Cyber-phisical systems modelling and implementation - course description

General information

Course name	Cyber-phisical systems modelling and implementation
Course ID	11.3-WE-INFD-C-PSMabdl-Er
Faculty	Faculty of Computer Science, Electrical Engineering and Automatics
Field of study	Computer Science
Education profile	academic
Level of studies	Second-cycle Erasmus programme
Beginning semester	winter term 2022/2023

Course information

Semester	2
ECTS credits to win	4
Course type	obligatory
Teaching language	english
Author of syllabus	• dr inż. Grzegorz Bazydło

Classes forms

The class form	Hours per semester (full-time)	Hours per week (full-time)	Hours per semester (part-time)	Hours per week (part-time)	Form of assignment
Lecture	15	1	-	-	Credit with grade
Laboratory	30	2	-	-	Credit with grade
Project	15	1	-	-	Credit with grade

Aim of the course

- Familiarize students with the designing methods of a control part of a cyber-physical system.
- Shaping basic skills for specification, analysis, and implementation of a control part of cyber-physical systems (especially distributed).

Prerequisites

Fundamentals of digital system design.

Scope

- Introduction: cyber-physical system (CPS), control part of the CPS, smart systems, Internet of Things (IoT), embedded and distributed CPSs.
- The general designing flow of a control part of the CPS: modelling, analysis (including validation and verification), implementation and hardware verification.
- Graphical specification methods of a control part of the CPS: FSM, Petri net (including interpreted Petri nets), UML diagrams.
- Methods of the analysis of a control part of the CPS: validation, formal verification, concurrency (state space analysis), and sequentiality analysis. The computational complexity of the algorithms for the CPS control part analysis.
- Modelling and decomposition of the CPS control algorithm: decomposition into state machine components, decomposition methods.
- Implementation of the CPS control algorithm: logic synthesis and implementation, system description in the hardware description languages (e.g., VHDL, Verilog) and programming languages (e.g., C/.C++), physical implementation in the FPGA device and microcontrollers (e.g., Arduino).
- Static and dynamic partial reconfiguration of the already implemented CPS control algorithm (with and without system stop), design framework of the CPS control part for future static and dynamic partial reconfiguration of the control module of the CPS.

Teaching methods

Lecture: conventional lecture, discussion.

Laboratory: laboratory exercises, work in groups.

Project: project method.

Learning outcomes and methods of theirs verification

Outcome description	Outcome symbols	Methods of verification	The class form
Knows and understands the need to use various methods of analysis (validation and verification) of the Cyber-Physical Systems.		• a discussion • activity during the classes • an evaluation test	• Lecture
Is able to model a cyber-physical system (the control part) with the application of interpreted Petri nets and selected UML diagrams.		• a project • activity during the classes • an ongoing monitoring during classes	• Laboratory • Project

Outcome description	Outcome symbols	Methods of verification	The class form
Has a basic knowledge on modelling and implementation of cyber-physical systems.		• a discussion • activity during the classes • an evaluation test	• Lecture • Laboratory

Assignment conditions

Lecture – the passing condition is to obtain a positive mark from the final test (written or oral).

Laboratory – the passing condition is to obtain positive marks from all laboratory exercises to be planned during the semester.

Project – the passing condition is to obtain a positive mark from all projects conducted during the semester.

Final mark components: lecture 30% + laboratory 40% + project 30%.

Recommended reading

1. E. A. Lee, S. A. Seshia, Introduction to Embedded Systems: A Cyber-Physical Systems Approach, Cambridge, MA, USA:MIT Press, 2017.
2. W. Reisig, Petri Nets: An Introduction, Berlin, Germany:Springer-Verlag, 2012.
3. R. Wiśniewski, Prototyping of Concurrent Control Systems Implemented in FPGA Devices, Cham, Switzerland:Springer, 2017.
4. I. Grobelna, R. Wiśniewski, M. Grobelny, M. Wiśniewska, "Design and verification of real-life processes with application of Petri nets", *IEEE Trans. Syst. Man Cybern. Syst.*, vol. 47, no. 11, pp. 2856-2869, Nov. 2017.
5. R. Wiśniewski, G. Bazydło, L. Gomes, A. Costa, "Dynamic partial reconfiguration of concurrent control systems implemented in FPGA devices", IEEE Trans. Ind. Informat., vol. 13, no. 4, pp. 1734-1741, Aug. 2017.

Further reading

1. E. Best, R. Devillers, M. Koutny, Petri Net Algebra, Berlin, Germany:Springer-Verlag, 2013.
2. L. Gomes, F. Moutinho, F. Pereira, "IOPT-tools - A Web based tool framework for embedded systems controller development using Petri nets", *Proc. 23rd Int. Conf. Field Program. Logic Appl.*, pp. 1, Sep. 2013.
3. Z. Li, N. Q. Wu, M. C. Zhou, "Deadlock control of automated manufacturing systems based on Petri nets - A literature review", *IEEE Trans. Syst. Man Cybern. C Appl. Rev.* , vol. 42, no. 4, pp. 437-462, Jul. 2012.
4. M. Zhou, N. Q. Wu, System Modeling and Control With Resource-Oriented Petri Nets, Boca Raton, FL, USA:CRC Press, 2009.
5. I. Grobelna, "Model checking of reconfigurable FPGA modules specified by Petri nets", J. Syst. Archit., vol. 89, pp. 1-9, Sep. 2018.
6. R. Wiśniewski, "Dynamic partial reconfiguration of concurrent control systems specified by Petri nets and implemented in Xilinx FPGA devices", *IEEE Access*, vol. 6, pp. 32376-32391, 2018.
7. V. Hahanov et al., "Cyber social computing" in Social Business and Industrial Applications, Cham, Switzerland:Springer, pp. 489-515, 2019.
8. R. Wiśniewski, A. Karatkevich, M. Adamski, A. Costa, L. Gomes, "Prototyping of concurrent control systems with application of Petri nets and comparability graphs", IEEE Trans. Control Syst. Technol., vol. 26, no. 2, pp. 575-586, Mar. 2018.
9. M.C. Golumbic, Algorithmic Graph Theory and Perfect Graphs, Academic Press, 1980.
10. R. Wiśniewski, G. Bazydło, P. Szcześniak, I. Grobelna, M. Wojnakowski, „Design and Verification of Cyber-Physical Systems Specified by Petri Nets - A Case Study of a Direct Matrix Converter", Mathematics, vol. 7, pp. 1-24, 2019.

Notes

Modified by dr inż. Grzegorz Bazydło (last modification: 21-04-2022 10:08)