COURSE DESCRIPTION
DISCRETE EVENT SYSTEMS AND SUPERVISORY CONTROL

SSD: AUTOMATICA (ING-INF/04)

DEGREE PROGRAMME: INGEGNERIA DELL'AUTOMAZIONE E ROBOTICA (P38)
ACADEMIC YEAR 2022/2023

COURSE DESCRIPTION

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GENERAL INFORMATION ABOUT THE COURSE

INTEGRATED COURSE: U2326 - ADVANCED CONTROL ENGINEERING
MODULE: U2328 - DISCRETE EVENT SYSTEMS AND SUPERVISORY CONTROL
CHANNEL: FG A-Z
YEAR OF THE DEGREE PROGRAMME: II
PERIOD IN WHICH THE COURSE IS DELIVERED: SEMESTER II
CFU: 6

REQUIRED PRELIMINARY COURSES

None

PREREQUISITES

Basic knowledge about closed loop control systems.

LEARNING GOALS

The course aims at providing students with a set of tools to model discrete event systems in the context of industrial automation and to design supervisory control systems. The course will focus on the finite state automata and language theory, as well as on Petri nets.

EXPECTED LEARNING OUTCOMES (DUBLIN DESCRIPTORS)

Knowledge and understanding

The course provides students the tools to analyze the behavior of discrete event systems (DES) and to design supervisory control systems. The student needs to show that he/she understood the peculiarities of DES and he/she is able to analyze the behavior of this special class of nonlinear

systems.

Applying knowledge and understanding

The student needs to show that he/she is able to model real systems, such as flexible manufacturing systems, logistic systems, IT systems, as DES by using either automata or Petri nets. The student needs also to show that he/she is able to formalize the control requirements for supervisory control and design the correspondent controller (supervisor).

COURSE CONTENT/SYLLABUS

1. Introduction to DES

1. Systems and models
2. Discrete event systems
3. Logic and timed models

2. Languages and automata

1. Languages
2. Operations on languages
3. Definition of (logic and deterministic) automata
4. Generated and marked languages of an automata
5. Operations on automata
6. Canonical recognizer of a regular language
7. State space minimization
8. Non-deterministic (logic) automata
9. Observers
10. Fault diagnosis and diagnosers
11. Regular expressions
12. The class of regular languages Reg(E) and recognizable languages. Kleene theorem
13. Pumping lemmas for regular and context free languages
14. Chomsky grammars
15. Decidability and complexity
16. Timed automata: the deterministic and the stochastic case

3. Petri Nets

1. Petri nets and Petri net systems
2. Petri net languages
3. Reachability set
4. Labeled net systems: generated and marked language
5. Reachability and coverability graphs
6. Behavioural properties: reachability, boundedness, conservativity, repeatibility, reversibility, liveness
7. Structural properties: P- and T-invariants, siphons and traps
8. Estimation of the reachability set
9. Classes of P/T nets and ordinary nets subclasses

10. Observability of net systems with uncertain marking: the observer coverability graph
11. K-diagnosability in bounded Petri nets via integer linear programming
12. Timed Petri nets: the server semantic

4. Supervisory control

1. Control requirements
2. The concept of supervisor and supervisory control under complete controllability and observability
3. Supervisory control in presence of uncontrollable events
4. Controllability theorem
5. Controllable languages
6. Controllability test for regular languages
7. Supremal controllable sublanguage and infimal prefix-closed superlanguage
8. Controllability and non-conflicting
9. Basic Supervisory Control Problem e Dual Basic Supervisory Control Problem
10. Controllability and non-blocking theorem
11. Observable languages
12. Controllability and observability theorem
13. Supervisory control in Petri nets using Generalized Mutual Exclusion Constraints

READINGS/BIBLIOGRAPHY

C. G. Cassandras e S. Lafortune, Introduction to Discrete Event Systems. Springer, 2008.
Control of Discrete-Event Systems. Springer, 2013.
Material available at http://wpage.unina.it/detommas/dssc.html

TEACHING METHODS OF THE COURSE (OR MODULE)

The teaching activities will be organized as follows:
•lectures for about 70% of the total hours,
•practical exercise in the classroom based on software tools for about 30% of the total hours.

EXAMINATION/EVALUATION CRITERIA

a) Exam type

- [x] Written
- [x] Oral
- [ ] Project discussion
- [ ] Other

In case of a written exam, questions refer to

- [ ] Multiple choice answers
- [x] Open answers
- [ ] Numerical exercises

b) Evaluation pattern

The final mark is weighted with respect to the CFU of each module as follows:

•Module Discrete event systems and supervisory control, 6 CFU, 50%

•Module Control of complex systems and networks, 6 CFU, 50%