Week 9 **Varad Meru**
CS 273a - Introduction to Machine Learning (Winter '15)* Student # 26648958
Prof. Alex Ihler Due Date: 03/10/2015

Homework 5†‡

Problem 1: Basics of Clustering

(a) The dataset is loaded in Matlab, as shown in Listing 1 and Figure 1

Listing 1: Loading Data

```
% Problem a
iris=load('data/iris.txt');     % load the text file
X = iris(:,1:2);       % features are other columns
features = char('Sepal length','Sepal width','Petal length','Petal ...
    width','Species');
features_short = char('SL','SW','PL','PW','SP');
whos

f = figure;
scatter(X(:,1), X(:,2), 'filled');
saveas(f,'scatter.png','png');
```

(b) The Listing 2 shows the code listing for problem of k-means for different values of k and initialization methods. The Figure 2 shows the plot of the created clusters.

Listing 2: K-Means on iris dataset for different values of k and initialization methods.

```
%% Problem b
k = 5;
[z,c,sumd] = kmeans(X,k);
[z1,c1,sumd1] = kmeans(X,k,'k++');

f = figure;
plotClassify2D([],X,z);
saveas(f,'kmeans_k_5_simple.png', 'png');

f = figure;
plotClassify2D([],X,z1);
saveas(f,'kmeans_k_5_kpp.png', 'png');

k = 20;
[z,c,sumd] = kmeans(X,k);
[z1,c1,sumd1] = kmeans(X,k,'k++');

f = figure;
plotClassify2D([],X,z);
saveas(f,'kmeans_k_20_simple.png', 'png');

f = figure;
plotClassify2D([],X,z1);
saveas(f,'kmeans_k_20_kpp.png', 'png');
```

(c) The Listing 3 shows the code listing for problem of k-means for different values of k and initialization methods. The Figure 3 shows the plot of the created clusters.

*Website: http://sli.ics.uci.edu/Classes/2015W-273a
†Questions available at http://sli.ics.uci.edu/Classes/2015W-273a?action=download&upname=HW5.pdf
‡All the figures and listing numbers are auto-referred.

Listing 3: Agglomerative clustering on iris dataset for different values of k and linkage methods.

```
%% Problem c
k = 5;
Z = linkage(X,'single');
c = cluster(Z,'maxclust',k);
f = figure;
plotClassify2D([],X,c);
saveas(f,'linkage_single_5.png', 'png');
f = figure;
dendrogram(Z)
saveas(f,'dendogram_5.png', 'png');

Z = linkage(X,'complete');
c = cluster(Z,'maxclust',k);
f = figure;
plotClassify2D([],X,c);
saveas(f,'linkage_complete_5.png', 'png');

k = 20;
Z = linkage(X,'single');
c = cluster(Z,'maxclust',k);
f = figure;
plotClassify2D([],X,c);
saveas(f,'linkage_single_20.png', 'png');
f = figure;
dendrogram(Z)
saveas(f,'dendogram_20.png', 'png');

Z = linkage(X,'complete');
c = cluster(Z,'maxclust',k);
f = figure;
plotClassify2D([],X,c);
saveas(f,'linkage_complete_20.png', 'png');
```

(d) The EM Gaussian mixture model is run with 5 and 20 components, as shown in Listing 4. The generated clusters can be seen in Figure 4.

Listing 4: The EM Gaussian mixture model for 5 and 20 components.

```
%% Problem d
k = 5;
[zx,Tx,softx,llx] = emCluster(X,k);
f = figure;
plotClassify2D([],X,zx);
saveas(f,'emgm_5.png', 'png');

k = 20;
[zx,Tx,softx,llx] = emCluster(X,k);
f = figure;
plotClassify2D([],X,zx);
saveas(f,'emgm_20.png', 'png');
```

All the three clustering mechanisms bring different properties and have different usecases. The Agglomerative clustering has a simple architecture and works well for simple and small dataset. EM Gaussian mixture models are well suited for fuzzy nature of dataset where a data might not be strictly associated with any cluster. Traditional means as a low computational complexity compared to others, $O(nkt)$, where n is the number of datapoints, k is the number of clusters and t is the number of iterations. And thus, it can be computed

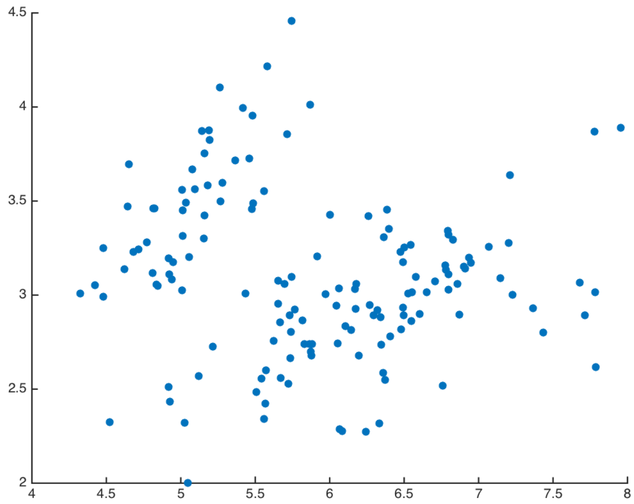
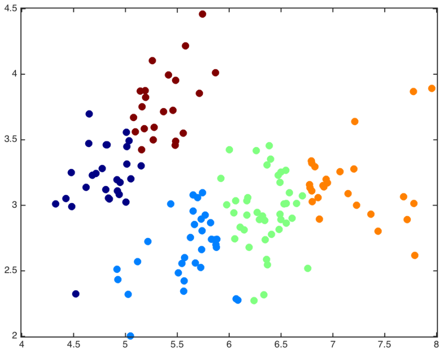
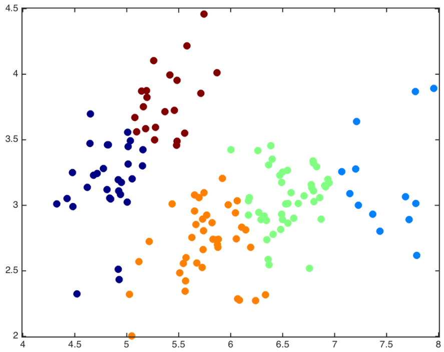


Figure 1: Data Loaded

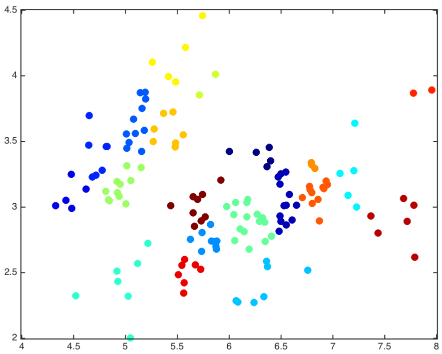
repeatedly to search for a good configuration. With all the methods, 'k-means ++' gave good results.



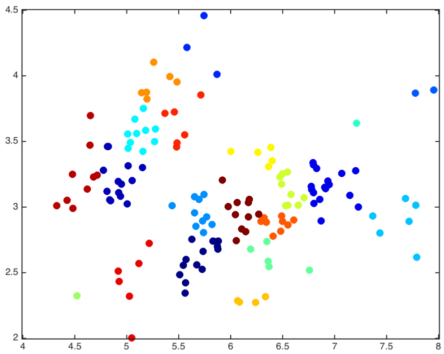
(a) `k=5` Random Initialisation



(b) `k=5` Initialisation using K-Means++

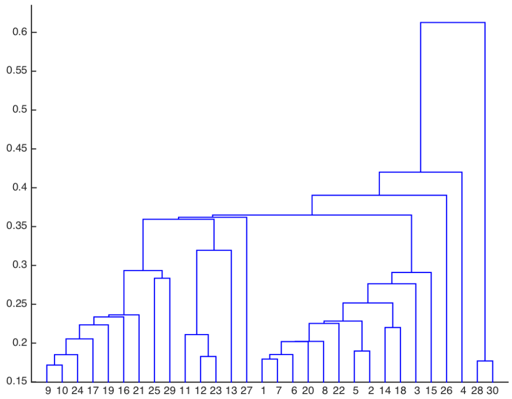


(c) `k=20` Random Initialisation

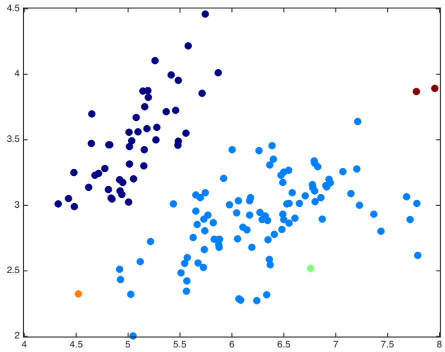


(d) `k=20` Initialisation using K-Means++

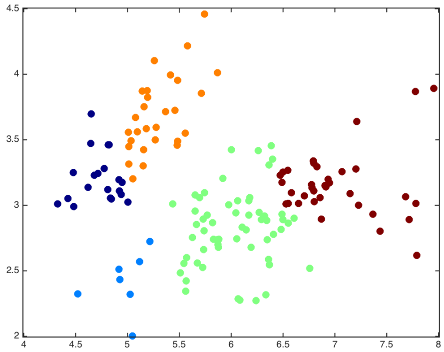
Figure 2: Various runs of K-Means different values of k and initialization methods



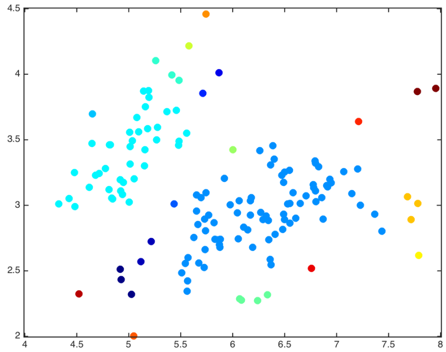
(a) Complete Dendrogram of the created clusters



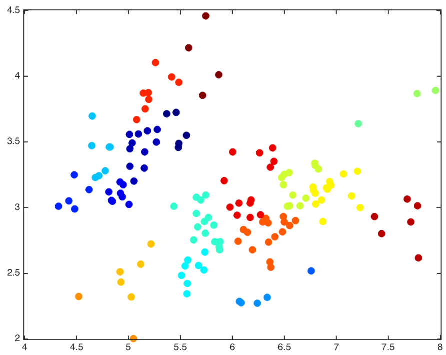
(b) k=5 Linkage method = single



(c) k=5 Linkage method = complete

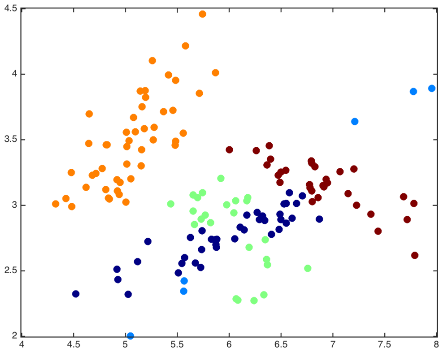


(d) k=20 Linkage method = single

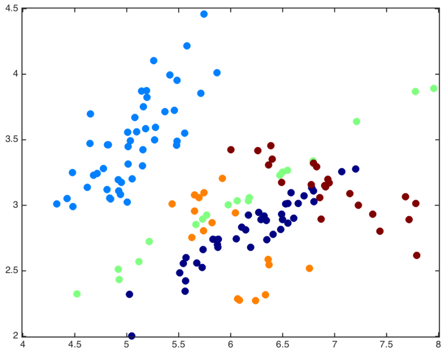


(e) k=20 Linkage method = complete

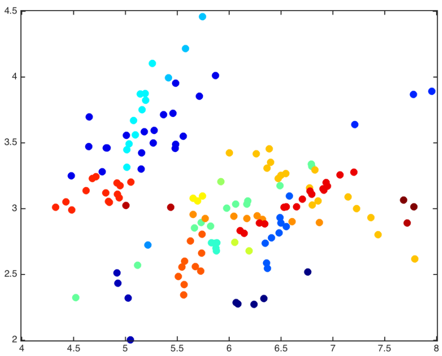
Figure 3: Various runs of Agglomerative clustering with different values of k and linkage methods



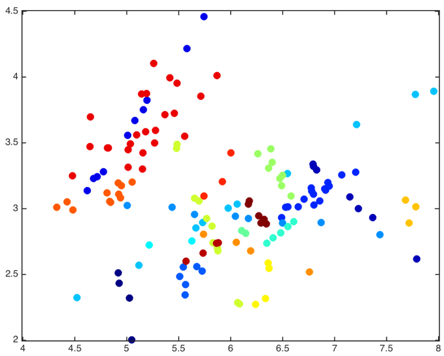
(a) `k=5` Random Initialisation



(b) `k=5` Initialisation using K-Means++



(c) `k=20` Initialisation using K-Means++



(d) `k=20` Initialisation using K-Means++

Figure 4: EM Gaussian mixture model with different values of k and initialization methods

Problem 2: K Means Clustering on Text

(a) The clusters are computed using `kmeans()` method provided by Matlab and the code that produces can be seen in Listing 5.

Listing 5: K-means on textual data with `k=20` and for part (b), the number of runs = 20

```
%% Problem (a, b)
k = 20;
[z,c,sumd] = kmeans(Xn,k);
disp(sumd)
disp('--------------')
for i=1:20;
    [z1,c1,sumd1] = kmeans(Xn,k);
    disp(sumd1)
    if sumd1 < sumd
        z = z1;
        c = c1;
        sumd = sumd1;
    end;
end;
display('Minimum-sumd')
disp(sumd)
%{
    2.4211
--------------
    2.0789
    2.1009
    2.0453
    2.0625
    2.0861
    2.4494
    2.0615
    2.0709
    2.0646
    2.1144
    2.0098
    2.0530
    2.4806
    2.0479
    2.0587
    2.0811
    2.4695
    1.9865
    2.4891
    2.0573

Minimum-sumd
    1.9865
%}
```

(b) Listing 5 shows 20 runs of K-Means on the textual data and I got the best value of the cost function to be `sumd = 1.9865`.

(c) For counting the document accusation with clusters, I use a function called `count_unique()`, and it gives the output as given in Listing 6 as well as the bar graph of the distribution can be seen at Figure 5. For the second part of the question, I used a slight modification of the original code given in the homework to populate the document terms. The code and the output can be seen in Listing 7.

Listing 6: The number of documents for each cluster

```
>> [uniques,numUnique] = count_unique(z)
>> [uniques,numUnique]
ans =
      1    21
      2    45
      3     4
      4     2
      5     7
      6     8
      7    69
      8     3
      9    10
     10     2
     11     2
     12     1
     13     1
     14     3
     15     1
     16     1
     17    15
     18     2
     19     3
     20     2
```

Listing 7: The "Most-Likely" terms in the 20 clusters

```
%% Problem (c) - 2
for i =1:size(c, 1);
    [sorted,order] = sort( c(i,:), 2, 'descend');
    fprintf('Doc %d: ',i);
    fprintf('%s ', vocab{order(1:10)});
    fprintf('\n');
end;
%{
Doc 1: times square millennium city 2000 night 000 eve york midnight
Doc 2: team game season coach games players league play going win
Doc 3: archbishop york bishop cardinal sports church began column ...
    american close
Doc 4: america boat team zealand cup nippon gilmour challengers round true
Doc 5: book century marks amp war week finds lives school boy
Doc 6: yeltsin putin russia russian president power political kremlin ...
    chechnya russians
Doc 7: city american national president 000 home millennium end political ...
    going
Doc 8: fireworks island city midnight celebration lot millennium hour ...
    calls celebrations
Doc 9: y2k koskinen system problems saturday 2000 reported computers ...
    friday officials
Doc 10: tutsi hutu rwanda burundi ethnic country experts africa van 1994
Doc 11: texas arkansas yards line offensive game season sacks games defensive
Doc 12: test end houston 000 0101 0102 100 1900 1900s 1968
Doc 13: cats beijing owners police association called carry chinese eat ...
    eating
Doc 14: hijackers hostages pakistan burger told government indian india ...
    passengers killed
Doc 15: sports angeles began brooklyn column los seen young eye game
Doc 16: economy government putin system america businesses country ...
    economic president russia
Doc 17: 2000 computer internet government systems york problem problems ...
    news city
Doc 18: lakers jackson game star phil players record conference practice ...
    monday
```

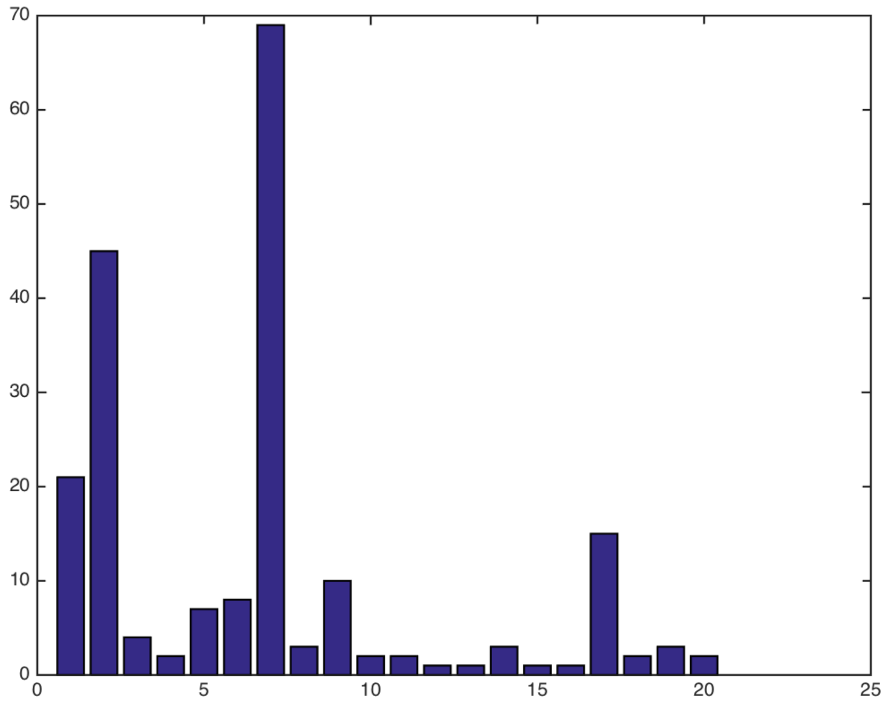


Figure 5: Distribution of the documents spread across `k=20` clusters.

```
Doc 19: news atlanta constitution journal service moved cox y2k cnn ...
    millennium
Doc 20: buses authority diesel natural gas plan mta city york hybrid
%}
```

(d) A

Problem 3: Eigen Faces

(a) Loading Eigen Faces Data, as can be seen in Listing 9. Also see Figure 6

Listing 8: Loading Face Dataset

```
clc;close all;clear all;
rand('seed',0);
X = load('data/faces.txt'); % load face dataset
```

(b) Normalisng the dataset.

Listing 9: Normalizing

```
%% Faces A
mu = mean(X);
X0 = bsxfun(minus,X,mu);size(mu);ans =1 576
```

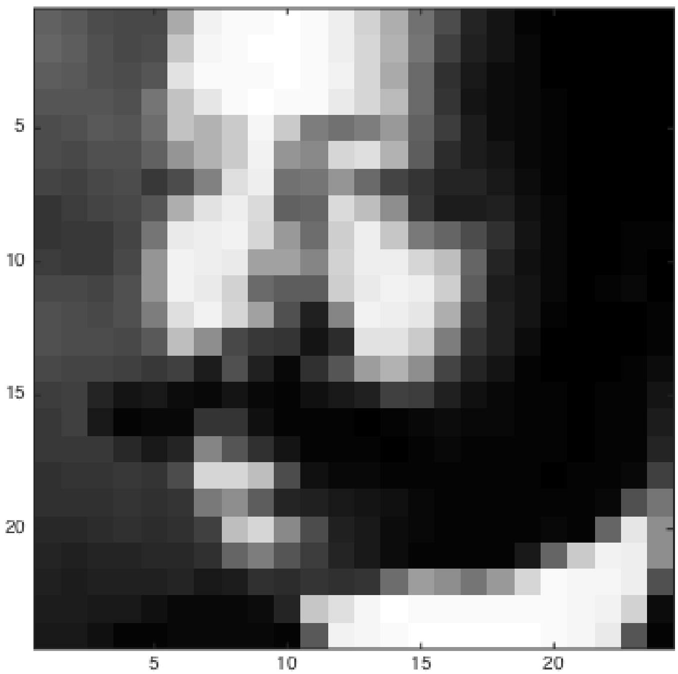


Figure 6: Face sample.