Pattern Recognition Practical 5

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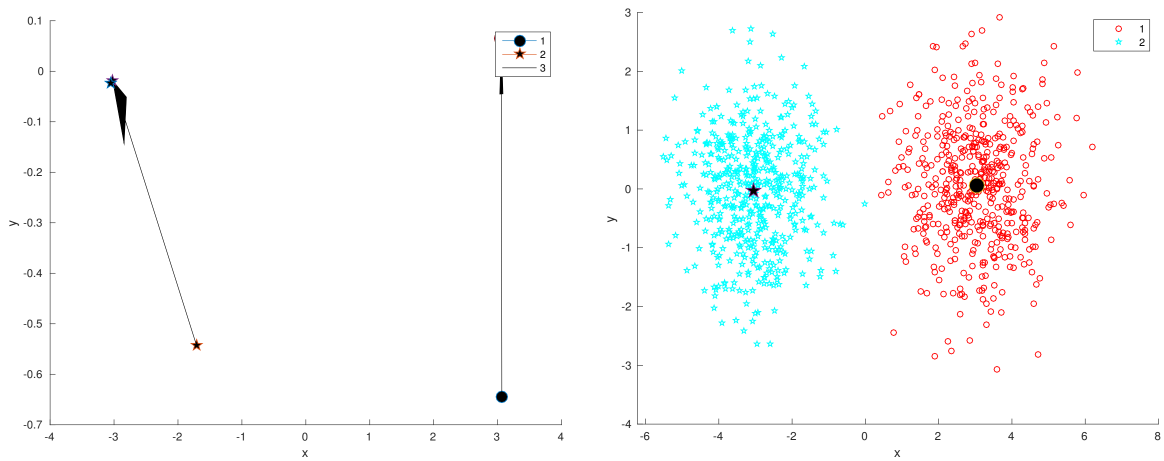
Assignment 1 k-means clustering, quantization error, gap statistic

1

Using the code given in the Appendix(kmeans.m and runKMeans.m), we created the plots shown in figures 1, 2 and 3.

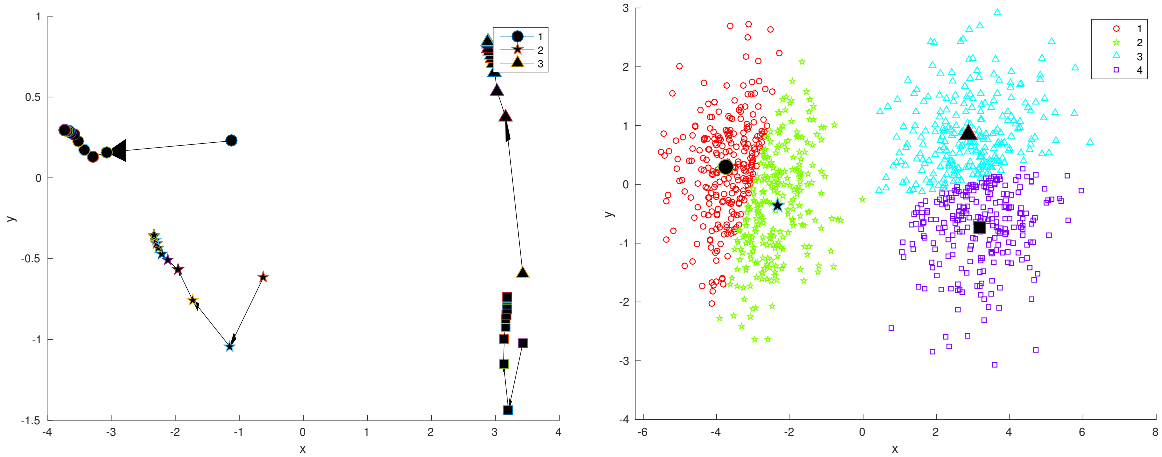
Figure 1: Results for k=2



(a) intermediate positions of the cluster means, with their progress indicated by the arrows.

(b) The final cluster means with their assigned data points)

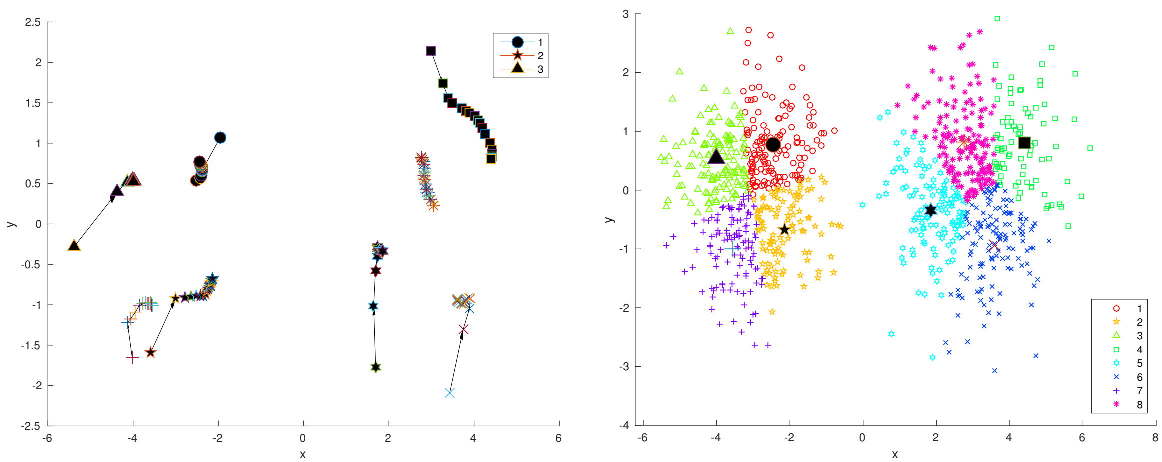
Figure 2: Results for k=4



(a) intermediate positions of the cluster means, with their progress indicated by the arrows.

(b) The final cluster means with their assigned data points)

Figure 3: Results for k=8



(a) intermediate positions of the cluster means, with their progress indicated by the arrows.

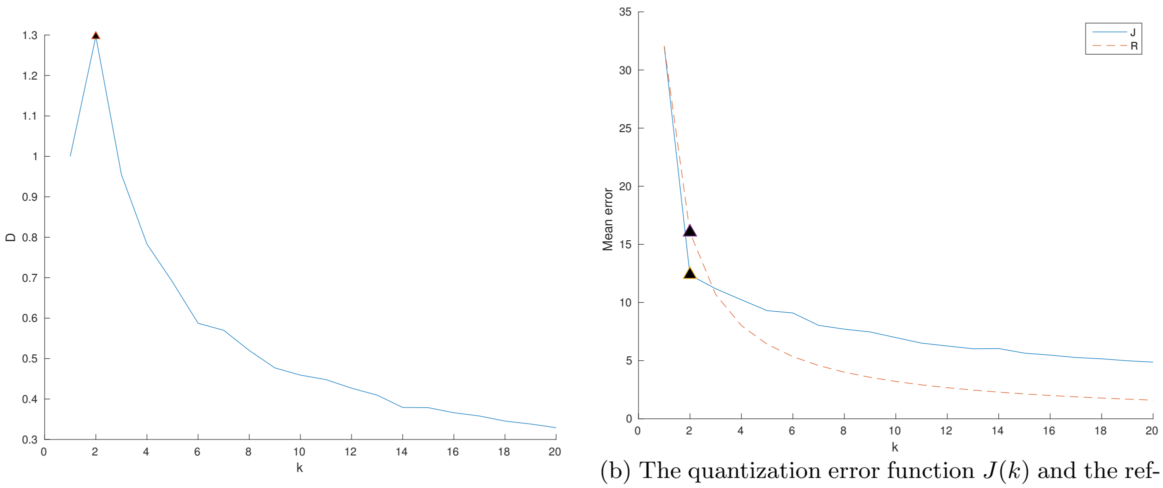
(b) The final cluster means with their assigned data points)

We we can clearly see that the data form two clusters. Therefore figure 1a shows the quickest convergence to the final cluster centers. Usually it takes about two epochs for the cluster centers to converge, as is shown in the figure. Figure 1b shows that these centers form in the places which the human eye observes to be the correct centers. When we choose k as 4, as shown in figure 2, we can see that the two clusters get separated into two clusters each (although this is dependent on the initialization). The number of epochs is quite higher. This can be explained by the fact that the data are not naturally separated into four clusters but in two, so the distances between the data points within a main cluster are small. This causes the algorithm to take longer to find a convergence, since the cluster centers switch often during the clustering process. Finally figure 3 shows the clustering for $k = 8$, which takes the longest amount of epochs to converge, because of the same reasoning. It separates both of the clusters into four subclusters.

2

Using the code given in the appendix (kmeans.m and runKMeans.m) we computed the quantization errors and D-function given in figure 4.

Figure 4: Results for $kmax = 20$



(a) The D-function.

(b) The quantization error function $J(k)$ and the reference function $R(k)$.

Assignment 2 Batch Neural gas vs k-means

Appendix

../Code/kmeans.m

```
function [qError] = kmeans(dat, k, writeOutput)
% K-means clustering algorithm
close all;
shapes = 'op^shx+*dv<>.';

% Init the prototypes to a random point
prototypes = zeros(k,ndims(dat));
for i = 1:k
    newPoint = dat(randi(length(dat)),1:2);
    while (sum(pdist2(prototypes, newPoint) == 0) ~= 0)
        newPoint = dat(randi(length(dat)),1:2);
    end
    prototypes(i,:) = newPoint;
end

%Init the first figure
% figure(1)
% hold on;
% xlabel('x');
% ylabel('y');
%
% for i = 1 : size(prototypes, 1)
%     plot(prototypes(i,1),prototypes(i,2),'Marker', shapes(i), 'MarkerSize', 10, '
    MarkerFaceColor', 'black')
% end

```

```matlab

% Perform k-means
loop = 1;
while(loop == 1)
    loop = 0;

    for point = 1 : length(dat)
        dat(point,3) = find(pdist2(dat(point,1:2), prototypes) == min(pdist2(dat(point,1:2), prototypes)),1);
    end

    for prototype = 1 : size(prototypes, 1)
        newMean = mean(dat(dat(:,3) == prototype,1:2));
        if newMean ~= prototypes(prototype,:)
            loop = 1;
        end
        %plot_arrow( prototypes(prototype,1), prototypes(prototype,2), newMean(:,1), newMean(:, 2));
        prototypes(prototype,:) = newMean;
        %plot(newMean(1),newMean(2),'Marker', shapes(prototype), 'MarkerSize', 10, 'MarkerFaceColor', 'black')
    end


end

% Calculate the quantization error
qError = 0;
for i = 1 : size(prototypes, 1)
    qError = qError + sum(pdist2(prototypes(i,:), dat(dat(:,3) == i,1:2)));
end

% More figure stuff
% legend(num2str(1:k))
% if writeOutput == 1
%     print(sprintf('../Report/Fig1_k%d', k), '-depsc');
% end
% figure(2)
% hold on;
% gscatter(dat(:,1),dat(:,2),dat(:,3),[],shapes, 5)
%
%
% for i = 1 : size(prototypes, 1)
%     plot(prototypes(i,1),prototypes(i,2),'Marker', shapes(i), 'MarkerSize', 13, 'MarkerFaceColor', 'black')
% end
%
% xlabel('x');
% ylabel('y');
% if writeOutput == 1
%     print(sprintf('../Report/Fig2_k%d', k), '-depsc');
% end
```

../Code/runKMeans.m

```matlab
load('kmeans1.mat', 'kmeans1');

error= zeros(1,10);
kmax = 20;
J = zeros(1, kmax);
R = zeros(1,kmax);

% kmeans(kmeans1,k, 0);

% Run for 1 to kmax clusters
```

```
for k = 1 : kmax
    k
    % Run it 10 times for every cluster and calculate the mean error and
    % reference
    for i = 1:10
        error(i) = kmeans(kmeans1,k, 0);
    end
    J(k) = mean(error)/10;
    R(k) = J(1) * k^(-2/ndims(kmeans1));
end

J = J/10;
R = R/10;
D = R ./ J;

% Plot D
[maxVal maxInd] = max(D);
figure(3)
hold on;
plot(D);
plot(maxInd, maxVal,'Marker', '^', 'MarkerSize', 6, 'MarkerFaceColor', 'black')
xlabel('k');
ylabel('D');
print(sprintf('../Report/Fig3'), '-depsc');

% Plot J and R
figure (4)
hold on ;
plot(J);
plot(R, '--');
plot(maxInd, J(maxInd),'Marker', '^', 'MarkerSize', 10, 'MarkerFaceColor', 'black')
plot(maxInd, R(maxInd),'Marker', '^', 'MarkerSize', 10, 'MarkerFaceColor', 'black')
xlabel('k');
ylabel('Mean error');
legend('J', 'R');
print(sprintf('../Report/Fig4'), '-depsc');
```