Logic & Constraint Prog.

Lists and recursion

Lists

- Many algorithms (like sorting) need some memory space and data structure to work on
- Conventional *iterative* programming languages use *arrays*
- Functional/logic programming languages use *linked lists*

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Examples of prolog lists: $[1, 2, 3, [-1, \mathsf{a}, [\,]\,], \mathsf{'movie\_bd'}]$ $[\,]$ $[\_, X, Y, 1]$

- A list is enclosed in squared brackets
- The elements are separated by commas “ , ”
- Elements of all types can be put in a list
- A list can contain other lists
- Character strings are lists:
  Prolog interprets "abcd" as the list of ASCII codes $[97, 98, 99, 100]$.

Lists : Data abstraction

An example Consider a database for the timetable of a faculty:

- it could containt facts of the form

  $$\mathsf{slot}(\mathsf{Start}, \mathsf{End}, \mathsf{Course}, \mathsf{Group}, \mathsf{Teacher})$$

  where Start and End give the start and end times of the slot
- most predicats and queries do not need to know how time points are represented

$\Rightarrow$ these could be represented by $[H, M]$, or $[H, M, S]$
or the number N of sec. elapsed since Jan. 1st, 1970.

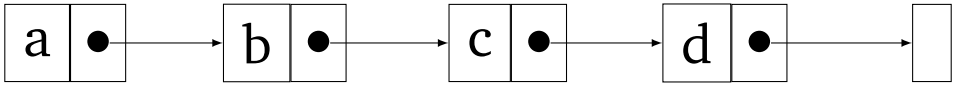
Remark [and] are special constructors, reserved for lists in Prolog
It is possible to use other constructors to use other structures,
but, in principle, lists are sufficient.

Lists : Pattern Matching and Filtering

An example Consider a program that deals with colors, and that is able to use to systems: RGB and CMYK:

- RGB: colors can be represented by lists with three numbers
- CMYK: colors can be represented by lists with four numbers
- clauses for a predicate darken, that computes a color darker than a given one could have clause like:
  $\mathsf{darken}([R, G, B], \mathsf{New}) \leftarrow \ldots$ calculation for a color defined by$R, G,$
  $\mathsf{darken}([C, M, Y, K], \mathsf{New}) \leftarrow \ldots$ calculation for a color defined by C
- for the goal $\mathsf{darken}([123, 255, 27], N)$ prolog will not try the second rule, which expects a list with 4 elements as first parameter

Lists : Recursive structure

A list: 

Prolog representation: $[\, a \mid [\, b \mid [\, c \mid d \mid [\ ]\,]\,]\,]$

- $[\ ]$ represents the empty list;
- $[X|L]$ represents a list, the first element of which is X, whereas the *tail* is a list L;
- the "," is a convenient shortcut to enumerate elements at the beginning of a list.

For instance, $[1,2,3,4] = [1,2,3|\,[4]\,] = [1|\,[2|\,[3|\,[4|\,[\,]\,]\,]\,]\,]$.
(But $[1,2,3,4] \neq [\,[1,2]\,|\,[3,4]\,]$. Why ?)

A list is a *compound term*, we could use an atom "list" to build lists:
• $[X \mid L]$ would be written $\mathsf{list}(X, L)$
• $[a,b,c,d]$ would be written $\mathsf{list}(a, \mathsf{list}(b, \mathsf{list}(c, \mathsf{list}(d, \mathsf{empty}))))$
(where "empty" would be another atom to denote the empty list).

Lists : Recursive structure

Examples of filtering with the recursive form of lists:

- isFirstElmtOf(X, L): true if X is the first element of the list $L \Rightarrow$

$$\mathsf{isFirstElmtOf}(X, L) \leftarrow L = [X|R].$$

  or simply

$$\mathsf{isFirstElmtOf}(X, [X|R]).$$

- isSecondElmtOf(X, L) ...

Recursive programming

We wish to retrieve the last element of a list: $\mathsf{isLastElmtOf}(X, L)$ must be true if X is the last element of L

- the linked list must be scanned until its last element is reached
- we do not know in advance how many steps will be needed
  $\Rightarrow$ *recursive programming:*

Recursive programming : The classical example

We wish to retrieve the last element of a list: $\mathsf{isLastElmtOf}(X, L)$ must be true if X is the last element of L

- the linked list must be scanned until its last element is reached
- we do not know in advance how many steps will be needed
  $\Rightarrow$ *recursive programming:*

X is last element of $[\ Y \mid R\ ]$ if and only if X is last element of R
Termination: X is the last element of $[X]$

In prolog:
$\mathsf{isLastElmtOf}(X, L) \leftarrow L = [X] \vee (L = [Y|R] \wedge \mathsf{isLastElmtOf}(X, R))$.

Example Write a definition for a predicate $\mathsf{member}/2$, such that $\mathsf{member}(X, L)$ is true if X is element of list L.