AGH UNIVERSITY OF SCIENCE AND TECHNOLOGY

Module name: Combinatorial explosion in analysis of concurrent systems

Academic year: 2019/2020 Code: ZSDA-3-0075-s ECTS credits: 3

Faculty of: Szkoła Doktorska AGH

Field of study: Szkoła Doktorska AGH Specialty: —

Study level: Third-cycle studies Form and type of study: Full-time studies

Lecture language: Polski i Angielski Profile of education: Academic (A) Semester: 0

Course homepage: —

Responsible teacher: dr hab. inż. Karatkevich Andrei (karatkevich@agh.edu.pl)

Module summary

State explosion problem, its causes, examples, related notions and concepts. Methods of handling the combinatorial expolsion, such as partial state space explosion, system decomposition and abstraction, symbolic model checking. The analysis problems which can be solved without explicite enumeration of the system state space.

Description of learning outcomes for module

MLO code	Student after module completion has the knowledge/ knows how to/is able to	Connections with FLO	Method of learning outcomes verification (form of completion)
Social competence: is able to			
M_K001	The student is able to analyze critically the known achievements in the field and his on results	SDA3A_K01	Activity during classes
Skills: he can			
M_U001	The student is able to analyze formal models of the parallel discrete systems using the advanced state space methods.	SDA3A_U01, SDA3A_U02	Activity during classes
Knowledge: he knows and understands			
M_W001	The student knows theoretical aspects of combinatorial explosion problem and the main notions and concepts of this field.	SDA3A_W01	Test
M_W002	He knows the main approaches and methods allowing to analyze the parallel discrete systems limiting the state explosion	SDA3A_W01	Activity during classes

Number of hours for each form of classes

	Form of classes										
Suma	Lectures	Auditorium classes	Laboratory classes	Project classes	Conversation seminar	Seminar classes	Practical classes	Fieldwork classes	Workshops	Prace kontrolne i przejściowe	Lektorat
30	20	0	0	0	0	10	0	0	0	0	0

FLO matrix in relation to forms of classes

MLO code	Student after module completion has the knowledge/ knows how to/is able to	Form of classes										
		Lectures	Auditorium classes	Laboratory classes	Project classes	Conversation seminar	Seminar classes	Practical classes	Fieldwork classes	Workshops	Prace kontrolne i przejściowe	Lektorat
Social competence: is able to												
M_K001	The student is able to analyze critically the known achievements in the field and his on results	-	-	-	-	-	+	-	-	-	-	-
Skills: he can												
M_U001	The student is able to analyze formal models of the parallel discrete systems using the advanced state space methods.	-	-	-	-	-	+	-	-	-	-	-
Knowledge: he knows and understands												
M_W001	The student knows theoretical aspects of combinatorial explosion problem and the main notions and concepts of this field.	+	-	-	-	-	-	-	-	-	-	-
M_W002	He knows the main approaches and methods allowing to analyze the parallel discrete systems limiting the state explosion	+	-	-	-	-	-	-	-	-	-	-

Student workload (ECTS credits balance)

Student activity form	Student workload
Udział w zajęciach dydaktycznych/praktyka	30 h
Preparation for classes	10 h
przygotowanie projektu, prezentacji, pracy pisemnej, sprawozdania	20 h
Realization of independently performed tasks	20 h
Contact hours	5 h
Summary student workload	85 h
Module ECTS credits	3 ECTS

Additional information

Module content

Lectures

Main notions and examples of combinatorial explosion
Rapid growth of complexity of certain cases of problems. Examples using games, quickly growing functions using in combinatorics, the Ackermann function. State space explosion in parallel systems

Parallel discrete systems and the tasks of their analysis
Liveness and safeness properties, deadlocks, livelocks. Properties expressed by temporal logic. Reachability graphs and interleaving.

Persistent set approach
Theoretical background: Mazurkiewicz traces, persistent sets. The stubborn set method in its basic form.

More possibilities of the stubborn set method
Application of the stubborn set method to special cases of parallel systems and applying its modifications for analysis of different properties.

The ignoring problem
How the persistent set approach may lead to eternal ignoring of possible transitions and how it can be avoided.

Parallel simulation approach
Janicki and Koutny’s method and other possibilities of concurrent simulation. Combining the persistent set approach and the concurrent simulation.

On-the-fly minimization of the state spaces
Dynamic reduction of the reachability graphs and its applying to analysis tasks.

Abstraction approach to analysis
Unfolding and different kinds of decomposition decreasing the state explosion.

Symbolic model checking
Characteristic functions using BDDs representing the state spaces, analysis methods using such representations instead of explicit enumeration of reachable states.

Bounded model checking
Model checking using iterative deepening search to limit the numer of explored states.

Seminar classes

Discussions and experiments on the algorithms and methods presented in the lectures. Student’s presentations on the selected topics.

Teaching methods and techniques:

Lectures: Classical lectures with using the multimediate presentations and discussion with the listeners
Seminar classes: Nie określono

Warunki i sposób zaliczenia poszczególnych form zajęć, w tym zasady zaliczeń poprawkowych, a także warunki dopuszczenia do egzaminu:

Activity at the seminars or presentation of a selected topic by the student,

Zasady udziału w poszczególnych zajęciach, ze wskazaniem, czy obecność studenta na zajęciach jest obowiązkowa:

Lectures:
– Attendance is mandatory: No
– Participation rules in classes: Nie określono
Seminar classes:
– Attendance is mandatory: Yes
– Participation rules in classes: Activity of the students during the seminars

Method of calculating the final grade

Evaluation of the activity at the seminar classes and/or presentation.

Sposób i tryb wyrównywania zaległości powstałych wskutek nieobecności studenta na zajęciach:

A student who has not attained at two or more seminar classes has to prepare a presentation on a topic defined together with the lecturer

Prerequisites and additional requirements

Basic knowledge on discrete mathematics, including combinatorics, Boolean algebra and temporal logic

Recommended literature and teaching resources

1. Valmari A., “State of the Art Report: Stubborn Sets”, Petri Net Newsletter, no. 46, April, pp. 6-14, 1994
2. Diekert V, Metivier Y., “Partial Commutation and Traces”, In G. Rozenberg and A. Salomaa, editors, Handbook of Formal Languages, Vol. 3, Beyond Words. Springer-Verlag, Berlin, 1997.
3. Valmari A.: “The State Explosion Problem”, ACPN 1996: Lectures on Petri Nets I: Basic Models pp 429-528, Springer, 1998.
4. Clarke E. M., Grumberg O., Peled D. A., Model Checking. MIT Press, 1999.
5. Flanagan C., Godefroid P., “Dynamic partial-order reduction for model checking software”. Proceedings of POPL ’05, 32nd ACM Symp. on Principles of Programming Languages. pp. 110–121, 2005.
6. Baier C., Katoen J.: Principles of Model Checking, 2008.

Scientific publications of module course instructors related to the topic of the module

1.Karatkevich A., “Memory-saving Analysis of Petri Nets”. In: Design of Embedded Control Systems, Springer, 2005.- pp. 63-72.

2.Karatkevich A., “Dynamic Analysis of Petri Net-Based Discrete Systems”, Lecture Notes in Control and Information Sciences, Vol. 356, Springer, 2007.
3.Karatkevich A., “Analysis of Parallel Discrete Systems: Persistent Sets vs. Concurrent Simulation”, Przegląd Elektrotechniczny R 85 № 7, 2009, pp. 182-184.
4.Karatkevich A., “Analysis of concurrent discrete systems by means of reduced reachability graphs”. In: Preprints of the IFAC Workshop DESDes’09, Gandia Beach, 2009.- pp. 51-56.
5.Karatkevich A., Łabiak G., “Deadlock-preserving reduction of Petri nets”. In: Materiały konferencji naukowej KNWS’14, Karpacz, 2014, pp. 60-61.
6.Karatkevich A., Grobelna I., “Deadlock detection in Petri nets: one trace for one deadlock?” In: Proceedings of the 2014 7th International Conference on Human System Interactions (HSI), Lisbon, 2014, pp. 227-231 (electronic edition)

Additional information

None