

Formal Methods: Automated Reasoning & Formal Verification Ch. 00: **Course Overview**

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M.S. in Computer Science, Mathematics, & Artificial Intelligence Systems
Academic year 2021-2022

last update: Monday 28th February, 2022, 11:41

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1 Practical Information

2 About the Course

Important:

Please be aware that all classes are video-recorded (including students' questions & speeches) and that the recordings will be made available online.

Target

- The course is given in **English**.
- For students of M.S. “**Computer Science**” and “**Mathematics**”:
“Formal Methods” is split into two consecutive modules:
 - **Module 1: Automated Reasoning** [6CFU]
 - **Module 2: Formal Verification** [6CFU]
- For students of M.S. “**Artificial Intelligence Systems**”:
the above modules are mutated respectively into the courses:
 - **Automated Reasoning** [6CFU]
 - **Formal Verification** [6CFU]
- These courses are open to whoever may be interested
 - in particular to PhD students of IECS school

Timetable

Timetable:

2nd Semester, **February 28th – June 7th**

- CLASS: Tuesday 08.30-11.30 Room A110 (Povo 1)
- LAB: Wednesday 11.30-13.30 Room A110 (Povo 1)
- CLASS: Thursday 09.30-11.30 Room A110 (Povo 1)

The course is given in presence. Recordings of the classes will be made available (see later).

Office Hours & Forum

Office hours:

- No weekly fixed-day
- Anytime in the week, **upon appointment only**
- In presence (only after class) or via zoom
- Appointments to be set in class or via email
- **Office hours only during class period (see above)!**

Forum

A forum for Q&A is available at the course page in the [Moodle](#) platform

Note: You must register to [Moodle](#)!

Important: Email Communications

Important

Teaching this course is only part of our job, and we receive a huge amount of email. Thus:

- email for **relevant** reasons only
- email to both me and the teaching assistant
- use as subject “[Formal Methods]: *<subject>*”
(or “[Automated Reasoning/Formal Verification]: *<subject>*”)
- email only from your “official” UNITN email address “name.surname@studenti.unitn.it”
 - emails coming from any other source address will be ignored
- be polite and respectful, with both me and the T.A.
(see e.g. [“Bad Email Reply – What not to say to your professor”](#))

PS: Notice that even professors use social media ([example](#))

Outline

1 Practical Information

2 About the Course

Motivations & Goals

- Formal reasoning & verification methods are increasingly used
 - as powerful **specification**, **verification** and **early debugging** methods in the development of industrial SW and HW systems.
 - as **backend engines** for many AI applications (e.g., planning, KR)
 - and **backend engines** for many NP-hard problems (e.g., cryptanalysis, circuit designs,...)
- The course will concentrate mainly on
 - **Automated Reasoning (AR)**
 - **Formal verification (FV)**, with particular attention to **Model Checking (MC)** technology
- A laboratory will be given in which the students will experience
 - the usage of AR techniques (SAT, SMT)
 - the usage of MC techniques (NuXMV)

Automated Reasoning

The main topics covered in the course are (not necessarily in order):

- Boolean Reasoning & Propositional Satisfiability (SAT)
- Ordered Binary Decision Diagrams
- Modern SAT Solving (CDCL)
- Extended SAT Functionalities
- Satisfiability Modulo Theories (SMT)
- Extended SMT Functionalities
- Temporal logics: LTL, CTL and CTL*
- Automated reasoning in Temporal Logics (LTL, CTL)
- Noteworthy Applications

Note: Depending on various circumstances, the covered topics might be subject to variations.

Topics (cont.)

Formal Verification

The main topics covered in the course are (not necessarily in order):

- Formal specification & formal validation
- Formal Representation of Systems
- Model Checking (MC): generalities
- Explicit-State MC and Symbolic MC
- CTL MC
- LTL MC
- SAT-based MC,
- abstraction in MC (hints)
- MC with Timed and Hybrid Systems

Note: Depending on various circumstances, the covered topics might be subject to variations.

Laboratory:

- SAT solvers
- SMT/AR solvers
- The MC NuXMV

References

Both Automated Reasoning and Formal Verification courses/modules:

- Notes from the lessons
- Slides (available from the URL of the course)
- Other material (available from the URL of the course)

Formal Verification course/module only:

- The NuXMV manual
- Suggested books (in alternative):
 - *Edmund Clarke, Orna Grumberg and Doron Peled.*
"Model Checking"
MIT Press
 - *Christel Baier and Joost-Pieter Katoen .*
"Principles of Model Checking"
MIT Press

Disclaimer

Some of the material presented in these slides (text, figures) is courtesy of the following people, listed in alphabetical order:

- **Massimo Benerecetti** (`bene@na.infn.it`)
- **Alessandro Cimatti** (`cimatti@fbk.eu`)
- **Paritosh Pandya** (`pandya@tifr.res.in`)
- **Marco Pistore** (`pistore@fbk.eu`)
- **Marco Roveri** (`marco.roveri@unitn.it`)
- **Stefano Tonetta** (`tonettas@fbk.eu`).

Furthermore, some examples are taken from the book:

[**E. Clarke, O. Grunberg & D. Peled, “Model Checking”, MIT Press**]

Requirements

- It is assumed some basic background in the following topics:
 - basic mathematics
 - algorithms and data structures
 - programming
- Some background in the following topics could be useful (but not strictly necessary):
 - Boolean logic
 - automata and formal languages
 - software engineering

Exam

Formal Methods module 1 & 2 – 12 CFU (M.S. in Computer Science or M.S in Mathematics)

2 parts:

- Script
 - lab test
 - the script test, on the topics of the course
- Oral Interview
 - interview on the topics of the course.

Automated Reasoning or Formal Verification – 6 CFU (M.S. in Artificial Intelligence Systems)

2 parts:

- lab test
- the script test, on the topics of the course

People from AIS M.S. willing to take **both** Automated Reasoning and Formal Verification (6+6 CFU) can alternatively take the Formal Methods exam for both.

- the same vote will be given to both courses

To copy at exams very dangerous is!

