Universidade do Minho
Escola de Engenharia
Departamento de Informática

Knowledge Representation

Prolog

MESTRADO INTEGRADO EM ENGENHARIA INFORMÁTICA
Sistemas de Representação de Conhecimento e Raciocínio

Fevereiro 2020

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Summary

- Introduction to Prolog;
- Facts, Rules and Queries;
- Prolog Syntax.

Prolog

- "Programming with Logic";
- Different from other programming languages;
- Declarative;
- Recursion;
- Relations;
- Unification;

Prolog

- Describe the problem in hands;
- Ask a Question.
- Prolog:
  - logically deduces new facts about the problem in hands;
  - returns its deductions as answers.

Prolog

- Think declaratively, not procedurally;
- Challenging;
- Requires a different approach;
- High-level language;
- Relatively low efficiency ;
- Rapid prototyping;
- Useful in many AI applications (knowledge representation, inference).

Prolog

- Programming in Prolog is :
  - Providing axioms that indicate some facts about the world;
  - Providing rules that allow to infer other facts about the world.
- What should be computed rather then how it should be computed…

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Syntax of Prolog

- Facts, rules and queries are built out off Prolog terms;

- A term is either:
  - A constant, which can be either an atom or a number;
  - A variable;
  - A complex term.

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Atoms

- A sequence of characters of upper-case letters, lower-case letters, digits, or underscore, starting with a lowercase letter
  - **Examples: mae, somaNumeros, jogar**
- An arbitrary sequence of characters enclosed in single quotes
  - **Examples: ‘Manuel', ‘Abraço', '@$%'**
- A sequence of special characters
  - **Examples: : , ; . :-**

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Numbers

- Integers:
  - 12, -34, 22342
- Floats:
  - 3473.32, 0.4567

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Variables

- A sequence of characters of upper- case letters, lower-case letters, digits, or underscore, starting with either an uppercase letter or an underscore
- **Examples:**
  - **X, Y, Variable, Ana, _tag**
  - underscore (_) represents an unknown variable

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Complex Terms

- Atoms, numbers and variables are building blocks for complex terms;
- Complex terms are built out of a functor directly followed by a sequence of arguments;
  - Arguments are put in round brackets, separated by comas;
  - The functor must be an atom.

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Complex terms

- Examples:
  - toca(joana).
  - gosta(mario, ana).
  - inveja(miguel, mario).

- Complex terms inside complex terms:
  - relacao(X,pai(pai(pai(rui))))

Arity

- The number of arguments a complex term has is called its arity

- **Examples:**

- **mulher(sara) is a term with arity 1**

gosta(vicente,sara) arity 2

pai(pai(rui)) arity 1

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Arity is important

- Predicates with the same functor but with different arity are not the same!
- Arity of predicate usually indicated with the suffix "/" followed by a number to indicate the arity

- Example: filho/2

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Example of Arity

```
feliz(ana).
ouvemusica(carlos).
ouvemusica(ana):- feliz(ana).
tocapiano(ana):- ouvemusica(ana).
tocapiano(joana):- ouvemusica(joana).
```

- This knowledge base defines
  - feliz/1
  - ouvemusica/1
  - tocapiano/1

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Knowledge Base example 1

```
mulher(ana).
mulher(joana).
tocaGuitarra(joana).
festa.


?- mulher(ana).
 yes
?- tocaGuitarra(joana).
yes
?- tocaGuitarra(ana).
 no
```

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Knowledge Base example 1

```
mulher(ana).
mulher(joana).
mulher(paula).
tocaguitarra(joana).
festa.

?- tatuada(joana).
! Existence error in user: tatuada/1
?-


?-concertoRock.


(answer?)
```

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Knowledge Base example 2

```
feliz(paula).
ouveMusica(ana).
ouveMusica(paula):- feliz(paula).
tocaguitarra(ana):- ouveMusica(ana).
tocaGuitarra(paula):- ouveMusica(paula).
```

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Knowledge Base example 2

feliz(paula). fact

ouveMusica(ana). fact

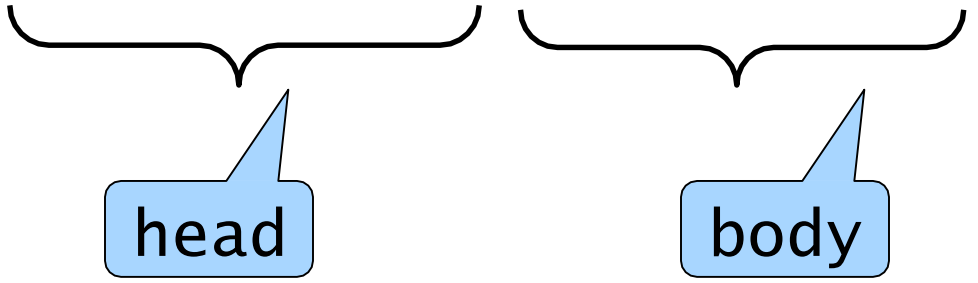
ouveMusica(paula):- feliz(paula). rule

tocaGuitarra(ana):- ouveMusica(ana). rule

tocaGuitarra(paula):- ouvemusica(paula). rule

Knowledge Base
Example 2

```
feliz(paula).
ouveMusica(ana).
ouveMusica(paula):- feliz(paula).
tocaGuitarra(ana):- ouveMusica(ana).
tocaGuitarra(paula):- ouveMusica(paula).
```



Knowledge Base example 2

```
feliz(paula).
ouveMusica(marco).
ouveMusica(paula):- feliz(paula).
tocaGuitarra(marco):- ouveMusica(marco).
tocaGuitarra(paula):- ouveMusica(paula).
```

```
?- tocaguitarra(marco).
yes
?- tocaGuitarra(paula).
yes
```

Clauses

```
feliz(paula).
ouveMusica(marco).
ouveMusica(paula):- feliz(paula).
tocaGuitarra(marco):- ouveMusica(marco).
tocaGuitarra(paula):- ouveMusica(paula).
```

There are five clauses in this knowledge base: two facts, and three rules.

The end of a clause is marked with a full stop.

Predicates

```
feliz(paula).
ouveMusica(marco).
ouveMusica(paula):- feliz(paula).
tocaGuitarra(marco):- ouveMusica(marco).
tocaGuitarra(paula):- ouveMusica(paula).
```

There are three predicates in this knowledge base:

feliz, ouveMusica, and tocaGuitarra

Expressing Conjunction

```
feliz(bruno).
ouveMusica(miguel).
tocaGuitarra(bruno):- ouveMusica(bruno), feliz(bruno).
tocaGuitarra(miguel):- feliz(miguel).
tocaGuitarra(miguel):- ouveMusica(miguel).
```

The comma "," expresses conjunction in Prolog

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Knowledge Base example 3

```
feliz(bruno).
ouveMusica(miguel).
tocaGuitarra(bruno):- ouveMusica(bruno), feliz(bruno).
tocaGuitarra(miguel):- feliz(miguel).
tocaGuitarra(miguel):- ouveMusica(miguel).

?- tocaGuitarra(bruno).
no
?-
```

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Knowledge Base example 3

```
feliz(bruno).
ouveMusica(miguel).
tocaGuitarra(bruno):- ouveMusica(bruno), feliz(bruno).
tocaGuitarra(miguel):- feliz(miguel).
tocaGuitarra(miguel):- ouveMusica(miguel).

?- tocaGuitarra(miguel).
yes
?-
```

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Expressing Disjunction

feliz(bruno).
ouveMusica(miguel).
tocaguitarra(bruno):- ouveMusica(bruno), feliz(bruno).
tocaGuitarra(miguel):- feliz(miguel).
tocaGuitarra(miguel):- ouveMusica(miguel).

feliz(bruno).
ouveMusica(miguel).
tocaGuitarra(bruno):- ouveMusica(bruno), feliz(bruno).
tocaGuitarra(miguel):- feliz(miguel); ouveMusica(miguel).

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Knowledge Base example 4

```
mulher(ana).
mulher(berta).
mulher(paula).

gosta(mario, ana).
gosta(miguel, ana).
gosta(pedro, helena).
gosta(helena, pedro).
```

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Knowledge Base example 4

```
mulher(ana).
mulher(berta).
mulher(paula).

gosta(mario, ana).
gosta(miguel, ana).
gosta(pedro, helena).
gosta(helena, pedro).
```

```
?- mulher(X).
X=ana;
X=berta;
X=paula;
 no
```

Knowledge Base example 4

```
mulher(ana).
mulher(berta).
mulher(paula).

gosta(mario, ana).
gosta(miguel, ana).
gosta(pedro, helena).
gosta(helena, pedro).

?- gosta(mario,X), woman(X).
X=ana
yes
?-
```

Knowledge Base example 4

```
mulher(ana).
mulher(berta).
mulher(paula).

gosta(mario, ana).
gosta(miguel, ana).
gosta(pedro, helena).
gosta(helena, pedro).

?- gosta(pedro,X), woman(X)
No
?-
```

Knowledge Base example 5

```
gosta(miguel,ana).
gosta(bruno,ana).
gosta(pedro, helena).
gosta(helena, pedro).

ciume(X,Y):- gosta(X,Z), gosta(Y,Z).
```

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Knowledge Base example 5

```
gosta(miguel,ana).
gosta(bruno,ana).
gosta(pedro, helena).
gosta(helena, pedro).

ciume(X,Y):- gosta(X,Z), gosta(Y,Z).

?- ciume(bruno,W).
W=miguel
?-
```

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References

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- Prolog Programming for Artificial Intelligence (4th Edition), Ivan Bratko, ISBN-13: 978-0321417466, 2011.
- Inteligência Artificial-Fundamentos e Aplicações, E.Costa, A.Simões; FCA, ISBN: 978-972-722-340-4, 2008.
- Artificial Intelligence: Foundations of Computational Agents, Poole and Mackworth, 2nd ed., ISBN 978-1107195394, 2017.
- Learn prolog Now!, http://www.learnprolognow.org/index.php

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Some Prolog Implementations

SWI-Prolog - A Free Software Prolog environment, licensed under the Lesser GNU public license. 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 Universidade do Porto and Universidade Federa do Rio de Janeiro. Free for use in academic environments.
http://www.ncc.up.pt/~vsc/Yap/

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