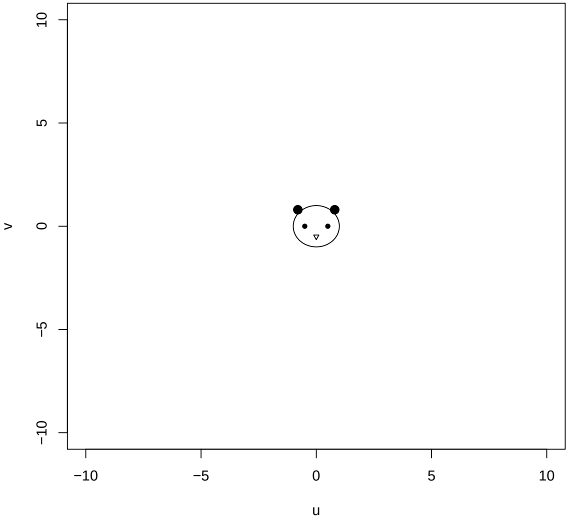
R: Programming

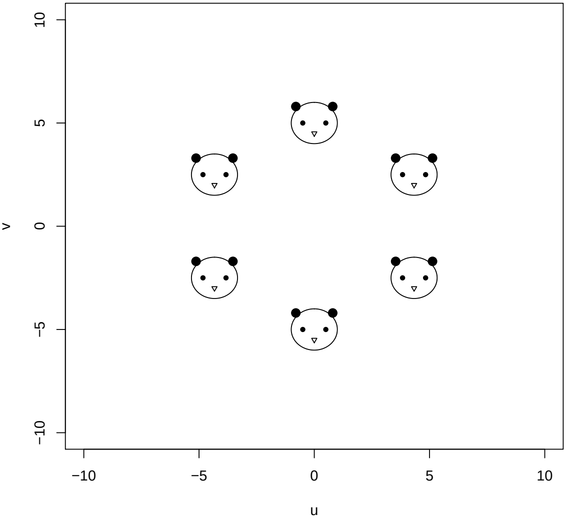
140.776 Statistical Computing

September 8, 2011

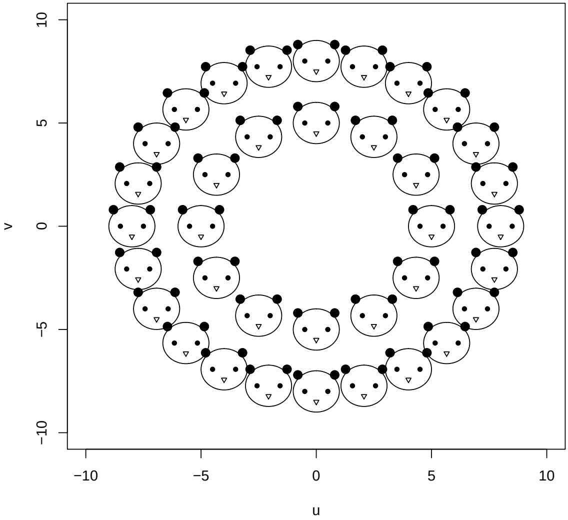
Why programming?



Why programming



Why programming



Control structures

Programming is more than just putting commands you've learnt so far into a *.R file. A key element of programming (which is also true for other languages) is that you can use *control structures* to control the flow of execution of the program.

For example, "for()" is a control structure in R to repeatedly execute a series of similar commands.

Control structures

Control structures commonly used in R include:

- if, else: testing a condition
- for: execute a loop for a fixed number of times
- while: execute a loop while a condition is true
- repeat: execute a loop until seeing a break
- break: break the execution of a loop
- next: skip an iteration of a loop
- return: exit a function

Conditional execution: if statements

```
if(<condition>) {
        ## do something
} else {
        ## do something else
}

if(<condition1>) {
        ## do something
} else if (<condition2>) {
        ## do something different
} else {
        ## do something else
}
```

Conditional execution: if statements

Example: compute the absolute value of x and assign it to y.

```
if(x<0) {
        y<-(-x)
} else {
        y<-x
}
```

Conditional execution: if statements

The else clause is not necessary:

```
if(<condition1>) {
        ## do something
}

is equivalent to

if(<condition1>) {
        ## do something
} else {
        ## do nothing
}
```

&& (AND) and || (OR) in conditions

Conditions often use && (AND) and || (OR).

```
if(x>0 && x<1) {
        y<-x^2
} else {
        y<-x^4
}
```

&& (AND) and || (OR) in conditions

```
> x<-c(1>2,2<3,3==4)
> x
[1] FALSE  TRUE FALSE
> y<-c(1<2,2<3,3!=4)
> y
[1] TRUE TRUE TRUE

> x&&y
```

&& (AND) and || (OR) in conditions

```
> x
[1] FALSE  TRUE FALSE
> y
[1] TRUE TRUE TRUE

> x&&y
[1] FALSE

> x&y
```

&& (AND) and || (OR) in conditions

```
> x
[1] FALSE  TRUE FALSE
> y
[1] TRUE TRUE TRUE

> x&&y
[1] FALSE

> x&y
[1] FALSE  TRUE FALSE
```

&& (AND) and || (OR) in conditions

&& and || are different from & and |:

- The shorter form (& and |) performs elementwise comparisons in much the same way as arithmetic operators.
- The longer form (&& and ||) evaluates left to right, examining only the first element of each vector. Evaluation proceeds only until the result is determined.

&& (AND) and || (OR) in conditions

```
1<2 || 2>3 && 1>2
```

&& (AND) and || (OR) in conditions

Compare the following three expressions:

```
> 1<2 || 2>3 && 1>2
[1] TRUE

> (1<2 || 2>3) && 1>2
[1] FALSE

> 1<2 || (2>3 && 1>2)
[1] TRUE
```

Why do you obtain different results?

&& (AND) and || (OR) in conditions

In R, operators belong to different precedence groups. && has higher precedence than ||, therefore && is evaluated first.

About precedence of operators:

- Use help(Syntax) to learn precedence of operators.
- Within an expression, operators of equal precedence are evaluated from left to right.
- If you are not sure about which operator is evaluated first, I recommend you to explicitly specify the priority by using ().
- There are substantial precedence differences between R and S. For example, in S, &, &&, | and || have equal precedence.

Repetitive execution: for loops

```
for(var in seq) {
        expr
}
```

For loops are commonly used for iterating over the element of an object (list, vector, etc.). For example:

```
for(i in 1:10) {
        print(i)
}
```

Repetitive execution: for loops

These loops have the same behavior:

```
x<-c("a","b","c","d")

for(i in 1:4) {
        print(x[i])
}

for(i in seq_along(x)) {
        print(x[i])
}

  for(letter in x) {
        print(letter)
}

for(i in 1:4) print(x[i])
```

Find banana

```
> load("apple-banana-array.rda")
```

Nested loops

Loops can be nested:

```
x<-matrix(1:60,6,10)

for(i in seq_len(nrow(x))) {
        for(j in seq_len(ncol(x))) {
                print(x[i,j])
        }
}
```

Repetitive execution: while

```
while(cond) {
      expr
}
```

While loops evaluate a condition repetitively. If the condition is true, then the expression in the loop body is executed. Otherwise, the loop will be ended. For example:

```
count<-0
while(count<10) {
      print(count)
      count<-count+1
}
```

Repetitive execution: while

Another example:

```
## simulate a random walk
z<-5
while(z>=3 && z<=10) {
        print(z)
        coin<-rbinom(1,1,0.5)
        if(coin == 1) {
                z<-z+1
        } else {
                z<-z-1
        }
}
```

Repetitive execution: repeat

```
repeat {
        expr
}
```

This statement executes the expression in the loop repeatedly until it sees a *break*. For example:

```
x0<-1
tol<-1e-8
repeat {
        x1<-computeEstimate()

        if(abs(x1-x0)<tol) {
                break
        } else {
                x0<-x1
        }
}
```

Breaking a loop: break

The *break* statement can be used to terminate any loop. It is the only way to terminate repeat loops. For example:

```
x0<-1
tol<-1e-8
err<-10
iter<-0
while (err>tol) {
        x1<-computeEstimate()
        err<-abs(x1-x0)
        x0<-x1
        iter<-iter+1
        if(iter == 100) {
                break
        }
}
```

next and return

next is used to skip an iteration of a loop.

```
for(i in 1:5) {
        if(i<=3) {
                next
        }
        print(i)
}
```

```
[1] 4
[1] 5
```

return signals that a function should exit and return a given value.

Find banana

```
> load("apple-banana-list.rda")

  (name="apple", nextnode)
                 |
                 V
         (name = "apple", nextnode)
                            |
                           ...
                            V
                      (name = "banana", nextnode)
                                          |
                                         ...
                                          V
                                         NA
```

Signalling Conditions

There are 4 main functions for signalling or handling conditions (i.e. unusual situations) in R.

- message: print a message to the console (not necessarily a bad thing)
- warning: non-fatal problem; print a message to the console
- stop: problem is fatal, execution of the program is halted
- try, tryCatch: testing for conditions and executing alternate code (exception handling)

Warnings, Messages

```
for(i in seq_along(x)) {
        if(<minor condition>) {
                message("a minor condition occurred")
        }
        if(<more serious condition>) {
                warning("something unusual is going on")
        }
        if(<fatal condition>) {
                stop("cannot continue, aborting")
        }
}
```

Good habits

- **Correct grammar**
  R code: immediately source-able; C code: can be compiled without errors
- **Correct results**
  Produce logically correct answer
- **Code readability**
  Use monospace font; <80 characters/line; indent your code; comment your codes
- **Code efficiency**
  Organize into functional modules; keep the code short if possible
- **Computational efficiency**
  Whoever runs fastest wins

Grading criteria

Example:

```
  correctness                 60%
+ computational efficiency    20%
+ readability                 10%
+ code efficiency             10%
=                            100%
```