CS 2210 – Logic for Computer Scientists

Fall Semester 2012

Slides 1 – August 28, 2012

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http://www.knoesis.org/pascal/

Real-life example

My daughter (3 years) to me:

You're my sister!

I:

I can't be your sister

because sisters have the same mom.

But your mom is Mommy, and my mom is Grandma.

So we have different moms,

and so we can't be sisters.

Daughter:

Sure we can!

My wife:

Daddy can't be your sister

because your sister would be a woman.

But Daddy is a man!

http://www.pascal-hitzler.de/teaching/f12/

Or go to http://www.pascal-hitzler.de and follow the link near the bottom of the page to the lecture.

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Today's Session

1. **Motivation (slides)**
2. **Organizational matters**
3. **Datalog (whiteboard)**

Logic

Logic is a fundamental organizing principle in nearly all areas in Computer Science. It runs a multifaceted gamut from the foundational to the applied. At one extreme, it underlies computability and complexity theory and the formal semantics of programming languages. At the other extreme, it drives billions of gates every day in the digital circuits of processors of all kinds. Logic is in itself a powerful programming paradigm, but it is also the quintessential specification language for anything ranging from real-time critical systems to networked infrastructures. Logical techniques link implementation and specification through formal methods such as automated theorem proving and model checking. Logic is also the stuff of knowledge representation and artificial intelligence. Because of its ubiquity, logic has acquired a central role in Computer Science education.

[Cited from the LPAR-10 Call for Papers]

Logic

"Logic is the Calculus of Computer Science"

- **Greek λογικός – possessed of reason, intellectual, dialectical, argumentative**
- **The study of reasoning.**

- **Dates back to Aristotle (384-322 BC)**
- **Has influenced western thinking and culture *decisively*.**
- **Some influences e.g. from Islamic philosophy (Avicennian logic)**

- **Aristotelian *syllogistic* logic dominated until mid-19th century.**
- **Then mathematical logic was developed [some big developments in mathematics at that time].**

  Boole, Frege, Whitehead, Russell, Wittgenstein

A treat
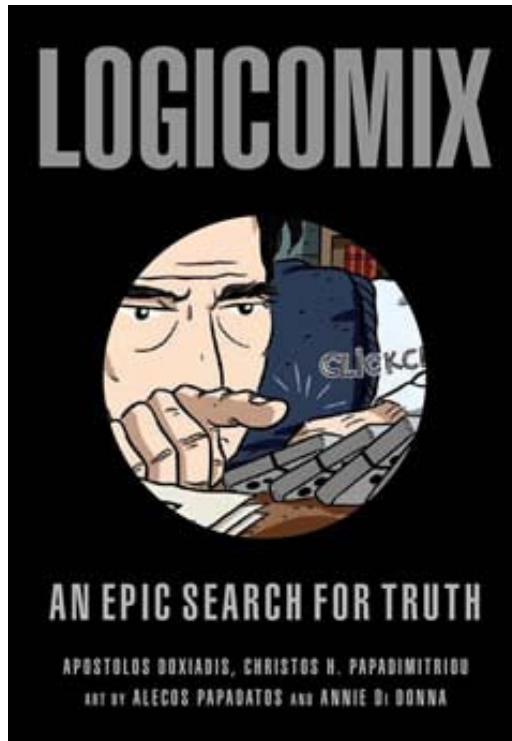
- **http://www.logicomix.com/**
- **Excellent comic about the groundbreaking developments in logic and mathematics end of the 19th century.**
- **It's actually very entertaining!**

Aristotelian syllogistic logic

- **The *Organon* – standard collection of Aristotle's six works on logic.**

- **When is an argument valid?**

- **Syllogism: "a discourse in which, certain things having been supposed, something different from the things supposed results of necessity because these things are so"**

- **Syllogism: a form of valid (logical) argument.**

mode, that affirms by affirming

(correct name: Modus ponendo ponens)

If P, then Q.

P.

Therefore, Q.

If today is Tuesday, then I will go to work.

Today is Tuesday.

Therefore, I will go to work.

mode, that denies by denying

(correct name: Modus tollendo tollens)

If P, then Q.

Not Q.

Therefore, not P.

If the watch-dog detects an intruder, the dog will bark.

The dog did nothing in the night-time.

Therefore, no intruder was detected.

mode, that affirms by denying

P or Q.

Not P.

Therefore, Q.

Either Monique is in the library, or she's in the pub.

But she's not in the library.

So she must be in the pub.

mode, that denies by affirming

Not both A and B.

A.

Therefore, not B.

Ann and Bill cannot both win the race.

Ann will win the race.

Therefore, Bill cannot win the race.

Syllogisms

- **We could go on for quite a bit.**

- **Can we do this in a more structured way?**

- **Yes, we'll do that: Propositional Logic (Section 2 of the lecture).**

"What is the secret of your long life?" a centenarian was asked. "I strictly follow my diet: If I don't drink beer for dinner, then I always have fish. Any time I have both beer and fish for dinner, then I do without ice cream. If I have ice cream or don't have beer, then I never eat fish."

Claim:

He has three options:

1. He has fish and beer, but no ice cream.
2. He has beer, but neither fish nor ice cream.
3. He has beer and ice cream, but no fish.

Why?

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Organizational Matters

- **Physical class meetings are Tuesdays and Thursdays 9:30am to 10:50am.**

- **Room: Russ 150**

- **Assistant open hours/ help desk:**
  Thursdays 4-5pm, Fridays 2:30pm to 3:30pm. Room tba
  Let us know if more/others are required.

- **I have to teach another class at 11am, i.e. I'm not available for questions after the lecture.**

  - **For content questions: ask during the lecture, or go to the open hours of the assistants, or send emails to the assistants. As a last resort, send by email and I'll answer (usually) in class.**

  - **For organizational issues: Preferably use email to assistant, or if appropriate to me. If you think it's better to talk in person, come to my office hours.**

Organizational Matters

- **Office Hours: Tuesdays 4pm to 5pm, Joshi 389.**
  Email contact preferred. Phone will only work by appointment.

- **Textbook (required):**
  Uwe Schöning, Logic for Computer Scientists, Birkhäuser, 2008.

- **Textbook (recommended):**
  Mordechai Ben-Ari, Mathematical Logic for Computer Science, Springer, 1993
  I will only take the Tableaux Algorithms from this one.

- **Grading:**
  2 exams during semester: 30% each
  Final exam: 40%
  Graded Homework Assignments: Half of all achievable points are required to be allowed into the final exam.

Organizational matters

- **We will frequently make exercise sessions.
  You will get exercises, to be done at home and graded by us,
  and discussed afterwards in class.**

- **Some exercises are labeled "hand-in". Only these "hand-in"
  exercises count towards your homework grade.**

- **Each "hand-in" exercise question counts 4 points.
  Exercises are due *one week after I pose them – before class*.**

- **The exercises are the tough part of the class. If you stay on top
  of them, you should find the exams relatively easy.**

Handing in homework solutions

- **Due one week after I pose them in class, due *before* class.**

- **Your name on every sheet.**
- **Answers clearly numbered as in class.**
- **Easily readable handwriting or typesetting.**
- **Remove fuzzy margins.**
- **Staple multiple pages (no paper clips or other methods).**

- **Explain and justify your solutions whenever appropriate.**

Doing exercises

- **It may be helpful to work in teams (e.g., two people) to discuss the more difficult exercises. However, I expect that, after discussion, each person writes the solution entirely by him/herself.**

- **If I get two identical or near-identical write-ups, or otherwise two versions which look like one is a copy of the other, both parties will receive zero points.**

- **And yes, it's easy to spot this. In fact, if you manage to do a *clever* copying – one where it's clear it's not a copy – then I don't have a problem with this (because this requires insight into the exercise).**

Organizational matters

- **I prefer to use a public website: http://www.pascal-hitzler.de/teaching/f12/**

- **The manuscript may also contain drafts of future material, taken from previous lectures, which is subject to change [you can ignore this, but you may find it instructive to take a look].**

- **The new manuscript will be posted shortly before class (usually, the evening before) in a near-final version. The final version will be posted, usually, on the evening of the class session.**

- **The manuscript bears a date (first page) and margin notes indicate the dates when which part was covered (important e.g. for due dates of exercises).**

Course overview

Tentative

We cover Schöning 1.1, 1.2, 1.4, then Ben-Ari 2.6

We cover Schöning 2.1, 2.2, 2.3, then Ben-Ari 5.5

We will also cover basics of Datalog, but there is no suitable textbook reference – please refer to the manuscript.

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