**Course No.: ELEN-857**

**Course Title: Advanced Pattern Recognition Method**

**Department: Electrical and Computer Engineering**

**Project 2: K-means clustering algorithm**

**Submitted To: Prepared By:**

**Dr. Robert Y.Li, Professor Name: Mrinmoy Sarkar**

**Department of Electrical Engineering Banner Id: 950-363-260 Telephone: (336) 285-3716; E-mail: eeli@ncat.edu E-mail: msarkar@aggies.ncat.edu**

**Contents:**

1. **Abstract**
2. **Technical Description**
3. **Results**
4. **Summary**
5. **Appendix**
6. **Abstract:**

The main purpose of the project is to apply K-means clustering algorithm to Fisher’s Iris data. Fisher’s Iris data contains a set of measurements related to 3 species of the Iris plant. The three species are Iris Setosa, Iris Versicolor, and Iris Virginica.

1. **Technical Description:**

The dataset contains 50 plants from each of the 3 species. There are 4 features in the dataset named sepal length, sepal width, petal length and petal width. MATLAB programming language is used to implement the K-means algorithm. Three different K (2,3,4) and two different thresholds T (0.01, 0.1) are used to cluster the 150 data samples. And corresponding confusion matrix is calculated.

1. **Results:**

**# (K = 2, T = 0.01) cluster 1: 53 cluster 2: 97**

**Initial centers: Z1 = (5.1000 3.5000 1.4000 0.2000),**

**Z2 = (7.0000 3.2000 4.7000 1.4000)**

**Final centers: Z1 = (5.0057 3.3604 1.5623 0.2887),**

**Z2 = (6.3010 2.8866 4.9588 1.6959)**

**Confusion Matrix:**

|  |  |  |
| --- | --- | --- |
|  | **Cluster 1** | **Cluster 2** |
| **A** | **50** | **0** |
| **B** | **3** | **47** |
| **C** | **0** | **50** |

**# (K = 2, T = 0.10) cluster 1: 53 cluster 2: 97**

**Initial centers: Z1 = (5.1000 3.5000 1.4000 0.2000),**

**Z2 = (7.0000 3.2000 4.7000 1.4000)**

**Final centers: Z1 = (5.0057 3.3604 1.5623 0.2887),**

**Z2 = (6.3010 2.8866 4.9588 1.6959)**

**Confusion Matrix:**

|  |  |  |
| --- | --- | --- |
|  | **Cluster 1** | **Cluster 2** |
| **A** | **50** | **0** |
| **B** | **3** | **47** |
| **C** | **0** | **50** |

**# (K = 3, T = 0.01) cluster 1: 50 cluster 2: 62 cluster 3: 38**

**Initial centers: Z1 = (5.1000 3.5000 1.4000 0.2000),**

**Z2 = (7.0000 3.2000 4.7000 1.4000),**

**Z3 = (6.3000 3.3000 6.0000 2.5000)**

**Final centers: Z1 = (5.0060 3.4180 1.4640 0.2440),**

**Z2 = (5.9016 2.7484 4.3935 1.4339),**

**Z3 = (6.8500 3.0737 5.7421 2.0711)**

**Confusion Matrix:**

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Cluster 1** | **Cluster 2** | **Cluster 3** |
| **A** | **50** | **0** | **0** |
| **B** | **0** | **48** | **2** |
| **C** | **0** | **14** | **36** |

**# (K = 3, T = 0.10) cluster 1: 50 cluster 2: 62 cluster 3: 38**

**Initial centers: Z1 = (5.1000 3.5000 1.4000 0.2000),**

**Z2 = (7.0000 3.2000 4.7000 1.4000),**

**Z3 = (6.3000 3.3000 6.0000 2.5000)**

**Final centers: Z1 = (5.0060 3.4180 1.4640 0.2440),**

**Z2 = (5.9194 2.7532 4.3903 1.4194),**

**Z3 = (6.8211 3.0658 5.7474 2.0947)**

**Confusion Matrix:**

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Cluster 1** | **Cluster 2** | **Cluster 3** |
| **A** | **50** | **0** | **0** |
| **B** | **0** | **48** | **2** |
| **C** | **0** | **14** | **36** |

**# (K = 4, T = 0.01) cluster 1: 50 cluster 2: 40 cluster 3: 32 cluster 4: 28**

**Initial centers: Z1 = (5.1000 3.5000 1.4000 0.2000),**

**Z2 = (7.0000 3.2000 4.7000 1.4000),**

**Z3 = (6.3000 3.3000 6.0000 2.5000),**

**Z4 = (5.8000 2.7000 5.1000 1.9000)**

**Final centers: Z1 = (5.0060 3.4180 1.4640 0.2440),**

**Z2 = (6.2525 2.8550 4.8150 1.6250),**

**Z3 = (6.9125 3.1000 5.8469 2.1312),**

**Z4 = (5.5321 2.6357 3.9607 1.2286)**

**Confusion Matrix:**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **Cluster 1** | **Cluster 2** | **Cluster 3** | **Cluster 4** |
| **A** | **50** | **0** | **0** | **0** |
| **B** | **0** | **23** | **0** | **27** |
| **C** | **0** | **17** | **32** | **1** |

**# (K = 4, T = 0.10) cluster 1: 50 cluster 2: 40 cluster 3: 32 cluster 4: 28**

**Initial centers: Z1 = (5.1000 3.5000 1.4000 0.2000),**

**Z2 = (7.0000 3.2000 4.7000 1.4000),**

**Z3 = (6.3000 3.3000 6.0000 2.5000),**

**Z4 = (5.8000 2.7000 5.1000 1.9000)**

**Final centers: Z1 = (5.0060 3.4180 1.4640 0.2440),**

**Z2 = (6.2541 2.8865 4.8486 1.6459),**

**Z3 = (6.9125 3.1000 5.8469 2.1312),**

**Z4 = (5.6000 2.6194 4.0032 1.2419)**

**Confusion Matrix:**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **Cluster 1** | **Cluster 2** | **Cluster 3** | **Cluster 4** |
| **A** | **50** | **0** | **0** | **0** |
| **B** | **0** | **23** | **0** | **27** |
| **C** | **0** | **17** | **32** | **1** |

1. **Summary:**

* For different values of K and T, we see that class A always belongs to cluster 1.
* As there exists overlapping data among classes, so K-means algorithm cannot separate all the data into three different clusters even though K is set to 3.
* If T is very low, the K-means algorithm takes more iteration to converse.
* Whatever the value of K, K-means algorithm always converses.
* For both values of T, K-means algorithm output the same result.
* The initial centers play an important role in correct clustering for k-means algorithms.

1. **Appendix**

**MATLAB Code:**

%% file name project2.m

% author: Mrinmoy Sarkar

% email: msarkar@aggies.ncat.edu

% date: 10/6/2017

clear;

close all;

% load data to a veriable

data = importdata('iris.txt');

% no. of class is 3 named Iris-setosa, Iris-versicolor and Iris-verginica

% there are 4 attributes named sepal-length, sepal-width, petal-length,

% petal-width

% there are 50 plants for each species

irisSetosa = zeros(50,4);

irisVersicolor = zeros(50,4);

irisVerginica = zeros(50,4);

n = size(data,1);

indxSeto = 1;

indxVers = 1;

indxVerg = 1;

for i=2:n

x = strsplit(cell2mat(data(i)));

if strcmp(x(5), 'Iris-setosa')

for j=1:4

irisSetosa(indxSeto,j) = str2double(cell2mat(x(j)));

end

indxSeto = indxSeto + 1;

elseif strcmp(x(5), 'Iris-versicolor')

for j=1:4

irisVersicolor(indxVers,j) = str2double(cell2mat(x(j)));

end

indxVers = indxVers + 1;

elseif strcmp(x(5), 'Iris-virginica')

for j=1:4

irisVerginica(indxVerg,j) = str2double(cell2mat(x(j)));

end

indxVerg = indxVerg + 1;

end

end

X\_true = {irisSetosa, irisVersicolor, irisVerginica};

X = [irisSetosa; irisVersicolor; irisVerginica];

%% K-means algorithms

noOfTrueClasses = 3;

trueA = array2table(X(1:50,:));

trueB = array2table(X(51:100,:));

trueC = array2table(X(101:150,:));

trueClasses = {trueA, trueB, trueC};

X = X';

Z\_init = [5.1 3.5 1.4 0.2;...

7.0 3.2 4.7 1.4;...

6.3 3.3 6.0 2.5;...

5.8 2.7 5.1 1.9]';

K = [2 3 4];

T = [0.01 0.1];

for i=1:length(K)

for j=1:length(T)

[z,classes] = kmeanAlgorithm(X,K(i),Z\_init(:,1:K(i)),T(j));

disp('Initial cluster centers:');

disp((Z\_init(:,1:K(i)))');

disp('Final cluster centers:');

disp(z');

fprintf('#(K = %d, T = %0.2f) ',K(i),T(j));

for cl = 1:K(i)

fprintf('cluster %d: %d ', cl , size(classes{cl},2))

end

fprintf('\n')

confusionMat = zeros(noOfTrueClasses, K(i));

for m = 1:noOfTrueClasses

for n = 1:K(i)

predictedData = (classes{n})';

count = 0;

for p=1:size(predictedData,1)

g = intersect(trueClasses{m},array2table(predictedData(p,:)));

if ~isempty(g)

count = count + 1;

end

end

confusionMat(m,n) = count;

end

end

% print confusion matrix

fprintf('Confusion Matrix:\n');

tc = 'ABC';

for c = 1:1:size(confusionMat,2)

fprintf(' | cluster %d ',c);

end

dasLine ={'\n---------------------------\n',...

'\n-----------------------------------------\n',...

'\n-------------------------------------------------------\n'};

fprintf(dasLine{i});

for r = 1:size(confusionMat,1)

fprintf('%c ',tc(r));

for c = 1:1:size(confusionMat,2)

fprintf('| %2d ',confusionMat(r,c));

end

fprintf(dasLine{i})

end

end

end

%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%

function [z,classes] = kmeanAlgorithm(x,k,z,T)

classes = cell(1,k);

for i=1:k

classes{1,i}=[];

end

iterationNo = 1;

while 1

%fprintf('Iteration Number : %d\n', iterationNo);

for i=1:size(x,2)

temp = ones(size(z)).\*x(:,i);

[m mi] = min(sum((z-temp).^2));

classes{1,mi} = [classes{1,mi} x(:,i)];

end

zNew = zeros(size(z));

for i=1:k

temp = classes{1,i};

zNew(:,i) = (1/size(temp,2))\*sum(temp,2);

end

if sum(sum(abs(z-zNew)> T)) == 0

break;

else

z=zNew;

end

for i=1:k

classes{1,i}=[];

end

iterationNo = iterationNo + 1;

end

fprintf('Iteration Number : %d\n', iterationNo);

end

**Output of the MATLAB Code:**

**>> project2**

**Iteration Number : 2**

**Initial cluster centers:**

**5.1000 3.5000 1.4000 0.2000**

**7.0000 3.2000 4.7000 1.4000**

**Final cluster centers:**

**5.0057 3.3604 1.5623 0.2887**

**6.3010 2.8866 4.9588 1.6959**

**#(K = 2, T = 0.01) cluster 1: 53 cluster 2: 97**

**Confusion Matrix:**

**| cluster 1 | cluster 2**

**---------------------------**

**A | 50 | 0**

**---------------------------**

**B | 3 | 47**

**---------------------------**

**C | 0 | 50**

**---------------------------**

**Iteration Number : 2**

**Initial cluster centers:**

**5.1000 3.5000 1.4000 0.2000**

**7.0000 3.2000 4.7000 1.4000**

**Final cluster centers:**

**5.0057 3.3604 1.5623 0.2887**

**6.3010 2.8866 4.9588 1.6959**

**#(K = 2, T = 0.10) cluster 1: 53 cluster 2: 97**

**Confusion Matrix:**

**| cluster 1 | cluster 2**

**---------------------------**

**A | 50 | 0**

**---------------------------**

**B | 3 | 47**

**---------------------------**

**C | 0 | 50**

**---------------------------**

**Iteration Number : 4**

**Initial cluster centers:**

**5.1000 3.5000 1.4000 0.2000**

**7.0000 3.2000 4.7000 1.4000**

**6.3000 3.3000 6.0000 2.5000**

**Final cluster centers:**

**5.0060 3.4180 1.4640 0.2440**

**5.9016 2.7484 4.3935 1.4339**

**6.8500 3.0737 5.7421 2.0711**

**#(K = 3, T = 0.01) cluster 1: 50 cluster 2: 62 cluster 3: 38**

**Confusion Matrix:**

**| cluster 1 | cluster 2 | cluster 3**

**-----------------------------------------**

**A | 50 | 0 | 0**

**-----------------------------------------**

**B | 0 | 48 | 2**

**-----------------------------------------**

**C | 0 | 14 | 36**

**-----------------------------------------**

**Iteration Number : 3**

**Initial cluster centers:**

**5.1000 3.5000 1.4000 0.2000**

**7.0000 3.2000 4.7000 1.4000**

**6.3000 3.3000 6.0000 2.5000**

**Final cluster centers:**

**5.0060 3.4180 1.4640 0.2440**

**5.9194 2.7532 4.3903 1.4194**

**6.8211 3.0658 5.7474 2.0947**

**#(K = 3, T = 0.10) cluster 1: 50 cluster 2: 62 cluster 3: 38**

**Confusion Matrix:**

**| cluster 1 | cluster 2 | cluster 3**

**-----------------------------------------**

**A | 50 | 0 | 0**

**-----------------------------------------**

**B | 0 | 48 | 2**

**-----------------------------------------**

**C | 0 | 14 | 36**

**-----------------------------------------**

**Iteration Number : 6**

**Initial cluster centers:**

**5.1000 3.5000 1.4000 0.2000**

**7.0000 3.2000 4.7000 1.4000**

**6.3000 3.3000 6.0000 2.5000**

**5.8000 2.7000 5.1000 1.9000**

**Final cluster centers:**

**5.0060 3.4180 1.4640 0.2440**

**6.2525 2.8550 4.8150 1.6250**

**6.9125 3.1000 5.8469 2.1312**

**5.5321 2.6357 3.9607 1.2286**

**#(K = 4, T = 0.01) cluster 1: 50 cluster 2: 40 cluster 3: 32 cluster 4: 28**

**Confusion Matrix:**

**| cluster 1 | cluster 2 | cluster 3 | cluster 4**

**-------------------------------------------------------**

**A | 50 | 0 | 0 | 0**

**-------------------------------------------------------**

**B | 0 | 23 | 0 | 27**

**-------------------------------------------------------**

**C | 0 | 17 | 32 | 1**

**-------------------------------------------------------**

**Iteration Number : 5**

**Initial cluster centers:**

**5.1000 3.5000 1.4000 0.2000**

**7.0000 3.2000 4.7000 1.4000**

**6.3000 3.3000 6.0000 2.5000**

**5.8000 2.7000 5.1000 1.9000**

**Final cluster centers:**

**5.0060 3.4180 1.4640 0.2440**

**6.2541 2.8865 4.8486 1.6459**

**6.9125 3.1000 5.8469 2.1312**

**5.6000 2.6194 4.0032 1.2419**

**#(K = 4, T = 0.10) cluster 1: 50 cluster 2: 40 cluster 3: 32 cluster 4: 28**

**Confusion Matrix:**

**| cluster 1 | cluster 2 | cluster 3 | cluster 4**

**-------------------------------------------------------**

**A | 50 | 0 | 0 | 0**

**-------------------------------------------------------**

**B | 0 | 23 | 0 | 27**

**-------------------------------------------------------**

**C | 0 | 17 | 32 | 1**

**-------------------------------------------------------**