Model 3

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```
library(dplyr)
```

```
##
## Attaching package: 'dplyr'
```

```
## The following objects are masked from 'package:stats':
##
##     filter, lag
```

```
## The following objects are masked from 'package:base':
##
##     intersect, setdiff, setequal, union
```

```
library(ggplot2)
library(ClusterR)
library(cluster)
library(h2o)
```

```
##
## ----------------------------------------------------------------------
##
## Your next step is to start H2O:
##     > h2o.init()
##
## For H2O package documentation, ask for help:
##     > ??h2o
##
## After starting H2O, you can use the Web UI at http://localhost:54321
## For more information visit https://docs.h2o.ai
##
## ----------------------------------------------------------------------
```

```
##
## Attaching package: 'h2o'
```

```
## The following objects are masked from 'package:stats':
##
##     cor, sd, var
```

```
## The following objects are masked from 'package:base':
##
##     %*%, %in%, &&, ||, apply, as.factor, as.numeric, colnames,
##     colnames<-, ifelse, is.character, is.factor, is.numeric, log,
##     log10, log1p, log2, round, signif, trunc
```

```
library(readr)
library(mclust)
```

```
## Package 'mclust' version 6.0.0
## Type 'citation("mclust")' for citing this R package in publications.
```

```
#PCA
rad_basket <- readr::read_csv("radiomics_completedata.csv")
```

```
## Rows: 197 Columns: 431
## -- Column specification --------------------------------------------------------
## Delimiter: ","
## chr   (1): Institution
## dbl (430): Failure.binary, Failure, Entropy_cooc.W.ADC, GLNU_align.H.PET, Mi...
##
## i Use `spec()` to retrieve the full column specification for this data.
## i Specify the column types or set `show_col_types = FALSE` to quiet this message.
```

```
dim(rad_basket)
```

```
## [1] 197 431
```

```
h2o.init()
```

```
##  Connection successful!
##
## R is connected to the H2O cluster:
##     H2O cluster uptime:         1 days 14 hours
##     H2O cluster timezone:       America/Toronto
##     H2O data parsing timezone:  UTC
##     H2O cluster version:        3.40.0.1
##     H2O cluster version age:    1 month and 24 days
##     H2O cluster name:           H2O_started_from_R_Mara_fqp316
##     H2O cluster total nodes:    1
##     H2O cluster total memory:   1.93 GB
##     H2O cluster total cores:    4
##     H2O cluster allowed cores:  4
##     H2O cluster healthy:        TRUE
##     H2O Connection ip:          localhost
##     H2O Connection port:        54321
##     H2O Connection proxy:       NA
##     H2O Internal Security:      FALSE
##     R Version:                  R version 4.2.3 (2023-03-15 ucrt)
```

```
rad_basket.h2o <- as.h2o(rad_basket)
```

```
##   |                                                                              |
```

```
rad_pca <- h2o.prcomp(
  training_frame = rad_basket.h2o,
  pca_method = "GramSVD",
  k = 197,
  transform = "STANDARDIZE",
  impute_missing = TRUE,
  max_runtime_secs = 1000
)
```

```
## Warning in .h2o.processResponseWarnings(res): Dropping bad and constant columns: [Institution].
```

```
##   |                                                                      |
```

```
summary(rad_pca)
```

```
## Model Details:
## ==============
##
## H2ODimReductionModel: pca
## Model Key:  PCA_model_R_1680258824506_64
## Importance of components:
##                             pc1      pc2      pc3      pc4      pc5      pc6
## Standard deviation     14.456647 7.279843 5.579402 5.506801 4.035804 3.596262
## Proportion of Variance  0.486034 0.123247 0.072395 0.070523 0.037878 0.030077
## Cumulative Proportion   0.486034 0.609281 0.681676 0.752198 0.790077 0.820154
##                             pc7      pc8      pc9     pc10     pc11     pc12
## Standard deviation     3.414341 3.012816 2.794083 2.204323 2.187949 2.061485
## Proportion of Variance 0.027111 0.021109 0.018156 0.011300 0.011133 0.009883
## Cumulative Proportion  0.847265 0.868374 0.886530 0.897830 0.908963 0.918846
##                            pc13     pc14     pc15     pc16     pc17     pc18
## Standard deviation     1.927843 1.809329 1.712724 1.541619 1.420100 1.405965
## Proportion of Variance 0.008643 0.007613 0.006822 0.005527 0.004690 0.004597
## Cumulative Proportion  0.927489 0.935102 0.941924 0.947451 0.952141 0.956738
##                            pc19     pc20     pc21     pc22     pc23     pc24
## Standard deviation     1.289286 1.257373 1.181975 1.093771 1.025610 0.947335
## Proportion of Variance 0.003866 0.003677 0.003249 0.002782 0.002446 0.002087
## Cumulative Proportion  0.960604 0.964281 0.967530 0.970312 0.972758 0.974845
##                            pc25     pc26     pc27     pc28     pc29     pc30
## Standard deviation     0.892379 0.883937 0.838724 0.826230 0.776392 0.730956
## Proportion of Variance 0.001852 0.001817 0.001636 0.001588 0.001402 0.001243
## Cumulative Proportion  0.976697 0.978514 0.980150 0.981738 0.983139 0.984382
##                            pc31     pc32     pc33     pc34     pc35     pc36
## Standard deviation     0.688004 0.677647 0.635309 0.608546 0.583634 0.578345
## Proportion of Variance 0.001101 0.001068 0.000939 0.000861 0.000792 0.000778
## Cumulative Proportion  0.985483 0.986551 0.987489 0.988351 0.989143 0.989921
##                            pc37     pc38     pc39     pc40     pc41     pc42
## Standard deviation     0.560745 0.538875 0.515707 0.504301 0.466510 0.459381
## Proportion of Variance 0.000731 0.000675 0.000618 0.000591 0.000506 0.000491
## Cumulative Proportion  0.990652 0.991327 0.991946 0.992537 0.993043 0.993534
##                            pc43     pc44     pc45     pc46     pc47     pc48
## Standard deviation     0.447875 0.430315 0.426441 0.402617 0.389966 0.364946
## Proportion of Variance 0.000466 0.000431 0.000423 0.000377 0.000354 0.000310
## Cumulative Proportion  0.994001 0.994431 0.994854 0.995231 0.995585 0.995894
##                            pc49     pc50     pc51     pc52     pc53     pc54
## Standard deviation     0.348751 0.330338 0.327391 0.312303 0.307262 0.306030
## Proportion of Variance 0.000283 0.000254 0.000249 0.000227 0.000220 0.000218
## Cumulative Proportion  0.996177 0.996431 0.996680 0.996907 0.997127 0.997344
##                            pc55     pc56     pc57     pc58     pc59     pc60
## Standard deviation     0.283895 0.273642 0.271243 0.262371 0.250213 0.246650
## Proportion of Variance 0.000187 0.000174 0.000171 0.000160 0.000146 0.000141
## Cumulative Proportion  0.997532 0.997706 0.997877 0.998037 0.998183 0.998324
##                            pc61     pc62     pc63     pc64     pc65     pc66
## Standard deviation     0.232007 0.229981 0.222103 0.216567 0.201592 0.192293
## Proportion of Variance 0.000125 0.000123 0.000115 0.000109 0.000095 0.000086
## Cumulative Proportion  0.998450 0.998573 0.998687 0.998796 0.998891 0.998977
##                            pc67     pc68     pc69     pc70     pc71     pc72
```

```
## Standard deviation     0.188133 0.172019 0.168711 0.159688 0.158168 0.150288
## Proportion of Variance 0.000082 0.000069 0.000066 0.000059 0.000058 0.000053
## Cumulative Proportion  0.999059 0.999128 0.999194 0.999253 0.999312 0.999364
##                            pc73     pc74     pc75     pc76     pc77     pc78
## Standard deviation     0.146283 0.145171 0.140737 0.138048 0.128514 0.124060
## Proportion of Variance 0.000050 0.000049 0.000046 0.000044 0.000038 0.000036
## Cumulative Proportion  0.999414 0.999463 0.999509 0.999553 0.999592 0.999627
##                            pc79     pc80     pc81     pc82     pc83     pc84
## Standard deviation     0.121165 0.118798 0.110177 0.105909 0.099597 0.098702
## Proportion of Variance 0.000034 0.000033 0.000028 0.000026 0.000023 0.000023
## Cumulative Proportion  0.999662 0.999694 0.999723 0.999749 0.999772 0.999794
##                            pc85     pc86     pc87     pc88     pc89     pc90
## Standard deviation     0.093183 0.089772 0.086281 0.082903 0.080233 0.075065
## Proportion of Variance 0.000020 0.000019 0.000017 0.000016 0.000015 0.000013
## Cumulative Proportion  0.999815 0.999833 0.999851 0.999867 0.999882 0.999895
##                            pc91     pc92     pc93     pc94     pc95     pc96
## Standard deviation     0.072105 0.067429 0.065270 0.062718 0.061389 0.055941
## Proportion of Variance 0.000012 0.000011 0.000010 0.000009 0.000009 0.000007
## Cumulative Proportion  0.999907 0.999917 0.999927 0.999937 0.999945 0.999953
##                            pc97     pc98     pc99    pc100    pc101    pc102
## Standard deviation     0.053349 0.051798 0.051192 0.049099 0.046743 0.045377
## Proportion of Variance 0.000007 0.000006 0.000006 0.000006 0.000005 0.000005
## Cumulative Proportion  0.999959 0.999965 0.999972 0.999977 0.999982 0.999987
##                           pc103    pc104    pc105    pc106    pc107    pc108
## Standard deviation     0.039417 0.037297 0.036219 0.034968 0.010609 0.000000
## Proportion of Variance 0.000004 0.000003 0.000003 0.000003 0.000000 0.000000
## Cumulative Proportion  0.999991 0.999994 0.999997 1.000000 1.000000 1.000000
##                           pc109    pc110    pc111    pc112    pc113    pc114
## Standard deviation     0.000000 0.000000 0.000000 0.000000 0.000000 0.000000
## Proportion of Variance 0.000000 0.000000 0.000000 0.000000 0.000000 0.000000
## Cumulative Proportion  1.000000 1.000000 1.000000 1.000000 1.000000 1.000000
##                           pc115    pc116    pc117    pc118    pc119    pc120
## Standard deviation     0.000000 0.000000 0.000000 0.000000 0.000000 0.000000
## Proportion of Variance 0.000000 0.000000 0.000000 0.000000 0.000000 0.000000
## Cumulative Proportion  1.000000 1.000000 1.000000 1.000000 1.000000 1.000000
##                           pc121    pc122    pc123    pc124    pc125    pc126
## Standard deviation     0.000000 0.000000 0.000000 0.000000 0.000000 0.000000
## Proportion of Variance 0.000000 0.000000 0.000000 0.000000 0.000000 0.000000
## Cumulative Proportion  1.000000 1.000000 1.000000 1.000000 1.000000 1.000000
##                           pc127    pc128    pc129    pc130    pc131    pc132
## Standard deviation     0.000000 0.000000 0.000000 0.000000 0.000000 0.000000
## Proportion of Variance 0.000000 0.000000 0.000000 0.000000 0.000000 0.000000
## Cumulative Proportion  1.000000 1.000000 1.000000 1.000000 1.000000 1.000000
##                           pc133    pc134    pc135    pc136    pc137    pc138
## Standard deviation     0.000000 0.000000 0.000000 0.000000 0.000000 0.000000
## Proportion of Variance 0.000000 0.000000 0.000000 0.000000 0.000000 0.000000
## Cumulative Proportion  1.000000 1.000000 1.000000 1.000000 1.000000 1.000000
##                           pc139    pc140    pc141    pc142    pc143    pc144
## Standard deviation     0.000000 0.000000 0.000000 0.000000 0.000000 0.000000
## Proportion of Variance 0.000000 0.000000 0.000000 0.000000 0.000000 0.000000
## Cumulative Proportion  1.000000 1.000000 1.000000 1.000000 1.000000 1.000000
##                           pc145    pc146    pc147    pc148    pc149    pc150
## Standard deviation     0.000000 0.000000 0.000000 0.000000 0.000000 0.000000
## Proportion of Variance 0.000000 0.000000 0.000000 0.000000 0.000000 0.000000
```

```
## Cumulative Proportion  1.000000 1.000000 1.000000 1.000000 1.000000 1.000000
##                           pc151    pc152    pc153    pc154    pc155    pc156
## Standard deviation     0.000000 0.000000 0.000000 0.000000 0.000000 0.000000
## Proportion of Variance 0.000000 0.000000 0.000000 0.000000 0.000000 0.000000
## Cumulative Proportion  1.000000 1.000000 1.000000 1.000000 1.000000 1.000000
##                           pc157    pc158    pc159    pc160    pc161    pc162
## Standard deviation     0.000000 0.000000 0.000000 0.000000 0.000000 0.000000
## Proportion of Variance 0.000000 0.000000 0.000000 0.000000 0.000000 0.000000
## Cumulative Proportion  1.000000 1.000000 1.000000 1.000000 1.000000 1.000000
##                           pc163    pc164    pc165    pc166    pc167    pc168
## Standard deviation     0.000000 0.000000 0.000000 0.000000 0.000000 0.000000
## Proportion of Variance 0.000000 0.000000 0.000000 0.000000 0.000000 0.000000
## Cumulative Proportion  1.000000 1.000000 1.000000 1.000000 1.000000 1.000000
##                           pc169    pc170    pc171    pc172    pc173    pc174
## Standard deviation     0.000000 0.000000 0.000000 0.000000 0.000000 0.000000
## Proportion of Variance 0.000000 0.000000 0.000000 0.000000 0.000000 0.000000
## Cumulative Proportion  1.000000 1.000000 1.000000 1.000000 1.000000 1.000000
##                           pc175    pc176    pc177    pc178    pc179    pc180
## Standard deviation     0.000000 0.000000 0.000000 0.000000 0.000000 0.000000
## Proportion of Variance 0.000000 0.000000 0.000000 0.000000 0.000000 0.000000
## Cumulative Proportion  1.000000 1.000000 1.000000 1.000000 1.000000 1.000000
##                           pc181    pc182    pc183    pc184    pc185    pc186
## Standard deviation     0.000000 0.000000 0.000000 0.000000 0.000000 0.000000
## Proportion of Variance 0.000000 0.000000 0.000000 0.000000 0.000000 0.000000
## Cumulative Proportion  1.000000 1.000000 1.000000 1.000000 1.000000 1.000000
##                           pc187    pc188    pc189    pc190    pc191    pc192
## Standard deviation     0.000000 0.000000 0.000000 0.000000 0.000000 0.000000
## Proportion of Variance 0.000000 0.000000 0.000000 0.000000 0.000000 0.000000
## Cumulative Proportion  1.000000 1.000000 1.000000 1.000000 1.000000 1.000000
##                           pc193    pc194    pc195    pc196    pc197
## Standard deviation     0.000000 0.000000 0.000000 0.000000 0.000000
## Proportion of Variance 0.000000 0.000000 0.000000 0.000000 0.000000
## Cumulative Proportion  1.000000 1.000000 1.000000 1.000000 1.000000
##
## H2ODimReductionMetrics: pca
##
## No model metrics available for PCA
##
##
##
## Scoring History for GramSVD:
##             timestamp   duration iterations
## 1 2023-04-01 21:05:55  0.109 sec          0
##
## Variable Importances: (Extract with `h2o.varimp`)
## =================================================
##
## Importance of components:
##                             pc1      pc2      pc3      pc4      pc5      pc6
## Standard deviation     14.456647 7.279843 5.579402 5.506801 4.035804 3.596262
## Proportion of Variance  0.486034 0.123247 0.072395 0.070523 0.037878 0.030077
## Cumulative Proportion   0.486034 0.609281 0.681676 0.752198 0.790077 0.820154
##                             pc7      pc8      pc9     pc10     pc11     pc12
## Standard deviation     3.414341 3.012816 2.794083 2.204323 2.187949 2.061485
```

```
## Proportion of Variance 0.027111 0.021109 0.018156 0.011300 0.011133 0.009883
## Cumulative Proportion  0.847265 0.868374 0.886530 0.897830 0.908963 0.918846
##                            pc13     pc14     pc15     pc16     pc17     pc18
## Standard deviation     1.927843 1.809329 1.712724 1.541619 1.420100 1.405965
## Proportion of Variance 0.008643 0.007613 0.006822 0.005527 0.004690 0.004597
## Cumulative Proportion  0.927489 0.935102 0.941924 0.947451 0.952141 0.956738
##                            pc19     pc20     pc21     pc22     pc23     pc24
## Standard deviation     1.289286 1.257373 1.181975 1.093771 1.025610 0.947335
## Proportion of Variance 0.003866 0.003677 0.003249 0.002782 0.002446 0.002087
## Cumulative Proportion  0.960604 0.964281 0.967530 0.970312 0.972758 0.974845
##                            pc25     pc26     pc27     pc28     pc29     pc30
## Standard deviation     0.892379 0.883937 0.838724 0.826230 0.776392 0.730956
## Proportion of Variance 0.001852 0.001817 0.001636 0.001588 0.001402 0.001243
## Cumulative Proportion  0.976697 0.978514 0.980150 0.981738 0.983139 0.984382
##                            pc31     pc32     pc33     pc34     pc35     pc36
## Standard deviation     0.688004 0.677647 0.635309 0.608546 0.583634 0.578345
## Proportion of Variance 0.001101 0.001068 0.000939 0.000861 0.000792 0.000778
## Cumulative Proportion  0.985483 0.986551 0.987489 0.988351 0.989143 0.989921
##                            pc37     pc38     pc39     pc40     pc41     pc42
## Standard deviation     0.560745 0.538875 0.515707 0.504301 0.466510 0.459381
## Proportion of Variance 0.000731 0.000675 0.000618 0.000591 0.000506 0.000491
## Cumulative Proportion  0.990652 0.991327 0.991946 0.992537 0.993043 0.993534
##                            pc43     pc44     pc45     pc46     pc47     pc48
## Standard deviation     0.447875 0.430315 0.426441 0.402617 0.389966 0.364946
## Proportion of Variance 0.000466 0.000431 0.000423 0.000377 0.000354 0.000310
## Cumulative Proportion  0.994001 0.994431 0.994854 0.995231 0.995585 0.995894
##                            pc49     pc50     pc51     pc52     pc53     pc54
## Standard deviation     0.348751 0.330338 0.327391 0.312303 0.307262 0.306030
## Proportion of Variance 0.000283 0.000254 0.000249 0.000227 0.000220 0.000218
## Cumulative Proportion  0.996177 0.996431 0.996680 0.996907 0.997127 0.997344
##                            pc55     pc56     pc57     pc58     pc59     pc60
## Standard deviation     0.283895 0.273642 0.271243 0.262371 0.250213 0.246650
## Proportion of Variance 0.000187 0.000174 0.000171 0.000160 0.000146 0.000141
## Cumulative Proportion  0.997532 0.997706 0.997877 0.998037 0.998183 0.998324
##                            pc61     pc62     pc63     pc64     pc65     pc66
## Standard deviation     0.232007 0.229981 0.222103 0.216567 0.201592 0.192293
## Proportion of Variance 0.000125 0.000123 0.000115 0.000109 0.000095 0.000086
## Cumulative Proportion  0.998450 0.998573 0.998687 0.998796 0.998891 0.998977
##                            pc67     pc68     pc69     pc70     pc71     pc72
## Standard deviation     0.188133 0.172019 0.168711 0.159688 0.158168 0.150288
## Proportion of Variance 0.000082 0.000069 0.000066 0.000059 0.000058 0.000053
## Cumulative Proportion  0.999059 0.999128 0.999194 0.999253 0.999312 0.999364
##                            pc73     pc74     pc75     pc76     pc77     pc78
## Standard deviation     0.146283 0.145171 0.140737 0.138048 0.128514 0.124060
## Proportion of Variance 0.000050 0.000049 0.000046 0.000044 0.000038 0.000036
## Cumulative Proportion  0.999414 0.999463 0.999509 0.999553 0.999592 0.999627
##                            pc79     pc80     pc81     pc82     pc83     pc84
## Standard deviation     0.121165 0.118798 0.110177 0.105909 0.099597 0.098702
## Proportion of Variance 0.000034 0.000033 0.000028 0.000026 0.000023 0.000023
## Cumulative Proportion  0.999662 0.999694 0.999723 0.999749 0.999772 0.999794
##                            pc85     pc86     pc87     pc88     pc89     pc90
## Standard deviation     0.093183 0.089772 0.086281 0.082903 0.080233 0.075065
## Proportion of Variance 0.000020 0.000019 0.000017 0.000016 0.000015 0.000013
## Cumulative Proportion  0.999815 0.999833 0.999851 0.999867 0.999882 0.999895
```

```
##                             pc91     pc92     pc93     pc94     pc95     pc96
## Standard deviation     0.072105 0.067429 0.065270 0.062718 0.061389 0.055941
## Proportion of Variance 0.000012 0.000011 0.000010 0.000009 0.000009 0.000007
## Cumulative Proportion  0.999907 0.999917 0.999927 0.999937 0.999945 0.999953
##                             pc97     pc98     pc99    pc100    pc101    pc102
## Standard deviation     0.053349 0.051798 0.051192 0.049099 0.046743 0.045377
## Proportion of Variance 0.000007 0.000006 0.000006 0.000006 0.000005 0.000005
## Cumulative Proportion  0.999959 0.999965 0.999972 0.999977 0.999982 0.999987
##                            pc103    pc104    pc105    pc106    pc107    pc108
## Standard deviation     0.039417 0.037297 0.036219 0.034968 0.010609 0.000000
## Proportion of Variance 0.000004 0.000003 0.000003 0.000003 0.000000 0.000000
## Cumulative Proportion  0.999991 0.999994 0.999997 1.000000 1.000000 1.000000
##                            pc109    pc110    pc111    pc112    pc113    pc114
## Standard deviation     0.000000 0.000000 0.000000 0.000000 0.000000 0.000000
## Proportion of Variance 0.000000 0.000000 0.000000 0.000000 0.000000 0.000000
## Cumulative Proportion  1.000000 1.000000 1.000000 1.000000 1.000000 1.000000
##                            pc115    pc116    pc117    pc118    pc119    pc120
## Standard deviation     0.000000 0.000000 0.000000 0.000000 0.000000 0.000000
## Proportion of Variance 0.000000 0.000000 0.000000 0.000000 0.000000 0.000000
## Cumulative Proportion  1.000000 1.000000 1.000000 1.000000 1.000000 1.000000
##                            pc121    pc122    pc123    pc124    pc125    pc126
## Standard deviation     0.000000 0.000000 0.000000 0.000000 0.000000 0.000000
## Proportion of Variance 0.000000 0.000000 0.000000 0.000000 0.000000 0.000000
## Cumulative Proportion  1.000000 1.000000 1.000000 1.000000 1.000000 1.000000
##                            pc127    pc128    pc129    pc130    pc131    pc132
## Standard deviation     0.000000 0.000000 0.000000 0.000000 0.000000 0.000000
## Proportion of Variance 0.000000 0.000000 0.000000 0.000000 0.000000 0.000000
## Cumulative Proportion  1.000000 1.000000 1.000000 1.000000 1.000000 1.000000
##                            pc133    pc134    pc135    pc136    pc137    pc138
## Standard deviation     0.000000 0.000000 0.000000 0.000000 0.000000 0.000000
## Proportion of Variance 0.000000 0.000000 0.000000 0.000000 0.000000 0.000000
## Cumulative Proportion  1.000000 1.000000 1.000000 1.000000 1.000000 1.000000
##                            pc139    pc140    pc141    pc142    pc143    pc144
## Standard deviation     0.000000 0.000000 0.000000 0.000000 0.000000 0.000000
## Proportion of Variance 0.000000 0.000000 0.000000 0.000000 0.000000 0.000000
## Cumulative Proportion  1.000000 1.000000 1.000000 1.000000 1.000000 1.000000
##                            pc145    pc146    pc147    pc148    pc149    pc150
## Standard deviation     0.000000 0.000000 0.000000 0.000000 0.000000 0.000000
## Proportion of Variance 0.000000 0.000000 0.000000 0.000000 0.000000 0.000000
## Cumulative Proportion  1.000000 1.000000 1.000000 1.000000 1.000000 1.000000
##                            pc151    pc152    pc153    pc154    pc155    pc156
## Standard deviation     0.000000 0.000000 0.000000 0.000000 0.000000 0.000000
## Proportion of Variance 0.000000 0.000000 0.000000 0.000000 0.000000 0.000000
## Cumulative Proportion  1.000000 1.000000 1.000000 1.000000 1.000000 1.000000
##                            pc157    pc158    pc159    pc160    pc161    pc162
## Standard deviation     0.000000 0.000000 0.000000 0.000000 0.000000 0.000000
## Proportion of Variance 0.000000 0.000000 0.000000 0.000000 0.000000 0.000000
## Cumulative Proportion  1.000000 1.000000 1.000000 1.000000 1.000000 1.000000
##                            pc163    pc164    pc165    pc166    pc167    pc168
## Standard deviation     0.000000 0.000000 0.000000 0.000000 0.000000 0.000000
## Proportion of Variance 0.000000 0.000000 0.000000 0.000000 0.000000 0.000000
## Cumulative Proportion  1.000000 1.000000 1.000000 1.000000 1.000000 1.000000
##                            pc169    pc170    pc171    pc172    pc173    pc174
## Standard deviation     0.000000 0.000000 0.000000 0.000000 0.000000 0.000000
```

```
## Proportion of Variance 0.000000 0.000000 0.000000 0.000000 0.000000 0.000000
## Cumulative Proportion  1.000000 1.000000 1.000000 1.000000 1.000000 1.000000
##                           pc175    pc176    pc177    pc178    pc179    pc180
## Standard deviation     0.000000 0.000000 0.000000 0.000000 0.000000 0.000000
## Proportion of Variance 0.000000 0.000000 0.000000 0.000000 0.000000 0.000000
## Cumulative Proportion  1.000000 1.000000 1.000000 1.000000 1.000000 1.000000
##                           pc181    pc182    pc183    pc184    pc185    pc186
## Standard deviation     0.000000 0.000000 0.000000 0.000000 0.000000 0.000000
## Proportion of Variance 0.000000 0.000000 0.000000 0.000000 0.000000 0.000000
## Cumulative Proportion  1.000000 1.000000 1.000000 1.000000 1.000000 1.000000
##                           pc187    pc188    pc189    pc190    pc191    pc192
## Standard deviation     0.000000 0.000000 0.000000 0.000000 0.000000 0.000000
## Proportion of Variance 0.000000 0.000000 0.000000 0.000000 0.000000 0.000000
## Cumulative Proportion  1.000000 1.000000 1.000000 1.000000 1.000000 1.000000
##                           pc193    pc194    pc195    pc196    pc197
## Standard deviation     0.000000 0.000000 0.000000 0.000000 0.000000
## Proportion of Variance 0.000000 0.000000 0.000000 0.000000 0.000000
## Cumulative Proportion  1.000000 1.000000 1.000000 1.000000 1.000000
```

```
set.seed(24)
data <- matrix(rnorm(200), ncol = 2)
#K-means
radK <- kmeans(data, centers = 3, nstart = 20)
str(radK)
```

```
## List of 9
##  $ cluster     : int [1:100] 2 2 2 2 1 1 1 3 2 1 ...
##  $ centers     : num [1:3, 1:2] 0.626 -0.366 -1.025 -0.378 0.788 ...
##   ..- attr(*, "dimnames")=List of 2
##   .. ..$ : chr [1:3] "1" "2" "3"
##   .. ..$ : NULL
##  $ totss       : num 187
##  $ withinss    : num [1:3] 27.8 32.4 26.6
##  $ tot.withinss: num 86.7
##  $ betweenss   : num 101
##  $ size        : int [1:3] 39 39 22
##  $ iter        : int 3
##  $ ifault      : int 0
##  - attr(*, "class")= chr "kmeans"
```

```
#cluster each observation
radK$cluster
```

```
##   [1] 2 2 2 2 1 1 1 3 2 1 2 1 2 3 1 3 3 1 1 1 2 2 3 1 2 2 1 1 1 3 3 2 1 2 1 3 3
##  [38] 2 1 2 2 1 2 2 2 3 1 2 1 2 1 3 1 1 3 1 3 1 1 1 1 1 3 1 1 3 3 2 1 3 2 2 3 2
##  [75] 2 3 2 2 2 2 3 2 2 2 1 1 3 1 2 2 2 2 3 2 1 1 1 2 1 1
```

```
#hierarchical cluster
radHC <- hclust(dist(data))
radHC
```

```
##
## Call:
## hclust(d = dist(data))
##
## Cluster method   : complete
## Distance         : euclidean
```

```
## Number of objects: 100
```

```
#K-means and hierarchical clustering are heuristic-base algorithms that create groupings based on the d
```

```
#model cluster
radMB <- Mclust(data)
radMB
```

```
## 'Mclust' model object: (XII,1)
##
## Available components:
##  [1] "call"           "data"           "modelName"      "n"
##  [5] "d"              "G"              "BIC"            "loglik"
##  [9] "df"             "bic"            "icl"            "hypvol"
## [13] "parameters"     "z"              "classification" "uncertainty"
```

```
#In model-based clustering, observations have a probability of belonging to each group. These methods o
```