CSCI 334: Principles of Programming Languages

Lecture 7: ML III

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Announcements

HW1 feedback and grade: look for pull request email

Announcements

Official SML family reference:

http://sml-family.org

Announcements

Homework help tonight 7-9pm (HERE)

fold

Intuition:

fold left

```
foldl (fn (x,acc) => acc+x) 0 [1,2,3,4]
```

```
  acc = 0, [1,2,3,4]
  acc = 0+1, [2,3,4]
    acc = 1+2, [3,4]
      acc = 3+3, [4]
         acc 6+4, []
    returns acc = 10
```

fold right

```
foldr (fn (x,acc) => acc+x) 0 [1,2,3,4]
```

```
[1,2,3,4], acc = 0
[1,2,3], acc = 0+4
[1,2], acc = 4+3
[1] acc = 7+2
[], acc = 9+1
returns acc = 10
```

fold

- Write a function number_in_month that takes a list of dates (where a date is int*int*int) and an int month and returns how many dates are in month
- Anyone try this at home?

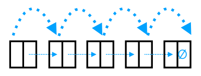
```
fun number_in_month dates month =
  foldl (fn ((_,m,_),acc) =>
    acc + (if m = month then 1 else 0)) 0 dates

val number_in_month =
    fn : ('a * ''b * 'c) list -> ''b -> int
```

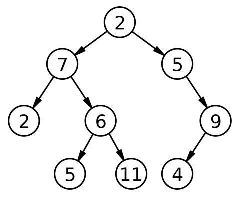
fold

structural recursion → fold it!

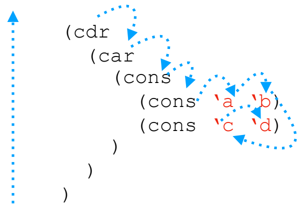
(in a nutshell: any problem that recurses on a subset of input)



list length



tree height



evaluation

pattern matching

We've used this already. Did you notice?

```
fun number_in_month dates month : int =
  foldl (fn ((_,m,_),acc) =>
    acc + (if m = month then 1 else 0)) 0 dates
```

pattern matching

A pattern is built from

- values,
- constructors,
- and variables

- Tests whether value(s) have shape defined by pattern
- If matches, binds variable(s) in pattern to value(s)

pattern matching

- Write a function `get_nth` that takes a list of strings and an `int n` and returns the nth element of the list, where the head is 1st.
- Anyone try this at home?

```
fun get_nth nil n      = NONE
 |  get_nth (x::xs) 1 = SOME x
 |  get_nth (x::xs) n =
       if n > 1 then get_nth xs (n-1) else NONE

val get_nth = fn : 'a list -> int -> 'a option
```

pattern matching

```
fun get_nth nil n      = NONE
 |  get_nth (x::xs) 1 = SOME x
 |  get_nth (x::xs) n =
      if n > 1 then get_nth xs (n-1) else NONE
```

handling errors with patterns

- Another example: handling errors.
- SML has exceptions (like Java)
- But an alternative, easy way to handle many errors is to use the option type:

  `datatype 'a option = NONE | SOME of 'a`

handling errors with patterns

```
fun get_nth nil n      = NONE
 |  get_nth (x::xs) 1 = SOME x
 |  get_nth (x::xs) n =
      if n > 1 then get_nth xs (n-1) else NONE
```

option type

- Why `option`?
- `option` is a data type;

  not handling errors is a static type error!
- Wait… isn't this just the same thing as "checked exceptions" from Java?
  - They are similar but not the same. We'll talk more about this in a coming lecture.

handling errors with patterns

```
– get_nth [1,2,3,4] 3
  val it = SOME 3 : int option
– get_nth [1,2,3,4] 0
  val it = NONE : int option
– get_nth [1,2,3,4] 5
  val it = NONE : int option
```

handling errors with patterns

Let's handle this error.

```
val i = … whatever …
val x = get_nth [1,2,3,4] i
case x of
  SOME n => print ((Int.toString n) ^ "\n")
| NONE   => print ((Int.toString i)
                ^ " is not a valid index!")
```

algebraic datatypes (pattern matching's best friend)

```
datatype 'a option =
  NONE
| SOME of 'a

datatype treat =
  SNICKERS
| TWIX
| TOOTSIE_ROLL
| DENTAL_FLOSS
```

algebraic datatypes (pattern matching's best friend)

```
datatype treat =
  SNICKERS
| TWIX
| TOOTSIE_ROLL
| DENTAL_FLOSS

fun trick_or_treat SNICKERS     = "treat!"
  | trick_or_treat TWIX         = "treat!"
  | trick_or_treat TOOTSIE_ROLL = "treat!"
  | trick_or_treat DENTAL_FLOSS = "trick!"
```

algebraic datatypes (pattern matching's best friend)

```
fun trick_or_treat SNICKERS     = "treat!"
 |  trick_or_treat TWIX         = "treat!"
 |  trick_or_treat TOOTSIE_ROLL = "treat!"
 |  trick_or_treat DENTAL_FLOSS = "trick!"
```

shorthand for case expression:

```
fun trick_or_treat t =
  case t of
    SNICKERS     => "treat!"
  | TWIX         => "treat!"
  | TOOTSIE_ROLL => "treat!"
  | DENTAL_FLOSS => "trick!"
```

Activity

Write a function `is_older` that takes two dates (where a date is `int*int*int`) and returns `true` or `false`. It evaluates to `true` if and only if the first argument is a date that comes before the second argument. If the two dates are the same, return false.

E.g.,
`is_older (2018,2,21) (2018,2,22)` returns `true`

Activity

Write a function `num_before_sum` that takes an `int` called `sum` (assume `sum` is positive) and an `int list` (assume all positive) and `returns an int`. The return value is an `n` such that the sum of the first `n` elements is < `sum` and the sum of the `n + 1` elements is >= `sum`. Assume that the sum of the entire list > `n`. Summing goes from left to right.

E.g.,
`num_before_sum 3 [0,1,2,3]` returns 2