Informatics 1

Functional Programming Lecture 5

Select, Take, Drop

Don Sannella

University of Edinburgh

Part I

Select, take, and drop

Select, take, and drop

```
> "words" !! 3
'd'

> take 3 "words"
"wor"

> drop 3 "words"
"ds"
```

Select, take, and drop (comprehensions)

```
selectComp :: [a] -> Int -> a   -- (!!)
selectComp xs i  =  the [ x | (j,x) <- zip [0..] xs, j == i ]
  where
  the [x]  =  x

takeComp :: Int -> [a] -> [a]
takeComp i xs  =  [ x | (j,x) <- zip [0..] xs, j < i ]

dropComp :: Int -> [a] -> [a]
dropComp i xs  =  [ x | (j,x) <- zip [0..] xs, j >= i ]
```

How take works (comprehension)

```
takeComp :: Int -> [a] -> [a]
takeComp i xs  =  [ x | (j,x) <- zip [0..] xs, j < i ]

  takeComp 3 "words"
=
  [ x | (j,x) <- zip [0..] "words", j < 3 ]
=
  [ x | (j,x) <- [(0,'w'),(1,'o'),(2,'r'),(3,'d'),(4,'s')],
        j < 3 ]
=
  ['w'|0<3]++['o'|1<3]++['r'|2<3]++['d'|3<3]++['s'|4<3]
=
  ['w']++['o']++['r']++[]++[]
=
  "wor"
```

Lists

Every list can be written using only `(:)` and `[]`.

```
[1,2,3]   =   1 : (2 : (3 : []))

"list"    =   ['l','i','s','t']
          =   'l' : ('i' : ('s' : ('t' : [])))
```

A *recursive* definition: A *list* is either

- *null*, written `[]`, or
- *constructed*, written `x:xs`,
  with *head* `x` (an element), and *tail* `xs` (a list).

Natural numbers

Every natural number can be written using only `(+1)` and `0`.

```
3  =  ((0 + 1) + 1) + 1
```

A *recursive* definition: A *natural number* is either

- *zero*, written `0`, or
- *successor*, written `n+1`
  with *predecessor* `n` (a natural number).

Select, take, and drop (recursion)

```
(!!) :: [a] -> Int -> a
(x:xs) !! 0  =  x
(x:xs) !! i  =  xs !! (i-1)

take :: Int -> [a] -> [a]
take 0 xs       =  []
take i []       =  []
take i (x:xs)   =  x : take (i-1) xs

drop :: Int -> [a] -> [a]
drop 0 xs       =  xs
drop i []       =  []
drop i (x:xs)   =  drop (i-1) xs
```

Pattern matching and conditionals (squares)

Pattern matching

```
squares :: [Int] -> [Int]
squares []       =  []
squares (x:xs)   =  x*x : squares xs
```

Conditionals with binding

```
squares :: [Int] -> [Int]
squares ws  =
  if null ws then
    []
  else
    let
      x  = head ws
      xs = tail ws
    in
      x*x : squares xs
```

Pattern matching and conditionals (take)

Pattern matching

```
take :: Int -> [a] -> [a]
take 0 xs      =  []
take i []      =  []
take i (x:xs)  =  x : take (i-1) xs
```

Conditionals with binding

```
take :: Int -> [a] -> [a]
take i ws
  if i == 0 || null ws then
    []
  else
    let
      x  = head ws
      xs = tail ws
    in
      x : take (i-1) xs
```

Pattern matching and guards (take)

Pattern matching

```
take :: Int -> [a] -> [a]
take 0 xs        =  []
take i []        =  []
take i (x:xs)    =  x : take (i-1) xs
```

Guards

```
take :: Int -> [a] -> [a]
take 0 xs                =  []
take i []                =  []
take i (x:xs) | i > 0    =  x : take (i-1) xs
```

How take works (recursion)

```
take :: Int -> [a] -> [a]
take 0 xs        =  []
take i []        =  []
take i (x:xs)    =  x : take (i-1) xs
```

```
  take 3 "words"
=
  'w' : take 2 "ords"
=
  'w' : ('o' : take 1 "rds")
=
  'w' : ('o' : ('r' : take 0 "ds"))
=
  'w' : ('o' : ('r' : []))
=
  "wor"
```

The infinite case

```
take :: Int -> [a] -> [a]
take 0 xs        =  []
take i []        =  []
take i (x:xs)    =  x : take (i-1) xs

takeComp :: Int -> [a] -> [a]
takeComp i xs    =  [ x | (j,x) <- zip [0..] xs, j < i ]

> take 3 [10..]
[10,11,12]

> takeComp 3 [10..]
[10,11,12    -- computation goes on forever!
```

The infinite case explained

Function `takeComp` is equivalent to `takeCompRec`.

```
takeCompRec :: Int -> [a] -> [a]
takeCompRec i xs  =  helper 0 i xs
  where
  helper j i []                  = []
  helper j i (x:xs) | j < i      =  x : helper (j+1) i xs
                    | otherwise  =  helper (j+1) i xs

  takeCompRec 3 [10..]
=
  helper 0 3 [10..]
=
  10 : helper 1 3 [11..]
=
  10 : (11 : helper 2 3 [12..])
=
  10 : (11 : (12 : helper 3 3 [13..]))
=
  10 : (11 : (12 : helper 4 3 [14..]))
= ...
```

Part II

Arithmetic

Arithmetic (recursion)

```
(+) :: Int -> Int -> Int
m + 0  =  m
m + n  =  (m + (n-1)) + 1

(*) :: Int -> Int -> Int
m * 0  =  0
m * n  =  (m * (n-1)) + m

(^) :: Int -> Int -> Int
m ^ 0  =  1
m ^ n  =  (m ^ (n-1)) * m
```

How arithmetic works (recursion)

```
 (+) :: Int -> Int -> Int
m + 0  =  m
m + n  =  (m + (n-1)) + 1

   2 + 3
=
   (2 + 2) + 1
=
   ((2 + 1) + 1) + 1
=
   (((2 + 0) + 1) + 1) + 1
=
   ((2 + 1) + 1) + 1
=
   5
```

Giuseppe Peano (1858–1932)

The definition of the natural numbers is named the *Peano axioms* in his honour.
Made key contributions to the modern treatment of mathematical induction.