CS 2210 – Logic for Computer Scientists

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Organizational Issues

Any questions?

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!

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”

Origins

- **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.**

Modus ponens

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.

Modus tollens

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.

Modus tollendo ponens

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.

Modus ponendo tollens

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).**

A teaser

"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?