CSC 120: Computer Science for the Sciences (R section)

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Week 9

Many Ways to Write a Simple Function

In this lecture, we'll look at many ways of writing a simple function called `is_not_decreasing`, which takes one argument, a vector, and returns TRUE if the elements in the vector are in non-decreasing order, and FALSE otherwise. We'll see some new R features along the way.

Examples:

```
> is_not_decreasing (c(4,8,8,9))
[1] TRUE
> is_not_decreasing (c(5,1,3))
[1] FALSE
> is_not_decreasing (7)
[1] TRUE
```

We'll assume that the vector has no NA values. What would be a reasonable thing to do if it did?

Ending a Loop Using a Logical Flag Variable

Here's one solution, that uses the setting of a logical variable as a way of terminating a `while` loop:

```
is_not_decreasing <- function (v) {
    answer_is_known <- FALSE
    i <- 2
    while (!answer_is_known) {
        if (i > length(v)) {
            answer <- TRUE
            answer_is_known <- TRUE
        }
        else if (v[i] < v[i-1]) {
            answer <- FALSE
            answer_is_known <- TRUE
        }
        i <- i + 1
    }
    answer
}
```

Using a `repeat` Loop and `break` Statement

This function used two logical variables — one to hold the answer returned, the other to indicate when the answer is now known, and hence the loop can end. We can instead use a loop written using `repeat`, which continues indefinitely, until a `break` statement is done:

```
is_not_decreasing <- function (v) {
    i <- 2
    repeat {
        if (i > length(v)) {
            answer <- TRUE
            break
        }
        if (v[i] < v[i-1]) {
            answer <- FALSE
            break
        }
        i <- i + 1
    }
    answer
}
```

Using `break` Within a `for` Loop

We can use `break` to immediately exit any kind of loop. Here's another way to write this function:

```
is_not_decreasing <- function (v) {
    answer <- TRUE
    if (length(v) > 1)
        for (i in 2:length(v)) {
            if (v[i] < v[i-1]) {
                answer <- FALSE
                break
            }
        }
    answer
}
```

In this version, we initially set `answer` to `TRUE`, which will be the answer if we don't find a place where the elements decrease. If we do find a decrease, we set `answer` to `FALSE`, and also immediately exit the `for` loop.

Caution: The `break` statement exits from the innermost loop that contains it. If you're inside two loops, you can't use `break` to exit both of them at once.

Returning a Value for a Function Immediately

Rather than exit a loop with `break` after setting `answer`, and then making `answer` the value of the function by putting it as the last thing, we can instead use `return` to exit the whole function, and specify the value it returns.

```
is_not_decreasing <- function (v) {
    if (length(v) > 1) {
        for (i in 2:length(v)) {
            if (v[i] < v[i-1])
                return(FALSE)
        }
    }
    return(TRUE)
}
```

At the end, we could just have written `TRUE` instead of `return(TRUE)` — they do the same thing at the end of a function.

Why is the check for `length(v) > 1` needed?

Avoiding Loops with a Vector Comparison

We can write `is_not_decreasing` without an R loop using a vector comparison and the `all` function:

```
is_not_decreasing <- function (v) all (v[-length(v)] <= v[-1])
```

In this version, `v[-length(v)]` will contain all of `v` except the last element, and `v[-1]` will contain all of `v` except the first element. So `v[-length(v)] <= v[-1]` compares each element except the last to the next element. The vector `v` is non-decreasing if all these comparisons are `TRUE`.

Here's another way to do the same thing:

```
is_not_decreasing <- function (v) {
    if (length(v) < 2)
        TRUE
    else
        all (v[1:(length(v)-1)] <= v[2:length(v)])
}
```

Why is the check for `length(v) < 2` needed here, but not in the version above?

Recursion — When a Function Calls Itself

As you know, an R function can call another R function, which can call yet another R function, etc.

Indeed, an R function can even call *itself*. This is called "recursion".

Of course, a function had better not *always* call itself, or it will just keep calling, and calling, and calling, without end.

But having a function sometimes call itself can be useful. Here's a recursive function to compute factorials in R:

```
fact <- function (n) if (n == 0) 1 else n * fact(n-1)
```

(Although R already has a pre-defined `factorial` function.)

In fact, anything computable can be computed using `if` and recursion, without any loops or assignment statements. That's not a typical style of programming in R, but it is typical for some other programming languages.

Two Recursive Versions of `is_not_decreasing`

We could write the `is_not_decreasing` function using recursion. Here's one way:

```
is_not_decreasing <- function (v) {
    if (length(v) <= 1)
        TRUE
    else if (v[2] < v[1])
        FALSE
    else
        is_not_decreasing(v[-1])
}
```

Here's another way that doesn't copy parts of `v`, and also extends the function's meaning so it checks only from a certain point forward (default, from the start):

```
is_not_decreasing <- function (v, from=1) {
    if (length(v) <= from)
        TRUE
    else if (v[from+1] < v[from])
        FALSE
    else
        is_not_decreasing(v,from+1)
}
```