model_based_clustering

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Model Based Clustering

So far while working with this data set, we have struggled to seperate class D, and by plotting the results of some of the methods in specific dimensions, we have been able to show that class D significantly overlaps the other classes. We have also seen from the two dimensional PCA scatterplot that this is general overlap between all the classes in the the first two principle componants of the data.

Lots of clustering methods struggle with seperating overlapping clusters, so for the final method I wanted to choose one that might perform better with this challenge in mind. I have chosen to try a gaussian mixture model - a model-based clustering technique that assumes that all the data is distributed according to the combination of different normal distributions. I think it might have a good chance of performing well on our dataset because it is probabalistic, calculating the probability that a data point is in each cluster. This can help it perform better than other methods like K-means when there aren't clear boundaries between the clusters such as we see with class D. Another advantage it has is that it has some flexibility in the geometry of the clusters it produces, unlike k-means which tends to produce spherical clusters. This is important because we have seen that in some dimensions our classes produce fairly elipsoidal clusters. It also operates on very different fundemental principles to our other unsupervised method - agglomerative heirarchical clustering - so it will be good to compare the two. If model-based clustering performs much better then it could suggest that the classes of our data are not heirarchical in nature.

Setting up

```
library(tidyverse)
library(caret)
library(mclust)  # For model based clustering
library(factoextra)  # Clustering Visualization
```

```r
library(GGally)  # For visualization
library(ggpubr)   # For visualization
```

```r
set.seed(2626)
data <- read_csv("data_clean.csv")
data$label <- as.factor(data$label)
head(data)
```

```
# A tibble: 6 x 21
      X1     X2     X3     X4     X5     X6     X7      X8     X9     X10    X11
   <dbl>  <dbl>  <dbl>  <dbl>  <dbl>  <dbl>  <dbl>   <dbl>  <dbl>   <dbl>  <dbl>
1 -0.324  0.759 -1.34  -1.59  -0.717  1.36   0.920 -1.71    0.407  0.129   0.141
2  1.01  -0.590 -1.33  -0.245 -0.902  0.199  0.263 -0.802  -0.127  0.918  -2.54
3  1.17   1.41   0.168  0.312  0.657  0.121 -1.19   0.265  -0.773  2.13   -1.10
4 -0.537 -0.298  0.738  1.34   1.10  -0.480 -1.32   0.0202 -0.594  1.22   -0.493
5  0.659 -1.40   0.570 -0.179 -0.706  0.941  0.656 -0.998   1.17  -1.96    0.889
6 -1.34   0.792 -0.180 -0.934  2.10   0.136 -0.124 -0.458   0.164 -0.0257 -0.914
# i 10 more variables: X12 <dbl>, X13 <dbl>, X14 <dbl>, X15 <dbl>, X16 <dbl>,
#   X17 <dbl>, X18 <dbl>, X19 <dbl>, X20 <dbl>, label <fct>
```

```r
# create test and train data splits we can use for the rest of the modelling
training.samples <- data$label %>%
  createDataPartition(p = 0.8, list = FALSE) # create 80:20 split for train:test
train_data  <- data[training.samples, ]
test_data <- data[-training.samples, ]


# check class distribution are similar in both splits
prop.table(table(train_data$label))
```

```
        A         B         C         D
0.2529253 0.2502250 0.2655266 0.2313231
```

```r
prop.table(table(test_data$label))
```

```
        A         B         C         D
0.2531646 0.2495479 0.2658228 0.2314647
```

```
# for unsupervised learning we need to remove the target variable
data_labels <- data %>% select(label) %>% mutate(label = as.factor(label))
data_features <- data %>% select(-label)


# we might not need test-train split, we can train on all data and test with the original lab
training_labels <- train_data %>% select(label) %>% mutate(label = as.factor(label))
training_features <- train_data %>% select(-label)

test_labels <- train_data %>% select(label) %>% mutate(label = as.factor(label))
test_features <- test_data %>% select(-label)
```

init

```
#Fit Model Based clustering
fitM <- Mclust(data_features)

#Choose the model
BIC <- mclustBIC(data_features)
plot(BIC)
```

VVE is the winner. Its promising (i think) that 4 clusters is the peak, since we know that there actually are four classes. In heirarchical clustering, we didn't see clear confirmation of four groups from the graphs using either the elbow method, gap method, or silloette method.

The three letters in the model name describe the shape, orientation, and orientation of the clusters that the model predicts. In this case, VVE is telling us that the model is predicting clusters that are elipsoids of equal orientation, but varying volume. This makes sense based on the PCA plots of the data where we see three roughly equally size elipses one above the other, with a fourth, larger elipses overlaying them, with the major axis of all four being roughly horizontal (along the first principle component)

```
summary(fitM)
```

```
----------------------------------------------------
Gaussian finite mixture model fitted by EM algorithm
----------------------------------------------------

Mclust VVE (ellipsoidal, equal orientation) model with 4 components:

 log-likelihood    n  df       BIC       ICL
      -69131.95 2775 353 -141062.6 -141420.1

Clustering table:
  1   2   3   4
699 705 704 667
```

```
fviz_mclust(fitM, "classification", geom = "point", pointsize = 1.5, palette = "jco")
```

this looks really similar to our original PCA plot, with class A B and C seperated and class D overlapping all three!.

```
dens <- densityMclust(data_features)
```

```
plot(dens, what = "density", type = "hdr", data = data_features)
```

what is this?

```r
fitM
```

```
'Mclust' model object: (VVE,4)

Available components:
 [1] "call"           "data"           "modelName"      "n"
 [5] "d"              "G"              "BIC"            "loglik"
 [9] "df"             "bic"            "icl"            "hypvol"
[13] "parameters"     "z"              "classification" "uncertainty"
```

```r
fitM$classification
```

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 [38] 2 2 2 2 2 2 2 2 2 2 2 2 4 2 2 2 4 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2
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[630] 2 2 2 2 2 2 2 2 2 2 2 2 4 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 4 2 2 2 2 2
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[2628] 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 2 4 3 4 2 2 2 4 2 2 4 4 4 2 4 4 4 4 4 4 4
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[2702] 4 4 4 4 4 4 4 4 4 4 4 4 1 4 3 4 4 4 4 4 4 4 1 1 2 2 4 4 4 1 4 4 4 4 4 4 4
[2739] 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 3 3 4 4 4 4 4 1 4 4 4 4 4 4 4 4 4 4 3 4 4 4
```

```
data_labels
```

```
# A tibble: 2,775 x 1
   label
   <fct>
 1 A
 2 A
 3 A
 4 A
 5 A
 6 A
 7 A
 8 A
 9 A
10 A
# i 2,765 more rows
```

```
results <- data_labels %>% mutate(prediction = fitM$classification) # %>% mutate(label = as.r

results
```

```
# A tibble: 2,775 x 2
   label prediction
   <fct>      <dbl>
 1 A              2
 2 A              2
 3 A              2
 4 A              2
 5 A              4
 6 A              2
 7 A              2
 8 A              2
 9 A              2
10 A              2
# i 2,765 more rows
```

we need to match the label to the most common prediction within that class so we can create a confusion matrix

```
Mode <- function(x) {
  ux <- unique(x)
  ux[which.max(tabulate(match(x, ux)))]
}

modal_prediction <- results %>% group_by(label) %>% summarise(avg = Mode(as.numeric(predicti

modal_prediction
```

```
# A tibble: 4 x 2
  label   avg
  <fct> <dbl>
1 A         2
2 B         3
3 C         1
4 D         4
```

so now in results, we need to map A to 2, B to 3, C to 1, and D to 4

```
map_classes <- function(r) {
  print(r)
  r <- as.character(r)

  if (r == "A") {
    l <- 2
  }
  if (r == "B") {
    l <- 3
  }
  if (r == "C") {
    l <- 1
  }
  if (r == "D") {
    l <- 4
  }

  return(l)
}
```

```r
results <- results %>% mutate(label = lapply(label, map_classes))
```

```
[1] A
Levels: A B C D
[1] A
Levels: A B C D
[1] A
Levels: A B C D
[1] A
Levels: A B C D
[1] A
Levels: A B C D
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results
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   label     prediction
   <list>         <dbl>
 1 <dbl [1]>          2
 2 <dbl [1]>          2
 3 <dbl [1]>          2
 4 <dbl [1]>          2
 5 <dbl [1]>          4
 6 <dbl [1]>          2
 7 <dbl [1]>          2
 8 <dbl [1]>          2
 9 <dbl [1]>          2
10 <dbl [1]>          2
# i 2,765 more rows
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