenance</td>
<td>Leo Hatvani</td>
</tr>
<tr>
<td>August 14</td>
<td>Maintenance</td>
<td>Antti Salonen</td>
</tr>
<tr>
<td>August 21</td>
<td>Additive Manufacturing – The MDH way</td>
<td>Christopher Gustafsson</td>
</tr>
<tr>
<td>August 28</td>
<td>Cobot</td>
<td>Mikael Hedelind</td>
</tr>
<tr>
<td>September 4</td>
<td>Optimization of Production Systems</td>
<td>Konstantinos Kyprianidis &amp; Yuanye Zhou &amp; Stavros Vouros</td>
</tr>
<tr>
<td>September 11</td>
<td>Industrialization: a multiple perspectives</td>
<td>Koteshwar Chirumalla</td>
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</tbody>
</table>
Production engineering courses autumn 2020
(5 credits/course)

● Lean production
Study period 2020-08-31 - 2020-11-08

● Internet of Things for the manufacturing industry
Study period 2020-08-31 - 2020-11-08

● Simulation of production systems
Study period 2020-08-31 - 2020-11-08

● Big Data and Cloud Computing for Industrial Applications
Study period 2020-11-09 - 2021-01-17

● Industrial maintenance development
Study period 2020-11-09 - 2021-01-17

For more information, visit mdh.se/premium
Production engineering courses spring 2021
(5 credits/course)

- **Optimization of production systems**
  Study period 2021-01-18 – 2021-03-28
- **Visualization for industrial applications**
  Study period 2021-01-18 – 2021-03-28
- **Industry 4.0 – Introduction**
  Study period 2021-03-29 - 2021-06-06
- **Industry 4.0 – Realisation**
  Study period 2021-03-29 - 2021-06-06
- **Industrialization and Time-to-Volume**
  Study period 2021-03-30 - 2021-06-08

For more information, visit [mdh.se/premium](https://mdh.se/premium)
Questions & Answers