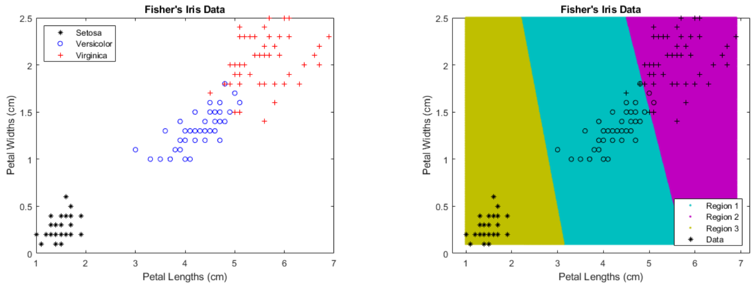
EE583 Pattern Recognition HW4

Kutay Uğurlu 2232841

December 4, 2021

1 Question 1



(a) (b)

Figure 1: The data distribution and partitioning

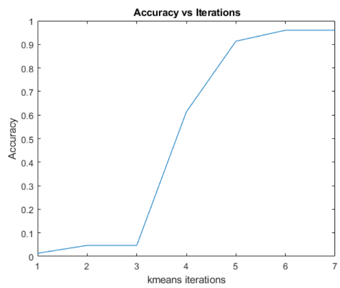
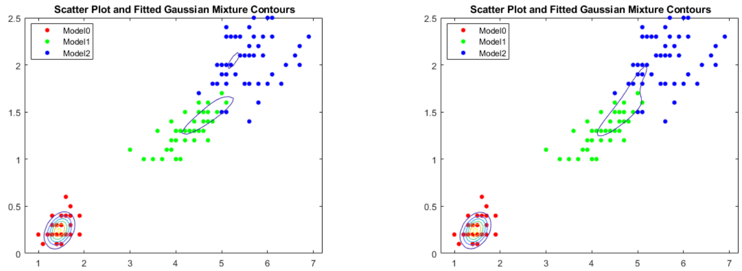


Figure 2: classification success for different centroids

The centroids are manually set according to the approximate mean deduced from the data distribution plot. Initial centroids can be found in 5.1. The accuracy is calculated in two steps. First, the confusion matrix is calculated, then the diagonal entries of it are added to obtain the true positive classifications. Finally, $Accuracy \triangleq \frac{\#TP}{\#Samples}$.
Figure 2 shows the accuracies of the iterations initialized with different centroids. Through careful centroid selection, the accuracy can be increased from 0.1 to 0.9647.

2 Question 2



(a) (b)

Figure 3: The data distribution and partitioning

3 Question 3

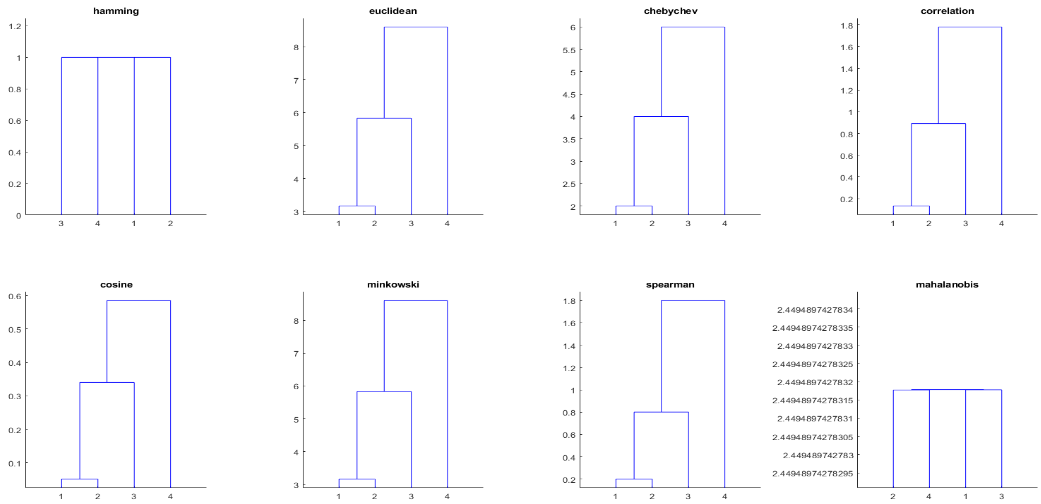
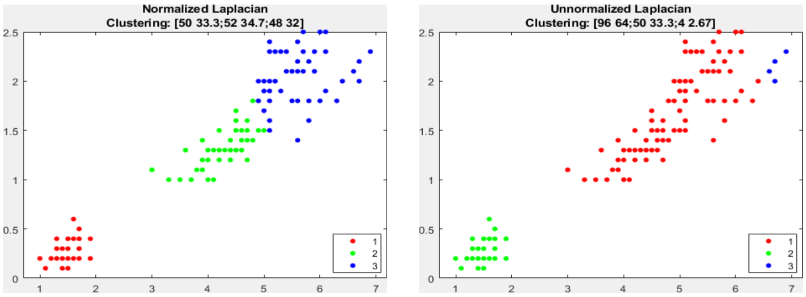


Figure 4: Dendrograms for different metrics

4 Question 4

4.1 Laplacian Matrix Normalization

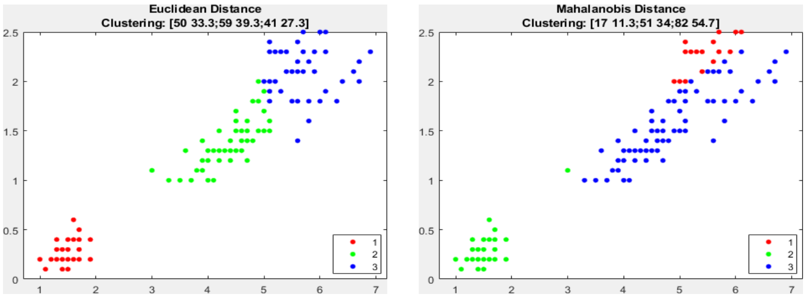


(a) (b)

Figure 5: Clustering for different cases

Using unnormalized Laplacian matrix increased the number of misclassifications.

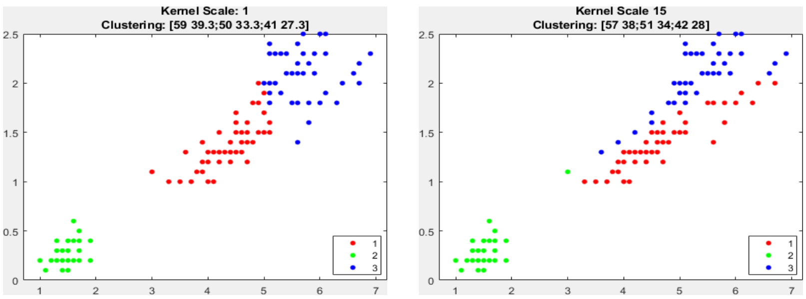
4.2 Distance Metrics



(a) (b)

Figure 6: Clustering for different cases

4.3 Kernel Scale



(a) (b)

Figure 7: Clustering for different cases

5 APPENDIX

The code given in this section is shared @.

5.1 Q1

```
load fisheriris
X = meas(:,3:4);
setosa_idx = strcmp(species,"setosa");
versicolor_idx = strcmp(species,"versicolor");
virginica_idx = strcmp(species,"virginica");

SETOSA = X(setosa_idx,:);
VERSICOLOR = X(versicolor_idx,:);
VIRGINICA = X(virginica_idx,:);

figure;
plot(SETOSA(:,1),SETOSA(:,2),'k*','MarkerSize',5);
hold on
plot(VERSICOLOR(:,1),VERSICOLOR(:,2),'bo','MarkerSize',5);
hold on
plot(VIRGINICA(:,1),VIRGINICA(:,2),'r+','MarkerSize',5);
title 'Fisher''s Iris Data';
xlabel 'Petal Lengths (cm)';
ylabel 'Petal Widths (cm)';
legend('Setosa','Versicolor','Virginica','Location','northwest')

%%
% rng(1); % For reproducibility

Cs = {};
Cs{1} = [6 2   ; 1.5  0.3   ; 4 1];
Cs{2} = [5.2 2.5; 4.4 1.25; 3.8 5.5];
Cs{3} = [5   2.4; 4.6 1.45; 3.3 3.5];
Cs{4} = [4.5 2.1; 4.8 1.55; 3.2 3.2];
Cs{5} = [4.2 1.8; 5.2 1.78; 2.5 2.1];
Cs{6} = [4.1 1.4; 5.5 1.89; 1.8 1.05];
Cs{7} = [4   1  ; 6   2   ; 1.5 0.3];
gnd_truth = repelem([3;1;2],50,1);
accs = [];
CONFMATS = {};
for i = 1:7
[idx,C_new] = kmeans(X,3,'MaxIter',1,'Start',Cs{i});
confusion_matrix = confusionmat(gnd_truth,idx);
accuracy = sum(diag(confusion_matrix)) / size(X,1);
C_old = C_new;
accs(end+1) = accuracy;
CONFMATS{end+1} = confusion_matrix;
end
figure
plot(accs)
```

```
title({'\bf Accuracy vs Iterations'})
ylabel('Accuracy')
xlabel('kmeans iterations')
%%
x1 = min(X(:,1)):0.01:max(X(:,1));
x2 = min(X(:,2)):0.01:max(X(:,2));
[x1G,x2G] = meshgrid(x1,x2);
XGrid = [x1G(:),x2G(:)]; % Defines a fine grid on the plot

idx2Region = kmeans(XGrid,3,'MaxIter',1,'Start',C_new);
    % Assigns each node in the grid to the closest centroid

figure;
gscatter(XGrid(:,1),XGrid(:,2),idx2Region,...
    [0,0.75,0.75;0.75,0,0.75;0.75,0.75,0],'..');
hold on;
plot(X(setosa_idx,1),X(setosa_idx,2),'k*','MarkerSize',5);
hold on
plot(X(versicolor_idx,1),X(versicolor_idx,2),'ko','MarkerSize',5);
hold on
plot(X(virginica_idx,1),X(virginica_idx,2),'k+','MarkerSize',5);
    title 'Fisher''s Iris Data';
xlabel 'Petal Lengths (cm)';
ylabel 'Petal Widths (cm)';
legend('Region 1','Region 2','Region 3','Data','Location','SouthEast
    ');
hold off;
```

5.2 Q2

```
load fisheriris.mat
X = meas(:,3:4);
GMModel = fitgmdist(X,3);
figure
y = [zeros(50,1);ones(50,1);2*ones(50,1)];
h = gscatter(X(:,1),X(:,2),y);
hold on
gmPDF = @(x,y) arrayfun(@(x0,y0) pdf(GMModel,[x0 y0]),x,y);
g = gca;
fcontour(gmPDF,[g.XLim g.YLim])
title('{\bf Scatter Plot and Fitted Gaussian Mixture Contours}')
legend(h,'Model0','Model1','Model2')
hold off
```

5.3 Q3

```
X = [0 1 2 3; 1 0 4 5; 2 4 0 6; 3 5 6 0];
y = squareform(X);

distances = ["hamming","euclidean","chebychev","correlation",...
    "cosine","minkowski","spearman","mahalanobis"];
figure('units','normalized','outerposition',[0 0 1 1])
for distance = distances
    idx = find(distances == distance);
    subplot(2,4,idx)
    Z = linkage(X,'complete',distance);
    dendrogram(Z)
    title(distance)
end
```

5.4 Q4

```
%%
chdir('..')
addpath('export_fig')
chdir('HW4')
%%
load fisheriris
X = meas(:,3:4);
gscatter(X(:,1),X(:,2),species);
dist_temp = pdist(X);
dist = squareform(dist_temp);
S = exp(-dist.^2);
k = 3; % Number of clusters
rng('default') % For reproducibility
mat = tabulate(species);
title({'Known distribution',['Clustering: ',mat2str(repmat
    ([50,33.3],3,1),3)]})
%% Use similarity mat(:,2:end)rix
figure
idx = spectralcluster(S,k,'Distance','precomputed','
    LaplacianNormalization','symmetric');
gscatter(X(:,1),X(:,2),idx);
mat = tabulate(idx);
title({'Similarity Matrix',['Clustering: ',mat2str(mat(:,2:end),3)
    ]})
%% Laplacian normalized
figure
idx2 = spectralcluster(X,k,'NumNeighbors',size(X,1),'
    LaplacianNormalization','symmetric');
gscatter(X(:,1),X(:,2),idx2);
mat = tabulate(idx2);
title({'Normalized Laplacian',['Clustering: ',mat2str(mat(:,2:end)
    ,3)]})
%% Laplacian unnormalized
figure
idx2 = spectralcluster(X,k,'NumNeighbors',size(X,1),'
    LaplacianNormalization','none');
gscatter(X(:,1),X(:,2),idx2);
mat = tabulate(idx2);
title({'Unnormalized Laplacian',['Clustering: ',mat2str(mat(:,2:end)
    ,3)]})

%% Distance Euclidean
figure
idx2 = spectralcluster(X,k,'NumNeighbors',size(X,1),'Distance','
    euclidean');
gscatter(X(:,1),X(:,2),idx2);
mat = tabulate(idx2);
title({'Euclidean Distance',['Clustering: ',mat2str(mat(:,2:end),3)
    ]})
```

```matlab
%% Distance mahalanobis
figure
idx2 = spectralcluster(X,k,'NumNeighbors',size(X,1),'Distance','mahalanobis');
gscatter(X(:,1),X(:,2),idx2);
mat = tabulate(idx2);
title({'Mahalanobis Distance',['Clustering: ',mat2str(mat(:,2:end),3)]})

%% Kernel Scale 1
figure
idx2 = spectralcluster(X,k,'NumNeighbors',size(X,1),'KernelScale',1);
gscatter(X(:,1),X(:,2),idx2);
mat = tabulate(idx2);
title({'Kernel Scale: 1',['Clustering: ',mat2str(mat(:,2:end),3)]})

%% Kernel Scale 15
figure
idx2 = spectralcluster(X,k,'NumNeighbors',size(X,1),'KernelScale',15);
gscatter(X(:,1),X(:,2),idx2);
mat = tabulate(idx2);
title({'Kernel Scale 15',['Clustering: ',mat2str(mat(:,2:end),3)]})


%%
figHandles = findall(0,'Type','figure');

for i = 1:numel(figHandles)
    export_fig(['Q4_',num2str(i)], '-png', figHandles(i), '-append')
end
```