

INFO 4300: HW IV

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1 Introduction

The purpose of this assignment was to implement the K-Means Clustering Algorithm and perform the algorithm on a corpus of 90 documents in order to observe the effects of varied seed documents and varied number of clusters.

2 Algorithms and Datastructures

- **Coordinate** - The **Coordinate** object inherits from Ruby's **Array** class and adds a few new methods and properties.
 - **data** - the payload.
 - **cluster** - the **Cluster** this **Coordinate** belongs to.
 - **Coordinate.centroid** - class-level method that takes a bunch of **Coordinates** and computes the centroid of all of them.
 - **add** - adds two **Coordinates**.
 - **distance_to** - calculates the distance between two **Coordinates**.
 - **norm** - takes the norm of the **Coordinate**.
 - **sphere!** - destructively spheres the **Coordinate**.
- **Cluster** - models a cluster, essentially just a big collection of **Coordinates**, but with a few extra pieces of functionality.
 - **elements** - the elements that belong to this **Cluster**.
 - **centroid** - the centroid of this **Cluster**.
 - **distance_to** - the distance between the centroid of this **Cluster** and the given **Coordinate**.
 - **recalculate_centroid** - recalculates the centroid of the **Cluster**.
 - **add** - adds the given **Coordinate** to this **Cluster**.
 - **remove** - removes the given **Coordinate** from this **Cluster**.
 - **residual_sum_squared** - computes and returns the residual sum squared of all the **Coordinates** in this **Cluster**.
 - **title** - finds the **Coordinate** closest to the centroid of the cluster and returns its **.data** property.

- **KMeans** - this is the object that actually performs the kmeans calculations. Simply initialize it with an array of **Coordinates** and a k-value and then call **compute**. You can then print it out and the **to_s** method will show each cluster with it residual sum squared value, a “title” which is just the closest document to the centroid, and a listing of the documents in the cluster with snippets from the documents.

3 Experiments

The first experiment was to run the algorithm on the 90-document corpus with a bisection (i.e. $k = 2$). Seed documents were chosen at random for each run and residual sum of squares was computed for each run of the algorithm. Below are the results of running the algorithm 100 times. Figure 1. shows a histogram of RSS values by frequency. Table 1. shows the statistics for the same run.

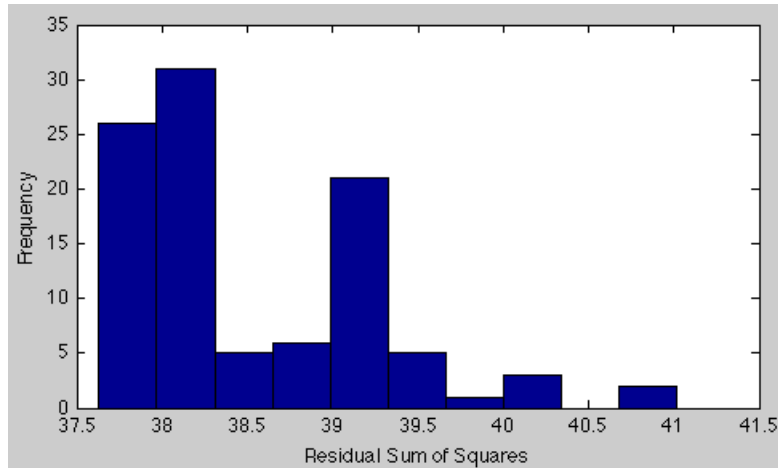


Figure 1: Histogram for Residual Sum of Squares for Bisecting K-Means

mean	38.5143
median	38.2318
mode	38.1501
std. dev.	0.7458

Table 1: Statistics for Residual Sum of Squares for Bisecting K-Means

The next experiment was to run the K-Means algorithm, varying the value of k . Below, in Figure 2., we see the values of RSS decreasing with increased k -value. There is a noticeable elbow around the value $k = 6$.

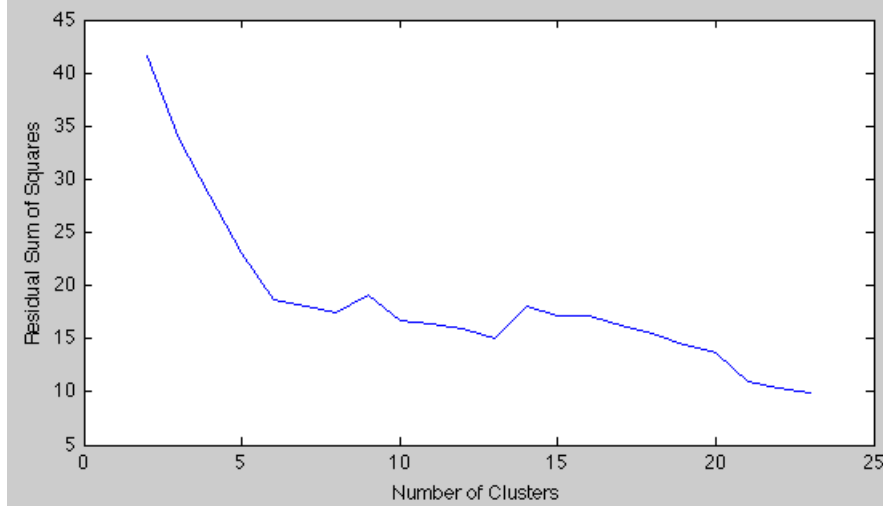


Figure 2: RSS Values of K-Means for Various Values of K

Finally, we observe multiple trials (3) for a few select values of k (2, 3, 5, 10 and 15). The major observations from this experiment are that the RSS is decreasing and that the implementation of the algorithm seems stable (the RSS values for a given k -value do not vary wildly, but are instead tightly-clustered with low standard deviation).

K	Trial 1	Trial 2	Trial 3
2	38.0832979610152	38.1501247211226	38.1501247211226
3	32.4422541652054	32.7308133672365	31.8585706358035
5	25.3651463086159	26.1058894419931	24.0089613268461
10	16.0332337390105	16.5255622335598	16.4953835016395
15	14.4289801639378	13.1821955003854	14.3464196487286

Table 2: Trials of K-Means for Various Values of K

topic	document	snippet
biology	file14.txt	Insects sense danger on mammals breath
space	file03.txt	NASA's First Robotic Crew Member to Tweet
internet	file25.txt	Will Facebook face Apple in trying

Table 3: Topic Labels for K=3 Clustering

Despite the elbow in Figure 2., indicating that the ideal value for k is about 6, my own experiment and attempts at labeling the clusters seem to indicate that there are roughly three clusters: biology, space, and internet technology.

I started by computing the document that is closest to the centroids for each cluster in a $k = 6$ clustering. I then visually inspected the representative documents for each cluster and attempted to come up with a keyword or two that would describe each cluster. After attempting this for $k = 6$, I noticed that there appeared to be only 3 clearly distinguishable clusters, so I repeated the experiment with $k = 3$, this time modifying my code to output some snippets of the documents in each cluster to confirm my hypothesis.

4 Instructions for Running

The program may be run by typing `ruby main.rb` from the root of the project folder. Sample output is shown below. For the sake of brevity, not all data is shown here. Ellipses between the cluster listings indicate missing rows.

```
1  $ ruby main.rb
2  computing tf.idf matrix...
3  ==
4  cluster (7.04160378065062) file23.txt: 10 9:12 AM PDT
   Microsofts IE9 look leaks to the We:
5  file21.txt: 10 5:01 PM PDT USA Today gets makeover for mobile
6  file22.txt: 10 4:00 AM PDT Broadcasters defend push for mandat
7  file23.txt: 10 9:12 AM PDT Microsofts IE9 look leaks to the We
8  ...
9  cluster (7.48513442049123) file25.txt: 10 3:17 PM PDT Will
   Facebook face Apple in trying :
10 file03.txt:  NASAS FIRST ROBOTIC CREW MEMBER TO TWEET FROM SPA
11 file05.txt: NASA SEEKS INNOVATIVE IDEAS ABOUT HUMAN HEALTH CHA
12 file06.txt: SPACE COAST TASK FORCE DELIVERS ECONOMIC STRATEGIE
13 ...
14 cluster (18.7845723220052) file14.txt: 0 05:11 PM Insects
   sense danger on mammals breath :
15 file02.txt:  NASA TELESCOPE FINDS ELUSIVE BUCKYBALLS IN SPACE
16 file01.txt:  MESSENGER SPACECRAFT REVEALS NEW INFORMATION ABOU
17 file04.txt: NASA AND ESAS FIRST JOINT MISSION TO MARS SELECTS
```

All software was tested on `snoopy.cs.cornell.edu`. A local version of `ruby 1.8.8dev (2010-10-30) [i686-linux]` was installed at `/home/jrm425/usr/local/bin/ruby`. A local version of `rubygems 1.3.7` was installed at `/home/jrm425/usr/local/bin/gem`.

5 References

- Formulas were used as per definition from the class website: <http://www.infosci.cornell.edu/Courses/info4300/2010fa/index.html>
- I collaborated with Karan Kurani for this project.