Logic Programming

Manipulating Programs

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Contents

Introduction

- Programs as data.
- Manipulating Prolog programs with other Prolog programs.
- Meta-Programming

`clause` Predicate

`clause(X,Y)`

- Built-in binary predicate, very important if one wishes to construct programs that examine or execute other programs.
- Satisfying `clause(X,Y)` causes `X` and `Y` to be matched with the head and body of an existing clause in the database.
- `X` must be instantiated so that the main predicate of the clause is known.

`clause` Predicate

Satisfying `clause(X,Y)`

- If there are no clauses that match `X`, the goal fails.
- If there is more than one clause that matches, Prolog returns the first one. The other matches will be chosen, one at a time, when Prolog backtracks.

`clause` Predicate. Examples

```
append([], X, X).
append([A|B], C, [A|D]) :-
    append(B, C, D).

?- clause(append(L1,L2,L3), Y).

L1 = []
L2 = L3
Y = true ;

L1 = [_G463|_G464]
L3 = [_G463|_G467]
Y = append(_G464, L2, _G467) ;

No
```

A Version of `listing` Predicate

`list1(X)`

- Satisfying the goal `list1(X)` will print out the clauses in the database whose head matches `X`.
- The definition of `list1(X)` will involve `clause` with `X` as the first argument.
- Therefore, `X` has to be sufficiently instantiated.

Definition of `list1`

```
list1(X) :-
    clause(X, Y),
    output_clause(X, Y),
    write('.'), nl,
    fail.
list1(_).

output_clause(X, true) :-
    !,
    write(X).
output_clause(X, Y) :-
    write((X:-Y)).
```

How Does `list1` Work?

- The first clause causes a search for a clause whose head matches `X`.
- If one found, it is printed and a failure is generated.
- Backtracking will reach the `clause` goal and find another clause, if there is one, and so on.
- When there is no more clause to be found, the `clause` goal will fail.
- At this point, the second clause for `list1` will be chosen, so the goal will succeed.
- As a “side effect", all the appropriate clauses will have been printed out.

How Does `output_clause` Work?

- Specifies how the clauses will be printed.
- It looks for a special case of the body `true`. In this case it just prints the head.
- Otherwise, it writes out the head and the body, constructed with the functor `:-`.
- The “cut” in the first rule for `output_clause` says that the first rule is the only valid possibility if the body is `true`.
- The “cut” is essential because the example relies on backtracking.

Writing Prolog Interpreter in Prolog

Idea:

- Define what it is to run a Prolog program by something which is itself a Prolog program.

The `interpret` Predicate

Idea:

- `interpret(X)` succeeds as a goal exactly when `X` succeeds as a goal.
- `interpret` is similar to built-in predicate `call`, but is more restricted: It does not deal with cuts or built-in predicates

The `interpret` Predicate

```
interpret(true) :-
    !.
interpret((G1, G2)) :-
    !,
    interpret(G1),
    interpret(G2).
interpret(Goal) :-
    clause(Goal, MoreGoals),
    interpret(MoreGoals).
```

The `interpret` Predicate

- The first clause of `interpret` deals with the special case when the goal is true.
- The second clause deals with the case when a goal is a conjunction.
- The third clause covers a simple goal: The procedure is the following:
  1. Find a clause whose head matches the goal
  2. `interpret` the goals in the body of that clause.
- Limitations: The program will not cope with programs using built-in predicates, because such predicates do not have clauses in the usual sense.

The `consult` Predicate

- `consult` is provided as a built-in predicate in most systems.
- Interesting to see how it can be defined in Prolog.
- A simplified definition.

retractall

First we define `retractall`:

```
retractall(X) :-
    retract(X),
    fail.
retractall(X) :-
    retract((X:-Y)),
    fail.
retractall(_).
```

Program for `consult`

```
consult(File):-
    retractall(done(_)),
    current_input(Old),
    open(File, read, Stream),
    repeat,
        read(Term),
    process(Term),
    close(Stream),
    set_input(Old),
    !.
```

Program for `consult`, Cont.

```
process(end_of_file) :- % eof marker read
    !.
process((?- Goals)) :-
    !,
    call(Goals),
    !,
    fail.
process((:- Goals)) :- % ignore directives
    !.
process(Clause) :-
    head(Clause, Head),
    record_done(Head),
    assertz(Clause),
    fail.
```

Program for `consult`, Cont.

```
:- dynamic done/1.

record_done(Head) :-
    done(Head),
    !.
record_done(Head) :-
    functor(Head, Func, Arity),
    functor(Proc, Func, Arity),
    asserta(done(Proc)),
    retractall(Proc),
    !.

head((A :- B), A) :-
    !.
head(A, A).
```

Program for `consult`. Explanations.

- `current_input(Old)` and `set_input(Old)` ensure that the current input file stays the same after the consult.
- `process` is to cause an appropriate action to be taken for each term read from the input.
- `process` only succeeds when its argument is the end of file mark.
- Otherwise, a failure occurs after the appropriate action, and backtracking goes back to the `repeat` goal.
- The “cut” at the end of the `consult` definition cuts out the choice introduced by `repeat`.

Program for `consult`. Explanations.

The actions `process` performs:

- Question read:

  ```
  process((?- Goals)) :- !, call(Goals), !,
  fail.
  ```

  Attempt to satisfy the appropriate goal and fails.

- Directive read:

  ```
  process((:- Goals)) :- !.
  ```

  Ignore. (Different systems treat them differently. SWI-Prolog makes no difference between questions and directives.)

Program for `consult`. Explanations.

```
process(Clause) :-
    head(Clause, Head),
    record_done(Head),
    assertz(Clause),
    fail.
```

- When the first clause for a given predicate appears in a file, all the clauses in the database for that predicate must be removed before the new one is added.
- Clauses must not be removed when later ones for that predicate appear, because then we will be removing clauses that have just been read in.
- How to determine whether a clause is the first one in the file for its predicate?

Program for `consult`. Explanations.

```
:- dynamic done/1.

record_done(Head) :- done(Head), !.
record_done(Head) :-
    functor(Head, Func, Arity),
    functor(Proc, Func, Arity),
    asserta(done(Proc)),
    retractall(Proc),
    !.
```

- Keep record of the predicates for which we have found clauses in the file.
- When the first clause of a predicate (e.g., of the binary predicate `foo`) is found, then
  - remove from the database the existing clauses for it, and
  - add the new clause in the database.
- In addition, the fact `done(foo(_,_))` is added.

Program for `consult`. Explanations.

```
:- dynamic done/1.

record_done(Head) :- done(Head), !.
record_done(Head) :-
    functor(Head, Func, Arity),
    functor(Proc, Func, Arity),
    asserta(done(Proc)),
    retractall(Proc),
    !.
```

- When a later clause for predicate `foo` is read from the file, we will be able to see that the old clauses have already been removed, and so we avoid removing new clauses.
- The test is `done(Head)` in the first clause, with `Head` instantiated by the head of the clause for predicate `foo`.