Homework 4
Introduction to Data Analysis and Mining
Spring 2018
CSCI-B 365

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All the work herein is solely mine.

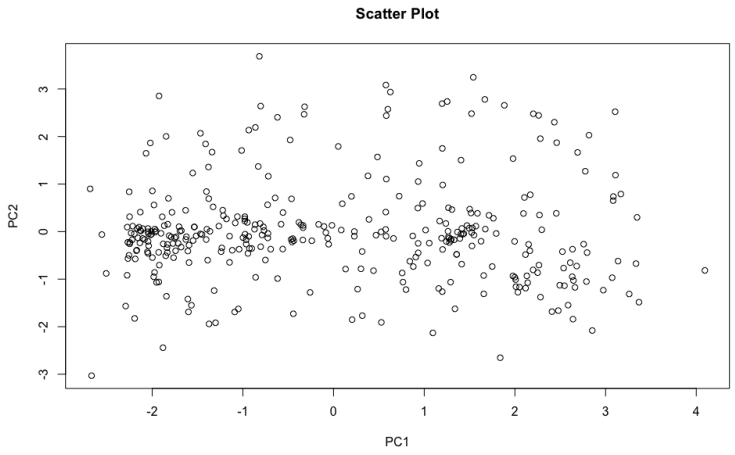
Directions

Please follow the syllabus guidelines in turning in your homework. I am providing the LaTeX of this document too. This homework is due Tuesday, March 20, 2018 10:00p.m. **OBSERVE THE TIME**. Absolutely no homework will be accepted after that time. All the work should be your own.

Problem 1 [30 points]

In this question, you will first perform principal component analysis (PCA) over Ionosphere Data Set and then cluster the reduced data using your k-means program (C_k) from previous homework. You are allowed to use R packages for PCA and ignore the class variables (35th variable) while performing PCA. Answer the questions below:

1.1) Perform PCA over Ionosphere data set and make a of PC1 and PC2 (the first two principal components). Are PC1 and PC2 linearly correlated?




```
PC1 and PC2 are uncorrelation
```

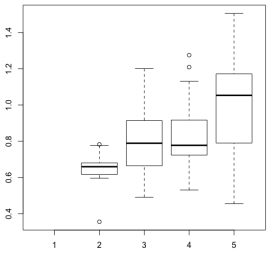
1.2) There are three methods to pick the set of principle components: (1) In the plot where the curve bends; (2) Add the percentage variance until total 75% is reached ($70 - 90\%$) (3) Use the components whose variance is at least one. Show the components selected in the Ionosphere data if each of these is used.

```
# Please see specific claculation in pca1.R
> i
[1] 9
```

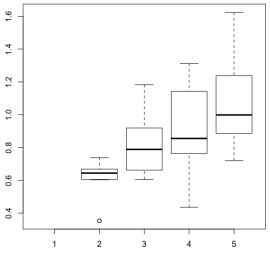
1.3) Observe the loadings using prcomp() or princomp() functions in R and discuss loadings in PCA?i.e., how are principal components and original variables related?

When using pca$rotation * pca$x, we can get a result that is similar to the origin data. So the loadings are items that connect PC and original variables.

1.4) Perform dimensionality reduction over Ionosphere data set with PCA. Keep 90% of variance after PCA and reduce Ionosphere data set and call this data Δ_R. Cluster Δ_R using your k-means program from previous assignment and report the total error rates for $k = 2, \ldots, 5$ for 20 runs each. Plots are generally a good way to convey complex ideas quickly, i.e., box plots, whisker plots. Discuss your results, i.e how did PCA affect performance of k-means clustering.



This is the box plot after keeping 90% variance



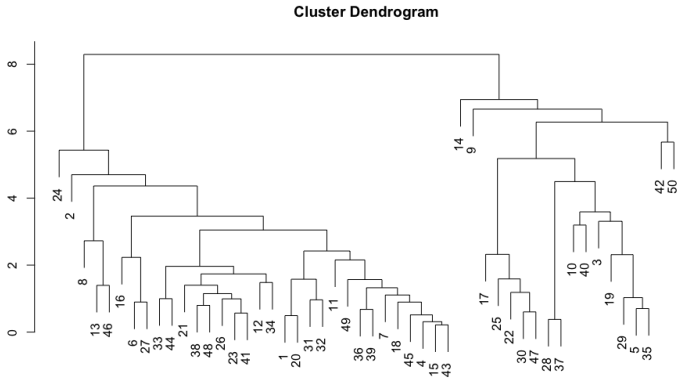
This id the box plot with orrigin data points

According to the difference between two box plot, we can find out that the error rate is increasing a little bit but all other parts are remain similarly. So I think that after reduce component based on PCA, the K-means algorithm is istill working kind of good.

Problem 2 [30 points]

Randomly choose 50 points from Ionosphere data set (call this data set I_{50}) and perform hierarchical clustering. You are allowed to use R packages for this question. (Ignore the class variable while performing hierarchical clustering.)

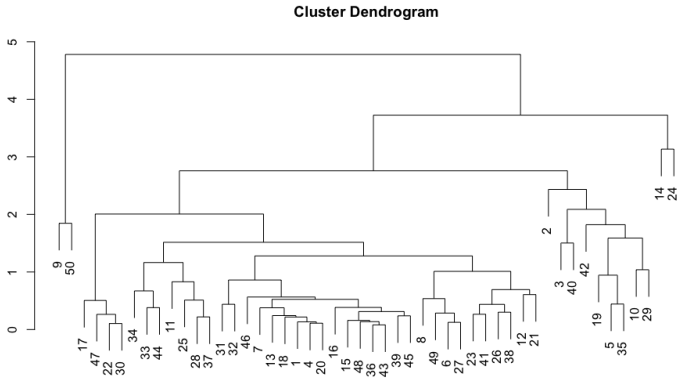
2.1) Using hierarchical clustering with complete linkage and Euclidean distance cluster I_{50}. Give the dendrogram.



2.2) Cut the dendrogram at a height that results in two distinct clusters. Calculate the error-rate.

```
# Please see detailed code in hierarchical2.R file
> error_rate1
[1] 0.09375
> error_rate2
[1] 0.5
```

2.3) First, perform PCA on I_{50} (Keep 90% of variance). Then hierarchically cluster the reduced data using complete linkage and Euclidean distance. Report the dendrogram.



2.4) Cut the dendrogram at a height that results in two distinct clusters. Give the error-rate. Discuss your findings, i.e., how did PCA affect hierarchical clustering results?

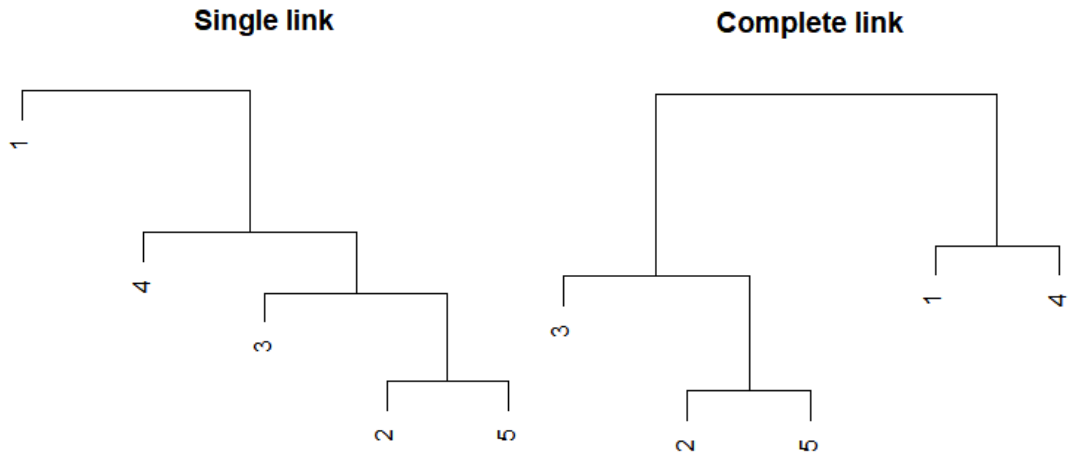
```
# Please see detailed code in hierarchical2.R file
> error_rate1
[1] 0.2083333
> error_rate2
[1] 0
```

Although we get the error rate reduced, we still meet a problem that one of the cluster only have two points. The reason that although we keep 90% of variance, first two columns of this data set is kind of usless, but we keep them. So that is some problem which we need to improve when using PCA.

Problem 3 [20 points]

From textbook, Chapter 8 exercises 16, 18 and 30 (Pages 563-566)

16. Perform single and complete link hierarchical clustering.



18. Suppose we find K clusters using Wards method, bisecting K-means, and ordinary K-means. Which of these solutions represents a local or global minimum? Explain.

`Although Ward's method using minimize SSE to choose clusters, it does not have maintine step, which means that this method does not have any refinement step. As for bisecting K-means, is also does not have any step about maintiness. Thus, does not like regular K-means, either Wards's method and bisecting K-means do not have local minimum. However, all the three methods cannot determain the global minimum.`

30. Clusters of documents can be summarized by finding the top terms (words) for the documents in the cluster, e.g., by taking the most frequent k terms, where k is a constant, say 10, or by taking all terms that occur more frequently than a specified threshold. Suppose that K-means is used to find clusters of both documents and words for a document data set.

(a) How might a set of term clusters defined by the top terms in a document cluster differ from the word clusters found by clustering the terms with K-means?

1) `The top clusters might be overlapped.`
2) `There are possibility that some items may not shown by the top terms.`

(b) How could term clustering be used to define clusters of documents?

`Take top documents as one term cluster.`

Extra Credit [10 points]

From textbook, Chapter 8 exercise 12 (Page 562).

12. The leader algorithm (Hartigan [4]) represents each cluster using a point, known as a leader, and assigns each point to the cluster corresponding to the closest leader, unless this distance is above a user-specified threshold. In that case, the point becomes the leader of a new cluster.
Note that the algorithm described here is not quite the leader algorithm described in Hartigan, which assigns a point to the first leader that is within the threshold distance. The answers apply to the algorithm as stated in the problem.

(a) What are the advantages and disadvantages of the leader algorithm as compared to K-means?

Advantage: 1) `Require less data`
2) `More efficiency`

Disadvantage: `Because Leader Algorithm is ordered, it will perduce same clusters every time. However, for K-means, it can perduce better clusters when using SSE to determine that.`

(b) Suggest ways in which the leader algorithm might be improved.

`Adding thresholds when clustering data points.`

What to Turn-in

Submit a .zip file that includes the files below. Name the .zip file as "usename-section number", i.e., hakurban-B365.

- The *tex and *pdf of the written answers to this document.
- *`R`files for:
  - R code for problem 1 ("pca1.R").
  - R code for problem 2 ("hierarchical2.R").