Exercise4

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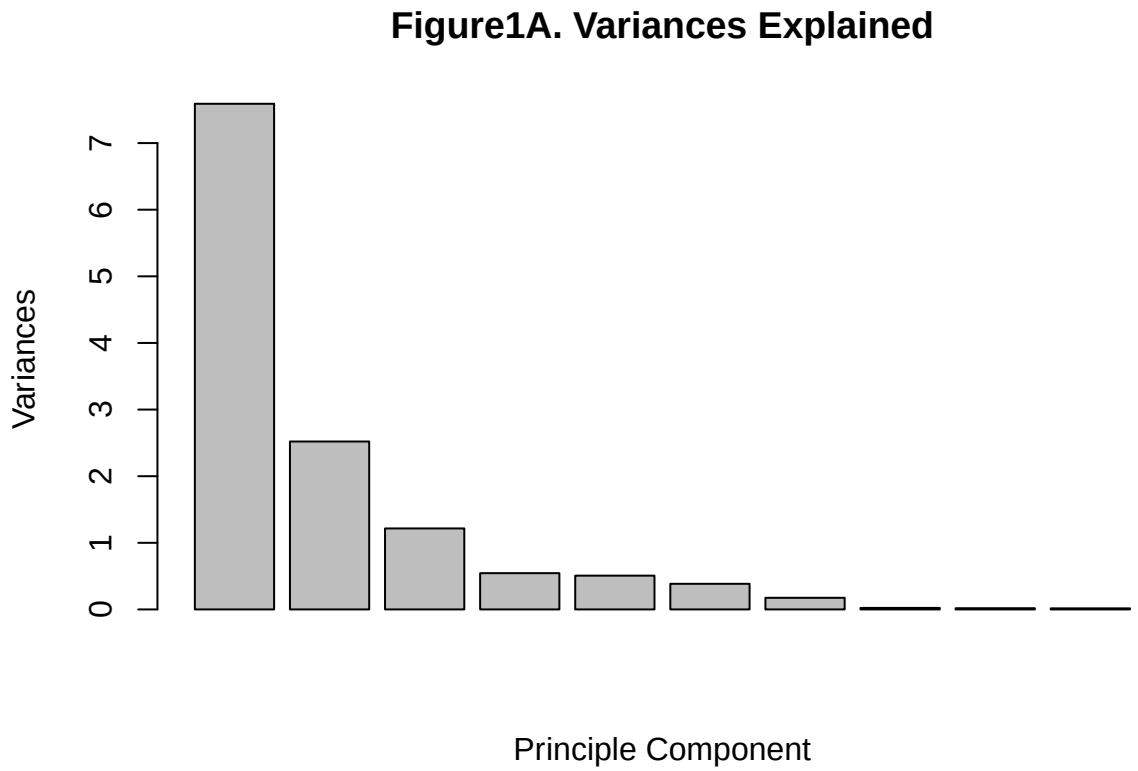
Problem1: Clustering and PCA

The data set in problem 1 contains information on 11 chemical properties of 6500 different bottles of vinho verde wine from northern Portugal. Our task is to choose an unsupervised learning method to distinguish the colors and qualities of wines contained in the data on chemical properties, after running both a clustering algorithm and PCA. It should be noted that before analyzing problems, the color variables are converted to 1 for red and 2 for white.

Part 1: PCA–Principle Component Analysis

Before running PCA, the variables should be scaled firstly.

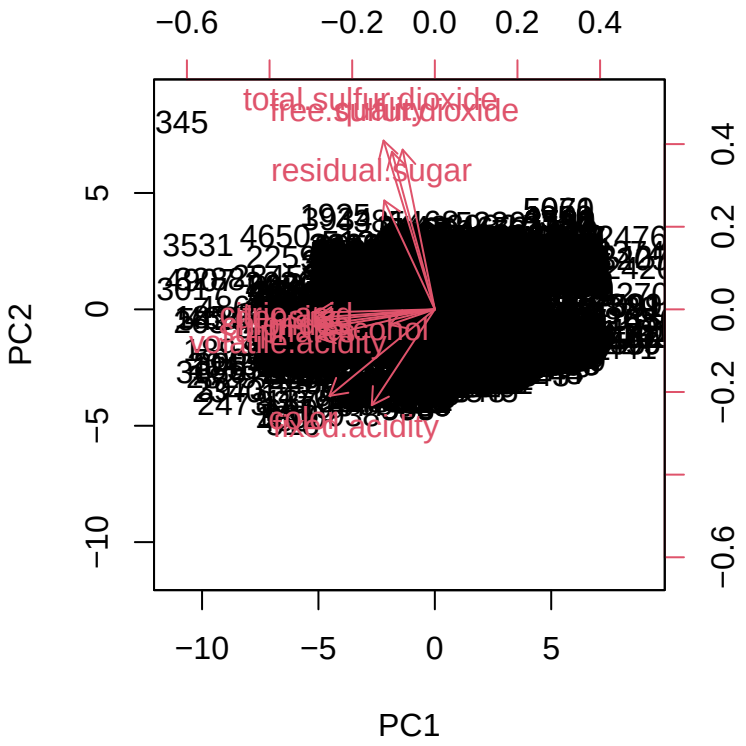



```
## Importance of components:
##                           PC1    PC2    PC3     PC4     PC5     PC6     PC7
```

```
## Standard deviation     2.7550 1.5876 1.1025 0.73768 0.71213 0.62027 0.41795
## Proportion of Variance 0.5838 0.1939 0.0935 0.04186 0.03901 0.02959 0.01344
## Cumulative Proportion  0.5838 0.7777 0.8712 0.91309 0.95210 0.98169 0.99513
##                            PC8     PC9    PC10    PC11    PC12      PC13
## Standard deviation     0.15153 0.13429 0.12698 0.07488 0.02421 0.0004722
## Proportion of Variance 0.00177 0.00139 0.00124 0.00043 0.00005 0.0000000
## Cumulative Proportion  0.99690 0.99828 0.99952 0.99995 1.00000 1.0000000
```

From this plot and summarized table above, we can learn that the first four principle components can explain about 91.3% variances of data, so 4 principle components are selected to analyze problems convincingly. Then a biplot below shows the scores of the principal components and the positions of the loading vectors, where the specific values of the load vectors are given in the table below.

```
##                              PC1          PC2          PC3          PC4
## fixed.acidity        -0.19077683 -0.290025718 -0.336260232  0.124215285
## volatile.acidity     -0.35525556 -0.086094618  0.004987411 -0.002185412
## citric.acid          -0.35917071 -0.009916111  0.018684316 -0.015409803
## residual.sugar       -0.15301218  0.329390424 -0.409698250 -0.685258813
## chlorides            -0.36074132 -0.034483189  0.022126971 -0.010135647
## free.sulfur.dioxide  -0.09744605  0.483349169 -0.144372684  0.633266986
## total.sulfur.dioxide -0.15523345  0.510715923 -0.083547403  0.194904935
## density              -0.36098618 -0.025258659  0.031729859 -0.018140464
## pH                   -0.35459542 -0.047357257  0.055303276  0.013606892
## sulphates            -0.35770820 -0.058613272  0.003522946  0.018204331
## alcohol              -0.13674490 -0.046597544  0.749778484 -0.048273665
## quality              -0.12974116  0.476713210  0.329097839 -0.248257532
## color                -0.31893242 -0.261700428 -0.125850579  0.104034476
```



From the results in the table and the biplot above, the values of volatile.acidity, density and color are similar in the first principle component and dioxide value is significant in the principle component, so the ability to distinguish the red wines from the white wines is not strong.

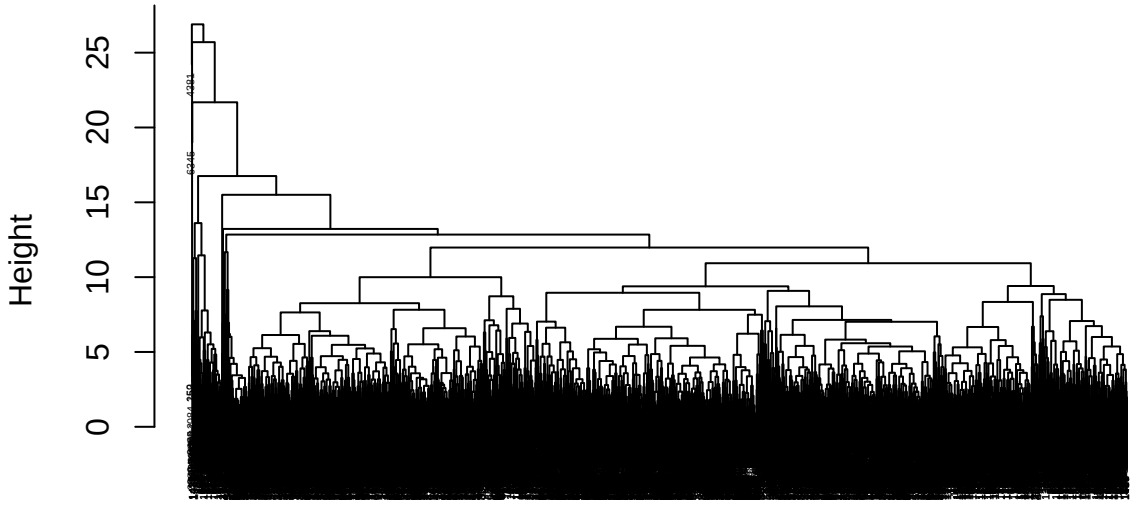
Part 2: A clustering algorithm – hierarchical clustering

Hierarchical clustering is selected to do the clustering analysis. Firstly, we should normalize the variables. Then use the single linkage, the complete linkage and the average linkage methods to do hierarchical clustering on the variables respectively, using the Euclidean distance as an indicator of the dissimilarity variables. A significant advantage of the hierarchical clustering method is that it can output a fascinating tree representation about individual observations, i.e., a dendrogram.

Figure1B. Cluster Dendrogram (Single)

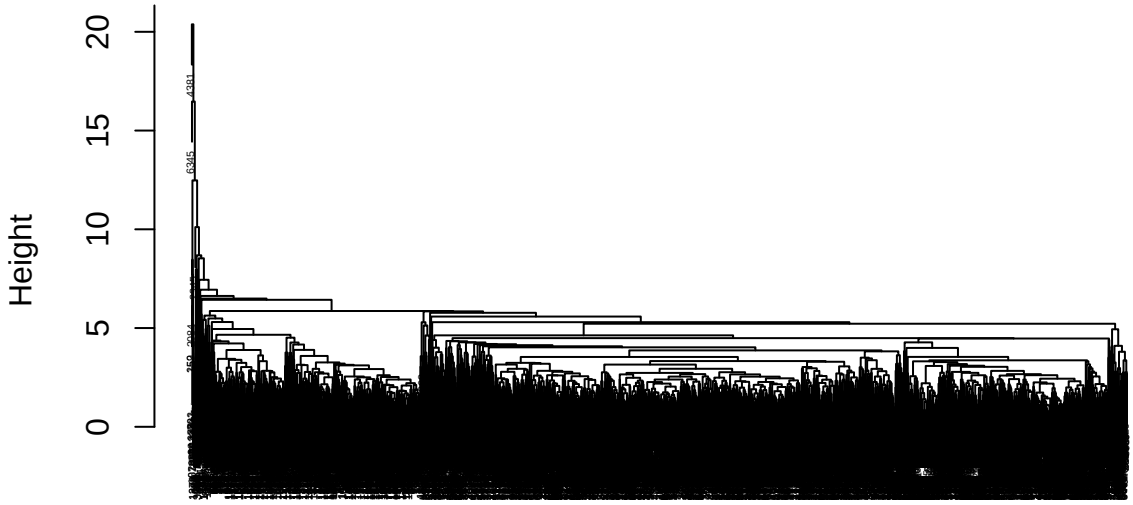
wine_distance_matrix
hclust (*, "single")

Figure1C. Cluster Dendrogram (Complete)



wine_distance_matrix
hclust (*, "complete")

Figure1D. Cluster Dendrogram (Average)



From the three dendrograms, it is obvious that using complete linkage to do hierarchical clustering can yield categories of relatively more balanced size. Since the dataset is very large, we set k=10 rather than 4 in PCA before.

```
##
## cluster2    0    1
##        1  2873 1231
##        2     0  168
##        3    12   26
##        4   164    4
##        5     0   15
##        6  1845  153
##        7     0    2
##        8     2    0
##        9     1    0
##        10    1    0
```

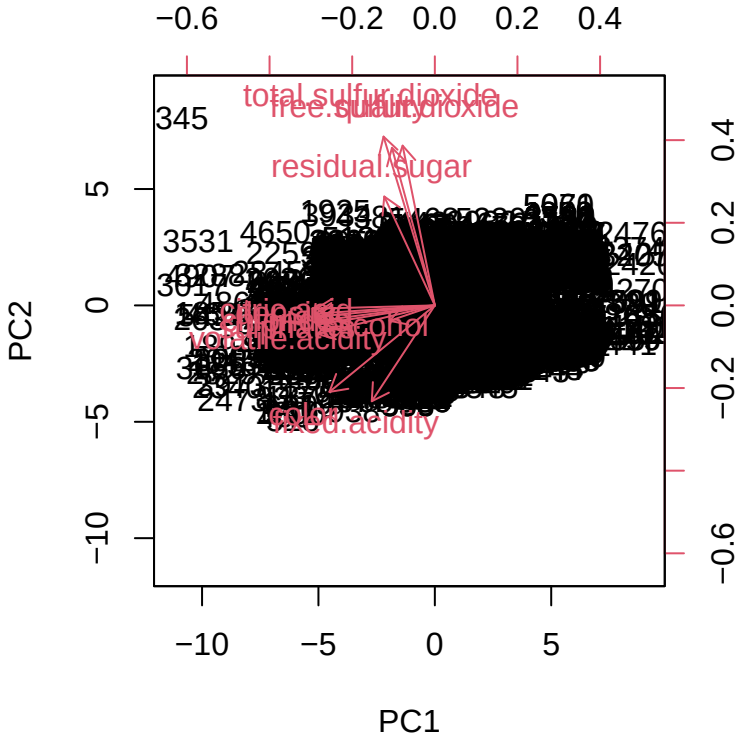
As the simple table shows, it is easy for us to distinguish the color of wines in some clusters. For example, white wines occupy the majority in cluster 4 and 6 while the reds occupy the majority in cluster 2 and 5. Especially, in the last four clusters, it is more obvious to distinguish the colors.

We then distinguished the quality of wines.

```
##
## cluster2    3    4    5    6    7    8    9
##        1    15  133 1583 1826  487   59    1
```

```
##        2     0     0    39    94    33     2     0
##        3     1     1    26     9     1     0     0
##        4     5     5   119    39     0     0     0
##        5     4     5     6     0     0     0     0
##        6     4    71   364   865   558   132     4
##        7     0     1     1     0     0     0     0
##        8     0     0     0     2     0     0     0
##        9     0     0     0     1     0     0     0
##        10    1     0     0     0     0     0     0
```

Comparing to color of wines, it is not very easy to distinguish the higher from the lower quality wines except for the last three clusters by using clustering. However, recalling the biplot in PCA before, the values of quality in PC2 is relatively very large (0.48), so it is easy to distinguish the higher from lower quality wines in PCA.



Problem 2: Market Segmentation

One purpose of market segmentation is to segment the market by identifying people who are more inclined to accept a particular form of advertising or who are more likely to buy a particular product. The data in this problem was collected in the course of a market-research study using followers of the Twitter account of a large consumer drinks brand called "NutrientH20"(just to have a label). The goal is to analyze this data, and to prepare a short report for NutrientH20 that identifies any interesting market segments that appear to stand out in their social-media audience. We decided to come up with some interesting, well-supported insights about the audience and give the client some insight as to how they might position their brand to maximally appeal to each market segment.

Part 1: Summaries of dataset

```
##     chatter       current_events      travel       photo_sharing
##  Min.   : 0.000   Min.   :0.000   Min.   : 0.000   Min.   : 0.000
##  1st Qu.: 2.000   1st Qu.:1.000   1st Qu.: 0.000   1st Qu.: 1.000
##  Median : 3.000   Median :1.000   Median : 1.000   Median : 2.000
##  Mean   : 4.399   Mean   :1.526   Mean   : 1.585   Mean   : 2.697
##  3rd Qu.: 6.000   3rd Qu.:2.000   3rd Qu.: 2.000   3rd Qu.: 4.000
##  Max.   :26.000   Max.   :8.000   Max.   :26.000   Max.   :21.000
##  uncategorized      tv_film       sports_fandom       politics
##  Min.   :0.000   Min.   : 0.00   Min.   : 0.000   Min.   : 0.000
##  1st Qu.:0.000   1st Qu.: 0.00   1st Qu.: 0.000   1st Qu.: 0.000
##  Median :1.000   Median : 1.00   Median : 1.000   Median : 1.000
##  Mean   :0.813   Mean   : 1.07   Mean   : 1.594   Mean   : 1.789
##  3rd Qu.:1.000   3rd Qu.: 1.00   3rd Qu.: 2.000   3rd Qu.: 2.000
##  Max.   :9.000   Max.   :17.00   Max.   :20.000   Max.   :37.000
##       food            family        home_and_garden      music
##  Min.   : 0.000   Min.   : 0.0000   Min.   :0.0000   Min.   : 0.0000
##  1st Qu.: 0.000   1st Qu.: 0.0000   1st Qu.:0.0000   1st Qu.: 0.0000
##  Median : 1.000   Median : 1.0000   Median :0.0000   Median : 0.0000
##  Mean   : 1.397   Mean   : 0.8639   Mean   :0.5207   Mean   : 0.6793
##  3rd Qu.: 2.000   3rd Qu.: 1.0000   3rd Qu.:1.0000   3rd Qu.: 1.0000
##  Max.   :16.000   Max.   :10.0000   Max.   :5.0000   Max.   :13.0000
##       news        online_gaming       shopping      health_nutrition
##  Min.   : 0.000   Min.   : 0.000   Min.   : 0.000   Min.   : 0.000
##  1st Qu.: 0.000   1st Qu.: 0.000   1st Qu.: 0.000   1st Qu.: 0.000
##  Median : 0.000   Median : 0.000   Median : 1.000   Median : 1.000
##  Mean   : 1.206   Mean   : 1.209   Mean   : 1.389   Mean   : 2.567
##  3rd Qu.: 1.000   3rd Qu.: 1.000   3rd Qu.: 2.000   3rd Qu.: 3.000
##  Max.   :20.000   Max.   :27.000   Max.   :12.000   Max.   :41.000
##   college_uni     sports_playing      cooking            eco
##  Min.   : 0.000   Min.   :0.0000   Min.   : 0.000   Min.   :0.0000
##  1st Qu.: 0.000   1st Qu.:0.0000   1st Qu.: 0.000   1st Qu.:0.0000
##  Median : 1.000   Median :0.0000   Median : 1.000   Median :0.0000
##  Mean   : 1.549   Mean   :0.6392   Mean   : 1.998   Mean   :0.5123
##  3rd Qu.: 2.000   3rd Qu.:1.0000   3rd Qu.: 2.000   3rd Qu.:1.0000
##  Max.   :30.000   Max.   :8.0000   Max.   :33.000   Max.   :6.0000
##    computers          business         outdoors           crafts
##  Min.   : 0.0000   Min.   :0.0000   Min.   : 0.0000   Min.   :0.0000
##  1st Qu.: 0.0000   1st Qu.:0.0000   1st Qu.: 0.0000   1st Qu.:0.0000
##  Median : 0.0000   Median :0.0000   Median : 0.0000   Median :0.0000
##  Mean   : 0.6491   Mean   :0.4232   Mean   : 0.7827   Mean   :0.5159
##  3rd Qu.: 1.0000   3rd Qu.:1.0000   3rd Qu.: 1.0000   3rd Qu.:1.0000
##  Max.   :16.0000   Max.   :6.0000   Max.   :12.0000   Max.   :7.0000
##    automotive           art            religion          beauty
##  Min.   : 0.0000   Min.   : 0.0000   Min.   : 0.000   Min.   : 0.0000
##  1st Qu.: 0.0000   1st Qu.: 0.0000   1st Qu.: 0.000   1st Qu.: 0.0000
##  Median : 0.0000   Median : 0.0000   Median : 0.000   Median : 0.0000
##  Mean   : 0.8299   Mean   : 0.7248   Mean   : 1.095   Mean   : 0.7052
##  3rd Qu.: 1.0000   3rd Qu.: 1.0000   3rd Qu.: 1.000   3rd Qu.: 1.0000
##  Max.   :13.0000   Max.   :18.0000   Max.   :20.000   Max.   :14.0000
##    parenting           dating            school        personal_fitness
##  Min.   : 0.0000   Min.   : 0.0000   Min.   : 0.0000   Min.   : 0.000
##  1st Qu.: 0.0000   1st Qu.: 0.0000   1st Qu.: 0.0000   1st Qu.: 0.000
```

```
##  Median : 0.0000   Median : 0.0000   Median : 0.0000   Median : 0.000
##  Mean   : 0.9213   Mean   : 0.7109   Mean   : 0.7677   Mean   : 1.462
##  3rd Qu.: 1.0000   3rd Qu.: 1.0000   3rd Qu.: 1.0000   3rd Qu.: 2.000
##  Max.   :14.0000   Max.   :24.0000   Max.   :11.0000   Max.   :19.000
##     fashion        small_business        spam             adult
##  Min.   : 0.0000   Min.   :0.0000   Min.   :0.00000   Min.   : 0.0000
##  1st Qu.: 0.0000   1st Qu.:0.0000   1st Qu.:0.00000   1st Qu.: 0.0000
##  Median : 0.0000   Median :0.0000   Median :0.00000   Median : 0.0000
##  Mean   : 0.9966   Mean   :0.3363   Mean   :0.00647   Mean   : 0.4033
##  3rd Qu.: 1.0000   3rd Qu.:1.0000   3rd Qu.:0.00000   3rd Qu.: 0.0000
##  Max.   :18.0000   Max.   :6.0000   Max.   :2.00000   Max.   :26.0000
```

Genarally, the summary of dataset shows that the most popular field is chatter, then some relatively popular fields contain photo-sharing, health-nutrition, cooking, and so on. In contrast, these areas such as business, small business, eco, which are in the business field, are less popular with the public.

Part 2: Method–PCA

PCA, principle component analysis, is a widely used class of methods in exploratory data analysis.

Before doing PCA, the variables should be centered and scaled. This is what sets PCA apart from other guided and unguided learning techniques.

Figure2A. PVE (Scree Plot)

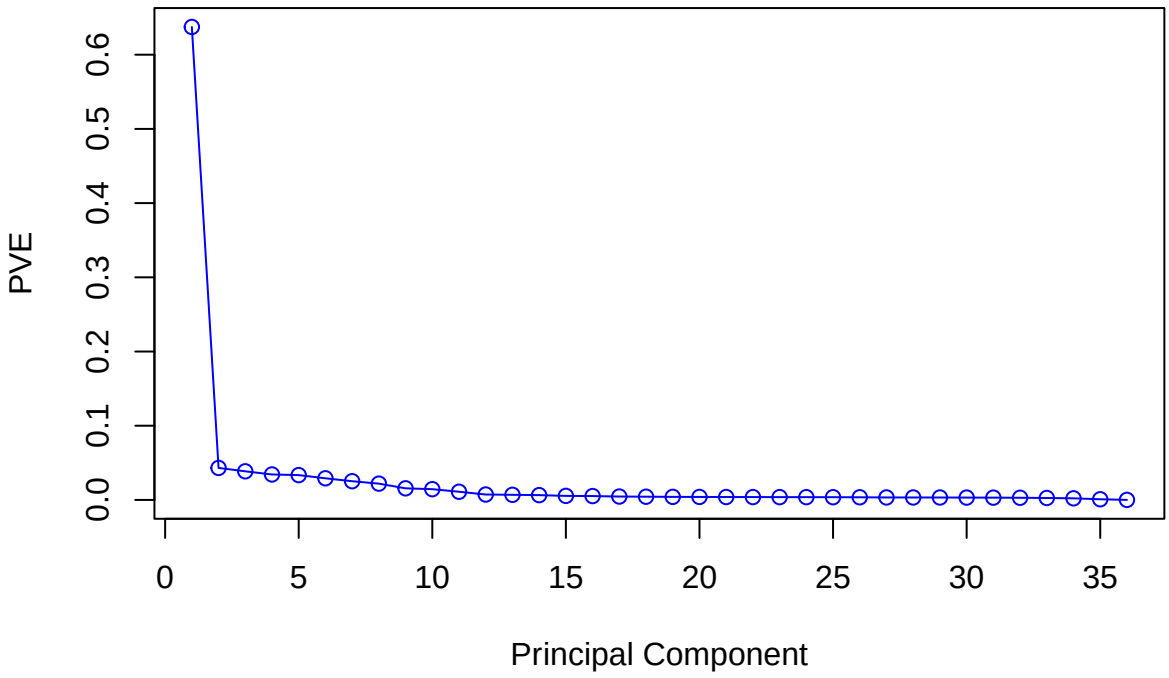
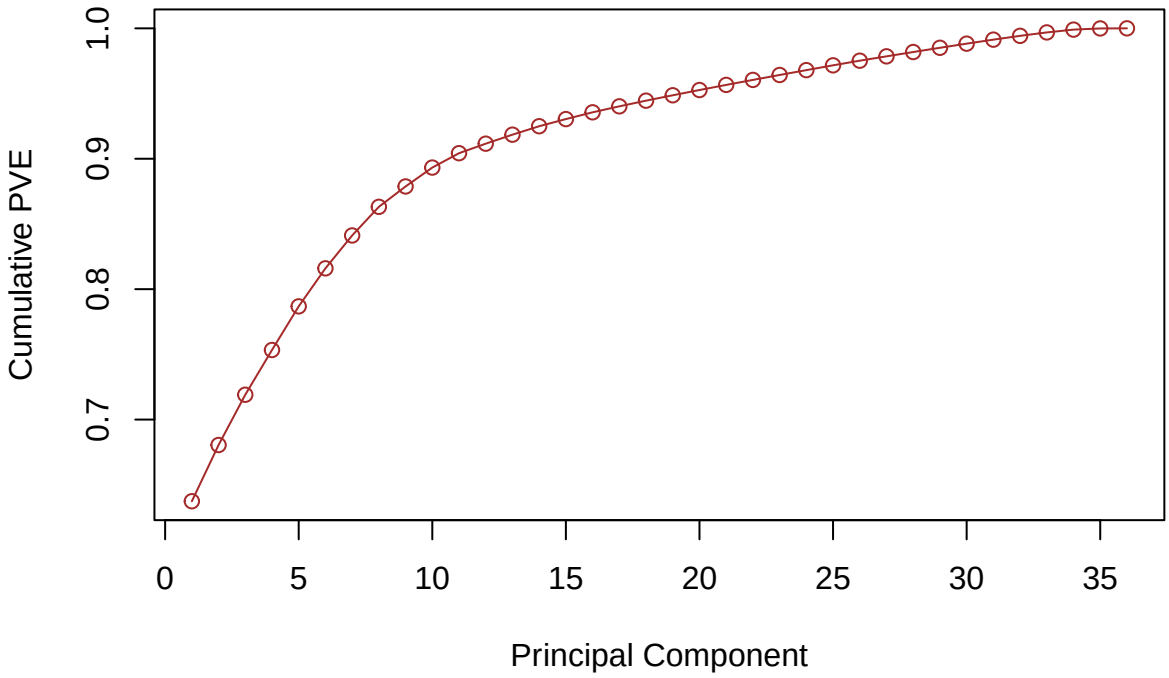


Figure2B. Cumulative PVE




```
## Importance of components:
##                            PC1     PC2     PC3     PC4     PC5     PC6     PC7
## Standard deviation     4.7901 1.24598 1.17792 1.11143 1.09756 1.02439 0.95299
## Proportion of Variance 0.6374 0.04312 0.03854 0.03431 0.03346 0.02915 0.02523
## Cumulative Proportion  0.6374 0.68049 0.71903 0.75335 0.78681 0.81596 0.84118
##                            PC8     PC9    PC10    PC11    PC12    PC13    PC14
## Standard deviation     0.88886 0.74999 0.72201 0.63002 0.51296 0.49885 0.48223
## Proportion of Variance 0.02195 0.01562 0.01448 0.01103 0.00731 0.00691 0.00646
## Cumulative Proportion  0.86313 0.87876 0.89324 0.90426 0.91157 0.91848 0.92494
##                           PC15   PC16    PC17    PC18    PC19    PC20    PC21
## Standard deviation     0.44388 0.4328 0.40543 0.39606 0.38596 0.38033 0.37588
## Proportion of Variance 0.00547 0.0052 0.00457 0.00436 0.00414 0.00402 0.00392
## Cumulative Proportion  0.93042 0.9356 0.94019 0.94454 0.94868 0.95270 0.95662
##                           PC22    PC23    PC24    PC25    PC26    PC27    PC28
## Standard deviation     0.37188 0.36858 0.36629 0.36358 0.35814 0.34694 0.34438
## Proportion of Variance 0.00384 0.00377 0.00373 0.00367 0.00356 0.00334 0.00329
## Cumulative Proportion  0.96047 0.96424 0.96797 0.97164 0.97520 0.97854 0.98184
##                           PC29    PC30    PC31    PC32    PC33    PC34    PC35
## Standard deviation     0.34217 0.33781 0.33287 0.32449 0.30627 0.27898 0.17880
## Proportion of Variance 0.00325 0.00317 0.00308 0.00292 0.00261 0.00216 0.00089
## Cumulative Proportion  0.98509 0.98826 0.99134 0.99426 0.99687 0.99903 0.99992
##                           PC36
## Standard deviation     0.05391
## Proportion of Variance 0.00008
## Cumulative Proportion  1.00000
```

The scree plot (PVE) and the cumulative PVE plot can decide the number of principle components that will be needed. It shows that from about 8th to 10th components, the cumulative PVE curve tends to be flat. Also. from the results in the table above, we can learn that the first eight principle components are able to explain about 86.3% variances of data, so 8 principle components can be selected to analyze problems convincingly.

Part 3: Results

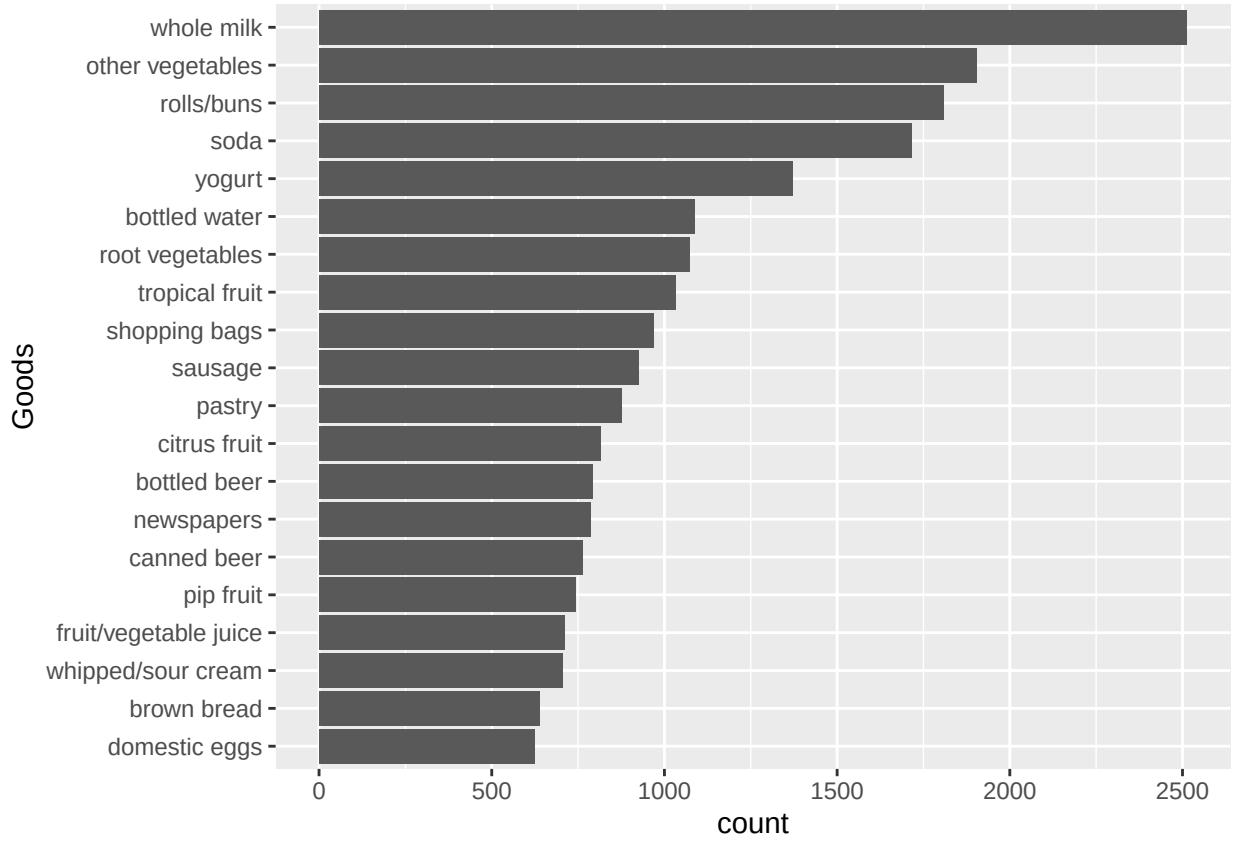
```
##                        PC1         PC2           PC3           PC4
## chatter          0.11209436 -0.10743212  0.3934699927 -0.2242585154
## current_events   0.17937017  0.02096689  0.0422732134 -0.0296155587
## travel           0.14686657  0.18236436  0.0089174062 -0.2705288979
## photo_sharing    0.13748816 -0.23267065  0.3856225890 -0.1495149430
## uncategorized    0.18496123 -0.07302189  0.0603684377  0.0465969999
## tv_film          0.16537891  0.05325504  0.0392665411  0.0938506452
## sports_fandom    0.15788551  0.16094238 -0.1939639491  0.0586961114
## politics         0.13323697  0.23072652 -0.0010593391 -0.3927090182
## food             0.16992144  0.04364553 -0.2424233948  0.0688517575
## family           0.18796309  0.07345794 -0.0631768341  0.0424910952
## home_and_garden  0.19522533  0.02394640 -0.0009120473  0.0083294293
## music            0.18764272 -0.01306012  0.0448978407  0.0423517734
## news             0.15602436  0.16463372 -0.0599567668 -0.2275593325
## online_gaming    0.13281669  0.07298073  0.1451653414  0.5021146982
## shopping         0.16419142 -0.08509270  0.2503509424 -0.1367463733
## health_nutrition 0.09527617 -0.47950292 -0.4224952251 -0.0323932378
## college_uni      0.12799000  0.07967757  0.1937887104  0.5197077269
## sports_playing   0.19072283  0.02851778  0.0544047462  0.1645918870
## cooking          0.11503348 -0.43945389  0.1133423884 -0.0008565557
## eco              0.19531330 -0.01114757 -0.0162746183 -0.0114454219
## computers        0.18471243  0.10123733  0.0062584441 -0.1557663738
## business         0.19725948  0.02467051  0.0261510039 -0.0204218007
## outdoors         0.18178523 -0.14964843 -0.1846932444 -0.0242790520
## crafts           0.19527458  0.03010044 -0.0154350997  0.0133583246
## automotive       0.17744453  0.09815167  0.0135016672 -0.0884365024
## art              0.16545625  0.03342213  0.0136070415  0.0756542382
## religion         0.16517703  0.13180237 -0.1970831879  0.0806309200
## beauty           0.18020053 -0.13378630  0.0977123145  0.0118107042
## parenting        0.17692690  0.10686748 -0.1591767545  0.0505247494
## dating           0.15994121 -0.01253876  0.0256638030 -0.0369614718
## school           0.18688843  0.06441144 -0.0673767756  0.0214946909
## personal_fitness 0.14200814 -0.37155582 -0.3314384849 -0.0267773506
## fashion          0.16246879 -0.22042645  0.1676430184  0.0084967661
## small_business   0.19798158  0.03727092  0.0269120059  0.0057073602
## spam             0.20267595  0.03809313 -0.0025266577  0.0104910771
## adult            0.09690372  0.22335536 -0.1204206532 -0.0657306002
##                         PC5           PC6           PC7           PC8
## chatter          0.134642292 -0.4619206971  0.1677417921 -0.181978464
## current_events   0.009854655 -0.0627491825 -0.0202404846  0.131366907
## travel          -0.303367003  0.1685447142  0.0144969751 -0.140566144
## photo_sharing    0.153942329 -0.1174129730 -0.0232160784 -0.207221003
## uncategorized   -0.057731573  0.1196647538  0.3503197692  0.164684154
## tv_film         -0.092182969  0.0134892137  0.1275922654  0.361761879
## sports_fandom    0.326724431  0.0452638689  0.1307622282 -0.251508078
## politics        -0.345145209  0.1744797553  0.0375683895 -0.284949868
## food             0.195311661 -0.0009766035  0.1139163656 -0.173628217
```

```
## family            0.136586526 -0.0197696825  0.0069502194 -0.040564730
## home_and_garden  -0.010520235 -0.0256493647 -0.0260240353  0.146352446
## music            -0.012676807  0.0098874634 -0.0002178457  0.149657662
## news             -0.188444823  0.1092892216  0.0110855487 -0.126991008
## online_gaming    -0.265405463 -0.0771992326 -0.0872097503 -0.300616658
## shopping          0.092018858 -0.2689713864  0.0572062103 -0.039190707
## health_nutrition -0.226551283 -0.2164348191  0.0271948313 -0.122498902
## college_uni      -0.284455786 -0.0539964278 -0.0011880674 -0.262259338
## sports_playing   -0.087592607 -0.0247511721 -0.0365099096  0.005554605
## cooking           0.077137707  0.4611088784 -0.2554079557 -0.147122562
## eco              -0.010731390 -0.0711409780 -0.0303414137  0.104318717
## computers        -0.138287900  0.0662322155 -0.0239571997 -0.051301398
## business         -0.014529366 -0.0263757065 -0.0209644294  0.124793644
## outdoors         -0.111312358 -0.0857608296 -0.0265226746  0.040693016
## crafts            0.025425153 -0.0260105226  0.0103031642  0.126792308
## automotive       -0.022316928 -0.0196102952 -0.0125823951 -0.042253518
## art              -0.064949531  0.0223460025  0.0543094974  0.344546812
## religion          0.317316385  0.0665548514  0.1206520612 -0.181233518
## beauty            0.122858606  0.2624263560 -0.1443636290  0.034801671
## parenting         0.261587940  0.0317005524  0.0676691337 -0.149655657
## dating           -0.031353391 -0.0241780087  0.0712799677  0.125331056
## school            0.197627160  0.0128969859  0.0535886330 -0.021030373
## personal_fitness -0.172331513 -0.1959518155  0.0117621393 -0.065790885
## fashion           0.109235488  0.3415705931 -0.1947096870  0.001430433
## small_business   -0.018280822 -0.0230967379 -0.0327990826  0.153037128
## spam             -0.012229093 -0.0301672733 -0.0517591757  0.160743722
## adult             0.086107751 -0.2974754055 -0.7909445848  0.043214630
```

In the table above, higher numbers of certain elements represent major characteristics of each market segment. To be specific, the values in the first principle component are similar to each other, so this is not very helpful to decide audiences' appeal to any market segment. More attention is paid to the following principle components below. In the fourth principle components, these audiences might be the group among undergraduates and graduates who are studying in school, because they care about college and university (0.51), online games (0.50), sports (0.16) and TV shows and films (0.09) more over the other elements, which are all concerns for the teenage age group and students. In the fifth principle component, this represents mainly a middle-aged group, since these audiences care much about religion (0.31), parenting (0.26) and sports (0.32). In the sixth principle component, the audiences may be a group of women, who pay much attention to cooking (0.46), fashion (0.34) and beauty (0.26). In the eighth principle component, the audiences may be a group of cultural artists or people who focus on the art field, because they care more about art (0.34), TV shows and films (0.36). So for each segmented principle components of the population, the clients are able to position their brand to maximally appeal to each market segment, by the needs of specific categories of customers.

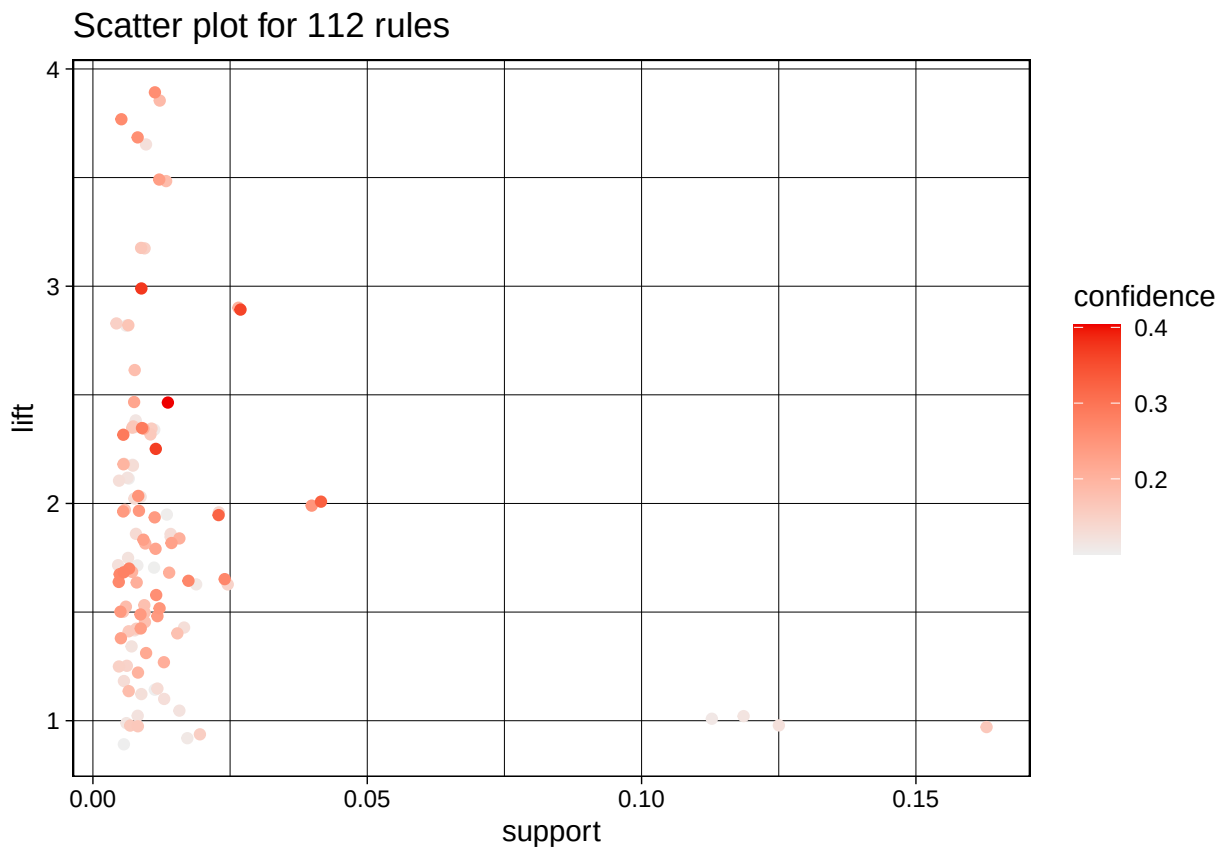
Problem 3: Association rules for grocery purchases

The data file in this problem is a list of shopping baskets: one person's basket for each row, with multiple items per row separated by commas. The goal is to use the data on grocery purchases and find some interesting association rules for these shopping baskets.

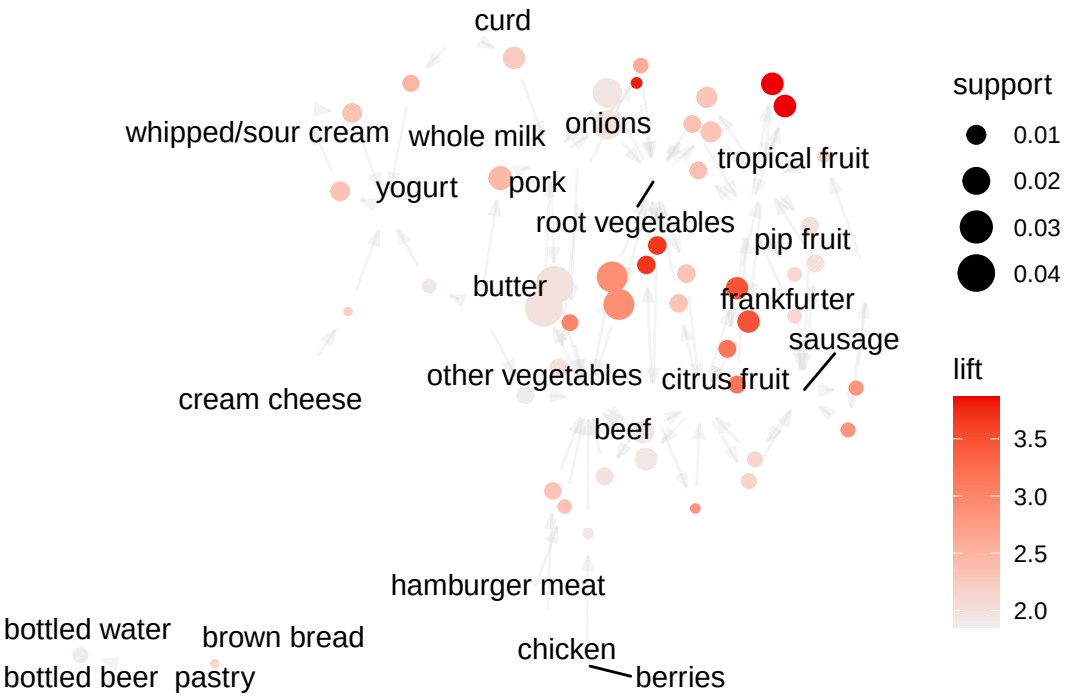


The graph above shows the top 20 popular goods among our customers in the dataset. We can see that whole milk ranks the most among these top 20 goods. Other vegetables, rolls/buns and soda are also very popular following after whole milk.

In the data pre-processing, we should firstly split data into a list of goods for each customer. After several steps we can run the 'apriori' algorithm. (Look at rules with support>0.01, confidence>0.1 and length <=5) Then make a plot of all the rules below.



The plot shows that there are so many rules here that makes it difficult for us to learn about the association rules well. So, we will look at subsets driven by the plot.



By choosing 50 rules for simplicity, this can make sense to some extent. For example, whipped/sour cream, cheese, butter, cream point to yogurt, since they all belong to the milk/dairy products. On the other hand, beef, onions, berries, chicken point to other vegetables. This also looks meaningful to us!