III Man-Machine Collaboration on a Shop Floor

Cyber-Human System
The relationship between Cyber-Physical Systems (CPSs) and Cyber-Human Systems (CHSs)
Cyber-Physical and Cyber-Human Systems

Cyber-physical Production Systems

Siemens(https://www.youtube.com/watch?v=wro3uoHR-ZY&t=3s)
Cyber-Physical and Cyber-Human Systems (CHS)

CHS: BESK

Cyber Human Systems (https://www.youtube.com/watch?v=o0R2mi5sqxs)

CHS: Lumbar support exoskeleton

Cyber Human Systems (https://www.youtube.com/watch?v=czNjfAQZ5KA)
A complementary Cyber-Human Systems framework for Industry 4.0 Cyber-Physical Systems

Comparison with 5 Components of Cyber-Physical Systems

- Smart connection level
- Data-to-information conversion level
- Cyber level
- Cognition level
- Configuration level

What is the human’s role?

(Krugh and Mears, 2019)
Cyber-Physical and Cyber-Human Systems

5 components architecture for implementation of CPS and CHS

Cyber-Physical Systems
- Self-configure for resilience
- Self-adjust for variation
- Self-optimize for disturbance
- Integrated simulation and synthesis
- Remote visualization for human
- Collaborative diagnostics and decision making
- Twin model for components and machines
- Time machine for variation identification and memory
- Clustering for similarity in data mining
- Smart analytics for
  - Component machine health
  - Multi-dimensional data correlation
  - Degradation and performance prediction
- Plug & Play
- Tether-free communication
- Sensor network

Cyber-Human Systems
- Self-configure for flexibility
- Recognize and adapt to variation
- Absorb disturbance
- Synthesis of known patterns with reality
- Visualization and understanding
- Collaborative decision making
- Twin model for individual human workers
- Recognition of individual human workers
- Recognition of patterns and classes
- Analytics for human readiness monitoring
- Converting data to information
- Identifying state changes
- Plug & Play people...
- Communication integrated to infrastructure
- Sensing in the data stream

(Krugh and Mears, 2019)
Cyber-Physical and Cyber-Human Systems

Information flow of CHS and CPS

Co-funded by the Erasmus+ Programme of the European Union

(Krugh and Mears, 2019)
Cyber-Physical-Human Systems (CPHSs)

Three dimensions of Cyber-Physical-Human Systems

- Physical dimension:
  Comprises all resources connected to the system through sensors and actuators

- Cyber dimension:
  Describes all computational, networking and cloud infrastructures that communicate resources’ data, processes and software.

- Human dimension:
  Describes the human elements, as well as their situations based on their goals and context.

Lorena, 2017: http://lcastaneda.com/research/cphs/
Cyber-Physical-Human Systems (CPHSs)

User-Centric Smart Cyber-Physical-Human Applications

Case Study of Online Grocery Shopping

Co-funded by the Erasmus+ Programme of the European Union

(Lorena, 2017)
Cyber-Physical-Human Systems (CPHSs)

User-Centric Smart Cyber-Physical-Human Applications

Case Study of Online Grocery Shopping

User-Centric Smart Application architecture

(Lorena, 2017)
Cyber-Physical-Human Systems (CPHSs)

CPHS Applications: Case Study of Car-Based e-Tourism

Cyber-Physical and Cyber-Human Systems

(Smirnov et al., 2017)
Cyber-Physical-Human Systems (CPHSs)

**CPHS Applications:** Case Study of Car-Based e-Tourism

Cyber-physical-human system configuration approach

(Smirnov et al., 2017)
Cyber-Physical-Human Systems (CPHSs)

CPHS Applications: Case Study of Car-Based e-Tourism

Aspects of Car-Based e-Tourism system

Situational awareness:
Infomobility support is supposed to be context-dependent and the situation is changing continuously

Context information components

- Tourist location
- Co-travelers
- Preferences (both explicit and tacit)
- Schedule restrictions
- Weather
- Traffic
- Attraction occupancy and opening hour

(Smirnov et al., 2017)
Cyber-Physical-Human Systems (CPHSs)

**CPHS Applications: Case Study of Car-Based e-Tourism**

**Aspects of Car-Based e-Tourism system**

**Behavioral awareness:**
Efficient infomobile information support has to be proactive, what assumes predicting human actions.

**Behavior patterns**

- **Context:** autumn, the temperature is relatively low, no rain
- **Antecedent:** a new forecast with rain soon has become available
- **Possible behavior:** continue to the attraction
- **Preferred behavior:** continue to the attraction
- **Consequence:** low evaluation of the attraction in the given context

(Smirnov et al., 2017)
Cyber-Physical-Human Systems (CPHSs)

**CPHS Applications:** Case Study of Car-Based e-Tourism

(Smirnov et al., 2017)

Co-funded by the Erasmus+ Programme of the European Union
Cyber-Physical-Human Systems (CPHSs)

**CPHS Applications:** Case Study of Car-Based e-Tourism

Service interaction

(Smirnov et al., 2017)
Human–Cyber–Physical Systems (HCPSs)

Evolution of HCPSs: Traditional manufacturing

Schematic of an Human–physical systems (Ji et al, 2019)
Human–Cyber–Physical Systems (HCPSs)

Evolution of HCPSs: Digital manufacturing

Co-funded by the Erasmus+ Programme of the European Union

(Ji et al, 2019)
Human–Cyber–Physical Systems (HCPSs)

Evolution of HCPSs: Digital manufacturing

HCPS2.0

3 basic paradigms of intelligent manufacturing

Co-funded by the Erasmus+ Programme of the European Union

(Ji et al, 2019)
Evolution of HCPS-based intelligent manufacturing

(Ji et al, 2019)
Technical framework of HCPS2.0 for NGIM

- Overall architecture of HCPS2.0
  - The value dimension of intelligent manufacturing and the functional properties of the HCPS
  - The technical dimension of intelligent manufacturing and the technical properties of HCPS

- Key technologies of unit-level HCPS2.0
  - Manufacturing domain technologies
  - Machine intelligence technologies: Intelligent sensing, Autonomous cognition, Intelligent decision-making and Intelligent control
  - Human–machine collaboration technologies

(Note: NGIM (Next Generation Instant Messaging))

(Ji et al, 2019)
Major challenges in HCPS2.0 for NGIM

• **System modeling:** In-depth integration of mathematical modeling and big-data-driven intelligent modeling
  - In big data intelligent modeling
  - In hybrid modeling

• **Knowledge engineering:** In-depth integration of manufacturing technology (root technology) and intelligent technology (enabling technology)
  - A challenge in manufacturing domain technology
  - Challenges in intelligent technology
  - In-depth integration of manufacturing technology and intelligent technology

Note: NGIM (Next Generation Instant Messaging) (Ji et al, 2019)
Major challenges in HCPS2.0 for NGIM

**Human–machine symbiosis:** In-depth integration of humans and CPSs (intelligent machines)

- How can the effective division of work and cooperation between humans and intelligent machines be better achieved?
- How can human–machine hybrid-augmented intelligence be achieved?
- How can safety, privacy, ethical, and other issues that may be introduced by AI and intelligent manufacturing be addressed?

Note: NGIM (Next Generation Instant Messaging)
Hierarchical levels of HCPS2.0 for NGIM

Note: NGIM (Next Generation Instant Messaging)
Human–Cyber–Physical Systems (HCPSs)

Unit-level HCPS2.0 and intelligent machine tools

CAD: computer-aided design;
CAM: computer-aided manufacturing;
NC: numerical control;
i-code: intelligent code,
Human–Cyber–Physical Systems (HCPSs)

Hierarchical levels of HCPS2.0 for NGIM

Note: NGIM (Next Generation Instant Messaging)

System-level HCPS in the COSMOPlat

(Ji et al, 2019)
Think

Why Cyber-Physical-Human System is important?
Co-funded by the Erasmus+ Programme of the European Union

Thank You

Together We Will Make Our Education Stronger

https://msie4.ait.ac.th/

@MSIE4Thailand

MSIE 4.0 Channel

Curriculum Development of Master’s Degree Program in Industrial Engineering for Thailand Sustainable Smart Industry