

Logic and Computation: Introduction

Alice Gao
Lecture 1

Come and sit in the front. I won't pick on you. :D

Outline

Let's get acquainted

What is Logic and Computation?

Logistics and Resources

Let's get acquainted

What is Logic and Computation?

Logistics and Resources

Who am I?

My name is Alice Gao. I grew up in Beijing, China, and have lived in Vancouver, Toronto, Cambridge (MA), Cambridge (UK), New York City, and Waterloo.

Research: artificial intelligence, game theory, education.

My work/education history:

- ▶ Lecturer, Computer Science, University of Waterloo.
- ▶ Postdoc, Computer Science, UBC.
- ▶ Ph.D., Computer Science, Harvard University.
- ▶ Undergraduate, Computer Science and Mathematics, UBC.

Hobbies: board games, escape room games, hiking, swimming, and traveling.

Meet your peers

- ▶ In the next 2 minutes, introduce yourself to someone you don't know.
- ▶ Talk about courses, co-op, summer activities, dorms, extracurricular activities...

I'd like to learn your names

On your index card, write	An example
Your name	Xi Gao
Your preferred name and tips for pronunciation	Alice Gao
Student number	15270036
Something interesting about you	I once had a pet hedgehog named Ebbie.

Let's get acquainted

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Logistics and Resources

CQ: Did you bring your clicker today?

Your expectations of this course

What have you heard about this course?

How do you feel about this course?

What do you expect the course to be like?

Some questions to answer

- ▶ Is logic useful especially for computer science?
- ▶ What is logic?
- ▶ Why do we need a formal language for logic?

Is logic useful for computer science?

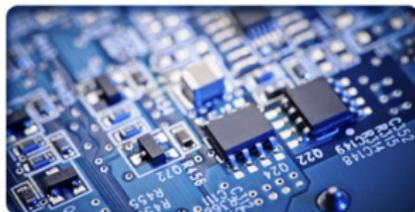
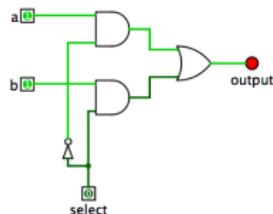
Yes, of course.

Think of at least one application of logic in computer science.

Logic in Computer Science

Circuit Design

- ▶ Digital circuits are the basic building blocks of an electronic computer.



- ▶ CS 251: Computer Organization and Design
CS 350: Operating Systems

Logic in Computer Science

Algorithms and Theory of Computing

- ▶ How much time and memory space do we need to solve a problem?
- ▶ Are there problems that cannot be solved by algorithms?
- ▶ CS 341: Algorithm Design and Analysis
CS 360: Introduction to the Theory of Computing

Logic in Computer Science

Artificial Intelligence

- ▶ 19 billion FCC spectrum auction: Buy airwaves from television broadcasters and sell them to mobile phone carriers.
- ▶ IBM Watson won the Jeopardy Man vs. Machine Challenge
- ▶ CS 486: Artificial Intelligence
CS 485: Machine Learning

Logic in Computer Science

Databases

- ▶ Structural Query Language (SQL) \approx first-order logic
- ▶ Efficient query evaluation based on relational algebra
- ▶ Scale to large databases with parallel processors
- ▶ CS 348: Introduction to Database Management
CS 448: Database Systems Implementation

Logic in Computer Science

Type Theory in Programming Language

- ▶ Propositions in logic \leftrightarrow types in a programming language
- ▶ Proofs of a proposition \leftrightarrow programs with the type
- ▶ Simplifications of proofs \leftrightarrow evaluations of the programs

- ▶ CS 241: The compiler course
CS 442: Principles of Programming Languages
CS 444: Compiler Construction

Logic in Computer Science

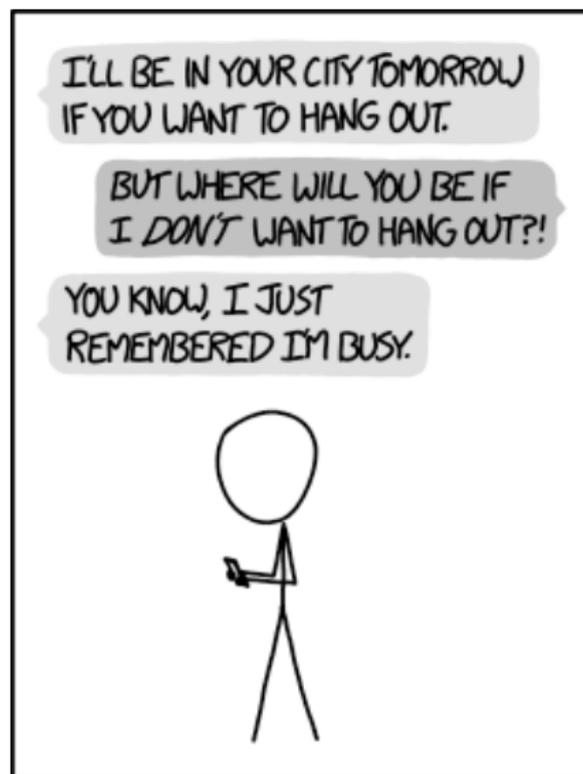
Formal Verification

- ▶ Prove that a program is bug free. Bugs can be **costly and dangerous** in real life.
- ▶ Intel's Pentium FDIV bug (1994) cost them half a billion dollars.
- ▶ Cancer patients died due to severe overdoses of radiation.
- ▶ CS 360: Theory of Computing (Finite Automata)

What is logic?

- ▶ Logic: Logykos (Greek) - pertaining to reasoning
- ▶ Logic = the science of reasoning, inference, and deduction.
- ▶ Logic = the analysis of arguments.

Being logical



WHY I TRY NOT TO BE
PEDANTIC ABOUT CONDITIONALS.

An example of logical deduction

Let's look at two clips from the TV series Sherlock.

Series 1, Episode 1, 9:23

Series 1, Episode 1, 18:00

Logical Arguments

- ▶ Logic is the analysis of arguments.
- ▶ An argument is a set of statements, consisting of one or more premises and a conclusion.
- ▶ Logic studies the forms of the arguments.
It does not study the content.

CQ: Is this argument valid?

The sun rises from the West. (premise)

If the sun rises from the West, then I will eat my hat. (premise)

I will eat my hat. (conclusion)

CQ: Is the above argument valid?

- (A) Yes, it is valid.
- (B) No, it is not valid.
- (C) I don't know...

Why do we need a formal language for logic?

- ▶ The English language is imprecise and ambiguous.
- ▶ Common sense is not always sufficient and reliable.

McDonald's Cheeseburger v.s. Eternal Happiness

Claim: McDonald's cheeseburger is better than eternal happiness.

Proof.

McDonald's cheeseburger is better than nothing.

Nothing is better than eternal happiness.

Since $a > b$ and $b > c$, we can conclude $a > c$.

Then, McDonald's cheeseburger is better than eternal happiness. □

Russell's paradox

Let R be the set of all sets that are not members of themselves.

$$R = \{x \mid x \notin x\}$$

Is R a member of itself?

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Grading

- ▶ Clicker questions (5%)
- ▶ Weekly assignments (20%)
- ▶ Midterm (25%)
 - ▶ Thursday, November 7, 4:30 pm to 6:20 pm
- ▶ Final exam (50%)

Resources

- ▶ **Course website**: things that do not change, e.g. office hours and lecture schedule.
- ▶ **Piazza**: things that do change, e.g. announcements, questions, and discussions.
- ▶ **Learn**: assignments, tutorial notes, assignment and exam solutions, and marks.

How do I succeed in this course?

- ▶ Engage during lectures and tutorials.
- ▶ Practice with the assignments and take advantage of office hours.
- ▶ Use learning goals as a study guide.
- ▶ Struggling is necessary for learning.