Logic and Computability

Course no. 705.033 (Lecture)
Course no. 705.034 (Practicals)

Georg Hofferek
IAIK – Graz University of Technology
georg.hofferek@iaik.tugraz.at
DI Dr.techn. Georg Hofferek

- Bachelor & Master “Telematik” (2002-2008)
  - Majors: IT-Security, System-on-Chip Design

- PhD in Computer Science (2008-2014)
  - Thesis: Controller Synthesis with Uninterpreted Functions

- Researcher and Teacher at IAIK (since 2008)
  - Research Focus: Automated Synthesis of Systems
  - Teaching:
    - Logic and Computability
    - AK Design & Verification
Contact Details:
- georg.hofferek@iaik.tugraz.at
- 0316 / 873 – 5554
- Inffeldgasse 16a/II, Room IF02068
- Twitter: @GeorgHofferek, #iaikLuB

Come by…
- … anytime
  (try your luck)
- … on appointment
Outline

- Administrative Information
  - Lecture
  - Practicals

- Introduction & Motivation
  - Use of Logic
  - Types of Logic
  - Classical Questions
Lecture

- Tuesday, Lecture Hall i2, 08:15 – 10:00
  - ca. 10-15 min break

- Course Material
  - Huth and Ryan, Logic in Computer Science, Cambridge University Press, 2004
  - Web: [http://www.iaik.tugraz.at/content/teaching/bachelor_courses/logik_und_berechenbarkeit/](http://www.iaik.tugraz.at/content/teaching/bachelor_courses/logik_und_berechenbarkeit/)
  - Newsgroup: tu-graz.lv.logik

- Topics
  - Propositional Logic
  - Predicate Logic (aka “First-Order Logic”)
## Preliminary Schedule

(Subject to changes, if necessary)

### Part 1: Propositional Logic

<table>
<thead>
<tr>
<th>Date</th>
<th>Topic</th>
</tr>
</thead>
<tbody>
<tr>
<td>2014-10-07</td>
<td>Administrative Information, Motivation, Overview</td>
</tr>
<tr>
<td>2014-10-14</td>
<td>Syntax, Semantics, Models</td>
</tr>
<tr>
<td>2014-10-21</td>
<td>Natural Deduction</td>
</tr>
<tr>
<td>2014-10-28</td>
<td>Normal Forms, Equivalence Checking, Tseitin Encoding</td>
</tr>
<tr>
<td>2014-11-04</td>
<td>SAT Solver, DPLL, Clause Learning, Refutation Proofs</td>
</tr>
<tr>
<td>2014-11-11</td>
<td>Symbolic Encoding, Craig Interpolation</td>
</tr>
<tr>
<td>2014-11-18</td>
<td>Binary Decision Diagrams</td>
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</table>
Preliminary Schedule
(Subject to changes, if necessary)

Part 2: Predicate Logic

<table>
<thead>
<tr>
<th>Date</th>
<th>Topic</th>
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</thead>
<tbody>
<tr>
<td>2014-11-25</td>
<td>Syntax, Semantics, Models</td>
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<tr>
<td>2014-12-02</td>
<td>Natural Deduction</td>
</tr>
<tr>
<td>2014-12-09</td>
<td>“A Real Proof”</td>
</tr>
<tr>
<td>2014-12-16</td>
<td>First-Order Theories, SMT Solver</td>
</tr>
<tr>
<td>2015-01-13</td>
<td>Decidability, Problem Reduction</td>
</tr>
<tr>
<td>2015-01-20</td>
<td>Summary &amp; Current Research</td>
</tr>
<tr>
<td>2015-01-26 (Monday!)</td>
<td>Question Hour</td>
</tr>
<tr>
<td>2015-01-27</td>
<td>Exam (9am – 12 noon, Lecture Hall G)</td>
</tr>
</tbody>
</table>
Anatomy of a Lecture

- Start: 08:15am

- \( \text{TOPIC} \)
  - Motivation
  - Overview
  - Learning Targets

- \( \text{CONTENT} \)
  - Part 1

- Break (ca. 15 min)
Anatomy of a Lecture (cont.)

- **${CONTENT}$**
  - Part 2
  - Summary

- Control of Success
  - Self-Control Questions

- End
Break

- Counteract …
  - Decrease of Concentration
  - Lack of
    - Oxygen
    - Movement
    - Coffee?

- Photograph & Clear Blackboard

- Discuss Questions
  - More privately
Self-Control Questions

- **Procedure**
  - Handed out at end of lecture
  - 5-10 minutes to answer
  - Presentation of correct answers by lecturer
  - No consequences

- **Purpose**
  - Use new knowledge immediately
    - Better memorization
  - Self-control of learning success
    - No risk
    - Correct answer → Sense of achievement,
    - Wrong answer → Realize *immediately*: more learning necessary
Self-Control Questions (cont.)

Don’t cheat yourself!

- Work alone
- Do not use notes
- Postpone discussions
Course Website

- Website contains:
  - Slides
  - Photographs of blackboard
  - Additional material
    - Handouts
    - Papers
    - Etc.
  - Videos
    - New: Interactive!

- Online *after* each lecture
  - Last minute updates
  - Focus on presentation
Videos
Videos

- Interactive Questions
  - Similar to Self-Control Questions
  - Multiple-Choice only
  - Ask questions
  - Statistics

- Register at http://live.learninglab.tugraz.at/
  - Use real name and student email

- Offline Viewing
  - Downloadable version in TeachCenter
Interactivity of Lecture

- Questions from audience
  - Clarification, repetition, etc.
  - Interrupt anytime!
    - Or: In break, after lecture

- Questions from lecturer
  - Benefit from participation
  - No negative influence on grading, etc.
  - Be active, not shy!
Written Exams

- Three exams per semester
  - Start (2014-10-02)
  - Middle (2014-12-05)
  - End (2015-01-27)

- Questions
  - Theoretic questions
    - Similar to self-control questions
  - Practical questions
    - Similar to tasks from practicals
  - Always new questions!
    - No old exams available

≥ 4 candidates required!
Oral Exams

- < 4 candidates for exam

- On individual basis
  - Make appointment!

- Questions
  - Solve and explain practical questions
  - Additional theory questions
Practicals

- Three groups (and tutors)
  - Georg Hofferek
    - georg.hofferek@iaik.tugraz.at
  - Georg Schadler
    - georg.schadler@student.tugraz.at
  - Christoph Thaller
    - christoph.thaller@student.tugraz.at
Registration for Practicals

- Registration Deadline: 2014-10-05 (passed)
  - Late Registration/Unregistration/Change Requests:
    - Today!!
  - Collision with “Logik und Logische Programmierung” (3rd Semester)

- First class meeting
  - Next Monday, 2014-10-13
  - “Assignment 0” online already
Mandatory Presence

- Always!
  - Yes, even when you solved no tasks

- Exceptions
  - Good reasons!
  - Inform tutor asap!
    - Before beginning of session!
  - Upload solutions
    - Special appointment for discussion with tutor
Assignments

- Put online on Mondays
  - [http://www.iaik.tugraz.at/content/teaching/bachelor_courses/logik_und_berechenbarkeit/practicals/](http://www.iaik.tugraz.at/content/teaching/bachelor_courses/logik_und_berechenbarkeit/practicals/)
  - Corresponding Lecture on Tuesday

- (at least) one week before due date
  - Assignment 0: Online already

- Assignments
  - Assignment 0 (fewer points)
  - 9 regular assignments
    - 15 points each
    - probably some bonus tasks
  - Bonus Assignment (15 points)
STicS – Student Tick System

→ https://stics.iaik.tugraz.at/

- Tick tasks you solved
  - Excused absence: Upload solution
  - Deadline: Monday, 09:00am

- Shows intermediate results/grades
  - Please check!
  - Report bugs to: stics@iaik.tugraz.at
Presentations

- One student (randomly) selected

- Up to 3 points
  - Correctness is prerequisite
    - Minor mistakes are tolerated
  - Focus on explanation
    - Tips and Demo in first class meeting
  - Help fellow students understand
Grading

- \( \text{RateTicks} = \frac{\text{Points of Ticked Tasks}}{\text{Total Points of (non–bonus) tasks}} \times 100\% \)

- \( \text{RatePres} = \frac{\text{Points from Presentations}}{\text{Number of Presentations} \times 3} \times 100\% \)

- \( \text{RateCombined} = \frac{3 \times \text{RateTicks} + \text{RatePres}}{4} \)
Grading

- If $RateTicks < 35\%$ for more than one single assignment:
  - (5) Nicht Genügend / Insufficient

- Else:

  - If $RateCombined$…
    - $\geq 87.5\%$: (1) Sehr Gut / Excellent
    - $\geq 75.0\%$: (2) Gut / Good
    - $\geq 62.5\%$: (3) Befriedigend / Satisfactory
    - $\geq 50.0\%$: (4) Genügend / Sufficient
    - $\geq 00.0\%$: (5) Nicht Genügend / Insufficient
More Rules

- Unable to explain solution (i.e. „Cheating“)
  - → Lose all ticks for this date

- Absent without excuse
  - → Lose all ticks for this date

- Two such incidents
  - → Fail course
Synergy: Lecture and Practicals

- Assignments help prepare for lecture exam

0 (almost) not helpful at all / wenig bzw. gar nicht hilfreich (0)
1 (1)
2 (2)
3 (3)
4 (4)
5 very helpful / sehr hilfreich (5)  

I did not take the exam in January 2013. (Please leave a comment why not!) / Ich bin nicht zum Vorlesung  

- ➔ Take the first exam! (2015-01-27)
Grading Comparison – Practicals and Lecture (WS 2012/13)

- ➔ Take the first exam! (2015-01-27)
Course Language

- Lecture, Assignments, Material: **English**
  - International Students
  - Technical Terms
  - Policy of Rectorate
  - Language Skill Improvement

- Take the opportunity
  - Try English
  - No blame/consequences for language mistakes
Questions

- Administrative or on subject matters
  - Transparency

- Anytime
  - Interrupt
  - During break
  - After lecture
  - Newsgroup
  - Email
  - Come by office
    - Make appointment
    - Try your luck
Feedback

- **Constructive** feedback always welcome
  - Positive & negative aspects
  - Technical & administrative aspects

- Personal or anonymous

- Evaluation at end of term
Logic and Computability

Introduction, Motivation & Overview

Georg Hofferek
IAIK – Graz University of Technology
georg.hofferek@iaik.tugraz.at
Motivation

- Use of Logic
  - Reasons
  - Examples

- Get you…
  - warmed up
  - interested
Outline

- Examples
- Use of Logic
  - In Computer Science
  - In General
- “Classical Questions” in Logic
- Current Research
Learning Targets

- List and explain uses of logic
  - (in computer science)

- Motivate the need for logic (in computer science) by examples

- Name and explain the “classical questions” in logic
He gave her cat food.
They are looking for teachers of Norwegian and Swedish.
Classical Questions in Logic

1. “Does one statement entail another?”
   - If $x$ then $y$. $x$ is true. *Therefore*, $y$ is true.
   - If $x$ then $y$. $y$ is false. *Therefore*, $x$ is false.

2. “Is this statement always true?”
   - $((x \implies y) \land x) \implies y$.

3. “Can this statement ever be true?”
   - $(x \implies y) \land x \land (\neg y)$.
   - $(x \implies y) \land (\neg x) \land y$.

4. “Is the statement true in this case?”
   - $x$ is true, $y$ is true. If so, is $(x \land y)$ true?
Current Research @

- Automated Synthesis
- Bug Localization
- Program Repair
Summary

- Unambiguous Reasoning
  - Examples

- Uses of Logic
  - In General
  - In Computer Science

- Types of Logic

- Classical Questions