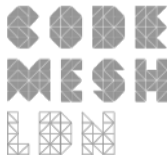




Programmation en Logique

Lars Hupel

November 8th, 2018





PROLOG

PROLOG

PROLOG

PROLOG

PROLOG

PROLOG

coffee bags: 100kr

PROLOG

PROLOG

PROLOG

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PROLOG

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```
talk(lars) :-  
    joke(funny), % laugh  
    introduction(prolog),  
    features(cool),  
    audience(Questions),  
    answer(Questions).
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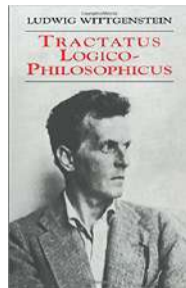
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Who invented Prolog?

- “ 1. *The world is everything that is the case.*
1.1 *The world is the totality of facts, not of things.*
1.11 *The world is determined by the facts, and by these being all the facts.*

”

Who invented Prolog?



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1.1 *The world is the totality of facts, not of things.*
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– Ludwig Wittgenstein, 1918

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    joke(funny), % laugh  
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```

Who invented Prolog?

(for real)

- ▶ appeared in the early 70s in France
- ▶ original developers: Alain Colmerauer and Philippe Roussel
- ▶ used the `.pl` extension before Perl
- ▶ radically different programming paradigm



A brief primer on Prolog

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Just like in SQL!

Hello World!

Program

```
hi.
```


Hello World!

Program

```
hi.
```

Interpreter

```
?- hi.  
true.
```

Hello World!

Program

hi.

hello(world).

Interpreter

?- hi.

true.

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Hello World!

Program

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hello(world).

Interpreter

?- hi.

true.

?- hello(world).

true.

?- hello(coworld).

false.

Hello World!

Program

```
hi.
```

```
hello(world).
```

Interpreter

```
?- hi.  
true.
```

```
?- hel  
true.
```

```
?- hello(coworld).  
false.
```

This used to be yes/no, for
100% toddler compatibility



Hello World!

Program

hi.

hello(world).

Interpreter

?- hi.

true.

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true.

?- hello(coworld).

false.

?- hello(X).

X = world.

Hello World!

Program

```
hi.
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hello(world).
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Interpreter

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?- hi.  
true.
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?- hello(world).  
true.
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?- hello(c  
false.
```

```
?- hello(X).  
X = world.
```

Variables: upper-case
Rest: lower-case

A small program

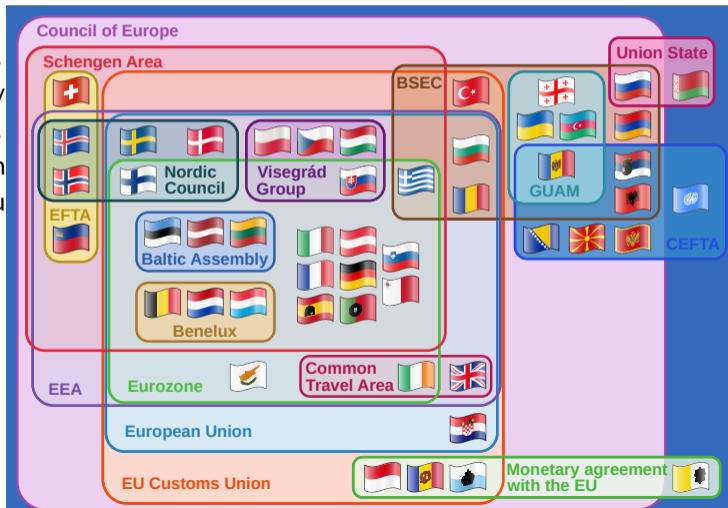
Facts

```
location(munich, germany).  
location(augsburg, germany).  
location(germany, europe).  
location(london, unitedkingdom).  
location(unitedkingdom, europe).
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A small program

Facts

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```

Rules

```
neighbour(X, Y) :-  
    location(X, Z), location(Y, Z).
```

A small program

Facts

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location(munich, germany).  
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```

Rules

```
is_in(X, Y) :- location(X, Y).  
is_in(X, Y) :- location(X, Z), is_in(Z, Y).
```

Prolog syntax

What's with the weird syntax?

Prolog syntax

What's with the weird syntax?

Is it stolen from Erlang?

Prolog syntax

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Hello, Alain!



Prolog syntax

What's with the weird syntax?

Is it stolen from Erlang?



Hello, Joe!



Erlang, inspired by Prolog

“*The first interpreter was a simple Prolog meta interpreter which added the notion of a suspendable process to Prolog ... [it] was rapidly modified (and re-written) ...*”

– Armstrong, Virding, Williams: Use of Prolog for developing a new programming language

```
talk(lars) :-  
    joke(funny), % laugh  
    introduction(prolog),  
    features(cool),  
    audience(Questions),  
    answer(Questions).
```

Backtracking

```
best_boy(X) :-  
    dog(good, X),  
    colour(dark_brown, X),  
    behind(X, Y),  
    colour(light_brown, Y).
```



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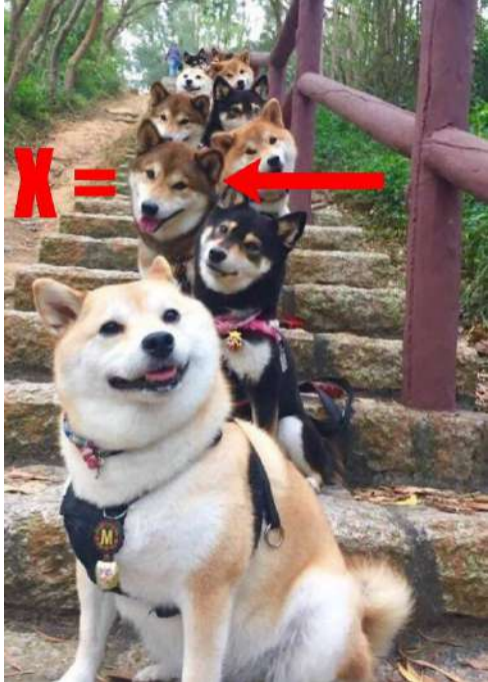
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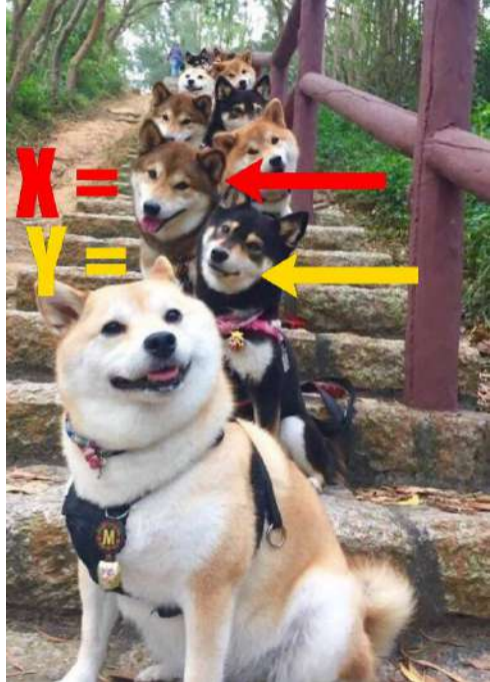
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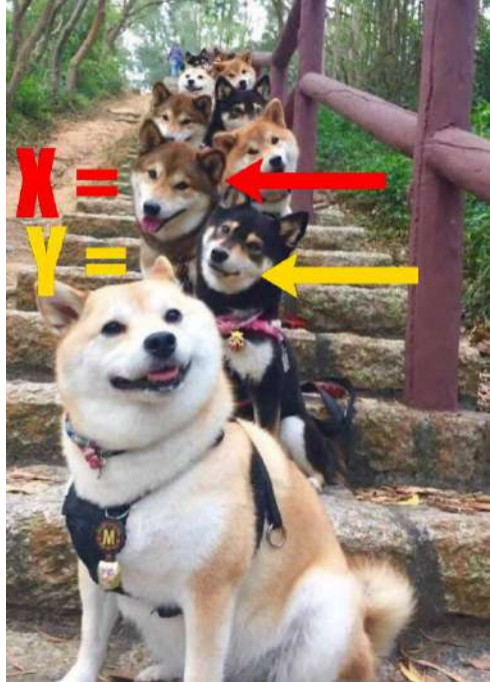
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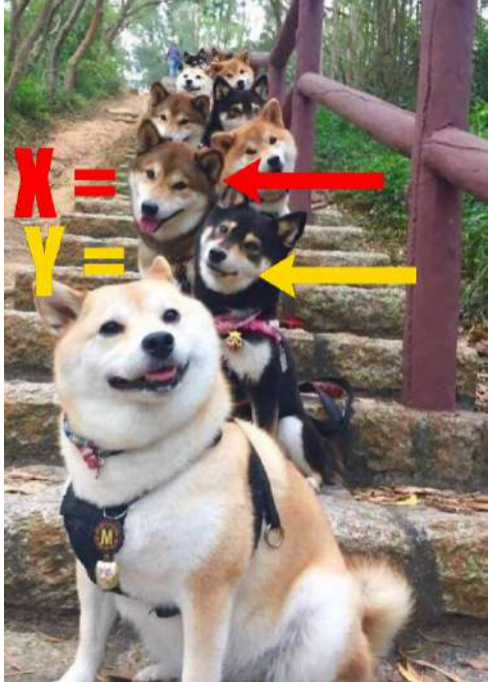
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Bi-directional computing

$$f : I \rightarrow O$$

Bi-directional computing



$$f : I \rightarrow O$$

Bi-directional computing



$$f : I \rightarrow O$$



$$R : (I \times O) \rightarrow \{0, 1\}$$

Bi-directional computing

Scala

```
def append[A](xs: List[A], ys: List[A]): List[A]
```


Bi-directional computing

Scala

```
def append[A](xs: List[A], ys: List[A]): List[A]
```

Prolog

```
append(?List1, ?List2, ?List1AndList2)
```

Bi-directional computing

Scala

```
def appendAll[A](xss: List[List[A]]): List[A]
```

Bi-directional computing

Scala

```
def appendAll[A](xss: List[List[A]]): List[A]
```

Prolog

```
append_all(+ListOfLists, ?List)
```

Mode signatures

- ++ Argument must be ground, i.e., the argument may not contain a variable anywhere.
- + Argument must be fully instantiated to a term that satisfies the type. This is not necessarily *ground*, e.g., the term `[_]` is a *list*, although its only member is unbound.
- Argument is an *output* argument. Unless specified otherwise, output arguments need not to be unbound. For example, the goal `findall(X, Goal, [T])` is good style and equivalent to `findall(X, Goal, Xs), Xs = [T]`⁴⁵ Note that the *determinism* specification, e.g., ```det''` only applies if this argument is unbound.
- Argument must be unbound. Typically used by predicates that create 'something' and return a handle to the created object, such as [open/3](#) which creates a *stream*.
- ? Argument must be bound to a *partial term* of the indicated type. Note that a variable is a partial term for any type. Think of the argument as either *input* or *output* or *both* input and output. For example, in `stream_property(S, reposition(Bool))`, the `reposition` part of the term is input and the uninstantiated `Bool` is output.
- : Argument is a meta-argument. Implies +. See [chapter 6](#) for more information on module handling.
- @ Argument is not further instantiated. Typically used for type tests.
- ! Argument contains a mutable structure that may be modified using [setarg/3](#) or [nb_setarg/3](#).

Not a silver bullet ...

```
?- member(X, [1, 2, 3]), Y = 2, X > Y.  
X = 3, Y = 2.
```

Not a silver bullet ...

?- member(X, [1, 2, 3]), Y = 2, X > Y.
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```



Not a silver bullet ...

```
?- member(X, [1, 2, 3]), Y = 2, X > Y.  
X = 3, Y = 2.
```

```
?- use_module(library(clpfd)).  
?- X #> Y, X in 1..3, Y = 2.
```

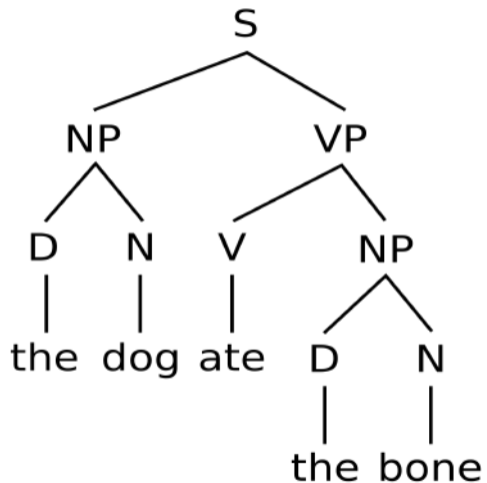

Constraint solving

Puzzle

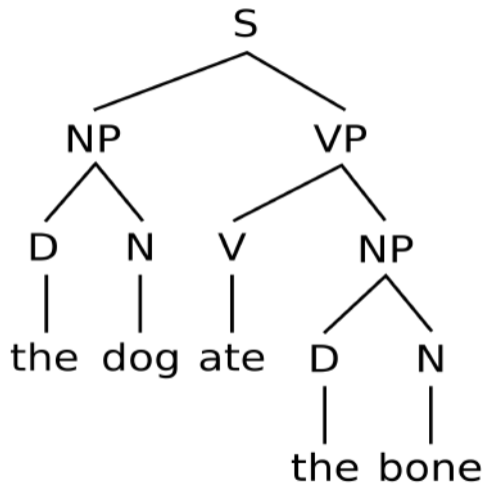
There are five houses.

1. The English person lives in the red house.
2. The Swedish person owns a dog.
3. The Danish person likes to drink tea.
4. The green house is left to the white house.
5. The owner of the green house drinks coffee.
6. ...

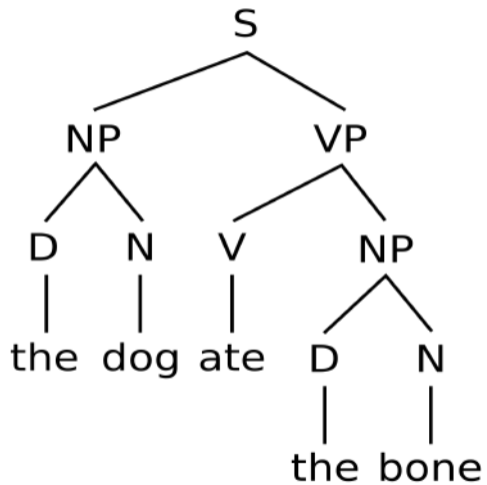
Grammars



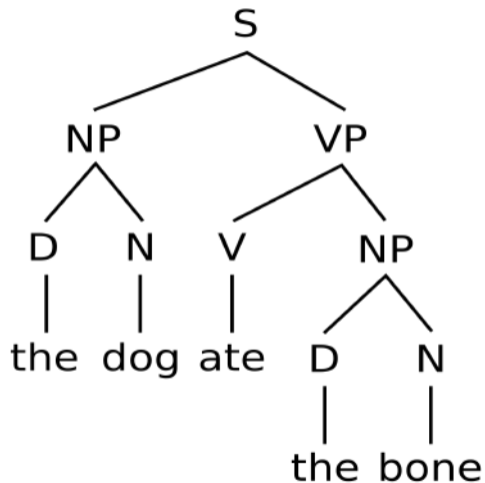
Grammars



Grammars



Grammars



$s \rightarrow np, vp.$

$np \rightarrow d, n.$

$d \rightarrow [the].$

$d \rightarrow [a].$

$vp \rightarrow v, np.$

$n \rightarrow [dog].$

$n \rightarrow [bone].$

Prolog is for parsing?

“*The programming language ... was born of a project aimed not at producing a programming language but at processing natural languages; in this case, French.*”

– Colmerauer, Roussel: The Birth of Prolog

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Parsing

Scala

```
type Parser[A] = String => List[(A, String)]
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Prolog

```
parse(?A, ?ListIn, ?ListOut)
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+ monad syntax

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+ DCG syntax

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    introduction(prolog),  
    features(cool),  
    audience(Questions),  
    answer(Questions).
```



```
?- talk(lars).  
true.
```



 larsrh

 larsr_h

 lars.hupel.info

Image sources

- ▶ Prolog coffee: Marek Kubica
- ▶ Shiba row: <https://www.pinterest.de/pin/424112489894679416/>
- ▶ Shiba with mlem: https://www.reddit.com/r/mlem/comments/6tc1of/shibe_doing_a_mlem/
- ▶ Happy dog: <https://www.rover.com/blog/is-my-dog-happy/>
- ▶ Kid with crossed arms: <https://www.psychologytoday.com/us/blog/spycatcher/201410/9-truths-exposing-myth-about-body-language>
- ▶ Noam Chomsky: https://en.wikipedia.org/wiki/File:Noam_Chomsky_Toronto_2011.jpg
- ▶ Alain Colmerauer: https://de.wikipedia.org/wiki/Datei:A-Colmerauer_web-800x423.jpg
- ▶ Joe Armstrong: Erlang, the Movie
- ▶ Signatures: <http://www.swi-prolog.org/pldoc/man?section=preddesc>
- ▶ Zebra puzzle: StackOverflow contributors (<https://stackoverflow.com/q/11122814/4776939>)
- ▶ Asking dog: <https://www.quickanddirtytips.com/pets/dog-behavior/how-to-teach-your-dog-tricks-and-manners-with-targeting>
- ▶ Owl: <https://www.theloop.ca/angry-owl-terrorizes-oregon-joggers/>