CS2209A 2017
Applied Logic for Computer Science

Lecture 1
Introduction, Motivation & Work Plan

Instructor: Yu Zhen Xie

We all do logic

- If it will rain today, I'd better bring an umbrella.
- If a course teaches useful knowledge, I want to take it. CS2209 teaches useful knowledge. Therefore, I want to take CS2209.
- … …
- How about judicial reasoning?

- **We all do logic when we try to clarify reasoning and separate good from bad reasoning.**

Natural vs. Logic language

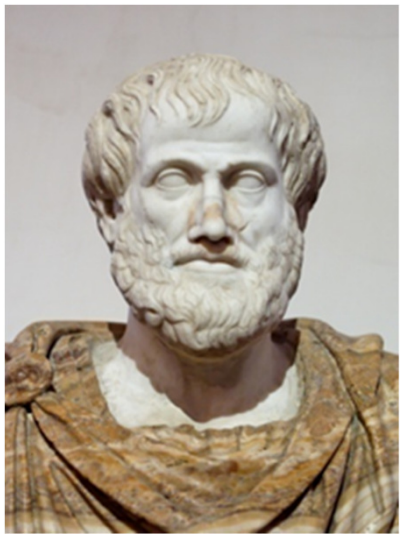
- Natural languages are ambiguous.
- For example, the word "any" can have different meanings depending on the context:
- **Any = some**
  - She will be happy if she can solve any question.
  - She will be happy if she can solve every question.
- **Any = all**
  - Any student knows this.
  - Every student knows this.

What is Logic?

Logic is the Science of Reasoning

- Etymology: Logykos (Greek) - pertaining to reasoning
- Logic: The science of reasoning, proof, thinking, or inference
- Logic: The fundamental science of thoughts and its categories
- Logic: The science or art of reasoning as applied to a department of knowledge
- Logic: The analysis and appraisal of arguments

History of logic



Aristotle (384-322 B.C) developed a general system of logic intended to incorporate the basic principles of good reasoning, and to provide a way to evaluate specific cases of reasoning.

History of logic

- An example of an **Aristotelian syllogism**:
  All humans are mortal.
  Socrates is human.
  Therefore, Socrates is mortal.
- A **syllogism** is a kind of logical argument in which one proposition (the conclusion) is inferred from two or more others (the premises) of a specific form.
- This syllogism is an example of good reasoning - constitutes a good argument - because it is truth-preserving.
- If the first two sentences (premises) are true, then the third sentence (conclusion) must also be true.

Why study logic?

- Enjoyable: game, puzzle, …
- Analytical thinking
- **Knowledge representation and reasoning**
- **Fundamental to Computer Science**
  - Logic gates, electronic circuits
  - Database queries
  - Program analysis
  - Artificial intelligence
    - Automated reasoning
    - Satisfiability (SAT) solver
    - Answer set programming (ASP), …
  - … …

Example application: database queries

- **Predicates | Microsoft Docs**
  https://docs.microsoft.com/en-us/sql/t-sql/queries/predicates

  Predicates are used in the search condition of WHERE clauses and HAVING clauses, the join conditions of FROM clauses, and other constructs where a **Boolean value** is required.

Example application: program analysis

- if (a<b) {
  x = b-a;
  y = a-b;
  } else {
  z = b-a;
  t = a-b;
  }
- Can we make this program more efficient?
- **Compiler optimization!**

Example application: program verification

- Consider the following algorithm for finding the max element in an array:

```
Max(A[1], ..., A[n]):
    m = A[1]
    for i = 2 to n
        if A[i] > m then
            m = A[i]
    return m
```

- **Prove that this algorithm works correctly.**
  What does it mean?
- How about the control system of a vehicle?




Knights and knaves

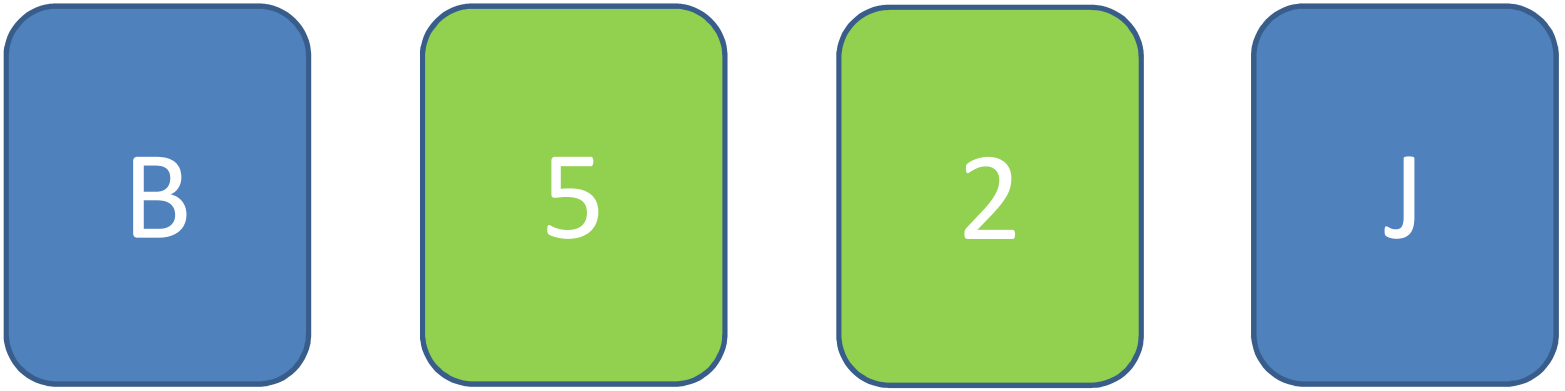
- On a mystical island, there are two kinds of people: knights and knaves. Knights always tell the truth. Knaves always lie.

- Puzzle 1: You meet two people on the island, Arnold and Bob. Arnold says “Either I am a knave, or Bob is a knight”.

  Is Arnold a knight or a knave?
  What about Bob?

A fun game

- You see the following cards. Each has a letter on one side and a number on the other.



- Which cards do you need to turn to check that **“if a card has a J on it then it has a 5 on the other side”?**

Course contents (tentative)

- Propositional logic and Boolean algebra
- Predicate logic (first-order logic) and basic set theory
- Methods of reasoning (incl. induction)
- Applications of logic to database systems and program verification and automated reasoning in artificial intelligence
- Limitations of logic (intractability and Gödel incompleteness theorem)

Work plan

Tentative Quiz (in-class) and Test Schedule

	Given	Due	Weight
Quiz 1	Wed. Sept. 27	8:30-9:00pm	3%
Quiz 2	Wed. Oct. 18	8:30-9:00pm	3%
Midterm Exam	Wed. Oct. 25	7:00-8:50pm	20%
Quiz 3	Wed. Nov. 8	8:30-9:00pm	3%
Quiz 4	Wed. Nov. 22	8:30-9:00pm	3%
Quiz 5	Wed. Dec. 6	8:30-9:00pm	3%
Final Exam	TBA		35%

Work plan

Tentative Assignment and Exercise Schedule

	Given	Due	Weight
Exe. 1	Wed. Sept. 20		
Assignment 1	Fri. Sept. 22	Thur. Oct. 5, midnight	5%
Exe. 2	Wed. Oct. 4		
Assignment 2	Thur. Oct. 5	Thur. Oct. 19, midnight	7%
Exe. 3	Wed. Oct. 18		
Exe. 4	Wed. Nov. 1		
Assignment 3	Thur. Nov. 9	Thur. Nov. 23, midnight	9%
Exe. 5	Wed. Nov. 15		
Assignment 4	Thur. Nov. 23	Thur. Dec. 7, midnight	9%
Exe. 6	Wed. Nov. 29		

Teaching crew & hours

- **Instructor**

  Yu Zhen Xie, PhD

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  Office: Middlesex College, Room 327

  Office hours: 4:30-6:30pm on Tuesdays

  Lecture hours: 3:30-4:30pm, 7:00-9:00pm on Wednesdays

  Lecture room: NS 1

- **Teaching Assistants**
  - Andrew Bloch-Hansen
  - Mehdi Samadieh
  - Linxiao Wang
  - Gurjit Randhawa (tutorial session)
  - Zihao Wang (tutorial session)

Get to know and help each other

- **Who are you?**
  - General science
  - Engineering
  - Computer science
  - Math, statistics, …
- **Questions?**
- **Feedback**
  - Feedback forum
  - Polls
  - Other forms?