CS339: Abstractions and Paradigms for Programming

Logic Paradigm (Cont.)

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Our beloved Vinay Wardhan sir has passed away.

He made his mark on thousands of students as a career coach and as an inspiration. Please remember him in your prayers.

Thank you for touching our lives, sir.
You'll be missed.

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Vinay Wardhan, Director, Career Path Pvt Ltd

You Pour Love, You Get Love.
The World is Circular.

From the homework

- Define a sibling relationship for our family tree:
  - What if you did this?
    - `sibling(X, Y) :- parent(W, X), parent (W, Y).`
  - The right way:
    - `sibling(X, Y) :- parent(W, X), parent (W, Y), X \= Y.`

- Prolog supports relational operators.

How does the Prolog engine work?

- **Program = logic + control.**
  - Logic is specified by user; control is managed by runtime.

- Given a query:
  - Consult the facts and rules in top-down order.
  - Try to instantiate variables in the RHS of rules.
  - Report instantiated values that satisfy the predicates resultant from the query.

Resolution and Unification

- **Resolution.** If h is the head of a Horn clause and it matches with one of the terms of another Horn clause, then that term can be replaced by h.
- **Unification.** A pattern-matching process that determines what particular instantiations can be made to variables while making a series of simultaneous resolutions.
  - Which resolutions are simultaneous?
    - Those that satisfy the given set of predicates.
- Example: `?- parent(brandon, bran).`

Do they unify?

- `a & a` ✅
- `a & b` ❌
- `a & A` ✅ `A = a`
- `a & B` ✅ `B = a`
- `f(x,y) & A` ✅ `A = f(x,y)`
- `f(X,b) & f(a,Y)` ✅ `X = a, Y = b`
- `f(a,b) & g(a,b)` ❌
- `f(X,b,c) & f(a,X,c)` ❌

Searching and Backtracking

When the path ahead is not nice,
say even mice, that backtracking is wise.

- Basic idea of logic paradigm:
  - Search through the solution space while trying to unify variables with values, till you get a solution.
  - If no further resolution can be done, then backtrack and try a different instantiation.
- Example: `?- parent(brandon, bran).`
- **Observe:** Multiple solutions are possible.
  - Example: `?- grandparent(rickard, Whoall).`

Lists

- **List:** the basic data structure in Prolog.
  - `[Head | Tail]`

- `[lists, wont, leave, you, in, app]`
  - Head: `lists`
  - Tail: `[wont, leave, you, in, app]`
  - What about `[H1, H2 | T]`?

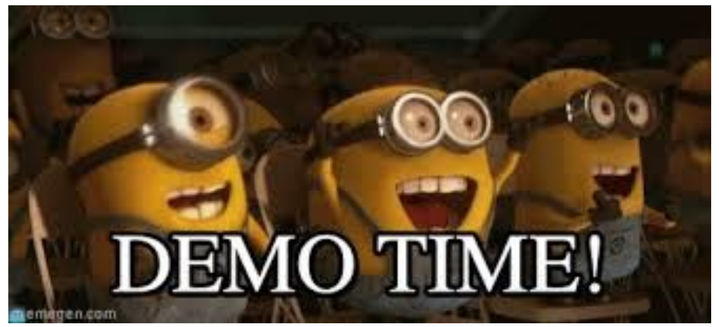
Operations on lists

- Concatenate two lists:

```
append([], X, X).
append([Head | Tail], Y, [Head | Z]) :- append(Tail, Y, Z).
```

- Prefix: `prefix(X, Z) :- append(X, Y, Z).`
- Suffix: `suffix(Y, Z) :- append(X, Y, Z).`
- Membership:

```
member(X, [X | _]).
member(X, [_ | Y]) :- member(X, Y).
```



But we had learnt numbers before lists in Scheme!

- Compute the factorial of a number in Prolog:

```
factorial(N, 1) :- N = 0.
factorial(N, Result) :- N > 0,
                        M is N - 1,
                        factorial(M, SubRes),
                        Result is N * SubRes.
```

- The infix operator ***is*** forces the instantiation of a variable by performing arithmetic operations.
- Is N > 0 important?
  - Try removing it!

Let's see another example

- Find the max of two numbers.

```
max(X, Y, Y) :- X =< Y.
max(X, Y, X) :- X > Y.
```

- **Observe:** The interpreter waits to try more solutions, even though the cases are mutually exclusive.
  - What we want: Abort searching if the first case is true.
- The same reasoning for the wait during `grandparent(rickard, bran).`