Introduction to KRR

Different Kinds of Reasoning Problems

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Objectives

Objective

Explain several different kinds of reasoning problems studied in KRR

Role of Formal Logic

Formal logic is the field of study of entailment relations, formal languages, truth conditions, semantics, and inference.

All propositions are represented as formulas which have a semantics according to the logic in question.

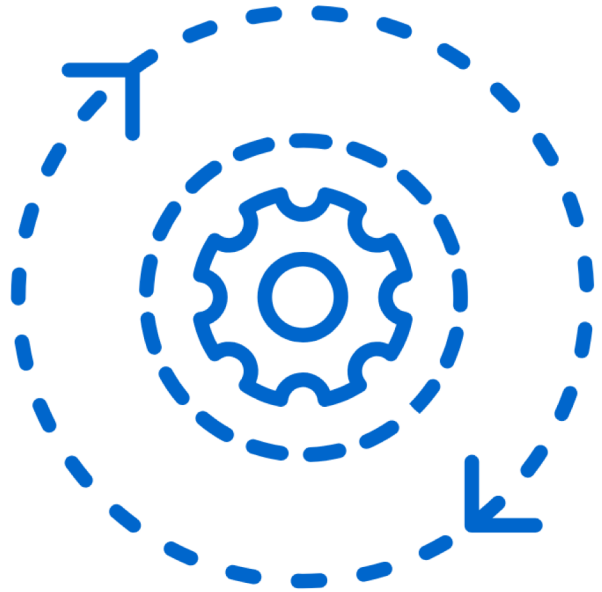
Formal logic gives us a framework to discuss different kinds of reasoning.

- deductive reasoning
- model finding
- abductive reasoning
- default reasoning
- epistemic reasoning
- …

Deductive Reasoning

Usually, we are interested in deriving implicit, entailed facts from a given collection of explicitly represented facts that are logically

- **sound** (the derived proposition must be true, given that the premises are true), and
- **complete** (all true consequences can be derived).



Deductive Reasoning, cont'd

Sometimes, however, we want logically unsound derivations

- e.g., reasoning based on assumptions; reasoning under uncertainty

Sometimes we want to give up completeness

- e.g., for efficiency reasons; computability/complexity

Deductive Reasoning, cont'd

A is green, C is blue, and the color of B is unstated.

Is there a green block next to a block that is not green?

case 1 B is green

yes

case 2 B is not green

yes

A. Yes. B. No C. Not enough information

Model Finding and Satisfiability

In planning and configuration tasks, we often get a set of constraints and a goal specification.

- We then have to find a solution satisfying all the constraints.

Example:

- Either round or square
- Either red or blue
- If red and round or if blue and square then wood
- If blue then metallic
- If square then not metallic
- If red then square

Which object is it?

- Square/round,
- metallic/wood,
- red/blue

Abductive Reasoning

- **Given a background theory, a set of explanations and an observation, find the *most likely explanation***
  - Earthquake implies alarm
  - Burglar implies alarm
  - {earthquake, burglar} is the set of abducibles
  - Alarm is observed
  - One explanation is earthquake…

- **There can be many possible explanations.**
- **Not a sound inference.**

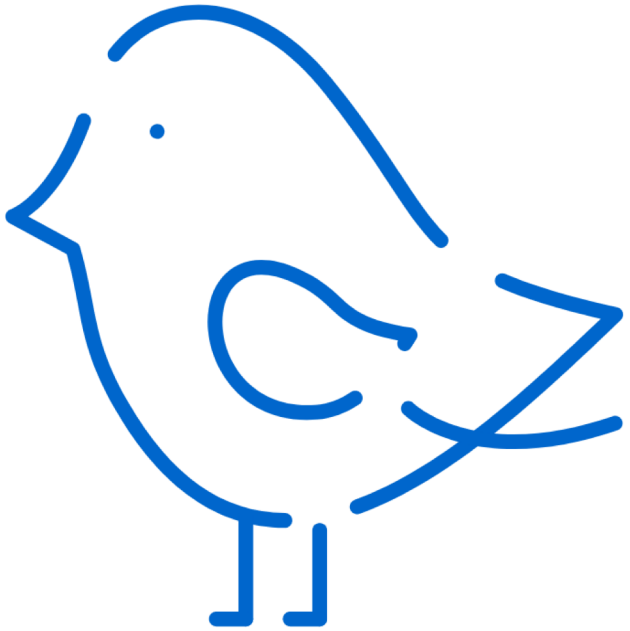
Default Reasoning

- **Jumping to conclusions**
- **Often we do not have enough information, but nevertheless want to reach a conclusion (that is likely to be true)**

- **In the absence of evidence to the contrary, we jump to a conclusion**
  - Birds are usually able to fly.
  - Tweety is a bird.
  - So, you would expect that Tweety is able to fly.

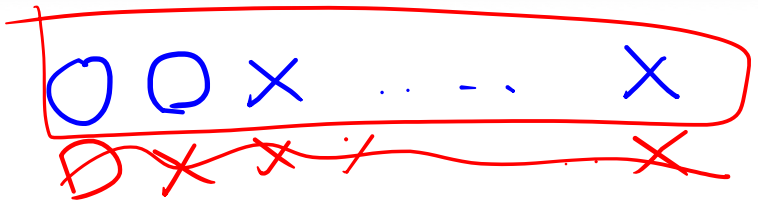
Default Reasoning, cont'd

- Unsound conclusion
- It might be necessary to withdraw conclusions when evidence to the contrary becomes available



Epistemic Reasoning

Reasoning about knowledge



Example: Muddy Children Puzzle

- 10 children are playing together outside. After playing they come inside and their father says to them, “at least one of you has mud on your forehead.”
- Each child can see the mud on others but cannot see his or her own forehead.
- The father then asks the following question: “Do you know if you have mud on your forehead?”
- The children responded “No.”
- Then he asks the same question again, them some children answered they could tell.
- How many children answered?

Many KRR Formalisms

General methods

- SAT, description logics, constraint programming, conceptual graphs, nonmonotonic logics, answer set programming, belief revision, …

Specialized methods: time, space, causation, action

- Temporal reasoning, knowledge and belief, action formalisms

Applications

- Query answering, semantic web, planning, cognitive robotics, multiagent systems

Wrap-Up