Master in Artificial Intelligence and Robotics (AIRO)
Electives in AI
Reasoning Agents

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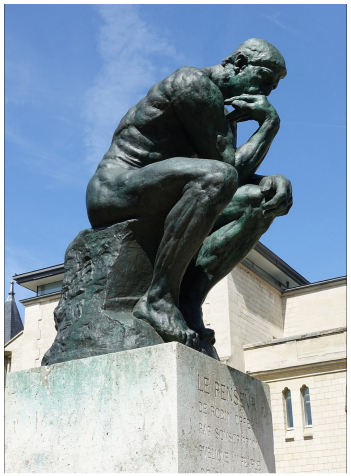
Information

- 3CFU
- Teacher: Fabio Patrizi
  - email: `patrizi@diag.uniroma1.it`
  - webpage: `www.diag.uniroma1.it/patrizi`
- Course website: see section "Teaching" of webpage above
- Classroom: see course website (register ASAP)
- Lectures:
  - Thu 13-17 Room A2 (DIAG)
  - Fri 15-17 Room A2 (DIAG)
- Student hour: Tue 17.00 (see webpage for details)
- Exam: paper presentation + project (joint with HRI)

Course Overview



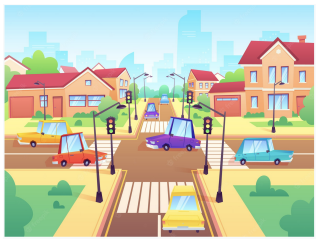
(Automated) Reasoning

- Analysis: observe *world* and draw *conclusions*
- Synthesis: observe *world* and *deliberate* to achieve desired *goals*

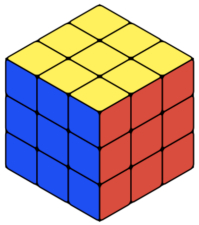
Course Overview

Examples

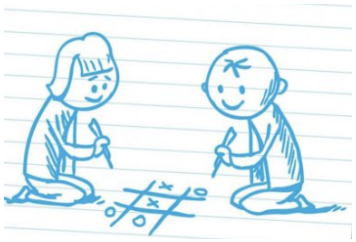
Alice is Bob's sister and Amy Alice's daughter.
Is Bob Amy's uncle? Has Bob any niece? (Analysis)



Can two traffic lights at some crossroad ever be green at the same time? (Analysis)



Given initial configuration, find a plan to solve Rubik's cube (Synthesis)



Find a strategy to win or tie Tic-Tac-Toe (Synthesis)

Course Overview

Automated Reasoning Requirements

- World (or *Domain*) model
- Formalisms for world properties (including goals)
- Formalisms for actions
- Models for plans and strategies
- Algorithms

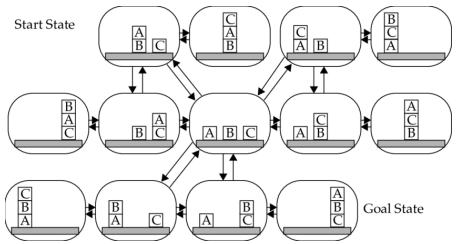
Course Overview

World Model

- *Formal abstract* model capturing relevant information about world
- No focus on representation formalisms (any is fine, e.g., PDDL)

Examples

- Graphs, Transition Systems



- Logical Axioms (e.g., FO)
  - $\forall x, y. \exists z. Sister(z, x) \wedge Daugther(y, z) \rightarrow Uncle(x, y)$
  - $Uncle(x, y) \wedge Female(y) \leftrightarrow Niece(y, x)$
  - $Uncle(x, y) \wedge Male(y) \leftrightarrow Nephew(y, x)$
  - ...

Course Overview

Formalisms for world properties

- To express world properties, e.g.: facts, axioms, assumptions, goals

Examples

- Propositional logic
  - $cloudy$, $cloudy \rightarrow \neg sunny$
- First-order logic
  - $\forall x.Man(x) \rightarrow Mortal(x)$, $Man(Socrates)$
- Temporal logics (many variants)
  - $\mathbf{F}\, sunny$ (it will be sunny some day, from now)
  - $\mathbf{G}(jump \rightarrow \mathbf{F}\, fall)$
    (it's always the case that if you jump, you'll eventually fall)

Course Overview

Formalisms for actions

- To model actions by which agents can change the world

Examples

- PDDL (1.x, 2.x, 3.x) ([GHK+98] and following)

```
(:action pickup
  :parameters (?ob)
  :precondition (and (clear ?ob) (on-table ?ob) (arm-empty))
  :effect (and (holding ?ob) (not (clear ?ob)) (not (on-table ?ob))
                             (not (arm-empty))))
```

- Situation Calculus [Rei01, MH69]

$$Poss(Pickup(x), s) \equiv ArmEmpty(s) \wedge OnTable(x, s) \wedge Clear(x, s)$$
$$ArmEmpty(do(a, s) \equiv (ArmEmpty(s) \wedge a \neq Pickup(x)) \vee a = Drop(x)$$
$$\ldots$$
$$Holding(x, do(a, s)) \equiv a = Pickup(x) \vee (Holding(x, s) \wedge a \neq Drop(x))$$
$$\ldots$$

- And many more...

Course Overview

Models for plans and strategies

- To represent when and which actions to execute

Examples

- Action sequences
  - $pickup(A)$ $stack(A, B)$ $pickup(C)$, $stack(C, B)$,...
- Propositional rules
  - If block A is on table and arm is empty: pickup block A
  - If arm is holding block A: drop block A
- ...

Course Overview

Algorithms

- To perform reasoning
- Use world model and representation formalism to find answer

Examples

- A* (e.g., Planning)
- DPLL (SAT)
- Tableaux methods (Satisfiability)
- Fixpoint computations (Model Checking)
- ...

Course Overview

This course concerns approaches to Automated Reasoning

- Need to study (some) models, formalisms, algorithms
- Some just touched
- Some studied in depth

You will learn how they work and how to use them to design Reasoning Agents!

References I

M. Ghallab, A. Howe, C. Knoblock, D. Mcdermott, A. Ram, M. Veloso, D. Weld, and D. Wilkins.

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