Perform Hierarchical clustering

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```
#NAME: Harini G

#install.packages("tidyverse")
#install.packages("factoextra")
library(tidyverse)  # data manipulation

## Warning: package 'tidyverse' was built under R version 4.0.5

## -- Attaching packages --------------------------------------- tidyverse
1.3.0 --

## v ggplot2 3.3.3     v purrr   0.3.4
## v tibble  3.0.3     v dplyr   1.0.5
## v tidyr   1.1.1     v stringr 1.4.0
## v readr   1.4.0     v forcats 0.5.0

## Warning: package 'dplyr' was built under R version 4.0.5

## -- Conflicts ------------------------------------------
tidyverse_conflicts() --
## x dplyr::filter() masks stats::filter()
## x dplyr::lag()    masks stats::lag()

library(cluster)    # clustering algorithms
library(factoextra) # clustering visualization

## Warning: package 'factoextra' was built under R version 4.0.5

## Welcome! Want to learn more? See two factoextra-related books at
https://goo.gl/ve3WBa

library(dendextend) # for comparing two dendrograms

## Warning: package 'dendextend' was built under R version 4.0.5

##
## --------------------
## Welcome to dendextend version 1.14.0
## Type citation('dendextend') for how to cite the package.
##
## Type browseVignettes(package = 'dendextend') for the package vignette.
## The github page is: https://github.com/talgalili/dendextend/
##
## Suggestions and bug-reports can be submitted at:
https://github.com/talgalili/dendextend/issues
## Or contact: <tal.galili@gmail.com>
##
##  To suppress this message use:
```

```
suppressPackageStartupMessages(library(dendextend))
## ---------------------

##
## Attaching package: 'dendextend'

## The following object is masked from 'package:stats':
##
##     cutree

head(mtcars)

##                    mpg cyl disp  hp drat    wt  qsec vs am gear carb
## Mazda RX4         21.0   6  160 110 3.90 2.620 16.46  0  1    4    4
## Mazda RX4 Wag     21.0   6  160 110 3.90 2.875 17.02  0  1    4    4
## Datsun 710        22.8   4  108  93 3.85 2.320 18.61  1  1    4    1
## Hornet 4 Drive    21.4   6  258 110 3.08 3.215 19.44  1  0    3    1
## Hornet Sportabout 18.7   8  360 175 3.15 3.440 17.02  0  0    3    2
## Valiant           18.1   6  225 105 2.76 3.460 20.22  1  0    3    1

class(mtcars) #class of the dataset

## [1] "data.frame"

typeof(mtcars) #datatype of the dataset

## [1] "list"

nrow(mtcars) #number of rows/observations in the dataset

## [1] 32

ncol(mtcars) #number of columns/features in the dataset

## [1] 11

dim(mtcars) #Shape/dimension of the dataset

## [1] 32 11

is.na(mtcars) #checking missing value in the dataset

##                       mpg   cyl  disp    hp  drat    wt  qsec    vs    am
gear
## Mazda RX4           FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
FALSE
## Mazda RX4 Wag       FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
FALSE
## Datsun 710          FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
FALSE
## Hornet 4 Drive      FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
FALSE
## Hornet Sportabout   FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
```

```
FALSE
## Valiant             FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
FALSE
## Duster 360          FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
FALSE
## Merc 240D           FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
FALSE
## Merc 230            FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
FALSE
## Merc 280            FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
FALSE
## Merc 280C           FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
FALSE
## Merc 450SE          FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
FALSE
## Merc 450SL          FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
FALSE
## Merc 450SLC         FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
FALSE
## Cadillac Fleetwood  FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
FALSE
## Lincoln Continental FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
FALSE
## Chrysler Imperial   FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
FALSE
## Fiat 128            FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
FALSE
## Honda Civic         FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
FALSE
## Toyota Corolla      FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
FALSE
## Toyota Corona       FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
FALSE
## Dodge Challenger    FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
FALSE
## AMC Javelin         FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
FALSE
## Camaro Z28          FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
FALSE
## Pontiac Firebird    FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
FALSE
## Fiat X1-9           FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
FALSE
## Porsche 914-2       FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
FALSE
## Lotus Europa        FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
FALSE
## Ford Pantera L      FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
FALSE
## Ferrari Dino        FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
```

```
FALSE
## Maserati Bora       FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
FALSE
## Volvo 142E          FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
FALSE
##                      carb
## Mazda RX4           FALSE
## Mazda RX4 Wag       FALSE
## Datsun 710          FALSE
## Hornet 4 Drive      FALSE
## Hornet Sportabout   FALSE
## Valiant             FALSE
## Duster 360          FALSE
## Merc 240D           FALSE
## Merc 230            FALSE
## Merc 280            FALSE
## Merc 280C           FALSE
## Merc 450SE          FALSE
## Merc 450SL          FALSE
## Merc 450SLC         FALSE
## Cadillac Fleetwood  FALSE
## Lincoln Continental FALSE
## Chrysler Imperial   FALSE
## Fiat 128            FALSE
## Honda Civic         FALSE
## Toyota Corolla      FALSE
## Toyota Corona       FALSE
## Dodge Challenger    FALSE
## AMC Javelin         FALSE
## Camaro Z28          FALSE
## Pontiac Firebird    FALSE
## Fiat X1-9           FALSE
## Porsche 914-2       FALSE
## Lotus Europa        FALSE
## Ford Pantera L      FALSE
## Ferrari Dino        FALSE
## Maserati Bora       FALSE
## Volvo 142E          FALSE

sum(is.na(mtcars)) #total number of missing values in the dataset

## [1] 0

str(mtcars) #Structure of the dataset

## 'data.frame':    32 obs. of  11 variables:
##  $ mpg : num  21 21 22.8 21.4 18.7 18.1 14.3 24.4 22.8 19.2 ...
##  $ cyl : num  6 6 4 6 8 6 8 4 4 6 ...
##  $ disp: num  160 160 108 258 360 ...
##  $ hp  : num  110 110 93 110 175 105 245 62 95 123 ...
##  $ drat: num  3.9 3.9 3.85 3.08 3.15 2.76 3.21 3.69 3.92 3.92 ...
```

```
##  $ wt  : num  2.62 2.88 2.32 3.21 3.44 ...
##  $ qsec: num  16.5 17 18.6 19.4 17 ...
##  $ vs  : num  0 0 1 1 0 1 0 1 1 1 ...
##  $ am  : num  1 1 1 0 0 0 0 0 0 0 ...
##  $ gear: num  4 4 4 3 3 3 3 4 4 4 ...
##  $ carb: num  4 4 1 1 2 1 4 2 2 4 ...

summary(mtcars)

##       mpg             cyl             disp             hp
##  Min.   :10.40   Min.   :4.000   Min.   : 71.1   Min.   : 52.0
##  1st Qu.:15.43   1st Qu.:4.000   1st Qu.:120.8   1st Qu.: 96.5
##  Median :19.20   Median :6.000   Median :196.3   Median :123.0
##  Mean   :20.09   Mean   :6.188   Mean   :230.7   Mean   :146.7
##  3rd Qu.:22.80   3rd Qu.:8.000   3rd Qu.:326.0   3rd Qu.:180.0
##  Max.   :33.90   Max.   :8.000   Max.   :472.0   Max.   :335.0
##       drat             wt             qsec             vs
##  Min.   :2.760   Min.   :1.513   Min.   :14.50   Min.   :0.0000
##  1st Qu.:3.080   1st Qu.:2.581   1st Qu.:16.89   1st Qu.:0.0000
##  Median :3.695   Median :3.325   Median :17.71   Median :0.0000
##  Mean   :3.597   Mean   :3.217   Mean   :17.85   Mean   :0.4375
##  3rd Qu.:3.920   3rd Qu.:3.610   3rd Qu.:18.90   3rd Qu.:1.0000
##  Max.   :4.930   Max.   :5.424   Max.   :22.90   Max.   :1.0000
##        am              gear            carb
##  Min.   :0.0000   Min.   :3.000   Min.   :1.000
##  1st Qu.:0.0000   1st Qu.:3.000   1st Qu.:2.000
##  Median :0.0000   Median :4.000   Median :2.000
##  Mean   :0.4062   Mean   :3.688   Mean   :2.812
##  3rd Qu.:1.0000   3rd Qu.:4.000   3rd Qu.:4.000
##  Max.   :1.0000   Max.   :5.000   Max.   :8.000

sapply(mtcars, class)#displaying the datatype of each column

##       mpg       cyl      disp        hp      drat        wt      qsec
vs
## "numeric" "numeric" "numeric" "numeric" "numeric" "numeric" "numeric"
"numeric"
##        am      gear      carb
## "numeric" "numeric" "numeric"

df <- na.omit(mtcars)#removing missing values if they are present

df <- scale(df)

#It works in a bottom-up manner.
#each object is initially considered as a single-element cluster (leaf).
#At each step of the algorithm, the two clusters that are the most similar
are combined into a new bigger cluster (nodes).
#This procedure is iterated until all points are member of just one single
big cluster (root).
#The result is a tree which is plotted using dendrogram.
```

```r
d <- dist(df, method = "euclidean")# Dissimilarity matrix
d
```

```
##                     Mazda RX4 Mazda RX4 Wag Datsun 710 Hornet 4 Drive
## Mazda RX4 Wag       0.4075899
## Datsun 710          3.2430644     3.1763654
## Hornet 4 Drive      4.4013651     4.2633265  3.4371367
## Hornet Sportabout   3.8803542     3.8196912  5.0032747      3.0421632
## Valiant             4.8437395     4.6756447  3.8681280      0.9936969
## Duster 360          4.1895788     4.1749365  5.8959064      4.3395668
## Merc 240D           3.9972560     3.8208496  2.5014249      2.5336229
## Merc 230            4.9177375     4.6700230  3.3122031      3.2698916
## Merc 280            3.1377712     2.9882339  3.2950024      2.9859746
## Merc 280C           3.2928005     3.1170530  3.3443599      2.9705073
## Merc 450SE          3.8563035     3.7329721  5.1667877      3.2468885
## Merc 450SL          3.7264672     3.6140741  5.0139378      3.0963299
## Merc 450SLC         3.8587627     3.7280140  5.0836872      3.1350053
## Cadillac Fleetwood  5.4495167     5.2848094  6.7701575      4.6845022
## Lincoln Continental 5.4799639     5.3127593  6.8196686      4.7868961
## Chrysler Imperial   5.0972757     4.9355861  6.5250751      4.6034009
## Fiat 128            4.0243306     3.9407293  1.7832069      4.1853934
## Honda Civic         4.0533412     4.0507443  2.6458745      5.2450434
## Toyota Corolla      4.3445000     4.2722835  2.2120337      4.5513874
## Toyota Corona       4.3303364     4.2137101  2.5743286      2.1359358
## Dodge Challenger    4.1089579     4.0529524  5.1794615      3.1033485
## AMC Javelin         3.7602309     3.6846550  4.8499144      2.9346504
## Camaro Z28          4.1191859     4.1051443  5.9277646      4.6740373
## Pontiac Firebird    4.1721471     4.0882070  5.2718706      3.1815173
## Fiat X1-9           3.6110861     3.5658305  1.0646650      3.9829642
## Porsche 914-2       2.5948592     2.6591243  2.9668981      5.3633226
## Lotus Europa        3.5593956     3.6429111  2.3504814      4.8654619
## Ford Pantera L      3.6239136     3.7004541  5.6724603      6.2182516
## Ferrari Dino        2.2173337     2.3107383  4.6711840      5.7255126
## Maserati Bora       4.9757567     5.0070559  7.2893098      7.4540115
## Volvo 142E          2.9056273     2.7880036  0.9799181      3.5836208
##                     Hornet Sportabout   Valiant Duster 360 Merc 240D  Merc
230
## Mazda RX4 Wag
## Datsun 710
## Hornet 4 Drive
## Hornet Sportabout
## Valiant                    3.3988179
## Duster 360                 1.8907332 4.5959496
## Merc 240D                  4.6074904 2.9114013  5.6208325
## Merc 230                   5.3601882 3.4090956  6.3074270 1.7677287
## Merc 280                   3.7603055 3.3860393  4.1159325 2.3467260
3.1736664
## Merc 280C                  3.8404534 3.2902323  4.2017096 2.3314789
2.9644001
```

```
## Merc 450SE                  1.2157212 3.3739087  1.7195474 4.6100696
5.2829002
## Merc 450SL                  1.0581618 3.2662012  1.7483591 4.4789673
5.1385834
## Merc 450SLC                 1.2772271 3.2103732  1.8280213 4.5289442
5.0939035
## Cadillac Fleetwood          2.8840440 4.6250214  2.4964362 6.0571351
6.4719931
## Lincoln Continental         2.9684612 4.7409039  2.4967056 6.1200901
6.5342344
## Chrysler Imperial           2.6262007 4.7149888  2.1314298 5.8475038
6.3195516
## Fiat 128                    5.8776367 4.7310845  6.9265472 2.8477338
3.4760961
## Honda Civic                 6.5054903 5.8852758  7.2973276 3.7432868
4.2793565
## Toyota Corolla              6.2330226 5.1096664  7.2823316 3.1877164
3.6385061
## Toyota Corona               4.4095161 2.5379207  5.4586640 1.8187717
2.3602221
## Dodge Challenger            1.0370480 3.2050198  2.1565615 4.7681748
5.5840526
## AMC Javelin                 0.8360206 3.1377397  2.0925400 4.4434196
5.1708093
## Camaro Z28                  2.3538211 5.0148655  1.0554323 5.7074187
6.3746076
## Pontiac Firebird            0.5475333 3.5076094  1.9842791 4.7856750
5.5292039
## Fiat X1-9                   5.6028144 4.4964851  6.5754940 2.7365898
3.4679554
## Porsche 914-2               5.5333206 5.9048663  6.1678160 4.0696390
4.9107991
## Lotus Europa                5.8906362 5.4091213  6.5673285 3.6797302
4.6690572
## Ford Pantera L              4.5704575 6.6597531  3.9756842 6.3426475
7.0037774
## Ferrari Dino                4.8737371 6.0393960  4.5054188 5.2004290
6.0347907
## Maserati Bora               5.7962447 7.6982401  4.5080940 7.6028670
8.1527622
## Volvo 142E                  4.9104611 4.0221723  5.5902795 2.4866260
3.1932948
##                      Merc 280 Merc 280C Merc 450SE Merc 450SL Merc 450SLC
## Mazda RX4 Wag
## Datsun 710
## Hornet 4 Drive
## Hornet Sportabout
## Valiant
## Duster 360
## Merc 240D
```

```
## Merc 230
## Merc 280
## Merc 280C           0.4082884
## Merc 450SE          3.5036558 3.5446708
## Merc 450SL          3.4252318 3.4663403  0.3944266
## Merc 450SLC         3.4613499 3.4571735  0.4901305  0.4172832
## Cadillac Fleetwood  4.8481443 4.8076108  2.3752167  2.6191633   2.4458852
## Lincoln Continental 4.8652211 4.8310582  2.4147746  2.6820009   2.5174149
## Chrysler Imperial   4.5331791 4.5497518  2.1301591  2.3833766   2.3303195
## Fiat 128            4.1044898 4.1942047  6.1027421  5.9176565   6.0522758
## Honda Civic         4.3521695 4.4596794  6.7429222  6.5608536   6.6876038
## Toyota Corolla      4.4495050 4.5273217  6.4894198  6.2849281   6.4199329
## Toyota Corona       3.0091888 2.9591531  4.5230838  4.3467458   4.3683285
## Dodge Challenger    3.9899083 4.0420607  1.2054395  1.1528213   1.2246720
## AMC Javelin         3.5713821 3.6040168  1.0549265  0.9430857   0.9626504
## Camaro Z28          4.0282873 4.1261450  2.1735238  2.2625903   2.3169202
## Pontiac Firebird    3.9725287 4.0518437  1.3039453  1.2653565   1.4562704
## Fiat X1-9           3.7810906 3.8551580  5.8249673  5.6428137   5.7474798
## Porsche 914-2       4.2059850 4.3568869  5.7510348  5.6099124   5.7482820
## Lotus Europa        4.1265650 4.3109976  6.1480650  5.9587741   6.1321085
## Ford Pantera L      4.7638360 4.9017138  4.6618197  4.6520853   4.7410691
## Ferrari Dino        3.8958003 4.0539793  4.6304461  4.5549676   4.6718041
## Maserati Bora       5.7612264 5.8672946  5.4444617  5.4646796   5.5262308
## Volvo 142E          2.7801612 2.8200779  4.9479927  4.8294785   4.8806503
##                     Cadillac Fleetwood Lincoln Continental Chrysler
Imperial
## Mazda RX4 Wag
## Datsun 710
## Hornet 4 Drive
## Hornet Sportabout
## Valiant
## Duster 360
## Merc 240D
## Merc 230
## Merc 280
## Merc 280C
## Merc 450SE
## Merc 450SL
## Merc 450SLC
## Cadillac Fleetwood
## Lincoln Continental          0.2956825
## Chrysler Imperial            1.0635310           0.9080748
## Fiat 128                     7.7973439           7.8458703
7.4347239
## Honda Civic                  8.3928547           8.4234897
7.9702830
## Toyota Corolla               8.2005281           8.2527181
7.8280569
## Toyota Corona                6.1484614           6.2160567
5.9697480
```

```
## Dodge Challenger             2.8372165           2.9549058
2.8683778
## AMC Javelin                  2.8988638           2.9910214
2.8183456
## Camaro Z28                   2.8150659           2.7412463
2.2659922
## Pontiac Firebird             2.5701272           2.6555931
2.3043685
## Fiat X1-9                    7.5268299           7.5797064
7.2243403
## Porsche 914-2                7.3428177           7.3625764
6.9369982
## Lotus Europa                 7.8314188           7.8778088
7.4655971
## Ford Pantera L               5.2908702           5.2360533
4.8165342
## Ferrari Dino                 5.8052611           5.8069129
5.4553770
## Maserati Bora                5.6040962           5.5359080
5.2173124
## Volvo 142E                   6.4042902           6.4299677
6.1099484
##                      Fiat 128 Honda Civic Toyota Corolla Toyota Corona
## Mazda RX4 Wag
## Datsun 710
## Hornet 4 Drive
## Hornet Sportabout
## Valiant
## Duster 360
## Merc 240D
## Merc 230
## Merc 280
## Merc 280C
## Merc 450SE
## Merc 450SL
## Merc 450SLC
## Cadillac Fleetwood
## Lincoln Continental
## Chrysler Imperial
## Fiat 128
## Honda Civic         1.9243376
## Toyota Corolla      0.5757917   1.7799297
## Toyota Corona       3.1795988   3.9646286      3.4386884
## Dodge Challenger    6.1897572   6.9208270      6.5812246     4.5624114
## AMC Javelin         5.8508670   6.4507155      6.2193563     4.1915369
## Camaro Z28          6.9503062   7.1027162      7.2970631     5.5640650
## Pontiac Firebird    6.1149641   6.7946533      6.4857014     4.6855121
## Fiat X1-9           0.9440123   1.8356814      1.2631917     2.8771692
## Porsche 914-2       3.2195133   2.9932093      3.4109616     4.6534714
## Lotus Europa        2.3907048   2.8622875      2.5923660     4.2445533
```

```
## Ford Pantera L      6.6166138   6.4835328      6.9120796     6.7110287
## Ferrari Dino        5.4662206   5.4859770      5.7728984     5.8353128
## Maserati Bora       8.1807755   8.1867266      8.4801671     8.0606070
## Volvo 142E          2.1944946   2.6127269      2.6006079     2.7534994
##                     Dodge Challenger AMC Javelin Camaro Z28 Pontiac
Firebird
## Mazda RX4 Wag
## Datsun 710
## Hornet 4 Drive
## Hornet Sportabout
## Valiant
## Duster 360
## Merc 240D
## Merc 230
## Merc 280
## Merc 280C
## Merc 450SE
## Merc 450SL
## Merc 450SLC
## Cadillac Fleetwood
## Lincoln Continental
## Chrysler Imperial
## Fiat 128
## Honda Civic
## Toyota Corolla
## Toyota Corona
## Dodge Challenger
## AMC Javelin                0.7827694
## Camaro Z28                 2.7782606   2.4813171
## Pontiac Firebird           1.1942533   1.1771569  2.4529311
## Fiat X1-9                  5.8525045   5.4949181  6.5789332
5.8831504
## Porsche 914-2              5.8698053   5.4885985  6.0073280
5.8049597
## Lotus Europa               6.1425433   5.9214212  6.6478423
6.1638574
## Ford Pantera L             5.0078711   4.7275036  3.6306118
4.7026976
## Ferrari Dino               5.0080706   4.8308278  4.5053590
5.0961648
## Maserati Bora              6.0178217   5.9396759  4.4569171
5.8678663
## Volvo 142E                 5.1510061   4.7542900  5.5099681
5.1557398
##                     Fiat X1-9 Porsche 914-2 Lotus Europa Ford Pantera L
## Mazda RX4 Wag
## Datsun 710
## Hornet 4 Drive
## Hornet Sportabout
## Valiant
```

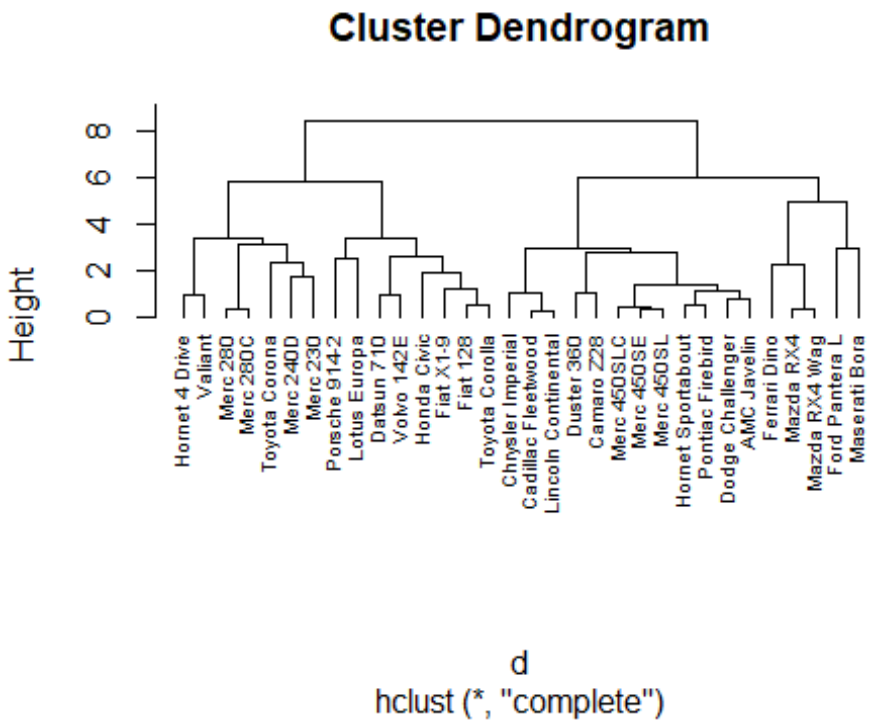
```
## Duster 360
## Merc 240D
## Merc 230
## Merc 280
## Merc 280C
## Merc 450SE
## Merc 450SL
## Merc 450SLC
## Cadillac Fleetwood
## Lincoln Continental
## Chrysler Imperial
## Fiat 128
## Honda Civic
## Toyota Corolla
## Toyota Corona
## Dodge Challenger
## AMC Javelin
## Camaro Z28
## Pontiac Firebird
## Fiat X1-9
## Porsche 914-2       2.9043943
## Lotus Europa        2.1786546     2.5613776
## Ford Pantera L      6.2258629     4.6929233    5.5540990
## Ferrari Dino        5.1088276     3.6305579    4.2187875      3.0648409
## Maserati Bora       7.8702812     6.5745699    6.9847187      3.0287549
## Volvo 142E          1.6207836     2.8881825    2.6646220      5.2160045
##                     Ferrari Dino Maserati Bora
## Mazda RX4 Wag
## Datsun 710
## Hornet 4 Drive
## Hornet Sportabout
## Valiant
## Duster 360
## Merc 240D
## Merc 230
## Merc 280
## Merc 280C
## Merc 450SE
## Merc 450SL
## Merc 450SLC
## Cadillac Fleetwood
## Lincoln Continental
## Chrysler Imperial
## Fiat 128
## Honda Civic
## Toyota Corolla
## Toyota Corona
## Dodge Challenger
## AMC Javelin
## Camaro Z28
```

```
## Pontiac Firebird
## Fiat X1-9
## Porsche 914-2
## Lotus Europa
## Ford Pantera L
## Ferrari Dino
## Maserati Bora          3.3719604
## Volvo 142E             4.2489749     6.7446456
```

```
hc1 <- hclust(d, method = "complete" )# Hierarchical clustering using
Complete Linkage
hc1
```

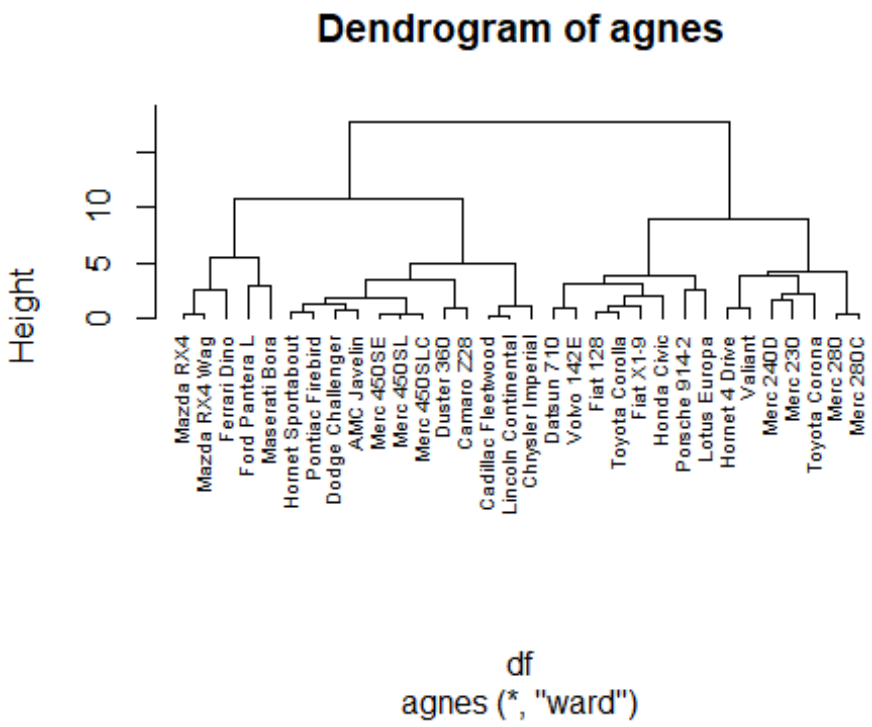
```
##
## Call:
## hclust(d = d, method = "complete")
##
## Cluster method   : complete
## Distance         : euclidean
## Number of objects: 32
```

```
plot(hc1, cex = 0.6, hang = -1)# Plot the obtained dendrogram
```

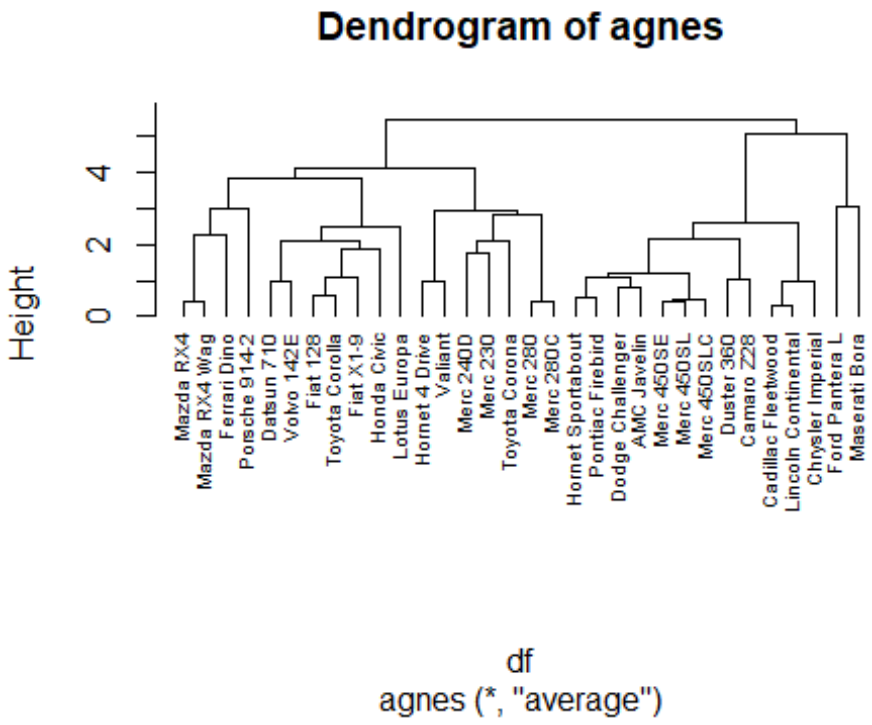



```
# methods to assess
m <- c( "average", "single", "complete", "ward")
names(m) <- c( "average", "single", "complete", "ward")
```

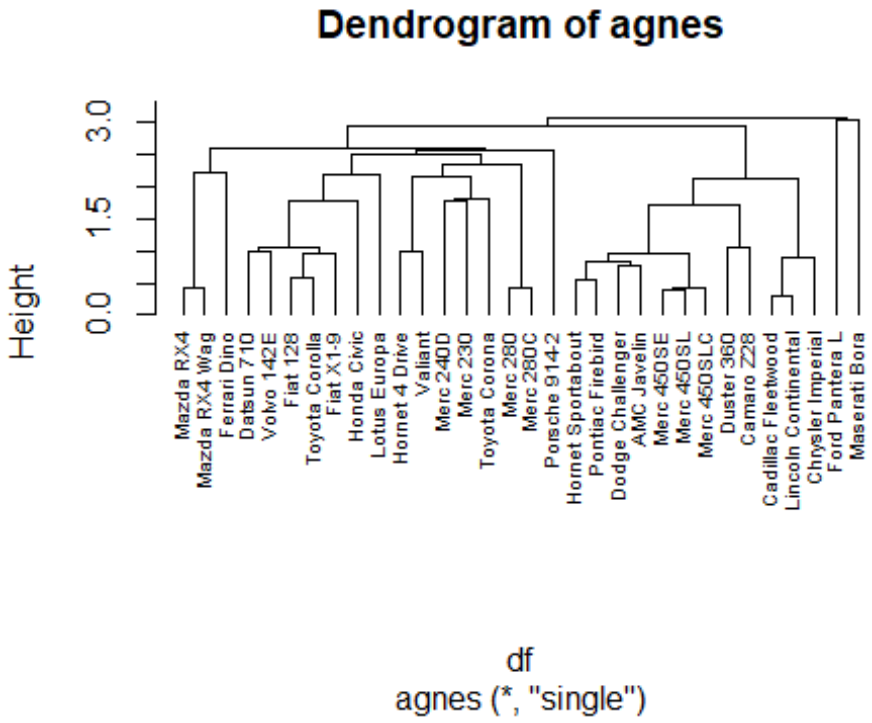
```r
# function to compute coefficient
ac <- function(x) {
  agnes(df, method = x)$ac
}

map_dbl(m, ac)

##   average    single  complete      ward
## 0.7898219 0.6400643 0.8636151 0.9338742

#Wards method identifies the strongest clustering structure of the four
methods

hc3 <- agnes(df, method = "ward")
pltree(hc3, cex = 0.6, hang = -1, main = "Dendrogram of agnes")
```



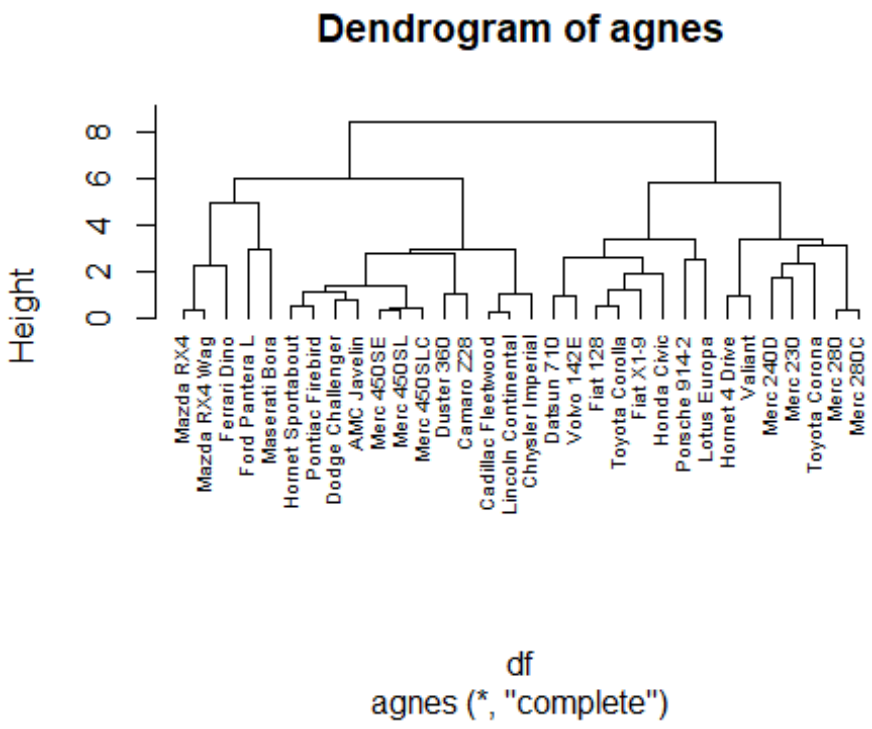

```r
hc3 <- agnes(df, method = "average")
pltree(hc3, cex = 0.6, hang = -1, main = "Dendrogram of agnes")
```



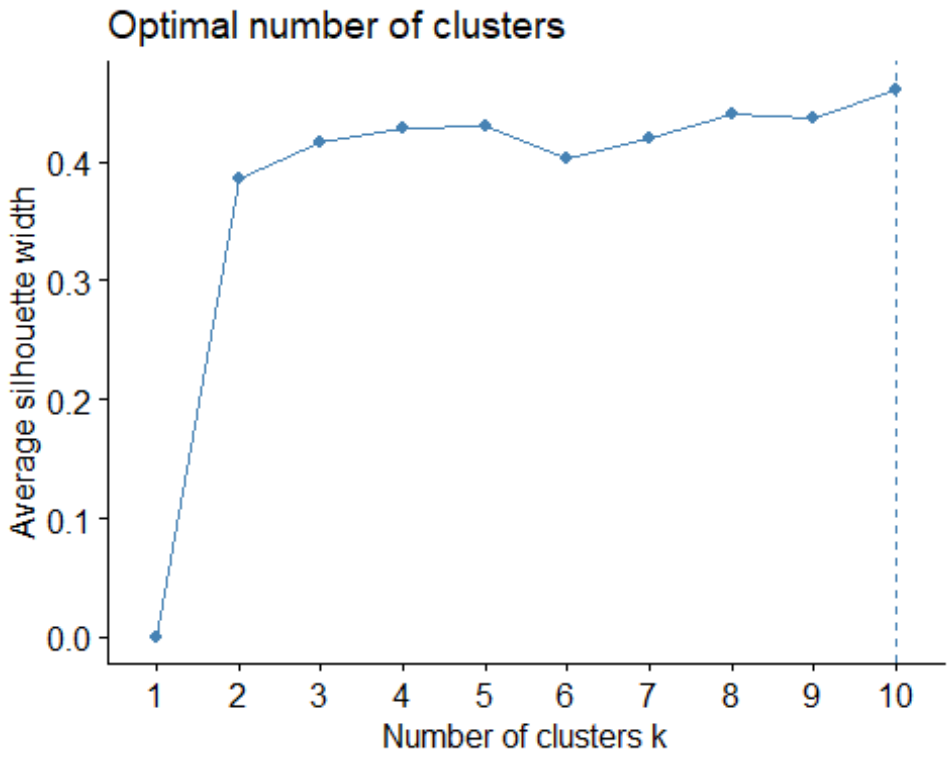

```
hc3 <- agnes(df, method = "single")
pltree(hc3, cex = 0.6, hang = -1, main = "Dendrogram of agnes")
```



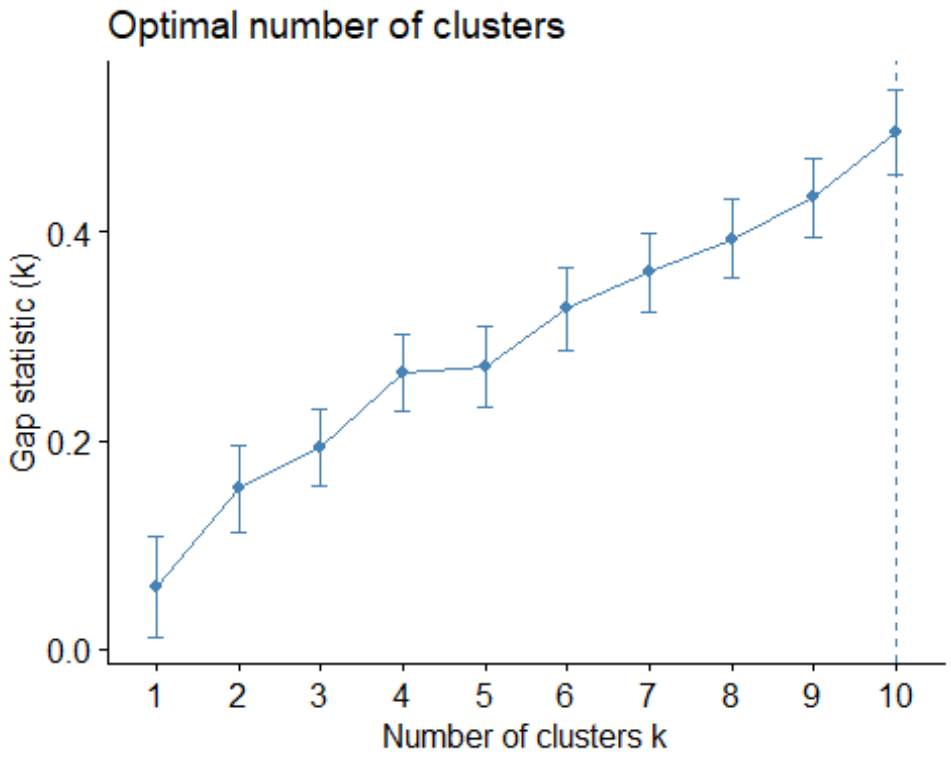
```
hc3 <- agnes(df, method = "complete")
pltree(hc3, cex = 0.6, hang = -1, main = "Dendrogram of agnes")
```




```
#Average Silhouette Method
fviz_nbclust(df, FUN = hcut, method = "silhouette")
```




```
#the optimal number of clusters required is 10, by using silhouette methos

#Gap Statistic Method
gap_stat <- clusGap(df, FUN = hcut, nstart = 25, K.max = 10, B = 50)
fviz_gap_stat(gap_stat)
```




```
#the optimal number of clusters required is 10, by using Gap Statistics
method
```