MTH208: Worksheet 5

Benchmarking R code and coding efficiently in R

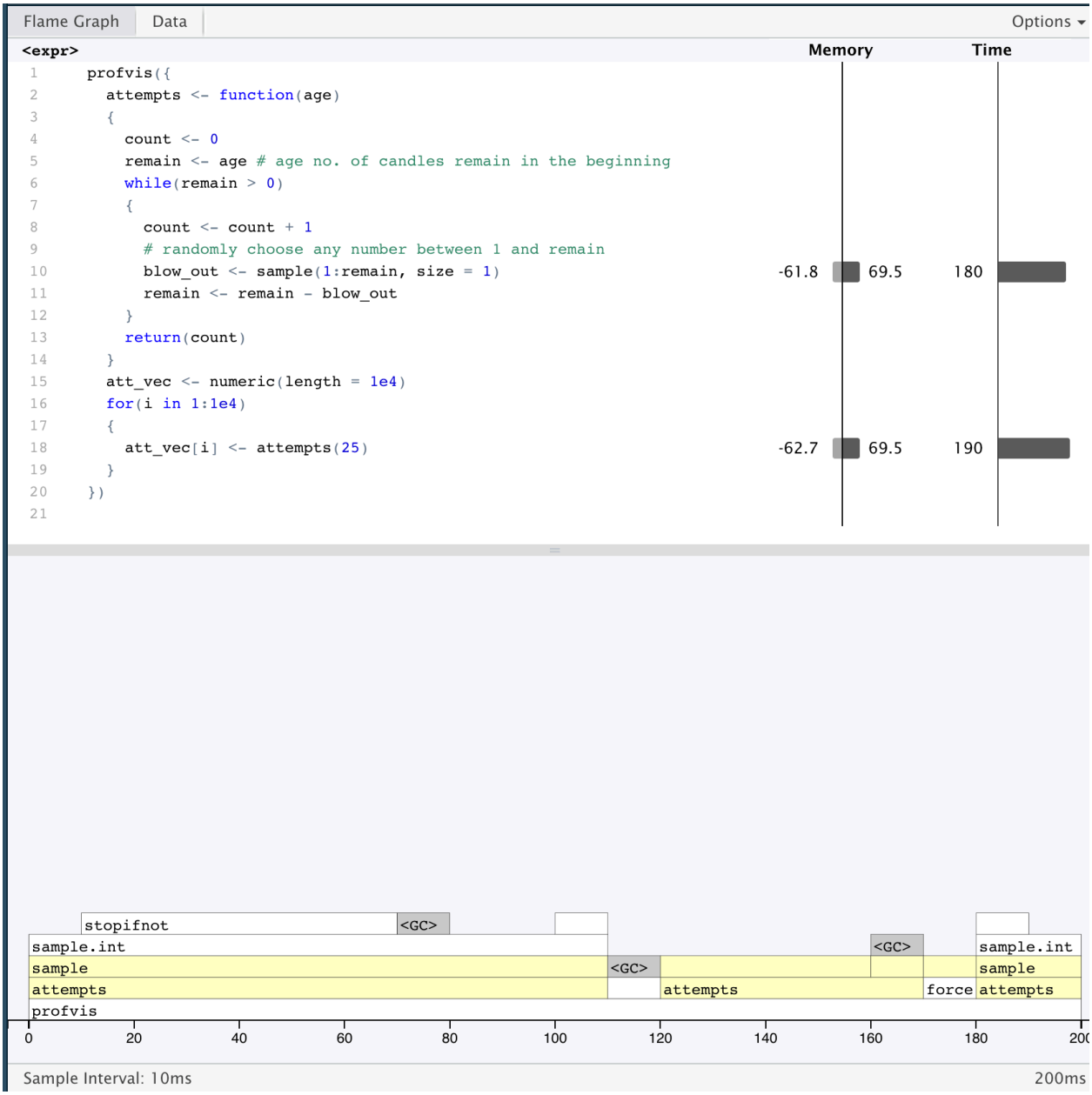
At this point, we have some experience with writing R codes for various tasks. As we learn to write more and more complicated code, it is important to know how to optimize the code and which lines of code take the most time.

The `profvis` package will help us do exactly this. Recall Problem 4 from Worksheet 3, where the task was to obtain the average number of attempts it takes to blow out the candles on my 25th birthday. The function `profvis()` will help us profile the code

```
library(profvis)

profvis({
  attempts <- function(age)
  {
    count <- 0
    remain <- age # age no. of candles remain in the beginning
    while(remain > 0)
    {
      count <- count + 1
      # randomly choose any number between 1 and remain
      blow_out <- sample(1:remain, size = 1)
      remain <- remain - blow_out
    }
    return(count)
  }
  att_vec <- numeric(length = 1e3)
  for(i in 1:1e3)
  {
    att_vec[i] <- attempts(25)
  }
})
```

The following Profile page will open up on your Script panel:



A flame graph is presented. On the x-axis is the time from 0 till the time it took to run the command. On the y-axis are the functions that took the time. So for example, naturally `profvis()` took the most time, followed by a series of usage of attempts() function. Within `attempts()`, function `sample` look all of `attempts()` time.

Go over the above code and interactive environment carefully. Now let's do some problems.

Problems

1. Lets think about how we can make this code a bit faster. The `attempts()` function seems like we may not be able to make it faster. However, we can replace the replications using `for` loop with `replicate`. That is, use the following code to replicate the experiment 10^3 times.

Replace the for loop in the example with the replicate function and profile again. Which functions does `replicate()` call in the background?

2. A natural question ask is, which of the two codes are faster? For this we will use the library `rbenchmark` and the function `benchmark()` in there.

```
benchmark({
  att_vec <- numeric(length = 1e3)
  for(i in 1:1e3)
  {
    att_vec[i] <- attempts(25)
  }},
  replicate(1e3, attempts(25)), replications = 100)
```

Which of the two ways of running the loop is faster?

3. Repeat the above for 10^4 reps instead of 10^3 and set `replications = 20`. Do you notice any difference?

4. Many students do the following instead of the usual for loop:

```
att_vec <- NULL
for(i in 1:1e4)
{
  att_vec <- c(att_vec, attempts(25))
}
```

Benchmark the above with the other two methods for `replications = 25`. What do you learn?

5. Create a matrix of size $n \times m$ for your choice of n and m, that is made from random numbers between (0,1). (Recall function `runif()`). Using `colMeans()` function and the `apply()` function, find two ways to determine the mean of each column. Which method is faster? Is the answer dependent on n and m?

Now that you've learned benchmarking and profiling a little bit, we will learn about coding efficiently in R.

Here are some general guidelines on making sure we code efficiently in R.

- Avoid loops when possible in R. If loops cannot be avoided, then make sure to allocate memory for the loop. This is a feature of high-level languages in R.

  Sometimes we cannot avoid loops. In such cases, we could switch to implementing C++ within R, which we will discuss in the next lab session.

- You should know how much memory a certain object will take. A single number takes roughly 8 bytes of memory. 1024 bytes = 1KB, 1024 KB = 1MB, 1024 MB = 1GB. Thus a vector of length `n` takes around $8n$ bytes of memory.

- Be careful about numerical instabilities. Sometimes numbers get too small or too large for R to handle. Make transformations to avoid this.

6. Write R code to draw 10^4 realizations from Uniform $(0, 1)$ one at a time (using a loop) and another code to draw the numbers all at once. Which one is faster?

7. Theoretically, assess roughy how much memory each of the objects below will take and then verify using `object.size()`.

```r
num1 <- numeric(length = 1e3)
num2 <- numeric(length = 1e6)

mat1 <- matrix(runif(100*1000), nrow = 100, ncol = 1000)
mat2 <- matrix(0, nrow = 100, ncol = 1000)

arr <- array(0, dim = c(100,100,100))
```