Tutorium to Introduction to AI, 3rd week -Nicolas Höning

Nicolas Höning

April 28, 2006

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organizational issues

some random tips and tricks

built-in predicates are not for free base cases: "once" vs "every time"

Gauss reconsidered the fruits of left recursion accumulators

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organizational issues

- sorry for the late homework results. we're having some technical problems...
 - almost all of them were really fine, so don't worry :-) we need to get all of you in groups, so what about these people:
 - Anna-Antonia Pape, Benjamin Wulff, Janine Yvonne Willbrand, Da Sheng Zhang, Annett Wegner, Gunther Baumgartner, Arthur Legler, Jonas Volger, Yvonne Eberl, Johannes Emden

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 - almost all of them were really fine, so don't worry :-) we need to get all of you in groups, so what about these people:
 - Anna-Antonia Pape, Benjamin Wulff, Janine Yvonne Willbrand, Da Sheng Zhang, Annett Wegner, Gunther Baumgartner, Arthur Legler, Jonas Volger, Yvonne Eberl, Johannes Emden
- we also found out yesterday that the Prolog system on VIPS didn't always show all error messages :-(

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organizational issues

 I am here to make your work easier.
 So if there is anything you want to talk about or that should be done differently, don't hesitate to tell me.

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 So if there is anything you want to talk about or that should be done differently, don't hesitate to tell me.
- that also includes repititions. if we need to reconsider some basic concepts in order for you to really get them, then that is really worth the time. Ask me!

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built-in predicates are not for free base cases: "once" vs "every time"

built-in predicates are not for free

this week's homework suggests to have a look at the manual to find a built-in predicate that appends a list to another list (it's uploaded in Stud.IP and called "learn_prolog.pdf" and it's really readable. check it out.)

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- this week's homework suggests to have a look at the manual to find a built-in predicate that appends a list to another list (it's uploaded in Stud.IP and called "learn_prolog.pdf" and it's really readable. check it out.)
- you should especially read chapter 6. It might help with that exercise, but mostly it helps to really grasp that damn recursion thing.

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built-in predicates are not for free base cases: "once" vs "every time"

built-in predicates are not for free

you would also learn that append is inefficient, because it always works up and down the same list. As we will later deal with efficiency a lot, this is good to understand right at the beginning.

Average programmers think of using a library function as one call, good programmers care about the implementation of that library function.

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- you would also learn that append is inefficient, because it always works up and down the same list. As we will later deal with efficiency a lot, this is good to understand right at the beginning.
 - Average programmers think of using a library function as one call, good programmers care about the implementation of that library function.
- if you have time on the bus, read this brilliant essay by Joel Spolsky about that topic (not Prolog-related, but a good read).

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built-in predicates are not for free base cases: "once" vs "every time"

base cases: "once" vs "every time"

we already said that a base case is, most of the time, just the simplest case imaginable

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built-in predicates are not for free base cases: "once" vs "every time"

base cases: "once" vs "every time"

- we already said that a base case is, most of the time, just the simplest case imaginable
- now, if your predicate is asked to do something <u>once</u>, it is even easier: you don't want the predicate to proceed to the simplest case, but stop once something is done the first time. Right?

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- ▶ a situation where that something is done, is your base case.

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- ▶ a base case returns true and does not proceed. perfect.

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- ▶ a situation where that something is done, is your base case.
- ▶ a base case returns true and does not proceed. perfect.
- the base case can be the distinction between "once" and "every time"

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the fruits of left recursion accumulators

last weeks Gauss: the limitations

do you remember last week's gauss(X,Y)-predicate to calculate this formula?

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last weeks Gauss: the limitations

do you remember last week's gauss(X,Y)-predicate to calculate this formula?

$$\sum_{i=0}^{x} i = \frac{x}{2}(x+1)$$

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last weeks Gauss: the limitations

```
▶ gauss(X,_) :- X < 0, !, fail.
gauss(0,0).
gauss(X,Y) :-
X1 is X - 1,
Y1 is Y - X,
gauss(X1,Y1).
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it needed <u>both</u> X and Y instantiated. Why?

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gauss(X,Y) :-
X1 is X - 1,
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gauss(X1,Y1).
```

- it needed <u>both</u> X and Y instantiated. Why?
- ▶ When you do not know X, and of course you don't yet know X1, the term X1isX 1 has infinitely many solutions. The same holds for Y1isY X

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the fruits of left recursion accumulators

Argument usage

So you (we) should always care about this issue when we document our program: What terms need to be instantiated?

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- from the lecture: Argument usage
 + means: value must be provided
 means: must be free, value will be computed
 - ? can be either free or a value

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- from the lecture: Argument usage
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- so last week's Gauss was gauss(+X,+Y)
- let's think about gauss(+X,-Y) now

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our only base case is still gauss(0,0). The problem is that we cannot substract from Y till we reach zero, because we have no idea what Y could be in the first place.

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- can't we <u>add</u> every X up to reach Y while we decrement X to zero? How could we tell Prolog to do that?

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- can't we <u>add</u> every X up to reach Y while we decrement X to zero? How could we tell Prolog to do that?
- How can we decrement X to zero, from the first call down to the base case, while we add all those Xes up to Y, <u>beginning</u> at the base case?

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left recursion: a simple example

ok, take a break, look at this simple predicate here: recurse([]). recurse([H|Rest]) :writeln('right... H is '+H), recurse(Rest), writeln('left.... H is '+H).

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left recursion: a simple example

- > ok, take a break, look at this simple predicate here: recurse([]). recurse([H|Rest]) :writeln('right... H is '+H), recurse(Rest), writeln('left.... H is '+H).
- it does nothing but recurse down a list until it is empty. Besides, it tells you what is the the actual head of the list. Twice.

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left recursion: a simple example

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- it does nothing but recurse down a list until it is empty. Besides, it tells you what is the the actual head of the list. Twice.
- Once in right-recursion-style and once in left-recursion-style. Now what will be the output of recurse([a,b,c,d]).?

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left recursion: a simple example

- this is the output of recurse([a,b,c,d]).:
 - right... H is +a right... H is +b right... H is +c right... H is +d left.... H is +d left.... H is +c left.... H is +b left.... H is +a

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left recursion: a simple example

- this is the output of recurse([a,b,c,d]).:
 - right... H is +a right... H is +b right... H is +c right... H is +d
 - left.... H is +d
 - left.... H is +c
 - left.... H is +b
 - left.... H is +a
- we see the way to the base case, and then we see the way back from it.

down the recursion tree and up again.

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left recursion: a simple example

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 - left.... H is +a
- we see the way to the base case, and then we see the way back from it.

down the recursion tree and up again.

Now, right recursion is the usual way to go, but left recursion seems to make sense for some problems....

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▶ ok, we should change our gauss example, but just a little:

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gauss(+X,-Y)

ok, we should change our gauss example, but just a little:

```
/* gauss_with_X(+X,-Y) */
gauss_with_X(X,_) :- X < 0, !, fail.
gauss_with_X(0,0).
gauss_with_X(X,Y) :-
X1 is X - 1,
gauss_with_X(X1,Y1),
Y is Y1 + X.
```

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gauss(+X,-Y)

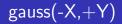
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```

the only changes are switching the last two lines, so we compute Y in left recursion (after it has been instantiated to zero by the base case), and using addition to compute Y instead of substraction.

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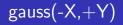
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ok, now what about gauss(-X,+Y)? Can we do it the same way?

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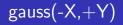
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- ok, now what about gauss(-X,+Y)? Can we do it the same way?
- the problem is: we cannot decrement Y just as easy as X. X was decremented by one, Y would be decremented by an X we don't yet know.

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- ok, now what about gauss(-X,+Y)? Can we do it the same way?
- the problem is: we cannot decrement Y just as easy as X. X was decremented by one, Y would be decremented by an X we don't yet know.
- I'll use another interesting technique to solve that one: the accumulator.

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accumulators: why?

ok, the problem again: if we have Y but no X, we cannot decrement Y till we reach zero, because we don't know by what we should decrement. We only have an X parameter that should hold the X we are looking for but is not instantiated

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accumulators: why?

- ok, the problem again: if we have Y but no X, we cannot decrement Y till we reach zero, because we don't know by what we should decrement. We only have an X parameter that should hold the X we are looking for but is not instantiated
- well... we could instantiate X with zero and increment it by one with every step. Then we could decrement Y by that X and if it comes down to zero, we incremented X up to the one we were looking for!

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accumulators: why?

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- But if we instantiate X with zero in the first place, we will never get to see that incremented X that comes up in the base case :-(

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- well... we could instantiate X with zero and increment it by one with every step. Then we could decrement Y by that X and if it comes down to zero, we incremented X up to the one we were looking for!
- But if we instantiate X with zero in the first place, we will never get to see that incremented X that comes up in the base case :-(
- so how about introducing another dummy parameter?

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the fruits of left recursion accumulators

accumulators: what?

- an accumulator is a name for another technique while using recursion.
 - It adresses just this problem we had by introducing another parameter that is instantiated empty (say, [] or 0).

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accumulators: what?

- an accumulator is a name for another technique while using recursion.
 - It adresses just this problem we had by introducing another parameter that is instantiated empty (say, [] or 0).
- this parameter is then recursively changed until the base case is reached.

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the fruits of left recursion accumulators

accumulators: what?

- an accumulator is a name for another technique while using recursion.
 - It adresses just this problem we had by introducing another parameter that is instantiated empty (say, [] or 0).
- this parameter is then recursively changed until the base case is reached.
- there the parameter we want to instantiate with the solution (here: X) is instantiated with the accumulator, passed up the recursion tree, and we're done.

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accumulators: what?

- an accumulator is a name for another technique while using recursion.
 - It adresses just this problem we had by introducing another parameter that is instantiated empty (say, [] or 0).
- this parameter is then recursively changed until the base case is reached.
- there the parameter we want to instantiate with the solution (here: X) is instantiated with the accumulator, passed up the recursion tree, and we're done.
- This technique does no harm to the efficiency of your program (you'll find it again in that chapter 6 I talked about earlier).

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the fruits of left recursion accumulators

gauss(-X,+Y)

```
ok, let's do this: Z is our accumulator:
gauss_with_Y_2(_,Y,_) :- Y < 0, !, fail.
gauss_with_Y_2(X,0,X).
gauss_with_Y_2(X,Y,Z) :-
Z1 is Z + 1,
Y1 is Y - Z1,
gauss_with_Y_2(X,Y1,Z1).
```

the fruits of left recursion accumulators

$$gauss(-X,+Y)$$

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we'll add it up from zero to the value that X should have. Then we unify it with X and pass X up the recursion tree

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$$gauss(-X,+Y)$$

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- we'll add it up from zero to the value that X should have. Then we unify it with X and pass X up the recursion tree
- we're back to good old right recursion again

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gauss(-X,+Y): cleaning up

 ok, the user probably doesn't want to call gauss_with_Y2(X,5050,0).

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the fruits of left recursion accumulators

gauss(-X,+Y): cleaning up

- ok, the user probably doesn't want to call gauss_with_Y2(X,5050,0).
- /* gauss_with_Y(-X,+Y) this pipes the problem to our special accumulator predicate */ gauss_with_Y(X,Y) :gauss_with_Y_2(X,Y,0).

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gauss(X,Y): cleaning up

and now we let the user call gauss(X,Y) and find out ourselves if X is in there or Y is:

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gauss(X,Y): cleaning up

and now we let the user call gauss(X,Y) and find out ourselves if X is in there or Y is:

```
gauss(X,Y) :-
number(X),
gauss_with_X(X,Y).
gauss(X,Y) :-
number(Y),
gauss_with_Y(X,Y).
```

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the end



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