ATHENS UNIVERSITY OF ECONOMICS AND BUSINESS

K-Means clustering algorithm in MapReduce

Authors:
Vaggelis Malandrakis
Kleio Fragkedaki

Course: Big Data Management Systems

Professor: Damianos Chatziantoniou

Department of Management Science and Technology

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2.1 createDataset.py

We created a text file, containing more than 1M data points in the form of (x, y), where x and y are real numbers. The generation of was biased toward the creation of three clusters. In other words, we chose randomly three centers (10, 25), (2, -9) and (-15, -35) and then, we generated the rest of the points around these, using some random distance following a skewed distribution.

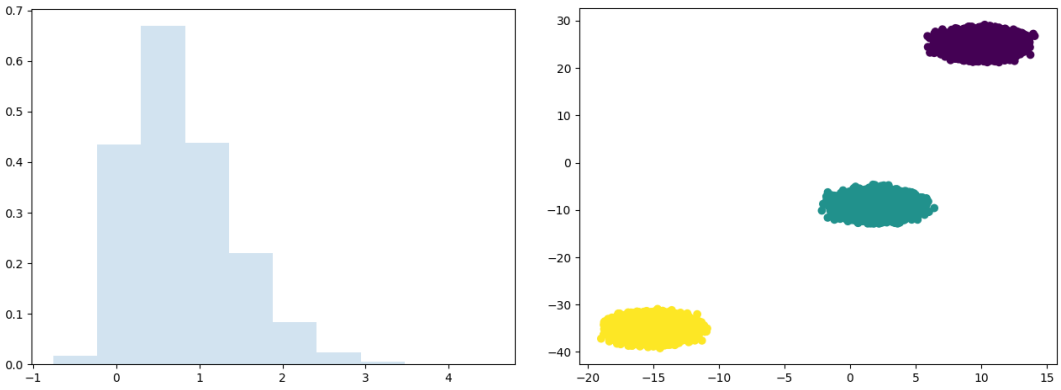
For this purpose we first found distances by using scipy.stats.skewnorm library and then we used these distance to choose random points as shown bellow.

```
1  from scipy.stats import skewnorm
2  import numpy as np
3  import matplotlib.pyplot as plt
4  import pandas as pd
5  from random import random, uniform
6  from math import sqrt, pow
7
8
9  # get random points that follows skew distribution and
10 # use them as distance
11 def skew():
12
13     fig, ax = plt.subplots(1, 1) # This function creates
                  # a figure and a grid of subplots
14
15     a = 5 # skewness parameter, when a = 0 the
16           # distribution is identical to a normal distribution
17
18     d = skewnorm.rvs(a, size=350000)
19
20      # histogram of numbers generated
21     plt.show()
22     ax.hist(d, density=True, histtype='stepfilled', alpha=0.2)
23
24     # return all the numbers generated with skew distribution
25     return d
26
27
28 # get random point from a circle that has as center
29 # given centroid and as radius the distance found in
30 # skew() function
```

```
31 def get_random_point(x, y, cluster):
32
33     array = []
34     distance = skew()
35
36     for d in distance:
37         while True:
38         angle = random() * math.pi * 2
39         x1 = x + math.cos (angle ) * d
40         y1 = y + math.sin (angle ) * d
41
42         if [x1, y1, cluster] not in array:
43             print('yeah')
44             break # if the pair of (x1,y1) exist find another pair
       of (x1,y1)
45
46         array.append([x1, y1, cluster])
47         print(x1, y1, cluster, len(array))
48
49     return array
50
51
52 if __name__ == "__main__":
53
54     # pre-define three centers for clusters
55     centers = [[10, 25], [2, -9], [-15, -35]]
56     data = [] # array with all the final data
57
58     for center in centers:
59         # concat the results of these
60         # three clusters in one array
61         data = data + get_random_point ( center[0], center[1],
       centers.index(center)) print(len(data))
62         print(data)
63
64     plt.scatter([item[0] for item in data], [item[1] for item in
       data], c=[item[2] for item in data])
65     plt.show()
66
67     df = pd.DataFrame(data)
68     df.drop(df.columns[[2]], axis=1, inplace=True)
69     df.to_csv("datasetNew", header=False, index= False, sep="," )
```

2.2 Plot of data points

The distances were generated with the use of skew() function and follow skew distribution as left image reveals.
The data points that were generated are shown in the right image.



Chapter 3

K-means Clustering Algorithm

K-means algorithm is the most well-known and commonly used clustering method. It takes the input parameter, k, and partitions a set of n objects into k clusters so that similarity of points outside cluster is high. Cluster similarity is measured according to the mean.

3.1 Instructions for running k-means in Cloudera

Before running k-means algorithm, we need to follow some steps. First of all, *download MapReduce folder* from our gitHub repository.
MapReduce folder includes six main files which are mapper.py, reducer.py, reader.py, run.sh, centroids.txt, dataset.txt. As regards, centroids.txt file includes three points in the shape of (x,y), that k-means algorithm gets as initial centroids. These points were selected in a way that k-means to be executed more than one times, but less than five so as the whole process not to be that long. On the other hand, the dataset.txt file is the one that was created in the previous chapter.These six files are necessary for k-means to be implemented and they are needed to be in the same folder.
After that, you need to enter MapReduce folder from terminal by using the command cd */path-to-MapReduce-Folder/MapReduce*. Secondly, you need to *install Python3 in Cloudera*. For this purpose, you can read **Python3Cloudera**.
In addition, we need to create a folder named "testMapReduce" in hdfs and parse dataset.txt file inside this folder. In order to create a folder in hdfs you can execute *hadoop fs –mkdir /testMapReduce* and to parse dataset *hadoop fs –copyFromLocal dataset.txt /testMapReduce/dataset.txt* command.
Finally, to run k-means algorithm you need to type *sh run.sh*.

3.2 run.sh & reader.py

In order to run k-means algorithm a lot of times, we created a bash shell script that starts mapreduce in hadoop with different cendroid.txt files every time it is running. This shell script ends when previous centroids minus newly generated ones have distance less than one (check reader.py script bellow).

More specifically, i variable is used for the creation of different outputs in hdfs and the idea of this script is to change centroid.txt file in local folder with the one generated as output and saved in hdfs from mapreduce process.

3.2.1 run.sh

```
#!/bin/bash

i=1
while :
do
    hadoop jar ../../../../usr/lib/hadoop-mapreduce/hadoop-
    streaming.jar -file centroids.txt -file ./mapper.py -mapper
    ./mapper.py -file ./reducer.py -reducer ./reducer.py -input
    /testMapReduce/dataset -output /testMapReduce/mapreduce-
    output$i

    rm -f centroids1.txt

    hadoop fs -copyToLocal /testMapReduce/mapreduce-output$i/part
    -00000 centroids1.txt

    seeiftrue=‘python reader.py‘
    if [ $seeiftrue = 1 ]
    then
        rm centroids.txt
        hadoop fs -copyToLocal /testMapReduce/mapreduce-output$i/
    part-00000 centroids.txt
        break
    else
        rm centroids.txt
        hadoop fs -copyToLocal /testMapReduce/mapreduce-output$i/
    part-00000 centroids.txt
    fi
    i=$((i+1))
done
```

3.2.2 reader.py

```
__authors__ = "Vaggelis Malandrakis, KLeio Fragkedaki"

from mapper import getCentroids

#check if distance of centroids and centroids1 is less than 1
def checkCentroidsDistance(centroids, centroids1):
    f1x = abs(centroids[0][0] - centroids1[0][0])<1
    f1y = abs(centroids[0][1] - centroids1[0][1])<1
    f2x = abs(centroids[1][0] - centroids1[1][0])<1
    f2y = abs(centroids[1][1] - centroids1[1][1])<1
    f3x = abs(centroids[2][0] - centroids1[2][0])<1
    f3y = abs(centroids[2][1] - centroids1[2][1])<1

    if f1x and f1y and f2x and f2y and f3x and f3y:
        print(1)
    else:
        print(0)

if __name__ == "__main__":
    centroids = getCentroids('centroids.txt')
    centroids1 = getCentroids('centroids1.txt')

    checkCentroidsDistance(centroids, centroids1)
```

3.3 MapReduce

To implement mapreduce in hadoop, we created two files, mapper.py and reducer.py, as described in **MapReducePythonPaper1** and **MapReducePythonPaper2**.

3.3.1 mapper.py

A regards mapper, mapper's job is to create the clusters. More specifically, every point of the dataset is matching with one of the centroids that are in the centroid.txt file at the time. So, in the end clusters are generated, which in our case are three in number.

```
#!/usr/bin/env python
"""mapper.py"""

__authors__ = "Vaggelis Malandrakis, KLeio Fragkedaki"

import sys
from math import sqrt

# get initial centroids from a txt file and add them in an array
def getCentroids(filepath):
    centroids = []

    with open(filepath) as fp:
        line = fp.readline()
        while line:
            if line:
                try:
                    line = line.strip()
                    cord = line.split(', ')
                    # cord[0] is x and cord[1] is y point of a centroid
                    centroids.append([float(cord[0]), float(cord[1])])
                except:
                    break
            else:
                break

        line = fp.readline()

    fp.close()
    return centroids

# create clusters based on initial centroids
def createClusters(centroids):

    #read dataset.txt
    for line in sys.stdin:
        line = line.strip()
        cord = line.split(',')
        min_dist = 100000000000000
        index = -1
```

```
41
42          for centroid in centroids:
43              try:
44                  cord[0] = float(cord[0])
45                  cord[1] = float(cord[1])
46              except ValueError:
47                  # float was not a number, so silently
48                  # ignore/discard this line
49                  continue
50
51              # euclidian distance from every point of dataset
52              # to every centroid
53              cur_dist = sqrt(pow(cord[0] - centroid[0], 2) + pow(
    cord[1] - centroid[1], 2))
54
55              # find the centroid which is closer to the point
56              if cur_dist <= min_dist:
57                  min_dist = cur_dist
58                  index = centroids.index(centroid)
59
60          var = "%s\t%s\t%s" % (index, cord[0], cord[1])
61          print(var)
62
63 if __name__ == "__main__":
64      centroids = getCentroids('centroids.txt')
65      createClusters(centroids)
```

3.3.2 reducer.py

On the other hand, reducer's job is to find the average centroids from the newly given cluster map . More specifically, every point of each cluster is being adding in order the center of this cluster to be found. So, in the end new centroids of each cluster are generated.

```
1  #!/usr/bin/env python
2  """reducer.py"""
3
4  __authors__ = "Vaggelis Malandrakis, KLeio Fragkedaki"
5
6  import sys
7
8  def calculateNewCentroids():
9      current_centroid = None
10     sum_x = 0
11     sum_y = 0
12     count = 0
13
14     # input comes from STDIN
15     for line in sys.stdin:
16
17     # parse the input of mapper.py
18     centroid_index, x, y = line.split('\t')
19
20     # convert x and y (currently a string) to float
```

```
21      try:
22          x = float(x)
23          y = float(y)
24      except ValueError:
25          # float was not a number, so silently
26          # ignore/discard this line
27          continue
28
29      # this IF-switch only works because Hadoop sorts map output
30      # by key (here: word) before it is passed to the reducer
31      if current_centroid == centroid_index:
32          count += 1
33          sum_x += x
34          sum_y += y
35      else:
36          if count != 0:
37              # print the average of every cluster to get
38              # new centroids
39              print(str(sum_x / count) + ", " + str(sum_y / count))
40
41          current_centroid = centroid_index
42          sum_x = x
43          sum_y = y
44          count = 1
45
46      # print last cluster's centroids
47      if current_centroid == centroid_index and count != 0:
48          print(str(sum_x / count) + ", " + str(sum_y / count))
49
50  if __name__ == "__main__":
51      calculateNewCentroids()
```

3.4 Plot Representation

References

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