Universidade do Minho
Escola de Engenharia
Departamento de Informática

Programação em Lógica

LICENCIATURA EM ENGENHARIA INFORMÁTICA
MESTRADO integrado EM ENGENHARIA INFORMÁTICA
Inteligência Artificial
2025/26

From the last lesson

Limitations of problem solving problems

- Search systems are very efficient at solving problems that can be formalised by:
  - an initial state, actions and final state (or final states).
- but they are not able to solve problems that require **reasoning based on knowledge about the *world***.
  - Because their *model of the world* is poor and their thinking is limited
    - e.g. medical diagnostics, expert systems in general,...
  - even in cases that are (apparently) solvable by search (using planning), it may be necessary to add explicit knowledge.

- Axioms: initial set of logical formulae
- Theorems: formulae derived from axioms and/or theorems (semantic consequences)
- Inference Rules: set of derivation rules
  - *Modus ponens* $\{(A \text{ se } B), B\} \vdash A$ (*sound* - valid)
  - *Modus tollens* $\{(A \text{ se } B), \neg A\} \vdash \neg B$ (*sound* - valid)
  - *Modus mistakens* $\{(A \text{ se } B), A\} \vdash B$ (*unsound* – not valid)
- Inference system: union of axioms and derivation rules $\mathcal{R}$
- Proof: sequence $\langle s_1, s_2, \ldots \rangle$ of s_i that are axioms or are derivations using $\mathcal{R}$ and a subset of the members of the sequence that precede s_i;
  - The sequence is a proof for s_n (derivation or deduction)
- Theory: union of the axioms and all the theorems derived using $\mathcal{R}$
  - It is said to be consistent if there is no formula s such that, in theory $\mathcal{T}$, there exists s and $\neg s$
- **None of these considerations take meaning into account!**
  Only syntactic structure!!!

- Knowledge and Reasoning;
- Logic;
- **Logic programming;**
- **Knowledge-Based Systems**.

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Logic Programming

- Logic Programming is a computer formalism that combines 2 basic principles:

1. Uses logic to represent knowledge
   (representation of assumptions and conclusions)

1. Use Inference to manipulate knowledge
   (establish logical relationships between assumptions and conclusions)
   (mechanising proof procedures; reasoning)

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Characterisation of Logic Programming
PROLOG

- A programme in PROLOG is created by adding formulas called clauses
- The clauses can be of 3 types:
  - Facts: express something that is always true

    p. son(xico,quim).

  - Rules: express something that is true, depending on the veracity of the conditions

    p if q. father(josé,joão) if son(joão,josé).

  - Questions: express something that is true, depending on the veracity of the conditions

    ?q. ? father(josé,joão).

    ¬q. ¬father (Joseph, John).

Characterisation of Logic Programming
PROLOG

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  - Questions: express something that is true, depending on the veracity of the conditions

    ?q. ? father(josé,joão).

    ¬q. ¬father (Joseph, John).

p if q.

- Horn's Clause (clausal notation of first-order logic)
  - It's a restricted version of Predicative Calculus
  - It's a well-formed formula
  - All formulas are universally quantified
  - All formulas are closed
  - Logical formulae only allow 1 term in the positive disjunction of literals

Horn clauses

  - $\boxed{\neg q \vee p_j}$
    - where $i \geq 0$, $0 \leq j \leq 1$

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Definitions

- Reasoning:
  - A set of linked thoughts
  - Linking facts that lead to a conclusion
  - A mixture of the previous 2

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Definitions

- Reasoning:
  1. …
  2. Logical train of thought
  3. …
  4. [LOGIC] Discursive operation of thought by which we conclude that one or more propositions (premises) imply the truth (…) of another proposition (conclusion).

(in Dicionário da Língua Portuguesa, Porto Editora)

- Three men, António, Belmiro and Carlos, are Dulce, Eduarda and Filipa's spouses.
- We don't know who is married to whom.
- Their backgrounds are in engineering, law and medicine.
- We don't know who does what.
- Based on the data below, find out the name of each wife and the profession of each man:
  - The doctor is married to Filipa;
  - Carlos is a lawyer;
  - Eduarda is not married to Carlos;
  - Belmiro is not a doctor.

(adapted from: www.novaconcursos.com.br/portal/dicas/questao-raciocinio-logico-para-concursos)

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Reasoning and Inference

- In order to convince people that the answer is not "a lucky shot", you need to explain the reasons that lead you to your conclusion!
conclusion!

What does this mean?

- In order to convince people that the answer is not "a lucky shot", you need to explain the reasons that lead you to your conclusion!
conclusion!

What does this mean?

- In order for the conclusion to be accepted, it is necessary to explain the reasoning mechanism applied, i.e. the **process of inference**.

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Definitions

- Inference:
    - It refers to the applied process that allows us to move from premises to conclusion.
    - Inference: deduction or conclusion.

(in Priberam Dictionary of the Portuguese Language)

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Definitions

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- Inference rules:
  - *Modus ponens*:
    - from: P , P → Q
    - it follows: Q

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- Inference:
  - It refers to the applied process that allows us to move from premises to conclusion.
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(in Priberam Dictionary of the Portuguese Language)

- Inference rules:
  - *Modus ponens*: (*modus ponendo ponens Latin meaning "the way that affirms by affirming"*)
    - from: P , P → Q
    - it follows: Q

P	Q	P → Q
$\mathbb{V}$	$\mathbb{V}$	$\mathbb{V}$
$\mathbb{V}$	$\mathbb{F}$	$\mathbb{F}$
$\mathbb{F}$	$\mathbb{V}$	$\mathbb{V}$
$\mathbb{F}$	$\mathbb{F}$	$\mathbb{V}$

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Definitions

- Inference:
  - It refers to the applied process that allows us to move from premises to conclusion.
  - Inference: deduction or conclusion.

(in Priberam Dictionary of the Portuguese Language)

- Inference rules:
  - *Modus ponens*:
    - from: P , $P \rightarrow Q$
    - it follows: Q
  - *Modus tollens*:
    - from: $P \rightarrow Q$, $\neg Q$
    - inferred: $\neg P$

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Definitions

- Inference:
    - It refers to the applied process that allows us to move from premises to conclusion.
    - Inference: deduction or conclusion.

(in Priberam Dictionary of the Portuguese Language)

- Inference rules:
    - *Modus ponens*:
        - from: P , $P \rightarrow Q$
        - it follows: Q
    - *Modus tollens* (Latin: way that negates by negation):
        - from: $P \rightarrow Q$, $\neg Q$
        - inferred: $\neg P$

P	Q	$\neg Q$	$P \rightarrow Q$
$\mathbb{V}$	$\mathbb{V}$	$\mathbb{F}$	$\mathbb{V}$
$\mathbb{V}$	$\mathbb{F}$	$\mathbb{V}$	$\mathbb{F}$
$\mathbb{F}$	$\mathbb{V}$	$\mathbb{F}$	$\mathbb{V}$
$\mathbb{F}$	$\mathbb{F}$	$\mathbb{V}$	$\mathbb{V}$

Resolution Algorithm

- The *modus ponens* inference rule makes it possible to derive the conclusion of a clause as true by proving its conditions:

$$\{ \ (\ A \text{ if } B\ ),\ B \ \} \vdash A$$

Resolution Algorithm

- The *modus ponens* inference rule makes it possible to derive the conclusion of a clause as true by proving its conditions:

$$\{ (\ A \text{ if } B\ ),\ B\ \} \vdash A$$

- Applying the *modus tollens* rule of inference makes it possible to direct the search for proof to a specific point in the reasoning process:

$$\{ (\ A \text{ if } B\ ),\ \neg A\ \} \vdash \neg B$$

- which makes it possible to develop a **mechanism of proof by contradiction**.

Resolution Algorithm

- Suppose we have a programme □ in which we want to determine the derivability of a question A:
  i. Let's admit the negation of A:
  $$\neg A$$
  ii. Insert the negation of A into the programme □:
  $$\mathcal{P} \cup \neg A$$
- If a contradiction occurs
  $$\{ A, \neg A \} \equiv \square$$
  it means that the initial question A is derivable from $\mathcal{P}$.

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Resolution Algorithm

- Suppose we have a programme □ in which we want to determine the derivability of a question A:
  - i. Let's admit the negation of A:

    $$\neg A$$

  - ii. Insert the negation of A into the programme □:

    $$\mathcal{P} \cup \neg A$$

- If a contradiction occurs

  $$\{ A, \neg A \} \equiv \Box$$

  it means that the initial question A is derivable from $\mathcal{P}$.

- Modus tollens inference rule, with B = true

$$\{ (A \text{ se } B), \neg A \} \vdash \neg B$$

$$\{ (A \text{ se } \mathbb{V}), \neg A \} \vdash \neg \mathbb{V}$$

$$\{ A, \neg A \} \vdash \mathbb{F}$$

$$\{ A, \neg A \} \vdash \Box$$

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Resolution Algorithm
Application example

```
% son: Son,Father → {𝕍,𝔽}

son( joao,jose ).
son( jose,manuel ).
son( carlos,jose ).

% father: Father,Son → {𝕍,𝔽}

father( P,F ) :- son( F,P ).
```

Consider the programme $\mathcal{P}$ shown opposite

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Resolution Algorithm
Application example (I)

- Is João José's son?

```
% son: Son,Father → {𝕍 , 𝔽}

son( joao,jose ).
son( jose,manuel ).
son( carlos,jose ).

% father: Father,Son → {𝕍 , 𝔽}

father( P,F ) :- son( F,P ).
```

Let's take the question posed above

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Resolution Algorithm
Application example (I)

- Is João José's son?

  ¬son(john,jose)

```
% son: Son,Father → {𝕍 , 𝔽}

son( joao,jose ).
son( jose,manuel ).
son( carlos,jose ).

% father: Father,Son → {𝕍 , 𝔽}

father( P,F ) :- son( F,P ).
```

In logical terms, the question is described as follows

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Resolution Algorithm
Application example (I)

- Is João José's son?

  ¬son(john,jose)

% son: Son,Father → $\{\mathbb{V}, \mathbb{F}\}$

son(joao,jose).
son(jose,manuel).
son(carlos,jose).

% father: Father,Son → $\{\mathbb{V}, \mathbb{F}\}$

father(P,F) :- son(F,P).

Of all the clauses in the programme $\mathcal{P}$, only those that offer conclusions about the predicate father/2 will contribute to the development of the test

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Resolution Algorithm
Application example (I)

- Is João José's son?

  ¬son(john,jose)

```
% son: Son,Father → {𝕍 , 𝔽}

son( joao,jose ).
son( jose,manuel ).
son( carlos,jose ).

% father: Father,Son → {𝕍 , 𝔽}

father( P,F ) :- son( F,P ).
```

Of the three clauses listed, the first will be used in the first step of developing the (tree of) evidence

Resolution Algorithm
Application example (I)

- Is João José's son?

¬son(john,jose)

joao | joao, jose | jose

% son: Son,Father → $\{\mathbb{V}, \mathbb{F}\}$

son(joao,jose).
son(jose,manuel).
son(carlos,jose).

% father: Father,Son → $\{\mathbb{V}, \mathbb{F}\}$

father(P,F) :- son(F,P).

The word joao unites with joao; the word jose unites with jose;

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Resolution Algorithm
Application example (I)

- Is João José's son?

¬son(john,jose)

joao | joao, jose | jose

¬(true)

% son: Son,Father → $\{\mathbb{V}, \mathbb{F}\}$

son(joao,jose).
son(jose,manuel).
son(carlos,jose).

% father: Father,Son → $\{\mathbb{V}, \mathbb{F}\}$

father(P,F) :- son(F,P).

Under the conditions established by the unifications, which used the first clause of $\mathcal{P}$, the initial question is reduced to the current one, because it is a fact

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Resolution Algorithm
Application example (I)

- Is João José's son?

¬son(john,jose)

joao | joao, jose | jose

¬(true)

–|–

□

% son: Son,Father → {𝕍 , 𝔽}

son(joao,jose).
son(jose,manuel).
son(carlos,jose).

% father: Father,Son → {𝕍 , 𝔽}

father(P,F) :- son(F,P).

From which a contradiction can be drawn □ (regardless of any unifications)

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Resolution Algorithm
Application example (II)

- Is José João's father?

```
% son: Son,Father → {𝕍,𝔽}

son( joao,jose ).
son( jose,manuel ).
son( carlos,jose ).

% father: Father,Son → {𝕍,𝔽}

father( P,F ) :- son( F,P ).
```

You want to know if José is João's father

Resolution Algorithm
Application example (II)

- Is José João's father?

  ¬father(jose,joao)

% son: Son,Father → $\{\mathbb{V}, \mathbb{F}\}$

son(joao,jose).
son(jose,manuel).
son(carlos,jose).

% father: Father,Son → $\{\mathbb{V}, \mathbb{F}\}$

father(P,F) :- son(F,P).

In logical terms, the question is described as follows

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Resolution Algorithm
Application example (II)

- Is José João's father?

  ¬father(jose,joao)

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% son: Son,Father → {𝕍 , 𝔽}

son( joao,jose ).
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% father: Father,Son → {𝕍 , 𝔽}

father( P,F ) :- son( F,P ).
```

Of all the clauses in the $\mathcal{P}$ programme, only those that offer conclusions about the father/2 predicate will contribute to the development of the test

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Resolution Algorithm
Application example (II)

- Is José João's father?

  ¬father(jose,joao)

```
% son: Son,Father →  {𝕍 , 𝔽}

son( joao,jose ).
son( jose,manuel ).
son( carlos,jose ).

% father: Father,Son →  {𝕍 , 𝔽}

father( P,F ) :- son( F,P ).
```

The only clause of the father/2 predicate that has been ticked will be used in the first step of developing the (proof) tree

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Resolution Algorithm
Application example (II)

- Is José João's father?

  ¬father(jose,joao)

  jose | P, joao | F

% son: Son,Father → $\{\mathbb{V}, \mathbb{F}\}$

son(joao,jose).
son(jose,manuel).
son(carlos,jose).

% father: Father,Son → $\{\mathbb{V}, \mathbb{F}\}$

father(P,F) :- son(F,P).

The term jose unifies with the variable P; the term joao unifies with the variable F;

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Resolution Algorithm
Application example (II)

- Is José João's father?

¬father(jose,joao)

jose | P, joao | F

¬child(john,jose)

% son: Son,Father • {?,•}

son(joao,jose).
son(jose,manuel).
son(carlos,jose).

% father: Father,Son • {?,•}

father(P,F) :- son(F,P).

To continue the (tree of) proof, the initial question is reduced to proof of the conditions of the clause used to make the unifications

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Resolution Algorithm
Application example (II)

- Is José João's father?

¬father(jose,joao)

jose | P, joao | F

¬son(john,jose)

% son: Son,Father → $\{\mathbb{V}, \mathbb{F}\}$

son(joao,jose).
son(jose,manuel).
son(carlos,jose).

% father: Father,Son → $\{\mathbb{V}, \mathbb{F}\}$

father(P,F) :- son(F,P).

Of all the clauses in the programme $\mathcal{P}$, only those that offer conclusions about the predicate son/2 will contribute to the development of the test

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Resolution Algorithm
Application example (II)

- Is José João's father?

¬father(jose,joao)

jose | P, joao | F

¬son(john,jose)

```
% son: Son,Father → {𝕍 , 𝔽}

son( joao,jose ).
son( jose,manuel ).
son( carlos,jose ).

% father: Father,Son → {𝕍 , 𝔽}

father( P,F ) :- son( F,P ).
```

Of the three clauses listed, the first will be used in the first step of developing the (tree of) evidence

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Resolution Algorithm
Application example (II)

- Is José João's father?

¬father(jose,joao)

jose | P, joao | F

¬son(john,jose)

joao | joao, jose | jose

% son: Son,Father → $\{\mathbb{V}, \mathbb{F}\}$

son(joao,jose).
son(jose,manuel).
son(carlos,jose).

% father: Father,Son → $\{\mathbb{V}, \mathbb{F}\}$

father(P,F) :- son(F,P).

The word joao unites with joao; the word jose unites with jose;

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Resolution Algorithm
Application example (II)

- Is José João's father?

¬father(jose,joao)

jose | P, joao | F

¬son(john,jose)

joao | joao, jose | jose

¬(true)

% son: Son,Father → $\{\mathbb{V}, \mathbb{F}\}$

son(joao,jose).
son(jose,manuel).
son(carlos,jose).

% father: Father,Son → $\{\mathbb{V}, \mathbb{F}\}$

father(P,F) :- son(F,P).

Under the conditions established by the unifications, which used the first clause of $\mathcal{P}$, the previous question is reduced to the current one, because it is a fact

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Resolution Algorithm
Application example (II)

- Is José João's father?

¬father(jose,joao)

jose | P, joao | F

¬child(john,jose)

joao | joao, jose | jose

¬(true)

–|–

□

% son: Son,Father → {𝕍 , 𝔽}

son(joao,jose).
son(jose,manuel).
son(carlos,jose).

% father: Father,Son → {𝕍 , 𝔽}

father(P,F) :- son(F,P).

From which a contradiction can be drawn □ (regardless of any unifications)

Resolution Algorithm
Application example (III)

- Is José John's son?

```
% son: Son,Father → {𝕍 , 𝔽}

son( joao,jose ).
son( jose,manuel ).
son( carlos,jose ).

% father: Father,Son → {𝕍 , 𝔽}

father( P,F ) :- son( F,P ).
```

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Resolution Algorithm
Application example (III)

- Is José John's son?

```
% son: Son,Father → {𝕍,𝔽}

son( joao,jose ).
son( jose,manuel ).
son( carlos,jose ).

% father: Father,Son → {𝕍,𝔽}

father( P,F ) :- son( F,P ).
```

Let's take the question posed above

Resolution Algorithm
Application example (III)

- Is José John's son?

  ¬son(jose,joao)

% son: Son,Father → $\{\mathbb{V}, \mathbb{F}\}$

son(joao,jose).
son(jose,manuel).
son(carlos,jose).

% father: Father,Son → $\{\mathbb{V}, \mathbb{F}\}$

father(P,F) :- son(F,P).

In logical terms, the question is described as follows; of the three clauses in the predicate son/2, the first will be used to develop the (tree of) evidence

Resolution Algorithm
Application example (III)

- Is José John's son?

¬son(jose,joao)

jose | ~~joao~~, ...

% son: Son,Father → $\{\mathbb{V}, \mathbb{F}\}$

son(joao,jose).
son(jose,manuel).
son(carlos,jose).

% father: Father,Son → $\{\mathbb{V}, \mathbb{F}\}$

father(P,F) :- son(F,P).

The term jose does not unify with joao because they are two different constants, so the proof procedure cannot evolve through this branch of proof

Resolution Algorithm
Application example (III)

- Is José John's son?

¬son(jose,joao)

jose | ~~joao~~, ...

% son: Son,Father $\rightarrow \{\mathbb{V}, \mathbb{F}\}$

son(joao,jose).
son(jose,manuel).
son(carlos,jose).

% father: Father,Son $\rightarrow \{\mathbb{V}, \mathbb{F}\}$

father(P,F) :- son(F,P).

Abandoning the first clause, the second is taken as an alternative to continue the development of the (tree of) proof;

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Resolution Algorithm
Application example (III)

- Is José John's son?

¬son(jose,joao)

jose | ~~joao~~, ...

jose | jose, joao | ~~manuel~~

% son: Son,Father → $\{\mathbb{V}, \mathbb{F}\}$

son(joao,jose).
<u>son(jose,manuel).</u>
son(carlos,jose).

% father: Father,Son → $\{\mathbb{V}, \mathbb{F}\}$

father(P,F) :- son(F,P).

The term jose unifies with jose; the term joao does not unify with manuel because they are two different constants, so the proof procedure cannot evolve through this branch of proof

Resolution Algorithm
Application example (III)

- Is José John's son?

¬son(jose,joao)

jose | ~~joao~~, ...

jose | jose, joao | ~~manuel~~

% son: Son,Father → $\{\mathbb{V}, \mathbb{F}\}$

son(joao,jose).
son(jose,manuel).
<u>son(carlos,jose).</u>

% father: Father,Son → $\{\mathbb{V}, \mathbb{F}\}$

father(P,F) :- son(F,P).

Also abandoning the second clause, the third (and last) is taken as an alternative to give continuity to the development of the (tree of) proof

Resolution Algorithm
Application example (III)

- Is José John's son?

¬son(jose,joao)

jose ~~| joao~~, ...

jose | jose, joao ~~| manuel~~

jose ~~| carlos~~, ...

% son: Son,Father → $\{\mathbb{V}, \mathbb{F}\}$

son(joao,jose).
son(jose,manuel).
son(carlos,jose).

% father: Father,Son → $\{\mathbb{V}, \mathbb{F}\}$

father(P,F) :- son(F,P).

The term jose does not unify with carlos because they are two different constants, so the proof procedure cannot evolve through this branch of proof

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Resolution Algorithm
Application example (III)

- Is José John's son?

¬son(jose,joao)

jose | ~~joao~~, ...

jose | jose, joao | ~~manuel~~

jose | ~~carlos~~, ...

% son: Son,Father → $\{\mathbb{V}, \mathbb{F}\}$

```
son( joao,jose ).
son( jose,manuel ).
son( carlos,jose ).
```

% father: Father,Son → $\{\mathbb{V}, \mathbb{F}\}$

```
father( P,F ) :- son( F,P ).
```

As there are no more clauses in the son/2 predicate that can be considered as alternatives in the (proof) tree, the procedure of applying the resolution algorithm ends without reaching any contradiction

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Resolution Algorithm
Application example (III)

- Is José John's son?

¬son(jose,joao)

jose ~~| joao~~, ...

jose | jose, joao ~~| manuel~~

jose ~~| carlos~~, ...

~~Is José John's son?~~

% son: Son,Father → $\{\mathbb{V},\mathbb{F}\}$

son(joao,jose).
son(jose,manuel).
son(carlos,jose).

% father: Father,Son → $\{\mathbb{V},\mathbb{F}\}$

father(P,F) :- son(F,P).

This means that the initial question doesn't generate any contradiction at $\mathcal{P}$, so it's false.

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Resolution Algorithm
Application example (IV)

¬ son(X,jose)

What is the meaning of this question?

Develop the evidence tree for this question

% son: Son,Father → $\{\mathbb{V}, \mathbb{F}\}$

```
son( joao,jose ).
son( jose,manuel ).
son( carlos,jose ).
```

% father: Father,Son → $\{\mathbb{V}, \mathbb{F}\}$

```
father( P,F ) :- son( F,P ).
```

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factorial(0,1):-!
factorial(N,F):-N1 is N-1,factorial(N1,F1),F is N*F1.

Let's see what happens when you call ?- factorial(3,F).

F=6

factorial(0,1) failure

factorial(3,F):-N1 ⟵ 3-1,factorial(2,F1) , F is 3*2. success (w/ F ⟵ 6)

factorial(0,1) failure

factorial(2,F):-N1 ⟵ 2-1,factorial(1,F1) , F is 2*1. success (w/ F ⟵ 2)

factorial(0,1) failure

factorial(1,F):-N1 ⟵ 1-1,factorial(0,F1) , F is 1*1. success (w/ F ⟵ 1)

factorial(0,1):-!. success

- These are systems that
  - They use explicitly represented knowledge to solve complex problems;
  - They manipulate knowledge and information;
  - They have "encrusted" the ability to reason:
    - The ability to define a set of steps for efficiently solving a problem;
    - The very mechanism of inference is knowledge.

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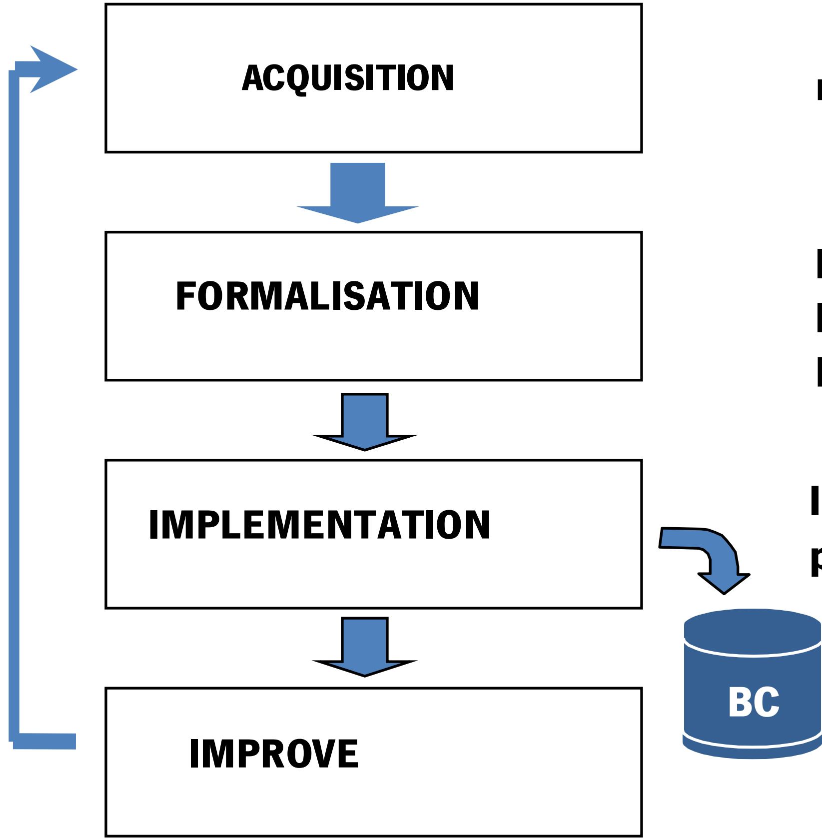
Knowledge-Based Systems

Level of Expertise

Logic Level

Level of Implementation



natural language

language of language knowledge

languages programme

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Types of Reasoning

- **Deduction**
  - facts + inference rules => new facts
  - cause → effect
    - If there is fire (cause), there is smoke (effect). There's fire here, so there's smoke here (new fact)
  - It's the only type of inference that holds true
    - *truth-preserving*
- **Abduction**
  - reverse deduction: from effect to cause
    - If there's smoke, there's fire. I saw smoke (effect), so there's fire here (cause)
  - This type of inference maintains the falsehood
  - We have generated a possible explanation that will have to be proven

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Types of Reasoning

- **Induction**
  - part of the facts to generate (new) rules
    - fact1 + fact2 + fact3 → rule!
    - ex. Mr Joaquim, like Mrs Isabel, has the flu and a headache, so everyone who has the flu has a headache
  - It transforms facts (knowledge in extension) into knowledge in the form of a hypothesis!
- **Analogue**
  - facts + similarities + adaptation rules
  - from facts, from the similarity between them, solves the problem without generating rules
    - e.g.: In the previous case of flu, I took an aspirin and it didn't work, so I'm not going to take aspirin in this similar case

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Reasoning in practice

- Deduction and Abduction
  - They are used in knowledge-based agents
- Induction and Analogy
  - They are used in machine learning

- Deduction: there are two large groups
  - Logic and the like
  - Treatment of uncertainty (e.g. probabilistic or *fuzzy*)

Prolog implementations

SWI-Prolog - A Free Software Prolog environment, licensed under the Lesser GNU public licence. This popular interpreter was developed by Jan Wielemaker. This is the interpreter we used while developing this book.
http://www.swi-prolog.org/

SICStus Prolog - Industrial strength Prolog environment from the Swedish Institute of Computer Science. http://www.sics.se/sicstus/

GNU Prolog - Another more widely used free Prolog compiler developed by Daniel Diaz. http://www.gprolog.org

YAP Prolog - A Prolog compiler developed at the University of Porto and Federal University of Rio de Janeiro. Free for use in academic environments.
http://www.ncc.up.pt/~vsc/Yap/

Synthetic Intelligence Lab

Recommended Bibliography

- Ivan Bratko, PROLOG: Programming for Artificial Intelligence, 4th Edition, Addison-Wesley Longman Publishing Co., Inc., ISBN-13: 978-0321417466, 2011.

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Departamento de Informática

Logic Programming

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