IIT Jodhpur

Biological Vision and Applications
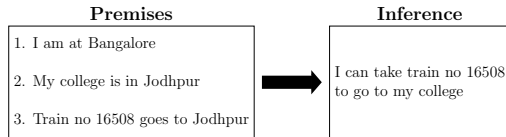# Module 03-01: Reasoning Paradigms

Hiranmay Ghosh
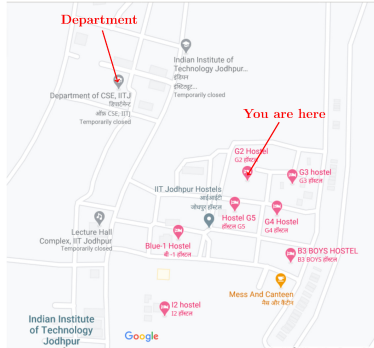
What is "reasoning"

- We "know" some facts
  - Supplied by others
  - Sensed by some sensors (percept)
- We infer unknown facts from the known facts
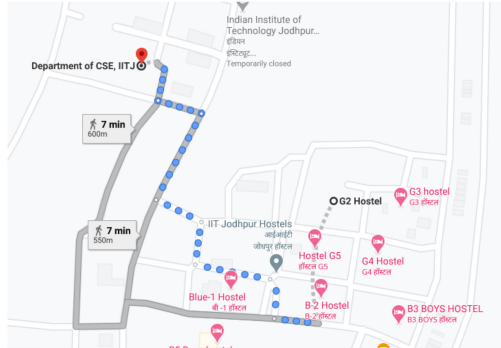
A simple example:

Premises

1. I am at Bangalore
2. My college is in Jodhpur
3. Train no 16508 goes to Jodhpur

→

Inference

I can take train no 16508 to go to my college

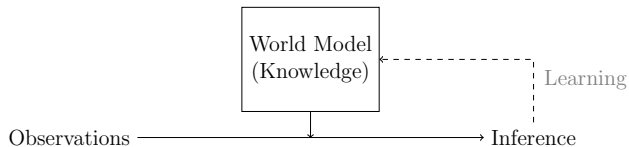# One more example

Premises

Inference

Reasoning paradigms

- In human mind, reasoning is intuitive
- For application to machines, we need to formalize the algorithms

- Reasoning paradigms
  - ▶ Knowledge driven (top-down)
    - ▶ Model based
    - ▶ Case based
  - ▶ Data driven (bottom-up)

Model-based reasoning


- Create a model of the world of discourse (knowledge)
- Interpret observations with that model leading to inference
- Learning: Inference may lead to change in the model

Model-based reasoning is the formal way of interpreting observations with the model

Rule-based reasoning
Also called deductive reasoning

Knowledge / Model:
$\forall x, parrot(x) \rightarrow fly(x)$

Observation:
$parrot(mybird)$

Inference:
$fly(mybird)$
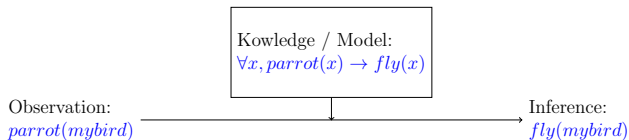
- Formalized as logic
  - ▶ Identical representation for knowledge, observation and inference (statements)
  - ▶ Define some formal rules
  - ▶ Apply an appropriate rules on knowledge + observations to "deduce" new statements

- Many flavors
  - ▶ Propositional calculus, predicate calculus
  - ▶ First order logic, second order logic, ...
  - ▶ Descriptions logic

See Norvig & Russell

Abductive reasoning
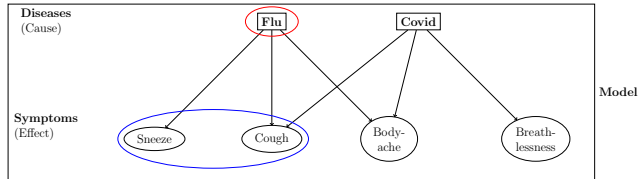
What is the best expnation for the observations ?

- Inexact match – robustness
  - ▶ Model may not be accurate – lack of knowledge
  - ▶ Inherent system uncertainty
  - ▶ Observations may be missing / inaccurate

Comparing deductive and abductive reasoning

- Reasoning is valid in deductive reasoning
  - ▶ If the premises are true, the consequence <u>must</u> be true – can be proved.
  - ▶ Inference <u>may not always be correct</u> for abductive reasoning
- Deductive reasoning can discover facts <u>implied by</u> known facts only
  - ▶ Abductive reasoning can discover <u>new</u> facts
  - ▶ ... e.g., detecting a new human face
- Deductive reasoning needs accurate information on premises
  - ▶ If premises are not accurately known, the reasoning breaks down
 - ▶ Abductive reasoning is robust

Induction
Generalization from observations

- Example: Suppose you observe
  - ▶ Parrot is a bird; parrot can fly
  - ▶ Crow is a bird; crow can fly
  - ▶ Mynah is a bird; mynah can fly
  - ▶ ...
- Now we ask: Hoopoe is a bird; can it fly?
- From your earlier observations
  - ▶ You create a generalized model of a bird
  - ▶ You extrapolate the properties to a new species of bird

- Induction is a special form of abduction

Wait till we study Hierarchial Bayesian Model
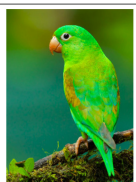
Case based reasoning
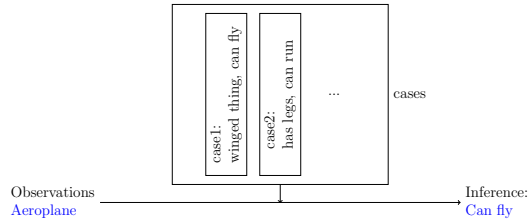
- Difference with Induction:
  - ▶ In induction, a generic model is formed
    - ▶ A new scenario is interpreted with the generic model
  - ▶ In CBR, no generic model is formed, cases exist in isolation
    - ▶ A new scenario is compared with earlier cases and the best match is used
- CBR can work with less experiential data

Exact match vs. Inexact match

- In real world, exact match is never possible
  - ▶ Inherent variations in the natural systems
  - ▶ Our knowledge about the world may be imprecise
- We resort to inexact match
  - ▶ Abduction: "Best" explanation
  - ▶ CBR: "Closest" case
- How to define the "best" or "closest"?
  - ▶ Objective measurement with "features"
  - ▶ The features are assumed to conform to metric space

- Uses statistical similarity/associations to discover patterns
- We learn the models from data
- Flexible – no prior models
- Can't handle sparse and noisy data

Observable data
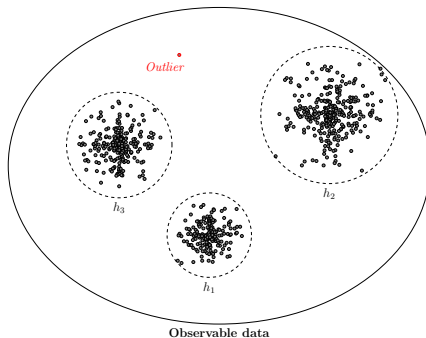
Data driven reasoning
Example

	Sneeze	Cough	Body ache	Breathlessness
Patient 1	X	X	X	
Patient 2	X	X		
Patient 3		X	X	X
Patient 4		X	X	
Patient 5		X	X	X
Patient 6	X	X	X	
Patient 7		X		X
Patient 8	X		X	
Patient 9	X	X	X	
Patient 10			X	X

- No prior knowledge about diseases
- Patients 1, 2, 6, and 8 have similar symptoms → disease 1
- Patients 3,4,5,9 and 10 have similar symptoms → disease 2
- Patient 7 has Unique symptom
  - ▶ Observation error?
  - ▶ A new unknown disease?

- Pros: can discover new patterns (new models)
- Cons: inductive generalization not possible

Which one ?

- Which form of reasoning in used in the human mental processes ?
  - ▶ Probably all of them, depending on context

- Which form of reasoning in used in the human perception ?
  - ▶ Involves processing of sensory data (noisy)
  - ▶ Differences in visual appearance of object instances (uncertainties)
  - ▶ Incomplete model of the world (incomplete knowledge)
  - ▶ Abduction / Induction seem to be most appropriate

EdPuzzle: Bayesian Reasoning

Quiz

Quiz 03-01

End of Module 03-01