

REACTIVE SYNTHESIS: MAIN ACHIEVEMENTS AND CURRENT TRENDS

Synthesis is a fundamental problem in computer science and mathematics, concerned with automatically generating programs that satisfy a given logical specification. Its applications span a range of domains, including formal verification, software engineering, and automated theorem proving. For instance, designing a controller that guides the behavior of a reactive system, that is, a system that continually interacts with its environment, can be framed as a synthesis problem. Similarly, the design and verification of a distributed system often depend on distributed synthesis, which finds programs that enforce correct component interaction and satisfy desired specifications.

The third edition of the UniVr/UniUd Summer School on Formal Methods for Cyber-Physical Systems offers an in-depth exploration of reactive synthesis, a topic that was already introduced in the first edition of the school. The lecturers will provide a systematic account of the main achievements and the current trends of research in reactive synthesis, covering both theory and applications.

The course will begin with an overview of the classical synthesis problem in the finite-state setting, as originally formulated by Church and solved by Büchi and Landweber. This introductory part will introduce the terminology of infinite two-player games, explain the automatic construction of winning strategies in "regular games", and address history of the subject, discussing extensions and open problems. From there, the course will investigate approaches for making reactive synthesis more efficient and practical, including techniques for solving the synthesis problem in restricted settings, for decomposing the problem into subproblems, and for employing algorithms, data structures, and heuristics to manage complexity. Variants of the synthesis problem will also be explored, such as control strategies for hybrid and distributed systems, monitor synthesis, synthesis under incomplete information, distributed synthesis, and symmetric synthesis. The implementation of synthesis tools will also receive significant attention, with a focus on recent advances and applications of UPPAAL Stratego and the SYNTCOMP reactive synthesis competition.

The summer school will conclude with a workshop on emerging research trends in synthesis, monitoring, and learning, which showcases some exciting interactions between formal methods and machine learning. Distinguished invited speakers will lead the workshop. Participants will also have the opportunity to engage with peers from around the world and may propose to

ADMISSION AND ACCOMMODATION

The course is offered in a hybrid format giving the possibility to remotely attend the course (on Microsoft Teams platform).

On-site places are limited and assigned on first come first served basis.

The registration fees are:

- On-site participation, 250.00 Euro + VAT*

This fee includes a complimentary bag, five fixed menu buffet lunches, coffee breaks, social dinner, downloadable lecture notes.

Deadline for on-site application is **July 28, 2023**.

- Online participation, 120.00 Euro + VAT*

This fee includes downloadable lecture notes.

Deadline for online application is **August 18, 2023**.

Course application is available at

<https://www.cism.it/en/activities/courses/J2303/>

A message of confirmation will be sent to accepted participants.

Additional information regarding...are available at:

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Upon request a limited number of on-site participants can be accommodated at CISM Guest House at the price of 35 Euro per person/night (mail to: foresteria@cism.it).

** where applicable (bank charges are not included)
Italian VAT is 22%.*

CANCELLATION POLICY

Applicants may cancel their registration and receive a full refund by notifying CISM Secretariat in writing (by email) no later than:

- July 28, 2023 for on-site participants (no refund after the deadline);

- August 18, 2023 for online participants (no refund after the deadline).

Cancellation requests received before these deadlines will be charged a 50.00 Euro handling fee. Incorrect payments are subject to Euro 50,00 handling fee.

For further information please contact:

CISM

Palazzo del Torso - Piazza Garibaldi 18 - 33100 Udine (Italy)

tel. +39 0432 248511 (6 lines)

e-mail: cism@cism.it | www.cism.it

ACADEMIC YEAR
2023

University of Udine
International Centre for Mechanical Sciences



UNIVERSITÀ
DEGLI STUDI
DI UDINE
hic sunt futura



Centro Internazionale
di Scienze Meccaniche
International Centre
for Mechanical Sciences

REACTIVE SYNTHESIS: MAIN ACHIEVEMENTS AND CURRENT TRENDS

Third Edition of the
UniVr/UniUd Summer School on
Formal Methods for Cyber-Physical Systems

CISM-UniUD Joint course
coordinated by

Angelo Montanari
University of Udine, Italy

Gabriele Puppis
University of Udine, Italy

Tiziano Villa
University of Verona, Italy



Udine August 28 - September 1 2023

LECTURERS

Alessandro Cimatti - Fondazione Bruno Kessler, Italy
3-hour lectures on: "Runtime verification and monitor synthesis"
Runtime Verification (RV) is a lightweight verification technique that aims at checking whether a run of a system under scrutiny (SUS) satisfies or violates a given correctness specification. The lecture will first overview the general framework of RV, and the techniques to synthesize run-time monitors that can be efficiently executed in combination with the SUS. Then, we will cover the relationship between RV and the field of Fault Detection and Isolation (FDI). In FDI, runtime monitors are built taking into account models of the SUS, in order to monitor the occurrence of internal (faulty) conditions that are not directly observable.

Dana Fisman - Ben-Gurion University of the Negev, Israel
3-hour lectures on: "Automata learning of languages of finite and infinite words"
In these lectures we will get acquainted with the research area called grammatical inference or automata learning. We will start with the earliest results on the subject, and span different learning paradigms. We will describe several positive results, and efficient algorithms for learning regular languages. We will prove several negative results for learning different classes of languages in different learning paradigms. We will then discuss state-of-the-art results on learning regular languages of infinite words.

Swen Jacobs - CISPA Helmholtz-Center for Information Security, Germany
3-hour lectures on: "Reactive synthesis: towards practice"
I will give an overview of different lines of research that try to make reactive synthesis (more) practical. This includes research into approaches to restrict the problem to more efficiently solvable fragments, into ways to split the problem into subproblems that can be solved independently or iteratively, and into efficient algorithms and data structures as well as heuristics that allow us to implement synthesis tools that can solve problems of significant size. I will report on progress observed in the reactive synthesis competition (SYNTCOMP), and on case studies and benchmark problems that demonstrate the capabilities of state-of-the-art synthesis tools.

Kim Larsen - Aalborg University, Denmark
3-hour lectures on: "Synthesis and Optimization for Cyber Physical Systems"
In these lectures we will present recent advances and applications of the tool UPPAAL Stratego (www.uppaal.org) supporting automatic synthesis of guaranteed safe and near-optimal control strategies for cyber physical systems. UPPAAL Stratego combines symbolic methods from model checking, reinforcement learning methods from machine learning, as well as abstraction techniques for hybrid games. Trade-offs between efficiency of strategy representation and degree of optimality subject to safety constraints will be discussed, as well as successful applications (autonomous driving maneuvers, heating systems, and traffic control).

Wolfgang Thomas - RWTH Aachen University, Germany
3-hour lectures on: "Synthesis of strategies in infinite two-player games"
We give an introduction to the synthesis of reactive systems in the finite-state setting, using the terminology of infinite two-player games and explaining the automatic construction of winning strategies in "regular games". We also address the history of the subject, discuss extensions, and mention basic problems that are still open.

Martin Zimmermann - Aalborg University, Denmark
3-hour lectures on: "Synthesis of infinite-state systems"
The reactive synthesis problem asks to compute, from a given specification of the input-output behavior of a reactive system, a system satisfying this specification (or to determine that no such system exists). In this lecture, we consider the synthesis of infinite-state systems with a focus on pushdown systems, which model simple recursive systems with finite data. On a technical level, we show how to solve infinite games on configuration graphs of pushdown automata and present recent work on generalizations to history-deterministic pushdown automata.

PROGRAMME

Monday, August 28

13:30 – 14:00 Registration
14:00 – 14:30 Course Introduction
14:30 – 16:00 L1 Thomas
16:00 – 16:30 Coffee break
16:30 – 18:00 L2 Thomas

Tuesday, August 29

09:30 – 11:00 L3 Zimmermann
11:00 – 11:30 Coffee break
11:30 – 13:00 L4 Zimmermann
13:00 – 14:00 Lunch
14:30 – 16:00 L5 Larsen
16:00 – 16:30 Coffee break
16:30 – 18:00 L6 Larsen

Wednesday, August 30

09:30 – 11:00 L7 Fisman
11:00 – 11:30 Coffee break
11:30 – 13:00 L8 Fisman
13:00 – 14:00 Lunch
14:30 – 16:00 L9 Jacobs
16:00 – 16:30 Coffee break
16:30 – 18:00 L10 Jacobs
19:00 – 23:00 *Social dinner*

Thursday, August 31

09:30 – 11:00 L11 Cimatti
11:00 – 11:30 Coffee break
11:30 – 13:00 L12 Cimatti
13:00 – 14:00 Lunch

Workshop on Synthesis, Monitoring and Learning

Chairmen

Dario Della Monica - Udine University, Italy
Ingo Pill - Silicon Austria Labs, Austria
Stefano Tonetta - Fondazione Bruno Kessler, Italy

Thursday, August 31

14:30 – 16:00 L13 Invited talk by Luca Geatti
16:00 – 16:30 Coffee break
16:30 – 18:00 L14 Invited talk by Leonardo Mangeruca

Friday, September 1

09:30 – 11:00 L15 Invited talk by Adrian Francalanza
11:00 – 11:30 Coffee break
11:30 – 13:00 L16 Invited talk by Bernhard Aichernig
13:00 – 14:00 Lunch