Assignment03

October 4, 2018

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- Description: implement k-means algorithm, explain and show the result
- github: https://github.com/mydream757/Computer_Vision

1. Import liabraries and define class

- import needed libraries.

```
In [1]: import math
        from random import *
        import matplotlib
        import matplotlib.pyplot as plt
```

- define class to construct points(x, y)

```
In [2]: class point:
            x = 0
            y = 0
            label = -1   #initial value is -1, 0 to k-1 is valid
            dist = []
            def initDist(self,k):
                self.dist = [0 for i in range(k)]
            def assignLabel(self):
                self.label = self.dist.index(min(self.dist))
            def __init__(self,x,y):
                self.x=x
                self.y=y
            def printAll(self):
                print(self.x, self.y, self.label)
                print(self.dist)
```

2. Define methods

- generate initial centroids randomly

```
In [3]: def generatePointCluster(min,max,k):
            #set seed for random
```

```
        #containers of clusters
        points = []
        #generate labels as many as numberOfClusters
        for i in range(k):
            seed()
            #The range of coordinates is preset: x[0:100] y[0:100]
            p = point(randrange(min,max,1),randrange(min,max,1))
            points.append(p)
        return points
```

- I use input data(=points) from data.txt file.
- generate input data and save to data.txt file.

```
In [4]: def writeRandomPoints(min,max,numberOfPoints,filename):
        f = open(filename,'w')
        x = []
        y = []
        for i in range(numberOfPoints):
            seed()
            tx = str(randrange(min,max,1))
            ty = str(randrange(min,max,1))
            txt = tx+" "+ty+"\n"
            f.writelines(txt)
        f.close()
```

- this reads data from data.txt. so, I don't need to generate data on each execution.

```
In [5]: def readFromText(filename):
        f = open(filename,'r')
        points = []
        while True:
            line = f.readline()
            if not line: break
            x, y = line.split()
            p = point(int(x),int(y))
            points.append(p)

        f.close()
        return points
```

- compute distance between two points. $d = \sqrt{(x_a - x_b)^2 + (y_a - y_b)^2}$

```
In [6]: def computeDistance(pA, pB):
        pow = math.pow((pA.x - pB.x),2) + math.pow((pA.y - pB.y),2)
        distance = math.sqrt(pow)
        return distance
```

- compute energy at i-iteration. $V = \frac{1}{N}\sum_{k=1}^{K}\sum_{n=1}^{N} r_{nk}\|X_n - c_k\|^2$

```
In [7]: def computeEnergy(points, clusters):
            sum = 0
            for k in range(len(clusters)):
                for i in range(len(points)):
                    if points[i].label == k:
                        sum = sum + math.pow(computeDistance(points[i],clusters[k]),2)
            return sum/len(points)
```

- compute centroid c_k.

```
In [8]: def computeCentroid(points, clusters):
            centroids = []
            for k in range(len(clusters)):
                count = 0
                sumX = 0
                sumY = 0
                for i in range(len(points)):
                    if points[i].label == k:
                        sumX = sumX + points[i].x
                        sumY = sumY + points[i].y
                        count = count + 1
                if count != 0:
                    centroid = point(sumX/count, sumY/count)
                else:
                    centroid = clusters[k]
                centroids.append(centroid)
            return centroids
```

- loop condition is "label change of points".
- if no change, loop stops.

```
In [9]: def checkChangeLabel(previous,current):
                for i in range(len(previous)):
                    if previous[i]!=current[i]:
                        return True
                return False
```

- make the list of labels. the index of the list is same with the index of the points list.

```
In [10]: def makeLabelList(points):
             Labels = []
             for i in range(len(points)):
                 Labels.append(points[i].label)
             return Labels
```

- using the computed distances, tagging label on the points

```
In [11]: def initializeLabel(points,clusters):
             for i in range(len(points)):
```

```
            points[i].initDist(len(clusters))
            for k in range(len(clusters)):
                points[i].dist[k] = computeDistance(clusters[k],points[i])
            points[i].assignLabel()       #tag labels to points
```

- list is of (x, y)
- seperate it to x list and y list to draw plot.

```
In [12]: def separatePointsToXY(points,indexOfCluster):
             x = []
             y = []
             for i in range(len(points)):
                 if points[i].label == indexOfCluster:
                     x.append(points[i].x)
                     y.append(points[i].y)
             return [x,y]
```

3. Execution and get result

- execute func. writeRandomPoints(,,,) if there is no input data.

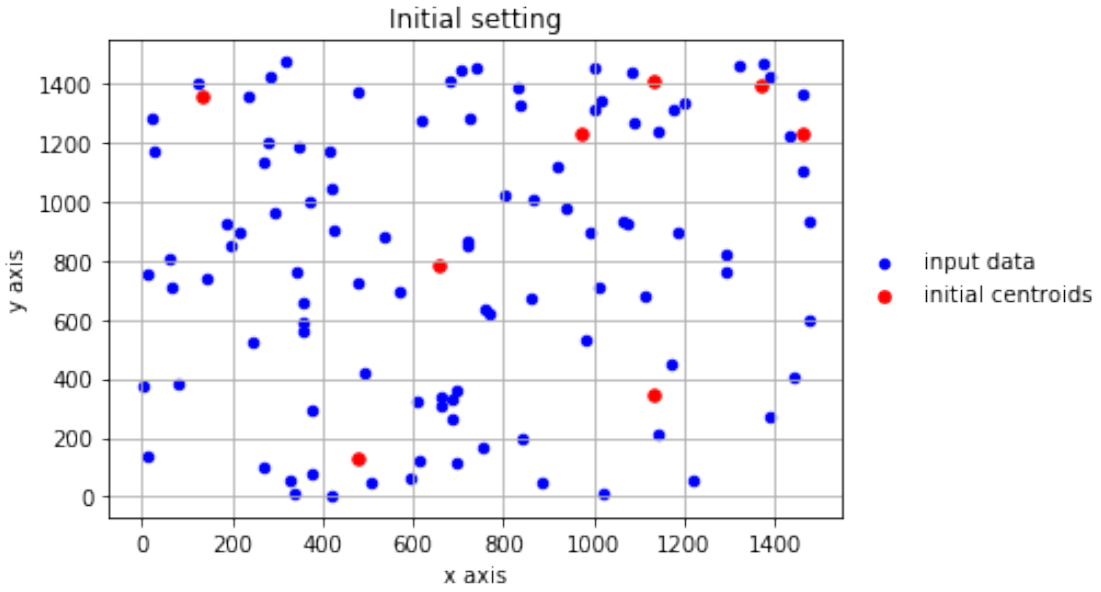
```
In [13]: #writeRandomPoints(0,1500,100,"data.txt")       #generate data set and save as .txt
```

- read data(=points) from text file and generate initial centroids

```
In [14]: ######  initial setting  ######
         points = readFromText("data.txt")           #initialize data from .txt file
         Px,Py = separatePointsToXY(points,-1)
         centroids = generatePointCluster(0,1500,8)     #generate initial centroids randomly
         Cx,Cy = separatePointsToXY(centroids,-1)
```

- figure the initial set. scattered data and centroids

```
In [15]: fig = plt.figure()
         plt.scatter(Px,Py,color='b',marker='o',s=20,label='input data')
         plt.scatter(Cx,Cy,color='r',marker='o',s=30,label='initial centroids')
         plt.xlabel('x axis')
         plt.ylabel('y axis')
         plt.title('Initial setting')
         plt.legend(loc='center left', bbox_to_anchor=(1.0, 0.5),frameon=False)
         plt.grid(True)
         plt.show()
```



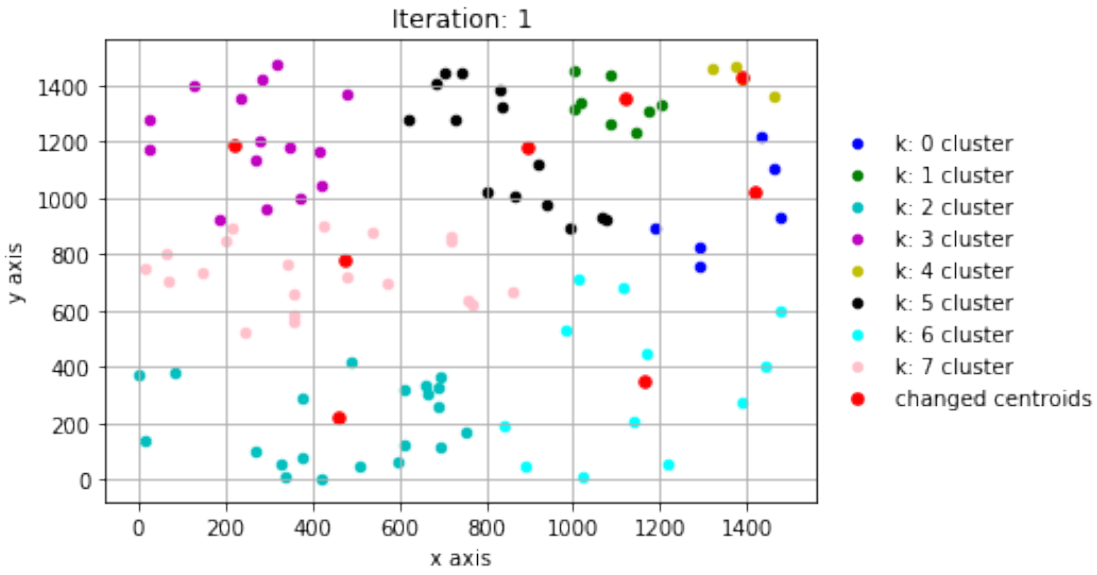
- save label list before initializing label
- initialize label
- save label list after the lnitialization
- the two list are used to check loop condition

```
In [16]: previous = makeLabelList(points)          #save initial label list
         initializeLabel(points,centroids)        #initialize Label
         current = makeLabelList(points)         #after assign label, make label list
```

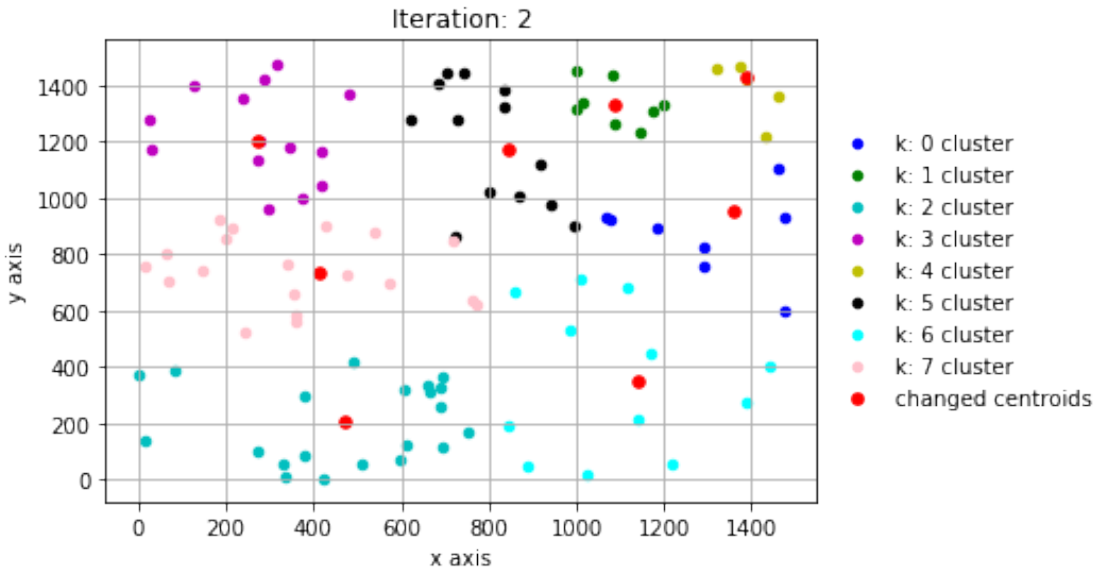
- loop the steps.
  - compute centroids.
  - tag labels to points.
  - condition check. if there is no change, loop stops
- graph the result of iteration.

```
In [17]: ######  loop clustering  ######
         count = 0
         while checkChangeLabel(previous,current):  #no change, loop stops
             count = count + 1
             previous = current                      #save the labels list
             nextCentroids = computeCentroid(points, centroids) #get new centroids
             initializeLabel(points, nextCentroids)   #tag labels
             current = makeLabelList(points)         #get labels list
             centroids = nextCentroids
             energy = computeEnergy(points, nextCentroids)  #compute energy
             xList = []
```

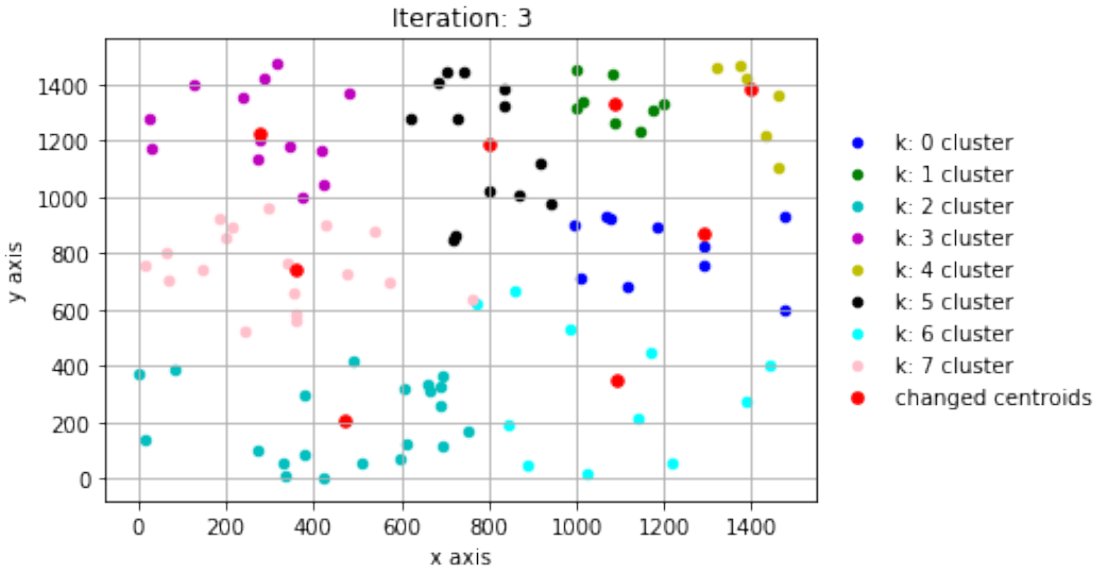
```
yList = []
fig = plt.figure()
for i in range(len(centroids)):
    x,y = separatePointsToXY(points,i)
    xList.append(x)
    yList.append(y)
    color = ['b','g','c','m','y','k','aqua','pink','purple']
    label = "k: "+str(i)+" cluster"
    plt.scatter(xList[i],yList[i],color=color[i],marker='o',s=20,label=label)
Cx,Cy = separatePointsToXY(centroids,-1)
plt.scatter(Cx,Cy,color='r',marker='o',s=30,label='changed centroids')
title = "Iteration: " + str(count)
plt.xlabel('x axis')
plt.ylabel('y axis')
plt.title(title)
plt.legend(loc='center left', bbox_to_anchor=(1.0, 0.5),frameon=False)
plt.grid(True)
plt.show()
print("Energy of iteration %d"%count,"%f"%energy,"\n")
```



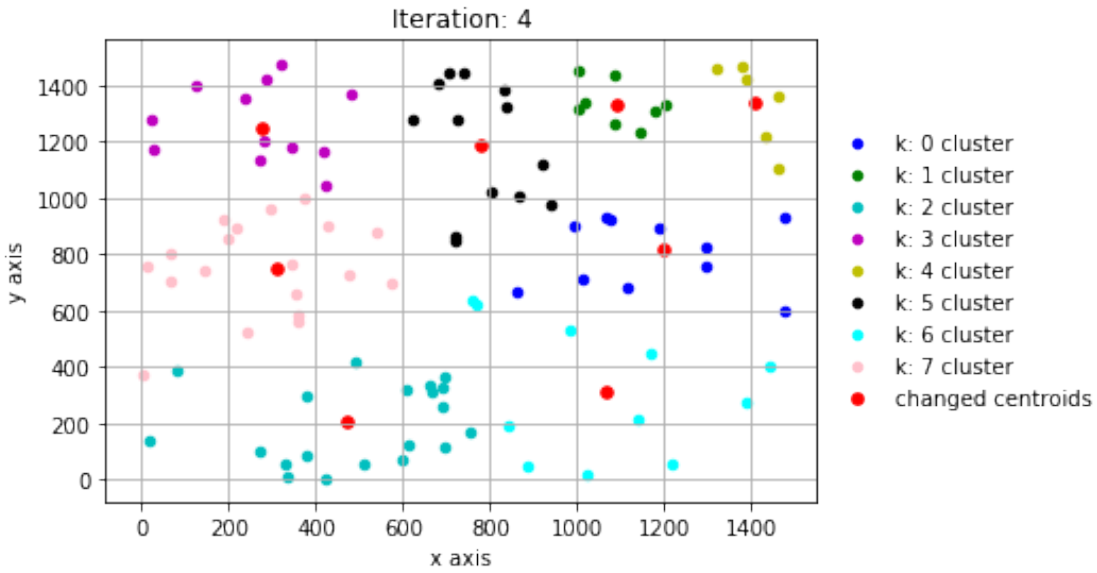

```
Energy of iteration 1 63013.808214
```



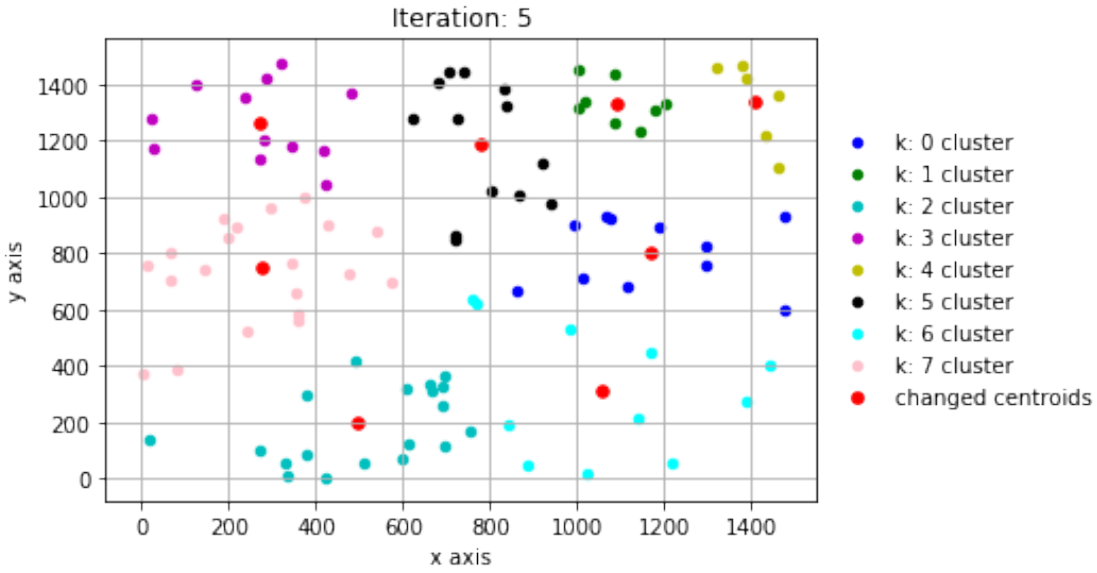
Energy of iteration 2 58725.672532



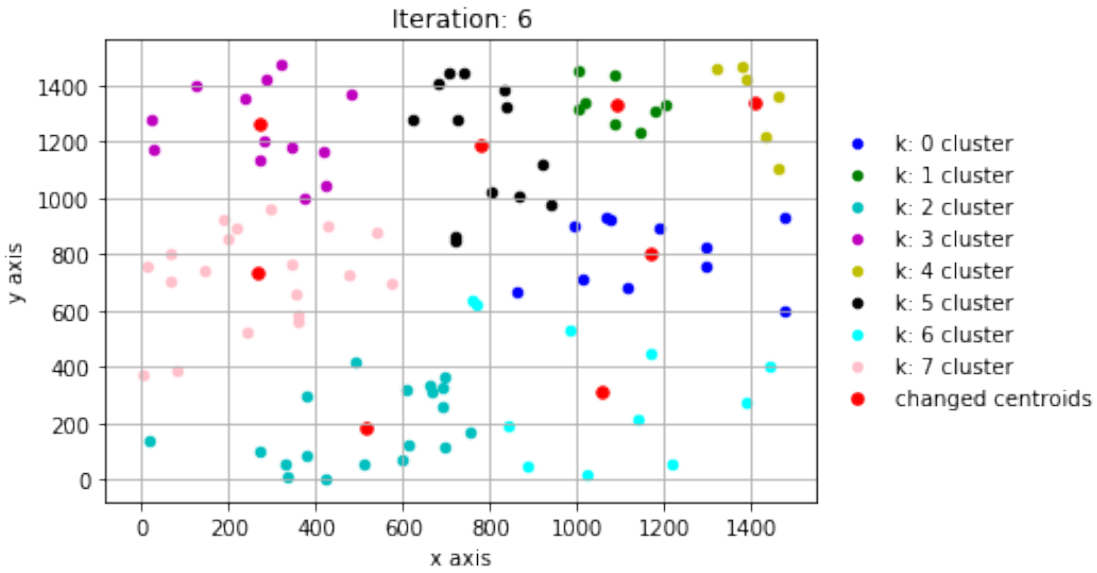
Energy of iteration 3 54997.849642



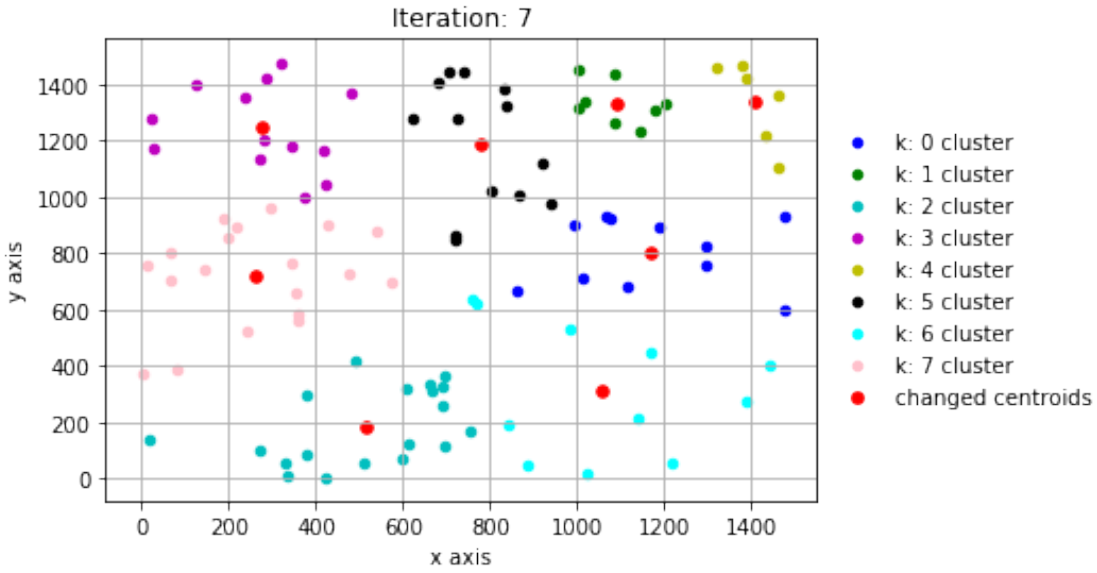
Energy of iteration 4 52291.431388



Energy of iteration 5 51410.284238



Energy of iteration 6 51192.842029



Energy of iteration 7 51086.954682