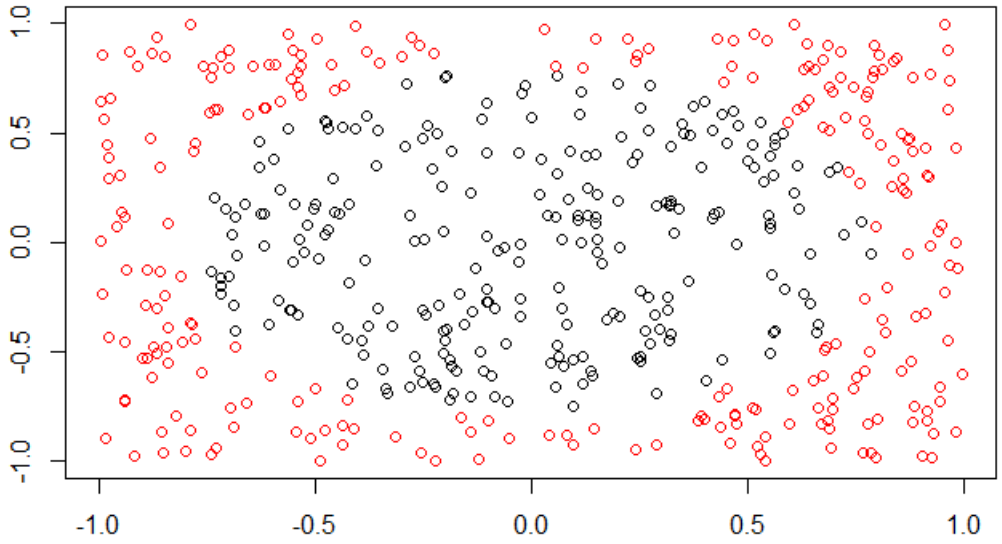
Question 5, MLBENCH

Code

Hide

```
library(mlbench)
library("corpcor")
circle<-mlbench.circle(500,2)
plot(circle)
```



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circle
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[398,] -0.105863390  0.638138334
[399,] -0.186078945 -0.564657107
[400,] -0.800577703 -0.953259711
[401,] -0.222459710 -0.661007631
[402,] -0.447853417 -0.391826044
[403,] -0.941060237  0.113270255
[404,]  0.630867229  0.625410313
[405,] -0.893485816 -0.284833311
[406,] -0.686150236  0.112804008
[407,] -0.742620123 -0.971246014
[408,] -0.444410143  0.128116643
[409,] -0.131158464 -0.115520826
[410,]  0.883256910  0.415427034
[411,] -0.959289592  0.074068557
[412,] -0.388556483 -0.516331963
[413,]  0.968410627 -0.101196169
[414,] -0.060347981 -0.461129008
[415,]  0.651346977 -0.628949335
[416,]  0.646013664 -0.279793635
[417,] -0.165490185 -0.232676111
[418,]  0.552806855  0.393204710
[419,] -0.541883343 -0.331041289
[420,] -0.240646009  0.532685245
[421,]  0.844778248  0.842610497
[422,] -0.842035472 -0.554059186
[423,]  0.474290986 -0.829705957
[424,] -0.533632159  0.673640085
[425,] -0.919971685 -0.978721711
[426,] -0.580817690  0.242291456
[427,] -0.204614372  0.051778005
[428,] -0.527827354 -0.048091296
[429,]  0.113635364 -0.004680523
[430,]  0.942957687 -0.725362341
[431,]  0.531063852  0.546632465
[432,]  0.954155280  0.997508172
[433,] -0.928768431  0.871645544
[434,]  0.857001592 -0.587822729
[435,]  0.631411039 -0.236853750
[436,]  0.659702003 -0.413676549
[437,] -0.216267769 -0.289170112
[438,] -0.883268431  0.477473372
[439,] -0.840883548  0.085897372
[440,]  0.954258580 -0.230532293
[441,] -0.782527880  0.418902070
[442,]  0.148258525  0.112991621
[443,] -0.358704926  0.350777010
[444,] -0.141580476  0.222852064
[445,]  0.733527503  0.319523697
[446,] -0.478266014  0.556429106
[447,] -0.026937027 -0.007369195
[448,]  0.398591575  0.641323332
[449,] -0.854307938 -0.963348810
[450,] -0.535252476  0.856245000
[451,]  0.124736157  0.395714864
[452,]  0.678322111 -0.495392151
[453,] -0.860586690  0.341563162
[454,]  0.510169671  0.754775645
[455,]  0.766326087 -0.961936980
[456,]  0.744593170  0.711611996
[457,] -0.244660912 -0.329856506
[458,] -0.718900004  0.847315177
[459,] -0.175010453 -0.590139237
[460,]  0.881796007  0.751488540
[461,] -0.563820678  0.949429234
[462,] -0.984744319 -0.895648490
[463,]  0.726930051  0.569019444
[464,]  0.322913311  0.173964645
[465,]  0.562346862 -0.401814093
[466,] -0.583159210  0.647262754
[467,] -0.224853072  0.862826432
[468,] -0.408846659  0.987501439
```

```
[469,]  0.127562277  0.121734294
[470,]  0.655044194  0.788221510
[471,]  0.188073494 -0.320416851
[472,]  0.769356122  0.556759072
[473,]  0.201702033 -0.022293188
[474,] -0.270966756  0.008881157
[475,]  0.094389876 -0.535993435
[476,] -0.182437883 -0.689187406
[477,]  0.115856285  0.685217964
[478,] -0.115294814  0.562587730
[479,]  0.911663522  0.431147482
[480,] -0.103080695 -0.269265938
[481,]  0.620001032  0.152369369
[482,]  0.685775378  0.896910012
[483,] -0.941683864 -0.716832094
[484,] -0.029801422  0.410864067
[485,]  0.777334939 -0.832086120
[486,]  0.641872956  0.654604350
[487,]  0.557903232  0.306514718
[488,] -0.719042240 -0.239122681
[489,]  0.837047676  0.823958191
[490,]  0.981487715  0.001523179
[491,]  0.453366035  0.452868403
[492,] -0.056175076 -0.728162298
[493,] -0.860452861 -0.135906527
[494,]  0.964098368  0.606486990
[495,]  0.261198026 -0.405973459
[496,] -0.689754308 -0.844444650
[497,] -0.001219955  0.573742902
[498,]  0.547003767  0.120846398
[499,]  0.151853741 -0.042847843
[500,] -0.455680071  0.692369002

$classes
  [1] 1 1 2 1 2 1 1 2 2 1 2 1 1 2 1 1 1 1 1 1 1 2 1 1 2 1 2 2 2 1 2 2 2 1 2 2 2 2 2 2 1 1 1 2 1 1 2 1 2
 [50] 2 1 1 2 2 2 1 2 1 1 2 2 2 2 1 1 1 1 2 1 2 2 1 1 1 2 2 2 2 2 2 1 1 1 1 1 2 1 1 2 1 1 1 2 1 1 2 1 2
 [99] 1 2 2 2 2 2 2 2 2 1 1 2 2 2 2 2 2 2 1 1 2 1 1 1 1 2 1 2 1 2 2 1 2 2 2 1 1 2 1 1 2 2 2 2 2 2 1 2 2 2
[148] 2 1 2 2 1 1 2 2 2 2 2 2 2 1 2 1 1 2 2 1 2 2 2 1 1 2 2 2 1 1 1 1 2 2 1 1 1 2 1 1 1 2 2 1 2 2 1 1 2
[197] 1 1 1 1 2 2 1 1 2 2 1 2 1 1 1 1 2 1 2 1 1 1 1 1 1 2 2 2 2 2 2 1 1 2 2 2 2 2 1 1 2 2 2 2 1 1 2 2 1
[246] 1 2 2 1 1 1 2 1 1 2 2 1 2 1 1 2 2 1 1 1 1 2 2 2 1 2 2 1 1 2 1 1 1 2 2 2 1 1 2 1 2 1 1 1 1 2 2 1
[295] 1 2 1 2 2 1 2 2 1 1 2 2 2 2 2 2 1 1 1 1 1 2 2 1 2 1 1 1 2 2 1 1 1 2 2 1 1 2 2 2 2 2 1 2 2 1 1 2 1 1 2 1 2
[344] 1 1 2 2 2 1 1 2 2 1 2 2 2 1 1 2 2 1 1 1 2 2 2 2 2 2 1 1 2 2 2 2 1 1 2 1 1 2 1 1 2 1 1 1 2 2 1 1 2 2 2 1
[393] 1 2 1 2 1 1 1 2 1 1 2 2 2 1 2 1 1 2 2 1 2 1 2 1 1 1 1 1 2 2 2 2 2 1 1 1 2 1 2 2 2 1 1 1 2 2 2 2
[442] 1 1 1 2 1 1 1 2 2 1 2 2 2 2 2 1 2 1 2 2 2 2 1 1 2 2 2 1 2 1 2 1 1 1 1 1 1 2 1 1 2 2 1 2 2 1 1 2 2
[491] 1 1 2 2 1 2 1 1 1 2
Levels: 1 2

attr(,"class")
[1] "mlbench.circle" "mlbench"
```

Hide

```
labels<-sign(as.numeric(circle$classes)-1.5)
labels
```

```
  [1] -1 -1  1 -1  1 -1 -1  1  1 -1  1 -1 -1  1 -1 -1 -1 -1 -1 -1  1 -1 -1  1 -1  1  1  1 -1  1  1  1
 [34] -1  1  1  1  1  1  1 -1 -1 -1  1 -1 -1  1 -1  1  1 -1 -1  1  1  1 -1  1 -1 -1  1  1  1  1 -1 -1 -1
 [67] -1  1 -1  1  1 -1 -1 -1  1  1  1  1  1  1 -1 -1 -1 -1 -1  1 -1 -1  1 -1 -1 -1  1 -1 -1  1 -1  1 -1
[100]  1  1  1  1  1  1  1 -1 -1  1  1  1  1  1  1  1 -1 -1  1 -1 -1 -1 -1  1 -1  1 -1  1  1 -1  1  1  1
[133] -1 -1  1 -1 -1  1  1  1  1  1  1 -1  1  1  1  1 -1  1  1 -1 -1  1  1  1  1  1  1  1 -1  1 -1 -1  1
[166]  1 -1  1  1  1 -1 -1  1  1  1 -1 -1 -1 -1  1  1 -1 -1 -1  1 -1 -1 -1  1  1 -1  1  1 -1 -1  1 -1 -1
[199] -1 -1  1  1 -1 -1  1  1 -1  1 -1 -1 -1 -1  1 -1  1 -1 -1 -1 -1 -1 -1  1  1  1  1  1  1 -1 -1  1  1
[232]  1  1  1 -1 -1  1  1  1  1 -1 -1  1  1 -1 -1  1  1 -1 -1 -1  1 -1 -1  1  1 -1  1 -1 -1  1  1 -1 -1
[265] -1 -1  1  1  1 -1  1  1 -1 -1 -1  1 -1 -1 -1  1  1  1 -1 -1  1 -1  1 -1 -1 -1 -1  1  1 -1 -1  1 -1
[298]  1  1 -1  1  1 -1 -1  1  1  1  1  1  1 -1 -1 -1 -1 -1  1  1 -1  1 -1 -1 -1  1  1 -1 -1 -1  1  1  1
[331]  1  1 -1  1  1 -1 -1  1 -1 -1  1 -1  1 -1 -1  1  1  1 -1 -1  1  1 -1  1  1  1 -1 -1  1  1 -1 -1 -1
[364]  1  1  1  1  1  1 -1 -1  1  1  1  1 -1 -1  1 -1 -1  1 -1 -1 -1  1  1 -1 -1  1  1  1 -1 -1  1 -1  1
[397] -1 -1 -1  1 -1 -1  1  1  1 -1  1 -1 -1  1  1 -1  1 -1  1 -1 -1 -1 -1 -1  1  1  1  1  1 -1 -1 -1 -1
[430]  1 -1  1  1  1 -1 -1 -1  1  1  1  1 -1 -1 -1  1 -1 -1 -1  1  1 -1  1  1  1  1  1 -1  1 -1  1  1  1
[463]  1 -1 -1  1  1  1 -1  1 -1  1 -1 -1 -1 -1 -1 -1  1 -1 -1  1  1 -1  1  1 -1 -1  1  1 -1 -1  1  1 -1
[496]  1 -1 -1 -1  1
```

Hide

```
dataset<-data.frame(cbind(circle$x[,1:2],labels))
dataset
```

Hide

```
write.table(dataset,"circle.txt",sep=",",row.names=FALSE)
```

Hide

```
circle<-read.table("circle.txt",sep=",",header=T)
circle
```

Hide

```
class.index<-dim(circle)[2]
train.index<-sample(nrow(circle),nrow(circle)*0.3)
train.index
```

```
  [1] 102 355 175 220 121 191 494 277 226 353  89 347 433 131 117  63 455  29 496  92 394 182 133  43
 [25]  87 253 329 352 434 372 358 258 320 429 365 317 130 145 484 453  71 308 462 379 271 322 184 266
 [49] 101 298 224 159 229  64 129 487 439 233 357  16 140 254 200 311  95 164 389 431 283 445 309 461
 [73] 141  50 276  83 398 350   2 359 106 189 157 248 399 452 144 222 414 328 390 435   9 356  51 134
 [97] 123 337 142 480   4 367 493 335 368  99 245 250 291 483 279 464 377 124 143 194 275 207 217 333
[121] 213 202 446 195 318 268 290 489 105   6 135 476   5  22 240 467 115 165  54 477 292 376  35  56
[145] 386 415  57 384  70  12
```

Hide

```
training.set<-circle[train.index,]
training.set
```

Hide

```
training.set.features<-training.set[,-class.index]
training.set.labels<-training.set[,class.index]
training.set.labels
```

```
  [1]  1  1  1 -1 -1 -1  1 -1  1 -1  1  1  1 -1  1  1  1 -1  1 -1 -1 -1 -1 -1  1  1  1 -1  1 -1
 [34] -1  1  1  1  1 -1  1  1  1  1 -1  1 -1 -1 -1  1  1  1 -1 -1 -1 -1 -1  1  1 -1 -1  1 -1 -1 -1 -1 -1
 [67]  1 -1 -1  1  1  1  1  1  1 -1 -1 -1 -1  1  1  1  1 -1  1 -1  1 -1  1  1 -1  1  1 -1 -1  1 -1  1
[100] -1 -1  1  1  1  1 -1 -1 -1 -1  1 -1 -1 -1 -1  1 -1 -1 -1 -1 -1  1  1 -1 -1 -1  1 -1  1  1 -1  1 -1
[133]  1  1  1  1  1  1  1 -1  1 -1  1 -1  1  1  1 -1  1 -1
```

Hide

```
test.set<-circle[-train.index,]
test.set
```

Hide

```
test.set.features<-test.set[,-class.index]
test.set.labels<-test.set[,class.index]
test.set.labels
```

```
  [1] -1  1 -1  1 -1  1 -1  1 -1 -1 -1 -1 -1 -1 -1 -1  1 -1  1  1 -1  1  1  1 -1  1  1  1  1 -1 -1  1
 [34] -1 -1  1 -1  1 -1  1  1 -1 -1  1  1  1 -1 -1 -1  1 -1 -1 -1 -1  1  1  1  1  1  1 -1 -1 -1 -1  1 -1
 [67] -1 -1  1 -1  1 -1  1  1  1  1 -1 -1  1  1  1  1  1  1 -1  1 -1 -1 -1  1 -1  1  1  1 -1 -1  1  1  1
[100]  1  1 -1  1  1 -1 -1  1  1  1  1  1 -1  1 -1  1 -1  1  1  1 -1 -1  1  1 -1 -1 -1 -1  1  1 -1  1 -1
[133] -1 -1  1  1  1  1 -1 -1 -1  1 -1 -1  1  1  1 -1 -1 -1 -1 -1  1 -1 -1 -1 -1  1  1  1 -1  1  1  1  1
[166] -1 -1  1  1  1 -1 -1  1  1 -1  1 -1 -1  1  1  1 -1 -1 -1  1  1 -1 -1 -1  1  1 -1  1 -1 -1 -1  1  1
[199]  1 -1  1 -1  1 -1 -1  1 -1 -1  1 -1  1 -1  1  1 -1 -1  1  1  1  1 -1 -1 -1 -1  1  1 -1  1  1 -1 -1
[232] -1  1  1  1  1 -1  1 -1 -1  1 -1  1 -1 -1  1  1 -1  1  1  1 -1 -1 -1  1  1  1 -1 -1  1  1  1  1 -1
[265]  1 -1 -1  1 -1 -1  1 -1 -1 -1  1 -1  1 -1 -1  1  1  1 -1  1 -1 -1  1  1 -1  1 -1 -1 -1 -1 -1  1  1
[298]  1  1  1 -1 -1 -1  1  1 -1 -1  1  1  1 -1 -1 -1 -1 -1  1  1 -1  1  1 -1  1 -1  1  1 -1  1  1 -1  1
[331] -1  1 -1 -1 -1 -1  1 -1  1  1  1 -1  1 -1 -1 -1 -1 -1 -1  1
```

2 centers—

Hide

```
rbf <- function(X, Y, K=2, gamma=1.0) {
  N<- dim(X)[1] # number of instances

  repeat {
    km <- kmeans(X, K)  # let's cluster K centers out of the dataset
    if (min(km$size)>0) # only accept if there are no empty clusters
      break
  }
  mus <- km$centers # the clusters points

  Phi <- matrix(rep(NA,(K+1)*N), ncol=K+1)
  for (lin in 1:N) {
    Phi[lin,1] <- 1    # bias column
    for (col in 1:K) {
      Phi[lin,col+1] <- exp( -gamma * norm(as.matrix(X[lin,]-mus[col,]),"F")^2 )
    }
  }
   w <- pseudoinverse(Phi) %*% matrix(as.numeric(Y))  # find RBF weights
  list(weights=w, centers=mus, gamma=gamma)  # return the rbf model
}
# now call rbf function
rbf.model<-rbf(training.set.features,training.set.labels)
rbf.model
```

```
$`weights`
          [,1]
[1,]  2.664381
[2,] -2.913368
[3,] -2.427644

$centers
          V1         V2
1 0.10226132  0.4980463
2 0.02772818 -0.5731002

$gamma
[1] 1
```

Hide

```
rbf.predict <- function(model, X, classification=FALSE) {
  gamma   <- model$gamma
  centers <- model$centers
  w       <- model$weights
  N       <- dim(X)[1]    # number of observations

  pred <- rep(w[1],N)  # we need to init to a value, so let's start with the bias
  for (j in 1:N) {
    # find prediction for point xj
    for (k in 1:length(centers[,1])) {
      # the weight for center[k] is given by w[k+1] (because w[1] is the bias)
      pred[j] <- pred[j] + w[k+1] * exp( -gamma * norm(as.matrix(X[j,]-centers[k,]),"F")^2 )
    }
  }

  if (classification) {
    pred <- unlist(lapply(pred, sign))
  }
  return(pred)
}
predictions<-rbf.predict(rbf.model,test.set.features,TRUE)
predictions
```

```
  [1] -1  1  1  1  1  1 -1  1 -1 -1 -1 -1 -1  1 -1 -1  1 -1  1  1 -1 -1  1  1 -1  1  1  1  1  1 -1  1
 [34] -1 -1  1 -1  1  1  1  1 -1 -1  1  1  1 -1 -1 -1  1 -1  1 -1  1 -1  1  1  1 -1  1 -1 -1 -1 -1  1 -1
 [67]  1 -1  1 -1  1 -1  1  1  1  1  1 -1  1  1  1  1 -1  1 -1  1 -1 -1 -1  1 -1  1  1  1  1 -1  1  1  1
[100]  1  1 -1  1  1  1 -1  1  1  1  1  1 -1  1 -1  1 -1  1  1  1 -1 -1  1  1  1 -1  1 -1  1  1 -1  1 -1
[133] -1 -1  1  1  1 -1 -1 -1 -1  1 -1 -1  1  1  1  1 -1 -1  1 -1  1 -1 -1 -1 -1  1  1  1 -1  1  1  1  1
[166] -1 -1  1  1  1 -1 -1  1  1 -1  1 -1  1  1  1  1 -1 -1 -1  1  1 -1 -1 -1  1  1 -1  1 -1 -1  1  1  1
[199]  1 -1  1  1  1 -1 -1  1  1  1  1 -1  1 -1  1  1 -1 -1  1  1 -1  1 -1 -1 -1 -1  1  1 -1  1  1  1 -1
[232] -1  1  1  1  1 -1  1 -1 -1  1 -1  1 -1 -1  1  1 -1  1  1 -1  1 -1 -1  1  1  1 -1 -1  1  1  1  1 -1
[265]  1 -1 -1  1 -1 -1  1 -1 -1  1  1 -1  1 -1 -1  1  1  1  1  1 -1 -1  1  1 -1  1 -1 -1 -1  1 -1  1  1
[298]  1  1  1  1 -1 -1  1  1  1 -1  1  1  1 -1 -1 -1 -1 -1  1  1 -1  1  1 -1  1 -1  1  1 -1  1  1 -1  1
[331] -1  1 -1 -1 -1 -1  1 -1  1  1  1  1  1 -1 -1 -1 -1 -1 -1  1
```

Hide

```
rbf.model<-rbf(training.set.features,training.set.labels)
rbf.model
```

```
$`weights`
          [,1]
[1,]  2.664381
[2,] -2.427644
[3,] -2.913368

$centers
          V1         V2
1 0.02772818 -0.5731002
2 0.10226132  0.4980463

$gamma
[1] 1
```

Hide

```
predictions<-rbf.predict(rbf.model,test.set.features,TRUE)
predictions
```

```
  [1] -1  1  1  1  1  1 -1  1 -1 -1 -1 -1 -1  1 -1 -1  1 -1  1  1 -1 -1  1  1 -1  1  1  1  1  1 -1  1
 [34] -1 -1  1 -1  1  1  1  1 -1 -1  1  1  1 -1 -1 -1  1 -1  1 -1  1 -1  1  1  1 -1  1 -1 -1 -1 -1  1 -1
 [67]  1 -1  1 -1  1 -1  1  1  1  1  1 -1  1  1  1  1 -1  1 -1  1 -1 -1 -1  1 -1  1  1  1  1 -1  1  1  1
[100]  1  1 -1  1  1  1 -1  1  1  1  1  1 -1  1 -1  1 -1  1  1  1 -1 -1  1  1  1 -1  1 -1  1  1 -1  1 -1
[133] -1 -1  1  1  1 -1 -1 -1 -1  1 -1 -1 -1  1  1  1  1 -1 -1  1 -1  1 -1 -1 -1 -1  1  1  1 -1  1  1  1  1
[166] -1 -1  1  1  1 -1 -1  1  1 -1  1 -1  1  1  1  1 -1 -1 -1  1  1 -1 -1 -1  1  1 -1  1 -1 -1  1  1  1
[199]  1 -1  1  1  1 -1 -1  1  1  1  1 -1  1 -1  1  1 -1 -1  1  1 -1  1 -1 -1 -1 -1  1  1 -1  1  1  1 -1
[232] -1  1  1  1  1 -1  1 -1 -1  1 -1  1 -1 -1  1  1 -1  1  1 -1  1 -1 -1  1  1  1 -1 -1  1  1  1  1 -1
[265]  1 -1 -1  1 -1 -1  1 -1 -1  1  1 -1  1 -1 -1  1  1  1  1  1 -1 -1  1  1 -1  1 -1 -1 -1  1 -1  1  1
[298]  1  1  1  1 -1 -1  1  1  1 -1  1  1  1 -1 -1 -1 -1 -1  1  1 -1  1  1 -1  1 -1  1  1 -1  1  1 -1  1
[331] -1  1 -1 -1 -1 -1  1 -1  1  1  1  1  1 -1 -1 -1 -1 -1 -1  1
```

Hide

```
cm<-table(test.set.labels,predictions)
cm
```

```
               predictions
test.set.labels  -1   1
             -1 146  28
              1   7 169
```

Hide

```
acc<-(cm[1][1]+cm[4][1])/sum(cm)
caption<-sprintf("RBF Accuracy: %.4f",acc)
caption
```

```
[1] "RBF Accuracy: 0.9000"
```

Hide

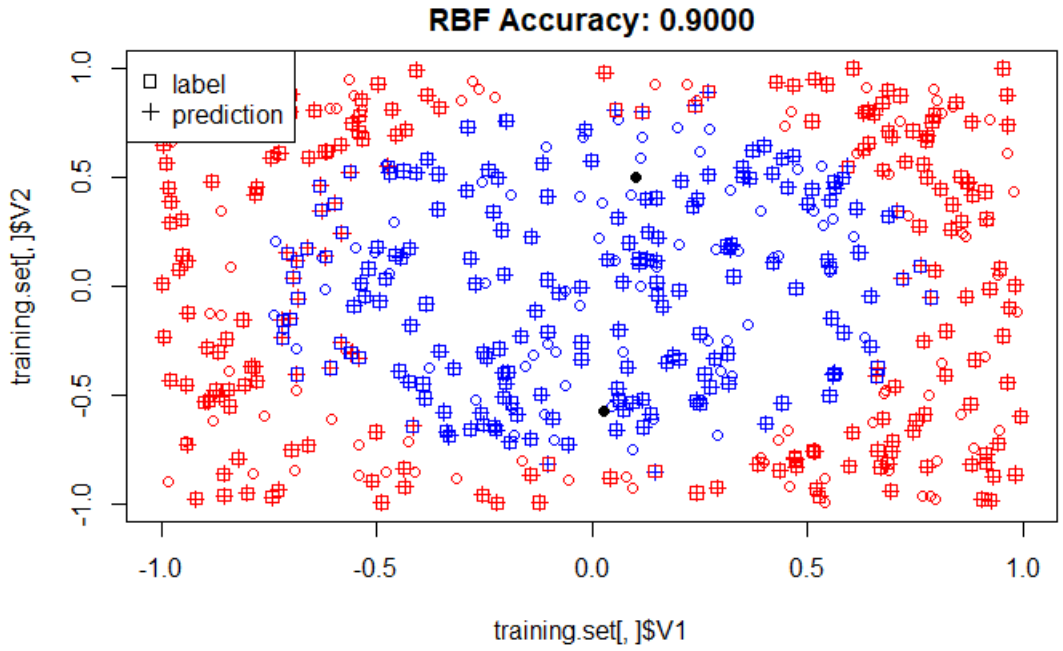
```
plot(training.set[,]$V1,training.set[,]$V2,xlim=c(-1,1),ylim=c(-1,1),col=c("blue","black","red")[training.se
t.labels[]+2])
points(test.set[,1],test.set[,2],col=c("blue","black","red")[predictions[]+2],pch=3)
```

Hide

```
points(test.set[,1],test.set[,2],col=c("blue","black","red")[test.set.labels[]+2],pch=0)
points(rbf.model$centers, col="black", pch=19)
```

Hide

```
legend("topleft",legend=c("label","prediction"),pch=c(0,3))
title(caption)
```



5 centers—-

Hide

```
rbf <- function(X, Y, K=5, gamma=1.0) {
  N<- dim(X)[1] # number of instances

  repeat {
    km <- kmeans(X, K)  # let's cluster K centers out of the dataset
    if (min(km$size)>0) # only accept if there are no empty clusters
      break
  }
  mus <- km$centers # the clusters points

  Phi <- matrix(rep(NA,(K+1)*N), ncol=K+1)
  for (lin in 1:N) {
    Phi[lin,1] <- 1    # bias column
    for (col in 1:K) {
      Phi[lin,col+1] <- exp( -gamma * norm(as.matrix(X[lin,]-mus[col,]),"F")^2 )
    }
  }
   w <- pseudoinverse(Phi) %*% matrix(as.numeric(Y))  # find RBF weights
  list(weights=w, centers=mus, gamma=gamma)  # return the rbf model
}
# now call rbf function
rbf.model<-rbf(training.set.features,training.set.labels)
rbf.model
```

```
$`weights`
          [,1]
[1,]  4.116540
[2,] -2.253777
[3,] -1.410527
[4,] -2.745746
[5,] -1.485688
[6,] -1.879957

$centers
           V1         V2
1 -0.54682461  0.5797476
2  0.02371673 -0.4528826
3  0.45696573  0.4853900
4  0.69020639 -0.6727129
5 -0.67215079 -0.5551943

$gamma
[1] 1
```

Hide

```
rbf.predict <- function(model, X, classification=FALSE) {
  gamma   <- model$gamma
  centers <- model$centers
  w       <- model$weights
  N       <- dim(X)[1]    # number of observations

  pred <- rep(w[1],N)  # we need to init to a value, so let's start with the bias
  for (j in 1:N) {
    # find prediction for point xj
    for (k in 1:length(centers[,1])) {
      # the weight for center[k] is given by w[k+1] (because w[1] is the bias)
      pred[j] <- pred[j] + w[k+1] * exp( -gamma * norm(as.matrix(X[j,]-centers[k,]),"F")^2 )
    }
  }

  if (classification) {
    pred <- unlist(lapply(pred, sign))
  }
  return(pred)
}
predictions<-rbf.predict(rbf.model,test.set.features,TRUE)
predictions
```

```
  [1] -1  1 -1  1  1  1 -1  1 -1 -1 -1 -1 -1 -1 -1 -1  1 -1  1  1 -1 -1  1  1 -1  1  1  1  1  1 -1 -1  1
 [34] -1 -1  1 -1  1 -1  1  1 -1 -1  1  1  1 -1 -1 -1  1 -1  1 -1 -1 -1  1  1  1  1  1 -1 -1 -1 -1  1 -1
 [67] -1 -1  1 -1  1 -1  1  1  1  1 -1 -1  1  1  1  1  1  1 -1  1 -1 -1 -1  1 -1  1  1  1 -1 -1  1  1  1
[100]  1  1 -1  1  1 -1 -1  1  1  1  1  1 -1  1 -1  1 -1  1  1  1 -1 -1  1  1  1 -1 -1 -1  1  1 -1  1 -1
[133] -1 -1  1  1  1 -1 -1 -1 -1  1 -1 -1  1  1  1 -1 -1 -1 -1 -1  1 -1 -1 -1 -1  1  1  1 -1  1  1  1  1
[166] -1 -1  1  1  1 -1 -1  1  1 -1  1 -1  1  1  1  1 -1 -1 -1  1  1 -1 -1 -1  1  1 -1  1 -1 -1 -1  1  1
[199]  1 -1  1 -1  1 -1 -1  1 -1 -1  1 -1  1 -1  1  1 -1 -1  1  1  1  1 -1 -1 -1 -1  1  1 -1  1  1  1 -1
[232] -1  1  1  1  1 -1  1 -1 -1  1 -1  1 -1 -1  1  1 -1  1  1  1 -1 -1 -1  1  1  1 -1 -1  1  1  1  1 -1
[265]  1 -1 -1  1 -1 -1  1 -1 -1 -1  1 -1  1 -1 -1  1  1  1 -1  1 -1 -1  1  1 -1  1 -1 -1 -1 -1 -1  1  1
[298]  1  1  1 -1 -1 -1  1  1  1 -1  1  1  1 -1 -1 -1 -1 -1  1  1 -1  1  1 -1  1 -1  1  1 -1  1  1 -1  1
[331] -1  1 -1 -1 -1 -1  1 -1  1  1  1 -1  1 -1 -1 -1 -1 -1 -1  1
```

Hide

```
rbf.model<-rbf(training.set.features,training.set.labels)
rbf.model
```

```
$`weights`
          [,1]
[1,]  4.108246
[2,] -2.292951
[3,] -2.657341
[4,] -1.870952
[5,] -1.473525
[6,] -1.453862

$centers
           V1         V2
1 -0.52739024  0.5836112
2  0.47573277  0.4890879
3 -0.67215079 -0.5551943
4  0.69020639 -0.6727129
5  0.02469287 -0.4346310

$gamma
[1] 1
```

Hide

```
predictions<-rbf.predict(rbf.model,test.set.features,TRUE)
predictions
```

```
  [1] -1  1 -1  1  1  1 -1  1 -1 -1 -1 -1 -1 -1 -1 -1  1 -1  1  1 -1 -1  1  1 -1  1  1  1  1 -1 -1  1
 [34] -1 -1  1 -1  1 -1  1  1 -1 -1  1  1  1 -1 -1 -1  1 -1  1 -1 -1 -1  1  1  1  1 -1 -1 -1 -1  1 -1
 [67] -1 -1  1 -1  1 -1  1  1  1  1 -1 -1  1  1  1  1  1  1 -1  1 -1 -1 -1  1 -1  1  1  1 -1 -1  1  1  1
[100]  1  1 -1  1  1 -1 -1  1  1  1  1  1 -1  1 -1  1 -1  1  1  1 -1 -1  1  1  1 -1 -1 -1  1  1 -1  1 -1
[133] -1 -1  1  1  1 -1 -1 -1 -1  1 -1 -1  1  1  1 -1 -1 -1 -1 -1  1 -1 -1 -1 -1  1  1  1 -1  1  1  1  1
[166] -1 -1  1  1  1 -1 -1  1  1 -1  1 -1  1  1  1  1 -1 -1 -1  1  1 -1 -1 -1  1  1 -1  1 -1 -1 -1  1  1
[199]  1 -1  1 -1  1 -1 -1  1 -1 -1  1 -1  1 -1  1  1 -1 -1  1  1  1  1 -1 -1 -1 -1  1  1 -1  1  1  1 -1
[232] -1  1  1  1  1 -1  1 -1 -1  1 -1  1 -1 -1  1  1 -1  1  1  1 -1 -1 -1  1  1  1 -1 -1  1  1  1  1 -1
[265]  1 -1 -1  1 -1 -1  1 -1 -1 -1  1 -1  1 -1 -1  1  1  1 -1  1 -1 -1  1  1 -1  1 -1 -1 -1 -1 -1  1  1
[298]  1  1  1 -1 -1 -1  1  1  1 -1  1  1  1 -1 -1 -1 -1 -1  1  1 -1  1  1 -1  1 -1  1  1 -1  1  1 -1  1
[331] -1  1 -1 -1 -1 -1  1 -1  1  1  1 -1  1 -1 -1 -1 -1 -1 -1  1
```

Hide

```
cm<-table(test.set.labels,predictions)
cm
```

```
               predictions
test.set.labels  -1   1
             -1 168   6
              1   3 173
```

Hide

```
acc<-(cm[1][1]+cm[4][1])/sum(cm)
caption<-sprintf("RBF Accuracy: %.4f",acc)
caption
```

```
[1] "RBF Accuracy: 0.9743"
```

Hide

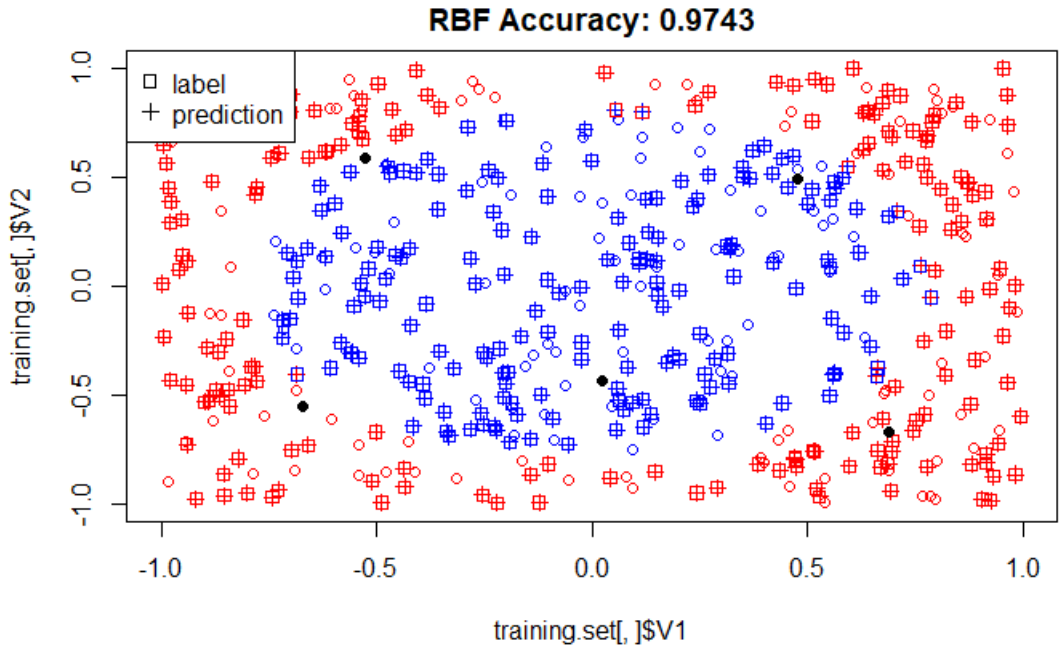
```
plot(training.set[,]$V1,training.set[,]$V2,xlim=c(-1,1),ylim=c(-1,1),col=c("blue","black","red")[training.se
t.labels[]+2])
points(test.set[,1],test.set[,2],col=c("blue","black","red")[predictions[]+2],pch=3)
```

Hide

```
points(test.set[,1],test.set[,2],col=c("blue","black","red")[test.set.labels[]+2],pch=0)
points(rbf.model$centers, col="black", pch=19)
```

Hide

```
legend("topleft",legend=c("label","prediction"),pch=c(0,3))
title(caption)
```



10 centers—

Hide

```
rbf <- function(X, Y, K=10, gamma=1.0) {
  N<- dim(X)[1] # number of instances

  repeat {
    km <- kmeans(X, K)  # let's cluster K centers out of the dataset
    if (min(km$size)>0) # only accept if there are no empty clusters
      break
  }
  mus <- km$centers # the clusters points

  Phi <- matrix(rep(NA,(K+1)*N), ncol=K+1)
  for (lin in 1:N) {
    Phi[lin,1] <- 1    # bias column
    for (col in 1:K) {
      Phi[lin,col+1] <- exp( -gamma * norm(as.matrix(X[lin,]-mus[col,]),"F")^2 )
    }
  }
   w <- pseudoinverse(Phi) %*% matrix(as.numeric(Y))  # find RBF weights
  list(weights=w, centers=mus, gamma=gamma)  # return the rbf model
}
# now call rbf function
rbf.model<-rbf(training.set.features,training.set.labels)
rbf.model
```

```
$`weights`
            [,1]
 [1,]  3.6042993
 [2,] -1.2411922
 [3,] -0.8176016
 [4,] -0.8027144
 [5,] -2.6285785
 [6,] -0.4121976
 [7,]  3.3266531
 [8,]  1.0611641
 [9,] -3.3630074
[10,] -4.3293923
[11,]  0.6609474

$centers
              V1          V2
1  -0.686931996  0.77806044
2   0.740195180  0.61425006
3  -0.653892512  0.03611672
4  -0.117621620 -0.42479561
5  -0.659791408 -0.72817722
6   0.614969404 -0.30372243
7   0.252819068 -0.76331757
8   0.750515633 -0.82453677
9   0.342420089  0.19816178
10  0.003246872  0.68833862

$gamma
[1] 1
```

Hide

```
rbf.predict <- function(model, X, classification=FALSE) {
  gamma   <- model$gamma
  centers <- model$centers
  w       <- model$weights
  N       <- dim(X)[1]    # number of observations

  pred <- rep(w[1],N)  # we need to init to a value, so let's start with the bias
  for (j in 1:N) {
    # find prediction for point xj
    for (k in 1:length(centers[,1])) {
      # the weight for center[k] is given by w[k+1] (because w[1] is the bias)
      pred[j] <- pred[j] + w[k+1] * exp( -gamma * norm(as.matrix(X[j,]-centers[k,]),"F")^2 )
    }
  }

  if (classification) {
    pred <- unlist(lapply(pred, sign))
  }
  return(pred)
}
predictions<-rbf.predict(rbf.model,test.set.features,TRUE)
predictions
```

```
  [1] -1  1 -1  1  1  1 -1  1 -1 -1 -1 -1 -1 -1 -1 -1  1 -1  1  1 -1 -1  1  1 -1  1  1  1  1  1 -1 -1  1
 [34] -1  1  1 -1  1 -1  1  1 -1 -1  1  1  1 -1 -1  1  1 -1  1 -1 -1  1  1  1  1  1  1 -1 -1 -1 -1  1 -1
 [67] -1 -1  1 -1  1 -1  1  1  1  1 -1 -1  1  1  1  1  1  1 -1  1 -1 -1 -1  1 -1  1  1  1  1 -1  1  1  1
[100]  1  1 -1  1  1 -1 -1  1  1  1  1  1  1  1 -1  1 -1  1  1  1 -1 -1  1  1  1 -1 -1 -1  1  1 -1  1 -1
[133] -1 -1  1  1  1  1 -1 -1 -1  1 -1 -1  1  1  1 -1 -1 -1 -1 -1  1 -1 -1 -1 -1  1  1  1 -1  1  1  1  1
[166] -1 -1  1  1  1 -1 -1  1  1  1  1 -1  1  1  1  1 -1 -1 -1  1  1  1 -1 -1  1  1 -1  1 -1 -1 -1  1  1
[199]  1 -1  1  1  1 -1 -1  1 -1 -1  1 -1  1 -1  1  1 -1 -1  1  1  1  1 -1 -1 -1 -1  1  1 -1  1  1  1 -1
[232]  1  1  1  1  1 -1  1  1 -1  1 -1  1 -1 -1  1  1 -1  1  1  1 -1 -1 -1  1  1  1 -1 -1  1  1  1  1 -1
[265]  1 -1 -1  1 -1 -1  1 -1 -1 -1  1 -1  1 -1 -1  1  1  1 -1  1 -1 -1  1  1 -1  1  1 -1 -1 -1 -1  1  1
[298]  1  1  1 -1 -1 -1  1  1  1 -1  1  1  1 -1 -1 -1 -1 -1  1  1 -1  1  1 -1  1 -1  1  1  1  1  1 -1  1
[331] -1  1 -1 -1 -1 -1  1 -1  1  1  1 -1  1 -1 -1 -1 -1 -1 -1  1
```

Hide

```
rbf.model<-rbf(training.set.features,training.set.labels)
rbf.model
```

```
$`weights`
             [,1]
 [1,]  3.33960625
 [2,] -2.19948447
 [3,]  2.21919011
 [4,] -0.93046811
 [5,] -0.72849192
 [6,] -1.07429115
 [7,]  0.84098056
 [8,] -1.20845010
 [9,] -0.04327114
[10,] -4.32978765
[11,] -0.13331634

$centers
               V1         V2
1   0.6494395848 -0.8101957
2   0.6103896302 -0.2774868
3  -0.6869319956  0.7780604
4  -0.0458318518 -0.5625462
5   0.7078064148  0.5577482
6  -0.0009512681  0.7389041
7  -0.7748794995 -0.2520229
8  -0.6436307018 -0.7732784
9   0.1789858487  0.1906485
10 -0.5913903177  0.1435872

$gamma
[1] 1
```

Hide

Hide

```
predictions<-rbf.predict(rbf.model,test.set.features,TRUE)
predictions
```

```
  [1] -1  1 -1  1  1  1 -1  1 -1 -1 -1 -1 -1 -1 -1 -1  1 -1  1  1 -1 -1  1  1 -1  1  1  1  1  1 -1 -1  1
 [34] -1  1  1 -1  1 -1  1  1 -1 -1  1  1  1 -1 -1  1  1 -1  1 -1 -1  1  1  1  1  1  1 -1 -1 -1 -1  1 -1
 [67] -1 -1  1 -1  1 -1  1  1  1  1 -1 -1  1  1  1  1  1  1 -1  1 -1 -1 -1  1  1  1  1  1  1 -1  1  1  1
[100]  1  1 -1  1  1 -1 -1  1  1  1  1  1  1  1 -1  1 -1  1  1  1 -1 -1  1  1  1 -1 -1 -1  1  1 -1  1 -1
[133] -1 -1  1  1  1  1 -1 -1 -1  1 -1 -1  1  1  1 -1 -1 -1 -1 -1  1 -1 -1 -1 -1  1  1  1 -1  1  1  1  1
[166] -1 -1  1  1  1 -1 -1  1  1  1  1 -1  1  1  1  1 -1 -1 -1  1  1  1 -1 -1  1  1 -1  1 -1 -1 -1  1  1
[199]  1 -1  1  1  1 -1 -1  1 -1 -1  1 -1  1 -1  1  1 -1  1  1  1  1  1 -1 -1 -1 -1  1  1 -1  1  1  1 -1
[232]  1  1  1  1  1 -1  1  1 -1  1 -1  1 -1 -1  1  1 -1  1  1  1 -1 -1 -1  1  1  1 -1 -1  1  1  1  1 -1
[265]  1 -1 -1  1 -1 -1  1 -1 -1 -1  1 -1  1 -1 -1  1  1  1 -1  1 -1 -1  1  1 -1  1  1 -1 -1 -1 -1  1  1
[298]  1  1  1 -1 -1 -1  1  1  1 -1  1  1  1 -1 -1 -1 -1 -1  1  1 -1  1  1 -1  1 -1  1  1  1  1  1 -1  1
[331] -1  1 -1 -1 -1 -1  1 -1  1  1  1 -1  1 -1 -1 -1 -1 -1 -1  1
```

Hide

```
cm<-table(test.set.labels,predictions)
cm
```

```
              predictions
test.set.labels  -1   1
             -1 155  19
             1    1 175
```

Hide

```
acc<-(cm[1][1]+cm[4][1])/sum(cm)
caption<-sprintf("RBF Accuracy: %.4f",acc)
caption
```

```
[1] "RBF Accuracy: 0.9429"
```

Hide

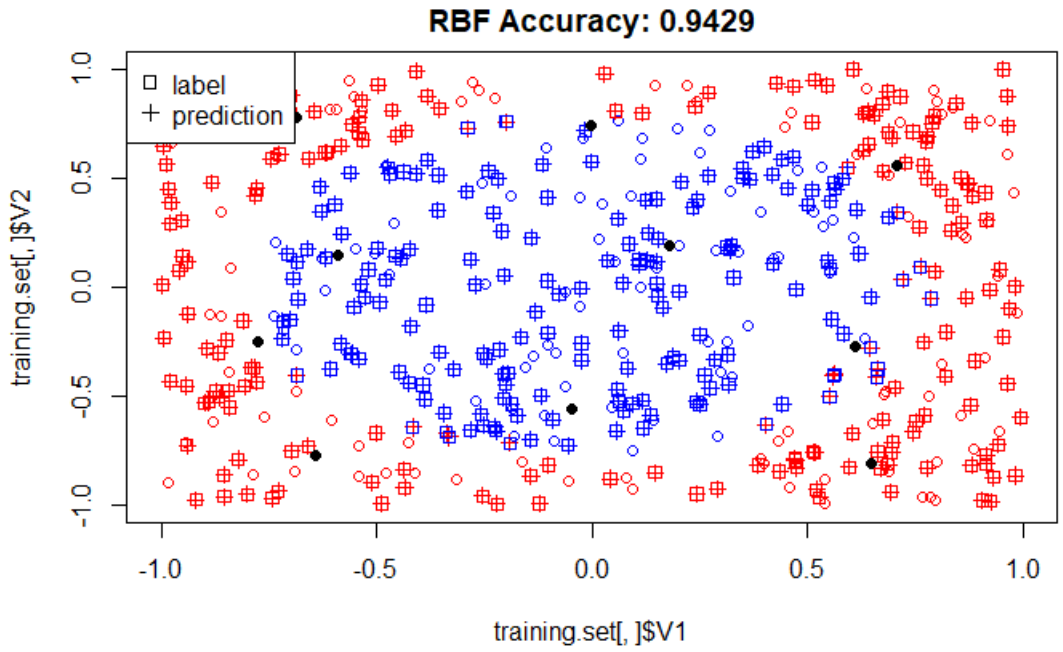
```
plot(training.set[,]$V1,training.set[,]$V2,xlim=c(-1,1),ylim=c(-1,1),col=c("blue","black","red")[training.se
t.labels[]+2])
points(test.set[,1],test.set[,2],col=c("blue","black","red")[predictions[]+2],pch=3)
```

Hide

```
points(test.set[,1],test.set[,2],col=c("blue","black","red")[test.set.labels[]+2],pch=0)
points(rbf.model$centers, col="black", pch=19)
```

Hide

```
legend("topleft",legend=c("label","prediction"),pch=c(0,3))
title(caption)
```

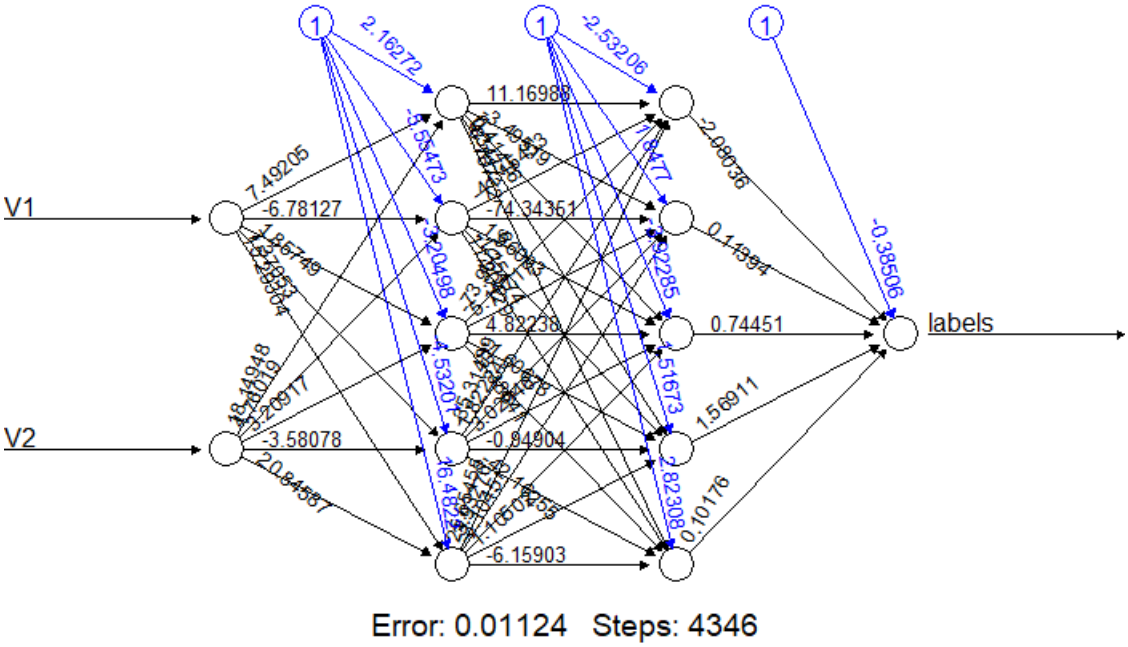


Hide

```
library(neuralnet)
net<-neuralnet(labels~V1+V2,training.set,hidden=c(5,5),rep=10)
```

Hide

```
plot(net,rep="best")
```



Hide

```
#net.prediction<-network<-neuralnet(labels~V1+V2,test.set,hidden=c(5,5),rep=5)
class.index<-length(test.set)
net.prediction<-compute(network,test.set[,-class.index])
net.prediction$net.result
```

```
             [,1]
1   -1.0044627850
3    1.0001214202
7   -1.0044627707
8    1.0057751835
10  -1.0038873985
11   1.0080209268
```

```
13  -1.0044623188
14   1.0001237191
15  -0.9879490633
17  -1.0044165266
18  -0.9646573654
19  -1.0044627851
20  -1.0044627851
21  -1.0044622104
23  -1.0044627851
24  -1.0044627851
25   1.0054919275
26  -1.0040356402
27   1.0057711563
28   1.0055511896
30  -1.0044627851
31   0.9417203626
32   1.0057743704
33   1.0080814858
34  -1.0044627851
36   1.0080331940
37   1.0024473763
38   1.0055509667
39   1.0057751834
40   1.0057751835
41  -1.0044627851
42  -1.0044627851
44   1.0012374331
45  -1.0044627851
46  -0.9512635127
47   0.9980593562
48  -0.9472764964
49   1.0057728708
52  -1.0044550535
53   0.9910111669
55   1.0285753497
58  -1.0044472729
59  -1.0044627851
60   0.9996451370
61   1.0057751835
62   1.0042047975
65  -1.0044627813
66  -1.0044627851
67  -1.0017972897
68   1.0057429490
69  -1.0044614789
72  -1.0122075218
73  -1.0044592580
74  -1.0044523296
75   1.0057742247
76   1.0057744046
77   1.0050526872
78   1.0026738020
79   1.0057751835
80   1.0075169850
81  -1.0044627851
82  -1.0044627851
84  -1.0044627851
85  -1.0044627851
86   0.8600236003
88  -1.0044627851
90  -0.9010351992
91  -1.0044627851
93   0.9952308711
94  -1.0044627851
96   1.0054398024
97  -1.0044627851
98   1.0080814857
100  1.0027934013
103  0.9989618632
104  0.9407035482
107 -1.0044627851
108 -1.0044590871
```

109 0.9681874081
110 1.0000248487
111 1.0000340970
112 1.0057747978
113 1.0080814857
114 1.0057750024
116 -1.0044627851
118 0.9617166023
119 -1.0044627851
120 -1.0044627851
122 -1.0044627851
125 1.0025153988
126 -1.0044627806
127 1.0439717242
128 1.0057751699
132 1.0588671652
136 -1.0028859259
137 -1.0044627851
138 1.0057751835
139 0.9924683518
146 1.0057696211
147 1.0057751835
148 1.0057751813
149 -1.0044627851
150 1.0057751835
151 1.0001528578
152 -1.0028611181
153 -1.0044627851
154 1.0057650785
155 1.0205932504
156 1.0081400702
158 1.0057751827
160 1.0057751459
161 -1.0038115277
162 1.0057751833
163 -1.0044489325
166 1.0057642292
167 -1.0044627851
168 1.0057750331
169 1.0057750754
170 0.9917508107
171 -1.0044627851
172 -1.0043944724
173 1.0054597519
174 0.9917216545
176 -0.9565938277
177 -0.9970639236
178 -1.0044626999
179 -1.0044627851
180 1.0056544241
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185 1.0057751313
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187 -1.0044627851
188 -1.0044627851
190 1.0057747655
192 1.0052344233
193 1.0057751835
196 0.9929131449
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198 -1.0044590636
199 -1.0044627851
201 1.0057751835
203 -1.0044627162
204 -1.0044627851
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206 0.9989235395
208 1.0057669073
209 -1.0044606884
210 -1.0044627851
211 -1.0044627851
212 -1.0044627851

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214 -1.0044625106
215  1.0057751819
216 -1.0044627851
218 -1.0044171846
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221 -1.0044627851
223  0.9983236202
225  1.0057695319
227  1.0057751835
228 -1.0044627851
230  0.9789817188
231  0.9909261235
232  1.0057751748
234  0.9916755762
235 -1.0044627851
236 -1.0044627828
237  1.0080814747
238  1.0057751730
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246 -1.0015482380
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252  1.0057749613
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262  1.0057751835
263 -0.9838492244
264 -1.0044627851
265 -1.0044627851
267  1.0057750512
269  1.0046231846
270 -1.0044627851
272  1.0001593118
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281  1.0001050292
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297 -1.0044627693
299  0.9995626223
300 -1.0044627850
301  1.0080812445
302  0.9910939755
303 -1.0044627851
304 -1.0042872028
305  1.0057751673
306  1.0057751835
307  0.9637811135
310  1.0057751835
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313 -1.0044627851
314 -1.0044627851
315 -1.0044627851
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316 0.9878535519
319 1.0015112007
321 -1.0044627851
323 1.0057751393
324 1.0057751754
325 -0.7913827836
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327 -0.9516266199
330 1.0041094082
331 1.0057750684
332 1.0002545342
334 1.0000897575
336 -1.0044619325
338 1.0055041632
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343 1.0001576900
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363 -1.0044627851
364 1.0057560217
366 0.8280794111
369 1.0057751835
370 -1.0044607648
371 -1.0044627851
373 1.0057750800
374 1.0001094675
375 1.0013895295
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383 -1.0044627851
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391 0.9983180378
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393 -1.0044627851
395 -1.0044627849
396 0.9183795559
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402 -1.0044627851
403 1.0057751834
404 1.0057720577
405 1.0057751780
406 -1.0044627848
407 1.0057748584
408 -1.0044627851
409 -1.0044627851
410 0.9925294871
411 1.0057751835
412 -1.0044627846
413 0.9966570941
416 -0.9981994149
417 -1.0044627851
418 -1.0044627851
419 -1.0044627851
420 -1.0044627851
421 1.0057751814

```
422  1.0057749452
423  1.0074542073
424  0.9939728282
425  1.0057751144
426 -1.0044627851
427 -1.0044627851
428 -1.0044627851
430  1.0000177675
432  1.0057751835
436 -0.9890535203
437 -1.0044627851
438  1.0057741051
440  1.0083690128
441  1.0027942620
442 -1.0044627851
443 -1.0044627851
444 -1.0044627851
447 -1.0044627851
448 -0.9928841088
449  1.0057750671
450  1.0057609605
451 -1.0044627851
454  1.0057689941
456  1.0057750788
457 -1.0044627851
458  1.0057743110
459 -1.0044627851
460  1.0056312111
463  1.0043881416
465 -0.9816750302
466  1.0003617520
468  1.0057707154
469 -1.0044627851
470  1.0057751835
471 -1.0044627851
472  0.9687765917
473 -1.0044627851
474 -1.0044627851
475 -1.0044627851
478 -1.0044627851
479  0.9922886951
481 -1.0044627854
482  1.0057751835
485  1.0002119141
486  1.0057749691
488 -1.0043599783
490  0.9987010697
491 -1.0044627851
492 -1.0037147731
495 -1.0044627851
497 -1.0044627851
498 -1.0044627851
499 -1.0044627851
500  0.8789334531
```

Hide

```
#net.prediction$net.result
```

Hide

```
classifications<-ifelse(net.prediction$net.result>0,1,-1)
classifications
```

```
    [,1]
1     -1
3      1
7     -1
8      1
10    -1
11     1
13    -1
```

```
14     1
15    -1
17    -1
18    -1
19    -1
20    -1
21    -1
23    -1
24    -1
25     1
26    -1
27     1
28     1
30    -1
31     1
32     1
33     1
34    -1
36     1
37     1
38     1
39     1
40     1
41    -1
42    -1
44     1
45    -1
46    -1
47     1
48    -1
49     1
52    -1
53     1
55     1
58    -1
59    -1
60     1
61     1
62     1
65    -1
66    -1
67    -1
68     1
69    -1
72    -1
73    -1
74    -1
75     1
76     1
77     1
78     1
79     1
80     1
81    -1
82    -1
84    -1
85    -1
86     1
88    -1
90    -1
91    -1
93     1
94    -1
96     1
97    -1
98     1
100    1
103    1
104    1
107   -1
108   -1
109    1
110    1
```

```
111    1
112    1
113    1
114    1
116   -1
118    1
119   -1
120   -1
122   -1
125    1
126   -1
127    1
128    1
132    1
136   -1
137   -1
138    1
139    1
146    1
147    1
148    1
149   -1
150    1
151    1
152   -1
153   -1
154    1
155    1
156    1
158    1
160    1
161   -1
162    1
163   -1
166    1
167   -1
168    1
169    1
170    1
171   -1
172   -1
173    1
174    1
176   -1
177   -1
178   -1
179   -1
180    1
181    1
183   -1
185    1
186   -1
187   -1
188   -1
190    1
192    1
193    1
196    1
197   -1
198   -1
199   -1
201    1
203   -1
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205    1
206    1
208    1
209   -1
210   -1
211   -1
212   -1
214   -1
215    1
```

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215    1
216   -1
218   -1
219   -1
221   -1
223    1
225    1
227    1
228   -1
230    1
231    1
232    1
234    1
235   -1
236   -1
237    1
238    1
239    1
241   -1
242   -1
243    1
244    1
246   -1
247    1
249   -1
251   -1
252    1
255    1
256    1
257   -1
259   -1
260   -1
261    1
262    1
263   -1
264   -1
265   -1
267    1
269    1
270   -1
272    1
273   -1
274   -1
278   -1
280    1
281    1
282    1
284   -1
285    1
286   -1
287    1
288   -1
289   -1
293    1
294   -1
295   -1
296    1
297   -1
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300   -1
301    1
302    1
303   -1
304   -1
305    1
306    1
307    1
310    1
312   -1
313   -1
314   -1
315   -1
316    1
```

```
319    1
321   -1
323    1
324    1
325   -1
326   -1
327   -1
330    1
331    1
332    1
334    1
336   -1
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341    1
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343    1
344   -1
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354    1
360    1
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363   -1
364    1
366    1
369    1
370   -1
371   -1
373    1
374    1
375    1
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381    1
382   -1
383   -1
385    1
387   -1
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391    1
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395   -1
396    1
397   -1
400    1
401   -1
402   -1
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404    1
405    1
406   -1
407    1
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409   -1
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411    1
412   -1
413    1
416   -1
417   -1
418   -1
419   -1
420   -1
421    1
422    1
423    1
```

```
424    1
425    1
426   -1
427   -1
428   -1
430    1
432    1
436   -1
437   -1
438    1
440    1
441    1
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444   -1
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450    1
451   -1
454    1
456    1
457   -1
458    1
459   -1
460    1
463    1
465   -1
466    1
468    1
469   -1
470    1
471   -1
472    1
473   -1
474   -1
475   -1
478   -1
479    1
481   -1
482    1
485    1
486    1
488   -1
490    1
491   -1
492   -1
495   -1
497   -1
498   -1
499   -1
500    1
```

Hide

```
table(test.set[,class.index],classifications)
```

```
   classifications
     -1   1
  -1 174   0
  1    0 176
```