June 2, 2022

The results below are generated from an R script.

```r
## Install a package manager and packages
if (!require("pacman")) {
  install.packages("pacman")
}
pacman::p_load(Rfast, foreach, doParallel, mvnfast, rstudioapi)
current_path = rstudioapi::getActiveDocumentContext()$path
setwd(dirname(current_path))

pacman::p_load_gh("pkimes/sigclust2")
shc = get("shc", env = environment(shc))

source("sequential_function.R")

# k = 3 # number of clusters (3 or 10)
# uneven = FALSE #whether or not to have uneven weights
# distribution = 't' # t distribution or normal distribution?
# iterations = 50 # number of iterations


n = 500 # total number of samples
alpha = 0.05


if (distribution=='t'){
  distribution_name = 'True distribution components: t-distrbution (df=3) mixture distribution'
  samplefunc <- function(n, mu, sigma, w){
    rmixt(n = n,mu = mus,sigma = sigmas,w = w,df = 3)
  }
}else{
  distribution_name = 'True distribution: Normal mixture distribution'
  samplefunc <- function(n, mu, sigma, w){
  rmixn(n=n, mu=mus, sigma=sigmas, w=w)
}
}


# formulating d, delta (dimension and distance between clusters)
if (k == 10){
  a = c(2, 1, 2, 2, 2, 3, 2, 4, 2, 5, 2, 6, 2, 7, 2, 8, 2, 9) # dim2
  b = c(8, 1, 8, 2, 8, 3, 8, 4, 8, 5, 8, 6, 8, 7, 8, 8, 8, 9) # dim8
  d_delta = matrix(c(a, b) , ncol = 2, byrow = T)
} else if (k == 3){
  a = c(2, 1, 2, 2, 2, 3, 2, 4, 2, 5, 2, 6, 2, 7, 2, 8, 2, 9) # dim2
```

```r
  b = c(8, 1, 8, 2, 8, 3, 8, 4, 8, 5, 8, 6, 8, 7, 8, 8, 8, 9) # dim8
  d_delta = matrix(c(a, b) , ncol = 2, byrow = T)
} else {
  stop("k != 3 or 10")
}


#weights
w = rep.int(1, k)
if (uneven){
  w[1] = 1 / 4
  w[2] = 1 / 2
}
w = w / sum(w)


K = floor(sqrt(n / 2)) #num clusters to test
K = min(K, 14L) # to ensure not estimating too many clusters

coresToUse = floor(detectCores() / 2) # cores to use

# function which creates data and performs one iteration
simulation <- function(iteration) {
  # simulate data
  set.seed(18 + iteration)
  data = samplefunc(n=n, mu=mus, sigma=sigmas, w=w)


  D1 = data[1:floor(n / 2), ]
  D2 = data[(floor(n / 2) + 1):n, ]

  # Estimate no.clusters
  Cluster_numbers = estimate.cluster.all(D1, D2, alpha, K)
  sigclust_splits = sum(shc(data, alpha = alpha)$nd_type == "sig")
  return(c(unlist(Cluster_numbers, use.names = F), sigclust_splits + 1L))
}


meanEstimate = matrix(nrow = nrow(d_delta), ncol = iterations)
medianEstimate = meanEstimate
meanEstimatel2 = meanEstimate
medianEstimatel2 = meanEstimate
AICEstimate = meanEstimate
BICEstimate = meanEstimate
sigclustEstimate = meanEstimate
RIFThierEstimate = meanEstimate

# For parallel computing
cl <- makeCluster(coresToUse) #not to overload computer
registerDoParallel(cl)


for (j in 1:nrow(d_delta)) {
```

```r
    d = d_delta[j, 1]
    delta = d_delta[j, 2]



    #sigmas = lapply(c(3,1,1), function(x) diag(x, nrow=d))
    sigmas = lapply(rep.int(1, k), function(x)
      diag(x, nrow = d))


    #mus = zeros(k, d)
    #mus[1,1] = delta
    #mus[2,2] = -delta
    #mus[3,2] = delta
    mus = outer(rep.int(1L, k), seq.int(d)) + delta * seq.int(0, k - 1L)

    estimates <-
      foreach(
        i = 1:iterations,
        .combine = cbind,
        .inorder = F,
        .packages = c("mclust", "Rfast", "mvnfast", "MASS"),
        .verbose = F
      ) %dopar% {
        simulation(i)
      }

    # format data into table
    meanEstimate[j, ] = estimates[1, ]
    medianEstimate[j, ] = estimates[2, ]
    meanEstimatel2[j, ] = estimates[3, ]
    medianEstimatel2[j, ] = estimates[4, ]
    BICEstimate[j, ] = estimates[5, ]
    AICEstimate[j, ] = estimates[6, ]
    RIFThierEstimate[j, ] = estimates[7, ]
    sigclustEstimate[j, ] = estimates[8, ]
    df = stack(data.frame(
      cbind(
        "Mean" = meanEstimate[j, ],
        "Meanl2" = meanEstimatel2[j, ],
        "Median" = medianEstimate[j, ],
        "Medianl2" = medianEstimatel2[j, ],
        "AIC" = AICEstimate[j, ],
        "BIC" = BICEstimate[j, ],
        "RIFT.hc" = RIFThierEstimate[j, ],
        "shc" = sigclustEstimate[j, ]
      )
    ))
    print(paste0("(dimension, delta) = (", d, ",", delta, ")"))
    colnames(df) = c("ESTIMATE" , "METHOD")
    tableEstimates = with(df, table(METHOD, ESTIMATE))
    print(tableEstimates)
}
```

```
## [1] "(dimension, delta) = (2,1)"
##         ESTIMATE
## METHOD    1  2  3  4  5  6  7  8  9 10 11 12 13 14 15 16 17 19 20
##   Mean    65 34  1  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0
##   Meanl2  64 35  1  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0
##   Median  33 59  8  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0
##   Medianl2 33 59  8  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0
##   AIC     15 66 18  0  1  0  0  0  0  0  0  0  0  0  0  0  0  0  0
##   BIC     52 48  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0
##   RIFT.hc 18 24 39 17  2  0  0  0  0  0  0  0  0  0  0  0  0  0  0
##   shc      0  0  0  0  6  7  6  8 14 17  5 12 10  3  6  1  3  1  1
## [1] "(dimension, delta) = (2,2)"
##         ESTIMATE
## METHOD    1  2  3  4  5  7  8  9 10 11 12 13 14 15 16 17
##   Mean    52 41  6  1  0  0  0  0  0  0  0  0  0  0  0  0
##   Meanl2  52 41  6  1  0  0  0  0  0  0  0  0  0  0  0  0
##   Median  19 55 23  1  1  0  0  0  0  1  0  0  0  0  0  0
##   Medianl2 18 56 24  1  0  0  0  0  0  1  0  0  0  0  0  0
##   AIC      3 57 36  3  1  0  0  0  0  0  0  0  0  0  0  0
##   BIC     32 63  5  0  0  0  0  0  0  0  0  0  0  0  0  0
##   RIFT.hc  3 39 40 16  2  0  0  0  0  0  0  0  0  0  0  0
##   shc      0  0  0  0  0  1  3 11 12 19 25  8 12  7  1  1
## [1] "(dimension, delta) = (2,3)"
##         ESTIMATE
## METHOD    1  2  3  4  5  6  8  9 10 11 12 13 14 16
##   Mean    28 20  7  0  2  0  0  8 11 15  6  3  0  0
##   Meanl2  28 21  7  0  2  0  0  8 12 15  4  3  0  0
##   Median   1  2  0  1  0  1  1 19 23 23 10  8 11  0
##   Medianl2 1  2  0  1  0  1  1 18 25 23 10  7 11  0
##   AIC      3 26 19  5  1  0  0  2 14 18  8  4  0  0
##   BIC     31 61  8  0  0  0  0  0  0  0  0  0  0  0
##   RIFT.hc  6 38 26 20  9  1  0  0  0  0  0  0  0  0
##   shc      0  0  0  0  0  0  0  2 59 21 13  3  1  1
## [1] "(dimension, delta) = (2,4)"
##         ESTIMATE
## METHOD    1  2  3  4  5  6  7  8  9 10 11 12 13 14
##   Mean     1  0  1  2  1  0  2  2 23 16 19 18  9  6
##   Meanl2   1  1  1  1  1  0  2  2 23 16 19 18  9  6
##   Median   0  0  0  0  0  1  0  6 29 23 16 10 11  4
##   Medianl2 0  0  0  0  0  1  0 11 25 23 14 11 11  4
##   AIC      0  0  0  0  0  1  1  0  9 13 23 26 17 10
##   BIC     21 29  4  0  0  0  0  0  3  9 14 14  5  1
##   RIFT.hc  6 40 27 15 10  1  1  0  0  0  0  0  0  0
##   shc      0  0  0  0  0  0  0  0  0 89 10  1  0  0
## [1] "(dimension, delta) = (2,5)"
##         ESTIMATE
## METHOD    1  2  3  4  5  6  7  8  9 10 11 12 13 14
##   Mean     1  0  0  0  0  1  1  8 16 19 23  9 13  9
##   Meanl2   1  0  0  0  0  2  1  7 15 20 22 10 12 10
##   Median   0  0  0  0  0  1  0 14 24 21 15 10  6  9
##   Medianl2 0  0  0  0  0  1  0 15 21 23 14 10  8  8
##   AIC      0  0  0  0  0  0  0  2 12 19 17 11 21 18
##   BIC      0  4  1  0  0  0  0  0 15 18 20  9 20 13
```

4

```
##   RIFT.hc   5 32 27 17 15  1  3  0  0  0  0  0  0  0
##   shc       0  0  0  0  0  0  0  0  0 88 11  1  0  0
## [1] "(dimension, delta) = (2,6)"
##        ESTIMATE
## METHOD    1  2  3  4  5  6  7  8  9 10 11 12 13 14
##   Mean    0  0  0  1  0  0  2  7 14 12 12 19 15 18
##   Meanl2  0  0  0  1  0  0  2  7 14 12 11 20 14 19
##   Median  0  0  0  0  0  0  2 12 33 15  5 11  7 15
##   Medianl2 0  0  0  0  0  0  2 13 29 19  6 10  7 14
##   AIC     0  0  0  0  0  0  0  1 17 10 15 17 21 19
##   BIC     0  0  0  0  0  0  1  1 20 10 14 16 20 18
##   RIFT.hc 8 31 27 18 11  2  3  0  0  0  0  0  0  0
##   shc     0  0  0  0  0  0  0  0  0 91  9  0  0  0
## [1] "(dimension, delta) = (2,7)"
##        ESTIMATE
## METHOD    1  2  3  4  5  6  7  8  9 10 11 12 13 14
##   Mean    0  0  0  0  0  0  0  7 17  7  8 17 20 24
##   Meanl2  0  0  0  0  0  0  0  7 17  7  7 18 19 25
##   Median  0  0  0  0  0  0  0 15 30 22  6  6 11 10
##   Medianl2 0  0  0  0  0  0  0 15 29 22  6  8  9 11
##   AIC     0  0  0  0  0  0  0  1 15  5  8 19 26 26
##   BIC     0  0  0  0  0  0  0  2 21  7  7 17 20 26
##   RIFT.hc 9 34 30 14  8  2  2  1  0  0  0  0  0  0
##   shc     0  0  0  0  0  0  0  0  0 89 10  1  0  0
## [1] "(dimension, delta) = (2,8)"
##        ESTIMATE
## METHOD    1  2  3  4  5  6  7  8  9 10 11 12 13 14
##   Mean    0  0  0  0  0  0  0  2 16  7 13 24 18 20
##   Meanl2  0  0  0  0  0  0  0  2 16  7 13 23 19 20
##   Median  0  0  0  0  0  0  1  6 53 11  6  6  8  9
##   Medianl2 0  0  0  0  0  0  1 10 47 12  7  6  8  9
##   AIC     0  0  0  0  0  0  0  0 13  3 10 28 23 23
##   BIC     0  0  0  0  0  0  0  0 15  3 11 26 22 23
##   RIFT.hc 9 35 28 15  5  3  4  1  0  0  0  0  0  0
##   shc     0  0  0  0  0  0  0  0  0 90  9  1  0  0
## [1] "(dimension, delta) = (2,9)"
##        ESTIMATE
## METHOD    1  2  3  4  5  6  7  8  9 10 11 12 13 14
##   Mean    0  0  0  0  0  0  0  1 15 12 17 23 18 14
##   Meanl2  0  0  0  0  0  0  0  1 15 11 17 24 18 14
##   Median  0  0  0  0  0  0  1  4 43 17  5  9  8 13
##   Medianl2 0  0  0  0  0  0  1  8 38 16  7  9  8 13
##   AIC     0  0  0  0  0  0  0  1 14  8 17 23 20 17
##   BIC     0  0  0  0  0  0  0  1 12 10 17 24 19 17
##   RIFT.hc 7 35 23 20  7  4  4  0  0  0  0  0  0  0
##   shc     0  0  0  0  0  0  0  0  0 89 10  1  0  0
## [1] "(dimension, delta) = (8,1)"
##          ESTIMATE
## METHOD     1  2  3  4  5  6  9 10 11 12 13 14 15 16 17 18 19 20 24
##   Mean    81 18  1  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0
##   Meanl2  81 18  1  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0
##   Median  33 62  5  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0
##   Medianl2 33 62  5  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0
##   AIC     59 40  1  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0
```

```
##   BIC       100   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
##   RIFT.hc    21  56   8  11   3   1   0   0   0   0   0   0   0   0   0   0   0   0
##   shc         0   0   0   0   0   0   4   6   8  18  10  10  18  10   7   3   2   3   1
## [1] "(dimension, delta) = (8,2)"
##           ESTIMATE
## METHOD     1  2  3  4  5  6  8  9 10 11 12 13 14
##   Mean    56 14  1  1  0  0  0 14  6  4  2  1  1
##   Meanl2  56 14  1  1  0  0  0 14  6  4  2  1  1
##   Median   0  1  0  0  0  0 11 49 22 11  4  1  1
##   Medianl2 0  1  0  0  0  0 11 49 23 10  4  1  1
##   AIC     31 33  1  0  0  0  0 20 10  3  2  0  0
##   BIC     99  1  0  0  0  0  0  0  0  0  0  0  0
##   RIFT.hc 21 63  3  6  5  2  0  0  0  0  0  0  0
##   shc      0  0  0  0  0  0  0  0 73 21  4  2  0
## [1] "(dimension, delta) = (8,3)"
##           ESTIMATE
## METHOD     1  2  3  5  8  9 10 11 12 13 14
##   Mean    15  7  3  0  0 21 22 15  7  5  5
##   Meanl2  15  7  3  0  0 21 22 15  7  5  5
##   Median   0  0  0  0  2 42 29 16  7  2  2
##   Medianl2 0  0  0  0  2 42 28 16  7  2  3
##   AIC      5  5  0  0  0 31 25 17  7  5  5
##   BIC     83  1  0  0  0  3  3  8  2  0  0
##   RIFT.hc 20 64 15  1  0  0  0  0  0  0  0
##   shc      0  0  0  0  0  0 86 12  2  0  0
## [1] "(dimension, delta) = (8,4)"
##           ESTIMATE
## METHOD     1  2  3  4  5  7  8  9 10 11 12 13 14
##   Mean     8  4  0  0  1  1  4 34 20  9  5 10  4
##   Meanl2   8  4  0  0  1  1  4 34 20  9  5 10  4
##   Median   0  0  0  0  0  0  1 52 25 16  3  2  1
##   Medianl2 0  0  0  0  0  0  1 52 24 17  3  2  1
##   AIC      4  5  0  0  0  0  0 38 23 12  6  8  4
##   BIC     44  1  0  0  0  0  0 27  8  8  3  7  2
##   RIFT.hc 17 66 14  1  2  0  0  0  0  0  0  0  0
##   shc      0  0  0  0  0  0  0  0 86 12  2  0  0
## [1] "(dimension, delta) = (8,5)"
##           ESTIMATE
## METHOD     1  2  3  4  5  7  8  9 10 11 12 13 14
##   Mean     4  1  0  0  0  6 23 34  7  8  3  7  7
##   Meanl2   4  1  0  0  0  6 23 34  7  8  3  7  7
##   Median   0  0  0  0  0  0  6 69 13  5  1  2  4
##   Medianl2 0  0  0  0  0  0  6 69 13  5  1  2  4
##   AIC      1  1  0  0  0  0  0 55 14 12  3  7  7
##   BIC     16  0  0  0  0  0  0 49 12  7  3  6  7
##   RIFT.hc 20 58 18  1  3  0  0  0  0  0  0  0  0
##   shc      0  0  0  0  0  0  0  0 88 11  1  0  0
## [1] "(dimension, delta) = (8,6)"
##           ESTIMATE
## METHOD     1  2  3  4  5  7  8  9 10 11 12 13 14
##   Mean     3  1  0  0  0 13 23 19  9  9  6  6 11
##   Meanl2   3  1  0  0  0 13 23 19  9  9  6  6 11
##   Median   0  0  0  0  0  0  3 69 16  9  2  1  0
##   Medianl2 0  0  0  0  0  0  3 69 16  9  2  1  0
```

```
##   AIC       0  1  0  0  0  0  1 48 14 11  8  6 11
##   BIC       9  0  0  0  0  0  0 44 14 11  7  6  9
##   RIFT.hc  19 54 23  1  3  0  0  0  0  0  0  0  0
##   shc       0  0  0  0  0  0  0  0 88 11  1  0  0
## [1] "(dimension, delta) = (8,7)"
##           ESTIMATE
## METHOD    1  2  3  5  6  7  8  9 10 11 12 13 14
##   Mean    3  0  0  0  3 12 19  5 17 19  5 10  7
##   Meanl2  3  0  0  0  3 12 19  5 17 19  5 10  7
##   Median  0  0  0  0  0  0  2 51 27 16  2  2  0
##   Medianl2 0 0  0  0  0  0  2 50 28 16  2  2  0
##   AIC     0  0  0  0  0  0  3 35 20 20  5 10  7
##   BIC     5  0  0  0  0  0  0 32 21 20  5 10  7
##   RIFT.hc 18 56 20  6  0  0  0  0  0  0  0  0  0
##   shc     0  0  0  0  0  0  0  0 88 11  1  0  0
## [1] "(dimension, delta) = (8,8)"
##           ESTIMATE
## METHOD    1  2  3  5  6  7  8  9 10 11 12 13 14
##   Mean    1  1  0  0  1  5 14  5 34 18  8  8  5
##   Meanl2  1  1  0  0  1  5 14  5 34 18  8  8  5
##   Median  0  0  0  0  0  0  3 36 39 15  2  3  2
##   Medianl2 0 0  0  0  0  0  3 36 39 15  2  3  2
##   AIC     0  0  0  0  0  0  4 22 35 18  7  9  5
##   BIC     5  0  0  0  0  0  0 20 36 18  7  9  5
##   RIFT.hc 17 58 19  6  0  0  0  0  0  0  0  0  0
##   shc     0  0  0  0  0  0  0  0 89 10  1  0  0
## [1] "(dimension, delta) = (8,9)"
##           ESTIMATE
## METHOD    1  2  3  5  6  7  8  9 10 11 12 13 14
##   Mean    1  0  0  0  1  5  6  3 44 21 10  3  6
##   Meanl2  1  0  0  0  1  5  6  3 44 21 10  3  6
##   Median  0  0  0  0  0  0  2 26 46 16  6  2  2
##   Medianl2 0 0  0  0  0  0  2 26 46 16  6  2  2
##   AIC     0  0  0  0  0  0  2 11 44 24 10  3  6
##   BIC     3  0  0  0  0  0  0 12 44 22 10  3  6
##   RIFT.hc 20 58 16  5  1  0  0  0  0  0  0  0  0
##   shc     0  0  0  0  0  0  0  0 88 11  1  0  0
```

```r
#stop cluster (parallel computing)
stopCluster(cl)

print(distribution_name )
```

```
## [1] "True distribution: Normal mixture distribution"
```

```r
print(paste(k, 'true clusters:'))
```

```
## [1] "10 true clusters:"
```

```r
print('Cluster weights:')
```

```
## [1] "Cluster weights:"
```

```r
print(w)
```

```
##  [1] 0.02857143 0.05714286 0.11428571 0.11428571 0.11428571 0.11428571 0.11428571
##  [8] 0.11428571 0.11428571 0.11428571
```

The R session information (including the OS info, R version and all packages used):

```
sessionInfo()
## R version 4.1.2 (2021-11-01)
## Platform: x86_64-apple-darwin17.0 (64-bit)
## Running under: macOS Monterey 12.0.1
##
## Matrix products: default
## LAPACK: /Library/Frameworks/R.framework/Versions/4.1/Resources/lib/libRlapack.dylib
##
## locale:
## [1] en_GB.UTF-8/en_GB.UTF-8/en_GB.UTF-8/C/en_GB.UTF-8/en_GB.UTF-8
##
## attached base packages:
## [1] grid      parallel  stats     graphics  grDevices utils     datasets  methods
## [9] base
##
## other attached packages:
##  [1] arm_1.12-2        lme4_1.1-27.1     Matrix_1.3-4      knitr_1.37
##  [5] sigclust_1.1.0    mixtools_1.2.0    gridExtra_2.3     ggplot2_3.3.5
##  [9] MASS_7.3-54       pracma_2.3.6      mclust_5.4.9      sigclust2_1.2.4
## [13] rstudioapi_0.13   mvnfast_0.2.7     doParallel_1.0.16 iterators_1.0.13
## [17] foreach_1.5.1     Rfast_2.0.6       RcppZiggurat_0.1.6 Rcpp_1.0.8
## [21] pacman_0.5.1
##
## loaded via a namespace (and not attached):
##  [1] minqa_1.2.4          colorspace_2.0-2      ellipsis_0.3.2
##  [4] dynamicTreeCut_1.63-1 htmlTable_2.4.0       XVector_0.34.0
##  [7] base64enc_0.1-3      ggdendro_0.1.23       bit64_4.0.5
## [10] AnnotationDbi_1.56.2 fansi_0.5.0           codetools_0.2-18
## [13] splines_4.1.2        cachem_1.0.6          impute_1.68.0
## [16] Formula_1.2-4        nloptr_1.2.2.3        broom_0.7.12
## [19] WGCNA_1.70-3         cluster_2.1.2         kernlab_0.9-29
## [22] GO.db_3.14.0         png_0.1-7             compiler_4.1.2
## [25] httr_1.4.2           backports_1.4.1       fastmap_1.1.0
## [28] htmltools_0.5.2      tools_4.1.2           coda_0.19-4
## [31] gtable_0.3.0         glue_1.6.1            GenomeInfoDbData_1.2.7
## [34] dplyr_1.0.7          ggthemes_4.2.4        Biobase_2.54.0
## [37] vctrs_0.4.1          Biostrings_2.62.0     preprocessCore_1.56.0
## [40] nlme_3.1-153         xfun_0.30             fastcluster_1.2.3
## [43] stringr_1.4.0        lifecycle_1.0.1       zlibbioc_1.40.0
## [46] scales_1.1.1         RColorBrewer_1.1-2    yaml_2.3.4
## [49] memoise_2.0.1        rpart_4.1-15          segmented_1.3-4
## [52] latticeExtra_0.6-29  stringi_1.7.6         RSQLite_2.2.10
## [55] highr_0.9            S4Vectors_0.32.3      blme_1.0-5
## [58] checkmate_2.0.0      BiocGenerics_0.40.0   boot_1.3-28
## [61] GenomeInfoDb_1.30.1  rlang_1.0.2           pkgconfig_2.0.3
## [64] matrixStats_0.61.0   bitops_1.0-7          evaluate_0.15
## [67] lattice_0.20-45      purrr_0.3.4           htmlwidgets_1.5.4
## [70] bit_4.0.4            tidyselect_1.1.1      magrittr_2.0.2
## [73] R6_2.5.1             IRanges_2.28.0        generics_0.1.1
## [76] Hmisc_4.6-0          DBI_1.1.2             pillar_1.6.4
## [79] foreign_0.8-81       withr_2.4.3           survival_3.2-13
## [82] KEGGREST_1.34.0      abind_1.4-5           RCurl_1.98-1.6
```

```
## [85] nnet_7.3-16          tibble_3.1.6          crayon_1.4.2
## [88] utf8_1.2.2           rmarkdown_2.13        jpeg_0.1-9
## [91] data.table_1.14.2    blob_1.2.2            forcats_0.5.1
## [94] digest_0.6.29        tidyr_1.1.4           stats4_4.1.2
## [97] munsell_0.5.0
```

```r
Sys.time()
```

```
## [1] "2022-06-02 15:03:46 BST"
```