CS344: Introduction to Artificial Intelligence

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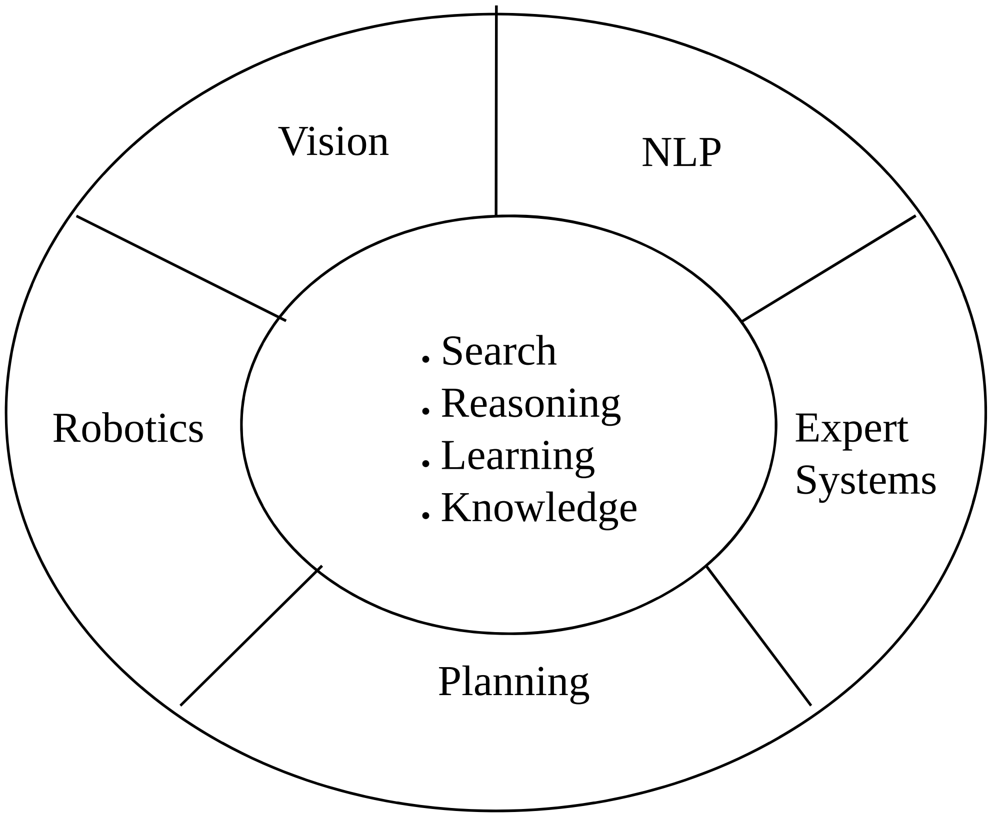
Lecture 7– Predicate Calculus and Knowledge Representation

Logic and inferencing



Obtaining implication of given facts and rules -- Hallmark of intelligence

Inferencing through

- Deduction (General to specific)
- Induction (Specific to General)
- Abduction (Conclusion to hypothesis in absence of any other evidence to contrary)

Deduction

Given: All men are mortal (rule)
Shakespeare is a man (fact)
To prove: Shakespeare is mortal (inference)

Induction

Given: Shakespeare is mortal
Newton is mortal (Observation)
Dijkstra is mortal
To prove: All men are mortal (Generalization)

If there is rain, then there will be no picnic

Deduction

Fact1: There was rain
Conclude: There was no picnic

Fact2: There was no picnic
Conclude: There was no rain (?)

Induction and abduction are fallible forms of reasoning. Their conclusions are susceptible to retraction

Two systems of logic

1) Propositional calculus
2) Predicate calculus

Propositions

- Stand for facts/assertions
- Declarative statements
  - As opposed to interrogative statements (questions) or imperative statements (request, order)

Operators

$$AND(\wedge), OR(\vee), NOT(\neg), IMPLICATION(\Rightarrow)$$

=> and ¬ form a minimal set (can express other operations)

- Prove it.

Tautologies are formulae whose truth value is always T, whatever the assignment is

Model

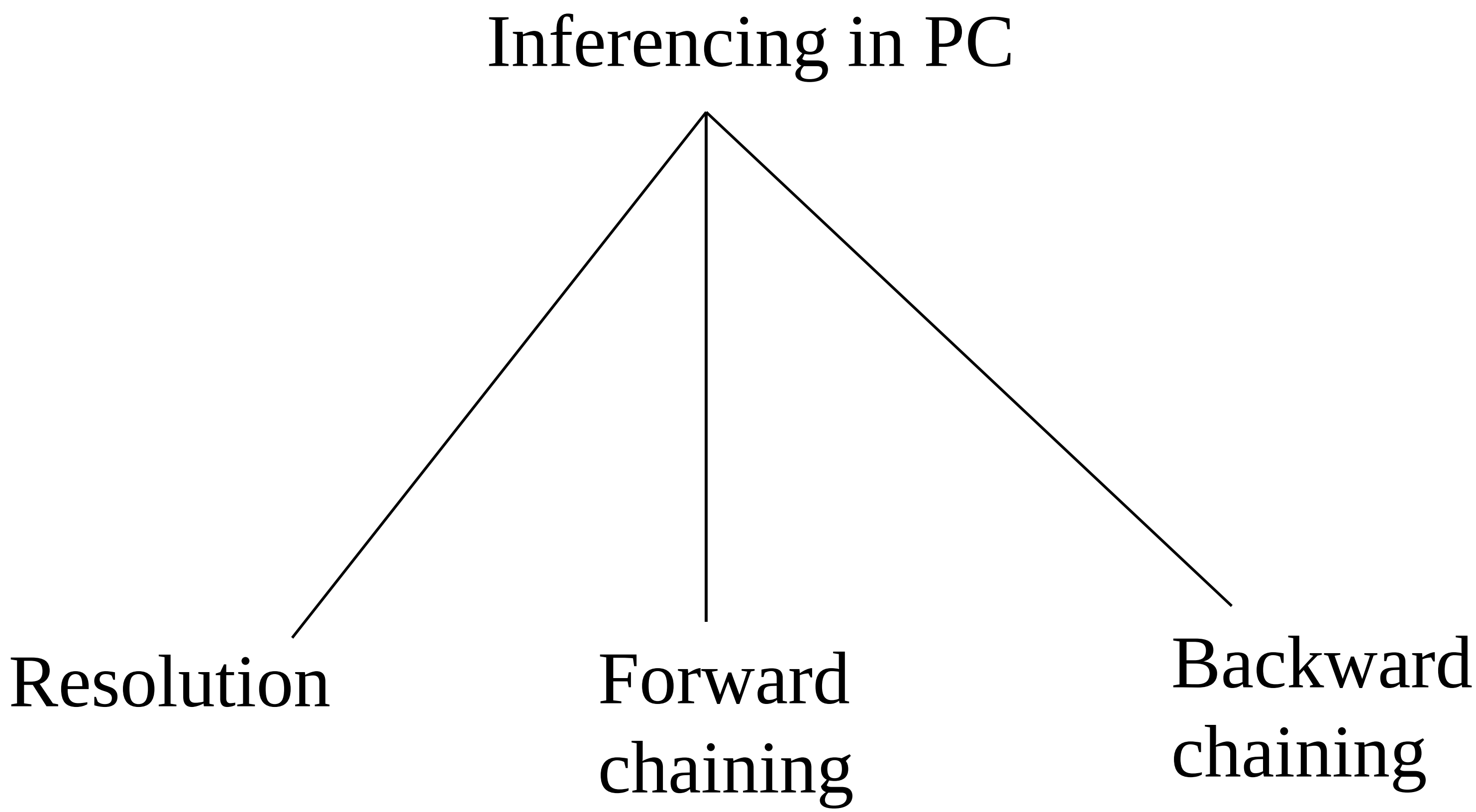
In propositional calculus any formula with n propositions has 2^n models (assignments)
- Tautologies evaluate to T in all models.

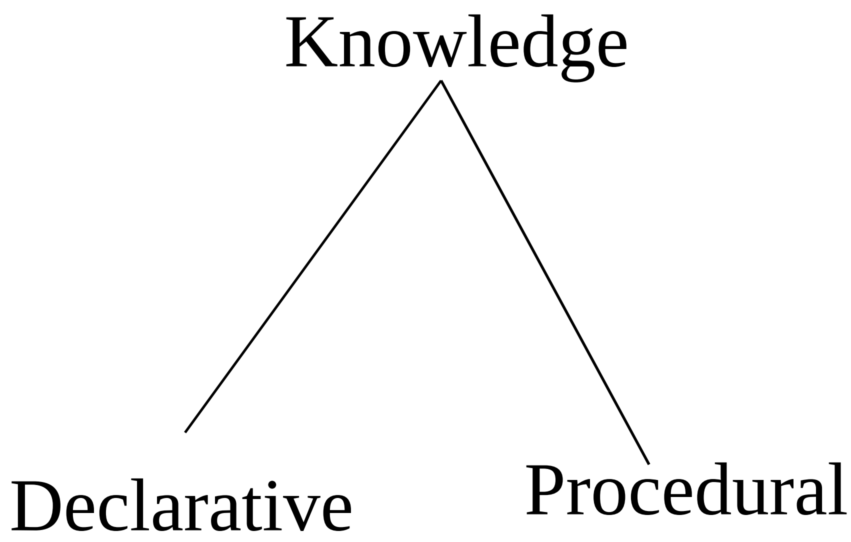
Examples:

1) $P \vee \neg P$

2) $\neg(P \wedge Q) \Leftrightarrow (\neg P \vee \neg Q)$

-e Morgan with AND


Inferencing in PC
Resolution
Forward chaining
Backward chaining



- Declarative knowledge deals with factoid questions (what is the capital of India? Who won the Wimbledon in 2005? etc.)
- Procedural knowledge deals with “How”
- Procedural knowledge can be embedded in declarative knowledge

Example: Employee knowledge base

Employee record

Emp id : 1124

Age : 27

Salary : 10L / annum

Tax : Procedure to calculate tax from basic salary, Loans, medical factors, and # of children

Predicate Calculus

Predicate Calculus: well known examples

- Man is mortal : rule

  $\forall x[man(x) \rightarrow mortal(x)]$

- shakespeare is a man
  man(shakespeare)

- To infer shakespeare is mortal
  mortal(shakespeare)

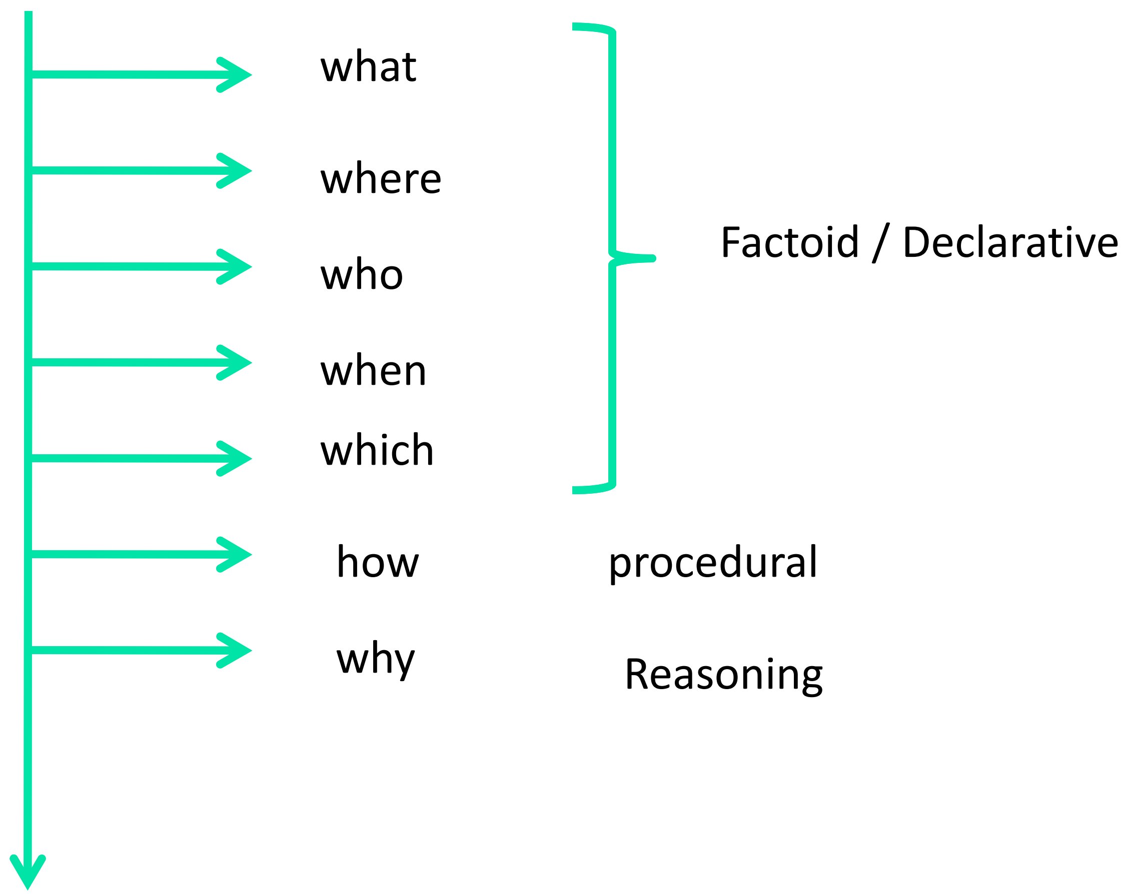
Forward Chaining/ Inferencing

- $man(x) \rightarrow mortal(x)$
  - *Dropping the quantifier, implicitly Universal quantification assumed*
  - *man(shakespeare)*
- Goal mortal(shakespeare)
  - Found in one step
  - x = shakespeare, unification

Backward Chaining/ Inferencing

- $man(x) \rightarrow mortal(x)$
- Goal mortal(shakespeare)
  - x = shakespeare
  - Travel back over and hit the fact asserted
  - man(shakespeare)

Wh-Questions and Knowledge



Fixing Predicates

- Natural Sentences

<Subject> <verb> <object>

Verb(subject,object)

predicate(subject)

Examples

- Ram is a boy
  - Boy(Ram)?
  - Is_a(Ram,boy)?

- Ram Playes Football
  - Plays(Ram,football)?
  - Plays_football(Ram)?

Knowledge Representation of Complex Sentence

- *"In every city there is a thief who is beaten by every policeman in the city"*

$$\forall x[\text{city}(x) \rightarrow \{\exists y((\text{thief}(y) \wedge \text{lives\_in}(y, x)) \wedge \forall z(\text{poleceman}(z, x) \rightarrow \text{beaten\_by}(z, y)))\}]$$