Course 10: Cyber-Physical Industrial Systems

Course Objective: Gaining knowledge about: the main types and characteristics of the Cyber-Physical Systems, their application areas, components selection rules, programming methodology, specific aspects related to different measured physical parameters, data storage, reporting and communications.

Learning Outcomes:

The students on the completion of this course would be able to:

CLO 1: Identify links between industrial engineering knowledge and methods, on one side, and the design, modeling and management activities related to CPIS, on the other side (Analyze)

CLO 2: Implement smart production and co-created product design & development concepts in CPIS related activities (Create)

CLO 3: Identify use cases of big data and real time data analytics applied for CPIS, for supporting smart production, product design & development and advanced manufacturing process (Evaluate)

CLO 4: Exploit the CPIS online connectivity for strengthening business capability (Apply)

CLO 5: Applying CPIS related knowledge and competences for improving sustainability (Apply)

Course content / activities

		CLO	Module
Introduction - concept of standard CPS, basics, model	Lecture	1	1
Establishing the projects' subjects and forming the teams	Discussion	1	1
Identify the physical quantities to be measured or the datasets to be acquired and computed	Teamwork	1	1
Types of transducers, characteristics, application fields, selection criteria	Lecture	2	1
Choose or design the sensors and/or the transducers for measuring or for data collection	Teamwork	2	1
Signal conditioning basics	Lecture	2	2
Data acquisition basics	Lecture	2	2

Choose or design the needed electronics (power supplies, signal conditioning, analog to digital converters, multiplexers, communication subsystems)	Teamwork	2	2
Connect the CPS components	Teamwork	2	2
Test the CPS assembly	Teamwork	2	2
Data acquisition programming basics	Lecture	2	3
Develop the CPS data acquisition software components	Teamwork	2	3
Data processing basics	Lecture	3	3
Develop the CPS data processing software components	Teamwork	3	3
Data communication basics	Lecture	4	3
IoT communication protocols basics	Lecture	4	3
Develop the CPS data communication software components	Teamwork	4	3
Cloud computing and artificial intelligence basics	Lecture	5	1, 2, 3
Feed artificial intelligence component with experimental data	Teamwork	5	1, 2, 3
Final project presentation	Evaluation		1, 2, 3

Learning resources:

Textbooks: No designated textbook, but class notes and handouts will be provided.

Reference books:

1. Wang, L. and Wang, X.V. (2018). Cloud-Based Cyber-Physical Systems in Manufacturing. Springer
2. Markwedel, P. (2018). Embedded System Design: Embedded Systems, Foundations of Cyber-Physical Systems, and the Internet of Things. Springer.
3. Brown, P. (Ed.) (2016). Sensors and Actuators: Technology and Applications. Library Press.
4. Morris, A.S. and Langari, R. (2017). Measurement and Instrumentation: Theory and Application (Second Edition). Elsevier.
5. Boyer, S.A. (2009). SCADA: Supervisory Control and Data Acquisition. ISA The Instrumentation, Systems and Automation Society
6. Buyya, R. and Dastjerdi, A.V. (Eds.) (2016). Internet of Things: Principles and Paradigms. Morgan Kaufmann

Teaching and Learning Methods

The teaching / learning methodology is mainly student-centered (active learning) rather than teacher-centered. The course comprises lectures and laboratory sessions (for projects' development). The lectures, besides the expositive part (teacher-centered), incorporate elements of active learning (e.g. small tasks to be solved individually or by teams in 5-10 minutes). The laboratory sessions adopt the project-based learning (PBL) approach. The projects are developed by teams and incorporate project management skills (e.g. time management and tasks' distribution), problem solving, hands-on work (learning by doing), communications skills (project presentation and discussion) and peer assessment.

Time Distribution and Study Load:

Lectures: 15 hours
Laboratory sessions: 45 hours
Autonomous work (self-study): 60 hours

Organisational topics

One semester course
15 - 20 students in a group, 3 - 4 students in a team
Different project for each team

Assessment

During lectures

- Presence is compulsory
- Students are graded according to their answers to questions addressed during the lecture

During teamwork lab activities

- Each student continuously assessed during the lab works, individually graded every week regarding:
    - solutions correctness
    - volume of needed support
    - adopted approach
    - innovative solutions
- Each student peer assessed, by the teammates, regarding:
    - contribution to the overall project objective achievement
    - Innovative solutions
- Team graded every week regarding the alignment to the project plan and milestones achievement

During the final project presentation:

- Each student individually graded regarding:

    - Solutions
    - Presentation skills (also peer assessed by other teams)
- Team graded regarding:
    - Technical solutions (also peer assessed by questions from other teams)
    - Quality of the technical report
    - Quality of teamwork
    - Questions asked to other teams

Evaluation Scheme

The final grade will be computed according to the following weight distribution:

- Assessment during lectures: 10 %
- Assessment during teamwork lab activities:
    - Individuall student grade: 50 %
    - Peer assessment by teammates: 10 %
    - Team grading: 10 %
- Assessment during final project presentation:
    - Individually: 10 %
    - Team assessment: 10 %