

### Stage3 - The Implementation Stage.

- Novelty

Users can already find tweets related to their topic by searching for keywords or hashtags related to their topic. However, this project will allow users to find tweets that are both semantically and structurally similar to their tweets, not just related to the topic of those tweets. Users will also be recommended hashtags, such as those of ‘intermediate popularity’, which users do not include in their tweets, but which are topically related to their tweets.

- Usefulness

This project will allow users to find which tweets and hashtags are similar to their own tweets. Thus, this project aims to bridge different Twitter communities by finding ‘hidden’ connections between them based on different measures of similarity. This will facilitate communication between previously isolated communities.

- Development Environment

This project is developed with Python language and the Linux operating system.

The deliverables for this stage include the following items:

#### **Section 1. Evaluation of tweet dissimilarity by Extended Edit Distance integrated Word2Vec (EDW), and clustering by the distance value (Implemented and written by Lingfei Zeng))**

- Sample small data snippet.

The input data are plain text of tweet contents. The plain text can be converted by Json file scraped from the webpage. In this section, the sample data are the scraped tweets in csv file, downloaded from <http://followthehashtag.com/datasets/>, named "USA Geolocated tweets". It contains 20,000 tweets and here is the sample of the data are in Table 1:

- Sample small output

In the distance evaluation job, the output of the system is distance value of two tweets, ranging from 0 to 1 . After clustering by k-medoids or hierarchical clustering method, the output are the clusters of tweets.

- Working code

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```
# Dissimilarity evaluation algorithm Extended Edit  
# Distance integrated Word2Vec (EDW)
```

```
def sentence_to_word(sentence):  
    sentence = re.sub("[^a-zA-Z]", " ", sentence.lower())
```

```

words = WORD.findall(sentence)
return words

def edit_distance(s1, s2):
    words_1 = sentence_to_word(s1)
    words_2 = sentence_to_word(s2)

    m=len(words_1)+1
    n=len(words_2)+1

    tbl = {}
    bestMove={}
    for i in range(m):
        tbl[i,0]=i
        bestMove[i, 0] = 'D'

    for j in range(n):
        tbl[0,j]=j
        bestMove[0, j] = 'I'

    for i in range(1, m):
        for j in range(1, n):
            if words_1[i-1] == words_2[j-1]:
                cost = 0
                minVal = 100000000
                if tbl[i, j - 1] + 1 < minVal:
                    minVal = tbl[i, j - 1] + 1
                    bestMove[i, j] = 'D'
                if tbl[i - 1, j] + 1 < minVal:
                    minVal = tbl[i - 1, j] + 1
                    bestMove[i, j] = 'I'
                if tbl[i - 1, j - 1] + cost < minVal:
                    minVal = tbl[i - 1, j - 1] + cost
                    bestMove[i, j] = ''
            else:
                try:
                    word2vec_cost = 1 - model.similarity(
                        words_1[i - 1],
                        words_2[j - 1])
                except KeyError, e:
                    word2vec_cost = 1

            cost = 2*word2vec_cost

```

```

minVal = 100000000
if tbl[i, j - 1] + 1 < minVal:
    minVal = tbl[i, j - 1] + 1
    bestMove[i, j] = 'D'
if tbl[i - 1, j] + 1 < minVal:
    minVal = tbl[i - 1, j] + 1
    bestMove[i, j] = 'I'
if tbl[i - 1, j - 1] + cost < minVal:
    minVal = tbl[i - 1, j - 1] + cost
    bestMove[i, j] = 'R'

tbl[i, j] = minVal

iTmp = i
jTmp = j
counting = 0
while True:
    if bestMove[iTmp, jTmp] == 'R' or bestMove[iTmp, jTmp] == 'D':
        if bestMove[iTmp, jTmp] == 'R':
            counting += 1
            iTmp -= 1
            jTmp -= 1
        elif bestMove[iTmp, jTmp] == 'D':
            jTmp -= 1
        elif bestMove[iTmp, jTmp] == 'I':
            iTmp -= 1
    if iTmp == 0 or jTmp == 0:
        break

counting += max(m-1, n-1)
return tbl[i, j]/counting

```

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- Demo and sample findings

The performance of EDW algorithm is evaluated by published paired-wised benchmark data set [1] first. Several benchmarking paired sentences with different similarities were tested with our algorithm. The results together with the comparison of the similarities reported in the literature are shown in Table 2. Since the benchmarking uses different scale of core system, the table lists the levels of similarities of each sentence pairs directly. Besides are the distance score generated by EDW, ranging from 0-1, from least similar to identical. From the comparison we can see that the EDW calculated the distance between benchmarking sentences in high accuracy.

Table 1: Data Snippet

Index	Tweet contents
1	I'm at, @DunkinDonuts in Lithonia, GA <a href="https://t.co/d6IU15ig5J">https://t.co/d6IU15ig5J</a>
2	Cleared:, Closure on #US1 SB at South of Olden Ave
3	Want to, work in #Burlington, MA? View our latest opening: <a href="https://t.co/qwwWQt0DMj">https://t.co/qwwWQt0DMj</a> , #Healthcare #Job #Jobs #Hiring #CareerArc

Table 2: Distance score generated by EDW, compared with reported benchmarking

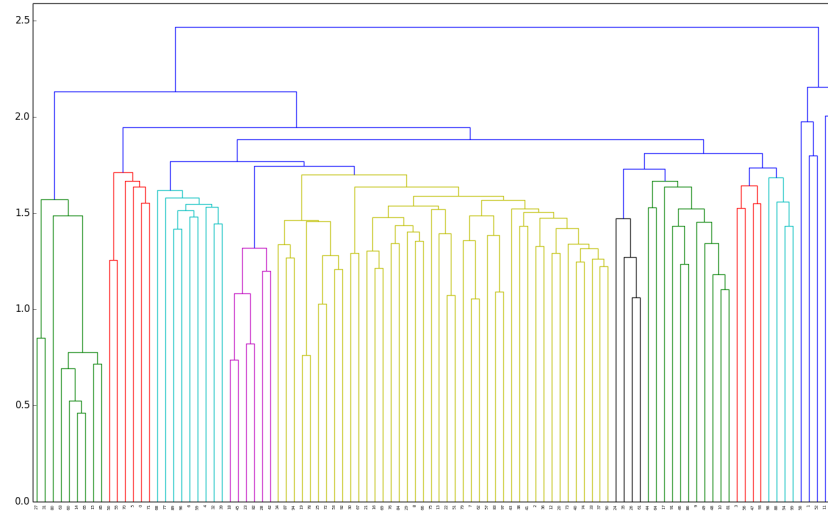
Sentence pair	Semantic similarities reported by [1]	Distance score by EDW
Midday is 12 o'clock in the middle of the day. Noon is 12 o'clock in the middle of the day.	Identical	0.081319882
A boy is a child who will grow up to be a man. A lad is a young man or boy.	Related	0.59221011
A hill is an area of land that is higher than the land that surrounds it. A mound of something is a large rounded pile of it.	Vaguely similar	0.76921332
Cord is strong, thick string. A smile is the expression that you have on your face when you are pleased or amused, or when you are being friendly.	Unrelated	0.91587261

Table 3: Sample result of tweet clusters

Tweet contents	Cluster label
I'm at, @DunkinDonuts in Lithonia, GA <a href="https://t.co/d6IU15ig5J">https://t.co/d6IU15ig5J</a>	0
I'm at, @InNOutBurger in Long Beach, CA <a href="https://t.co/uqmEomzVKZ">https://t.co/uqmEomzVKZ</a>	0
I'm at Home, <a href="https://t.co/fDCP5atErT">https://t.co/fDCP5atErT</a>	0
I'm at Los Angeles, International Airport (LAX) - @flylaxairport in Los Angeles, CA, <a href="https://t.co/rCVIJrXCMX">https://t.co/rCVIJrXCMX</a>	0
I'm at Twerk in, Horsham, PA <a href="https://t.co/VRmWIJssIC">https://t.co/VRmWIJssIC</a>	0
Cleared:, Closure on #US1 SB at South of Olden Ave	1
Cleared:, Incident on #I87NYSThruway NB at Exit 21 (I-87) - Catskill (Rte 23)	1
Want to, work in ? View our latest opening: <a href="https://t.co/47mSniYiPU">https://t.co/47mSniYiPU</a> #Hospitality, #Veterans #Job #Jobs #Hiring #CareerArc	2
Want to, work in #Burlington, MA? View our latest opening: <a href="https://t.co/qwwWQt0DMj">https://t.co/qwwWQt0DMj</a> , #Healthcare #Job #Jobs #Hiring #CareerArc	2
Want to, work in #Charlotte, NC? View our latest opening: <a href="https://t.co/nkrJjulisQ">https://t.co/nkrJjulisQ</a> , #BusinessMgmt #insurance #Job #Jobs #Hiring	2
Want to, work in #FALLSCHURCH, VA? View our latest opening: <a href="https://t.co/sgxNmVakQl">https://t.co/sgxNmVakQl</a> , #Healthcare #Job #Jobs #Hiring #CareerArc	2

Then using the tweet data set, a pair-wised distance matrix was generated based on the score calculated by EWD. This distance matrix was utilized to do the clustering with k-medoids or hierarchical clustering method. The functions are available in related Python packages Kmedoids and Scipy. For k-medoids method, the outputs are index of tweets in different clusters. For hierarchical clustering method, the outputs are tweet clusters and a dendrogram. A sample output by the k-medoids method were shown in the Table 3. The tweets have been grouped into 3 clusters and the similarities of tweets in the same clusters are very high. A sample output of dendrogram of 100 tweets generated by hierarchical clustering are shown in Figure 1.

Figure 1: Dendrogram generated by EDW and hierarchical clustering)



After clustering the tweets, we can also find the representative tweet in each clustering. The method is as follows: for each tweet in one cluster, sum the distance between it and every other tweets, and find the one tweet with the minimal summed distance. This tweet is the representative of this cluster. Thus we can find a representative for every cluster. Later, when user input a new tweet, it is compared with the representatives. Whichever cluster with the representative has the shortest distance with the new tweet, the cluster is the new tweet to be assigned to. Then if we would like to find similar tweets to the new tweets, we just need to compare every tweets in this cluster and return the highest hits. Since we can maintain a relative high number of clusters so the number of tweets in one cluster is limited (or else the classification would not be accurate), the computation time is small.

## Section 2. Evaluation of tweet similarity by TF-IDF based document2vec and Hierarchical Clustering (Implemented by Xunjie Zhu and written by Michael Lan)

- Sample Small Data Snippet (This is a subset 3 tweets out of thousands of tweets used)

211 : RT @KCONTV: Fans dancing in front of the @HondaCenter before the #BTSinAnaheim concert! #TWTinAnaheim #BTS <https://t.co/QAVet0uqYn>

212 : RT @BTS\_V\_sana: 02line(01)ARMY all #ARMY #BTSRT #RT <https://t.co/uL8yrSGBJB>  
213 : RT @bangtanitl: #BTS was mentioned on Kangnam Style, 170331 <https://t.co/qJ0IINaTrH>

- Sample Small Data Output

The word and paragraph vectors, along with the document-term frequency matrix, are huge, so we did not include them in Phase 3 write-up. Additionally, they are only intermediate outputs. The dendrogram of the clustering results is the final output, and a visual and description of it is given below the pipeline description in this section.

- Pipeline Description

Since it would be quite lengthy to include all the code used, only the hierarchical clustering algorithm code has been given at the end of this section. Also, the bipartite graph and Simrank code was completed but are not part of the main pipeline yet, so only a histogram of their output is given; the code is not included. The rest of the code can be given upon request, and may be included in the final report. The pipeline is briefly described:

The data crawler uses a listener to find new tweets that contain certain keywords or hashtags, collectively called a ‘filter’. To find tweets that are related to certain topics but do not necessarily contain the hashtags of those topics, we first gathered tweets containing initial keywords. New keywords, hashtags, and topics were found from in this first iteration of tweets, and were added to the filter. Then, we ran the data crawler again using this new filter, and repeated this multiple times. Essentially, we used previous iterations of keywords or hashtags to find new topics, and we only ran clustering on the tweets found in the final iteration. Each iteration is called a ‘generation’.

There were two separate methods we used to find new topics: 1) We took the 10 most frequent new, non-trivial keywords hashtags found in this first iteration of tweets and added them to the filter 2) We used LDA to find new topics. IE) Filter in Gen 1: music, concerts Filter in Gen 2: music, concerts, classical, metal Filter in Gen 3: music, concerts, classical, metal, bach

Later, the crawler and topic finding scripts will be deployed to a linux server to be run periodically. This will be implemented by crontab.

The pipeline is described as follows:

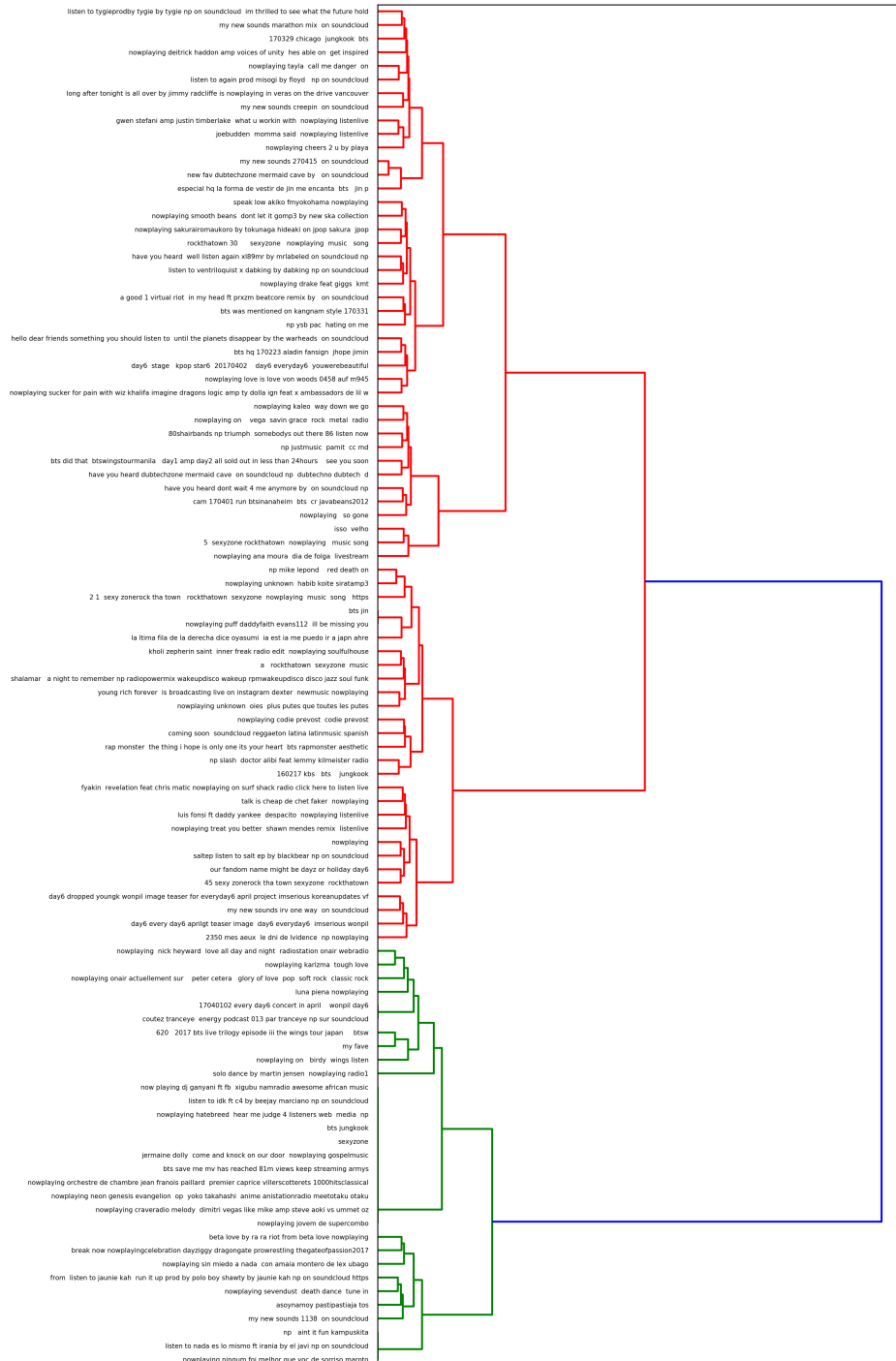
1. Start up a listener of incoming tweets. Uses the Tweepy library to connect to Twitter Streaming API. Outputs a JSON text file of data
2. Read a JSON text file and outputs a file of tweets
3. Use term frequency and latent dirichlet allocation respectively to find new topics from existing tweets

4. Read file of tweets and uses regular expressions to do some preprocessing
5. Train word vector and tf-idf weighted sum of word vector to form document vector. Computes similarity between tweets. Outputs word and paragraph vectors
6. Cluster the tweets into topics and outputs a dendrogram
  - Interesting findings in Dendrogram

Since there were thousands of tweets that were gathered, we created a dendrogram for 100 tweets. There appear to be two main groups, and within the red group, there were 4 main subgroups. This sample shows that our algorithms work. However, since we did not input in meaningful data yet, and since this dendrogram only shows 100 of thousands of tweets, we do not expect this sample to give meaningful results. Later, we will gather better data and perform an analysis.



Figure 2: Dendrogram generated by LDA and hierarchical clustering)



- Working Code

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```
class HierarchicalClusterer(object):
    def __init__(
        self,
        distance_matrix,
        linkage_function,
        minium_clusters=2):
        self.distance_matrix = distance_matrix
        self.linkage_function = linkage_function
        self.minium_clusters = minium_clusters

    def build_clusters(self):
        print 'a'

    def do_link_clustering(self, cluster_id_list, cluster_nodes):

        def small_big(first, second):
            if first < second else (second, first)

        def merge(cluster1,
                   cluster2,
                   distance,
                   cluster_ids,
                   cluster_nodes):
            cluster1, cluster2 = small_big(cluster1, cluster2)
            cluster_ids[cluster1].extend(cluster_ids[cluster2])
            cluster_ids[cluster2] = []
            node = Node()

            if cluster_nodes[cluster1]:
                node.left = cluster_nodes[cluster1]
                cluster_nodes[cluster1].parent = node
            else:
                node.left_instance = cluster1

            if cluster_nodes[cluster2]:
                node.right = cluster_nodes[cluster2]
                cluster_nodes[cluster2].parent = node
            else:
                node.right_instance = cluster2

            node.set_height(distance, distance)
            cluster_nodes[cluster1] = node

        length = self.distance_matrix.shape[0]
```

```

cluster_number = self.distance_matrix.shape[0]
distance_list = [
    ClusterPair(first,
        second,
        self.distance_matrix[first][second], 1, 1)
    for first in range(length) for second in range(first +
length)]

distance_queue = MyHeap(
    initial=distance_list,
    key=lambda x: x.distance)

while cluster_number - self.minium_clusters > 0:
    pair = distance_queue.pop()
    if not pair:
        break

    if not valid_pair(pair, cluster_id_list):
        continue

    merge(pair.cluster1, pair.cluster2,
        pair.distance, cluster_id_list, cluster_nodes)

    for index in range(length):
        if index != pair.cluster1 \
            and cluster_id_list[index]:
            cluster1, cluster2 = \
                small_big(cluster1, cluster2)

            new_distance = self.linkage_function(
                self.distance_matrix,
                cluster_id_list[smaller],
                cluster_id_list[bigger])

            distance_queue.push(ClusterPair(
                smaller,
                bigger,
                new_distance,
                len(cluster_id_list[smaller]),
                len(cluster_id_list[bigger])))

cluster_number -= 1

```

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### Section 3. Evaluation by SimRank (Implemented by Michael Lan)

This was written in Python 2.7, using the Sublime Text Editor. We gathered data, called ‘Dataset 8’, which belongs to 2 very different communities: Music

and Politics. This dataset uses the initial filter:

*#music, #concert, #politics, #trump, #russia, #brexit*

The Gaming hashtags #gaming, #gamers, #pc, and #xbox were also included, but they did not yield many tweets.

Sample Findings: We tested to see if the system would say that tweets or hashtags about music would be similar to music-related tweets and hashtags, and did the same with politics. The Demo Video in Phase 4 shows that the system was able to do this.

Since the rest of the code has many lines, it is not included in this report. The small data snippet (around 37 Mb), small sample output and the code are uploaded on Github: <https://github.com/circlefive05/SimRank-on-Twitter-UI>

Some more information on SimRank can be found on here: <http://cs512extrainfo.blogspot.com/2017/04/cs512-more-info-on-simrank.html>

Implementation Steps:

1. Using the Tweepy API, start up a listener of incoming tweets. Two iterations: first iteration uses a set of ‘initial hashtags’. Second iteration uses the top 25% most frequent hashtags from the previous iteration’s tweets, plus the hashtags from the previous iteration’s filter, to filter tweets in the second iteration. A JSON file is outputted, and tweets, in plain text, are extracted from this using the Pandas library.
2. Create bipartite graph  $G$ . Use positive ID integers for tweets, and negative ID integers for hashtags. Create an adjacency matrix  $M$  such that each node is assigned an index id.
3. Compute  $M^k$  for even numbers up to  $k = K_{\max}$ . Assuming sparsity, choose  $K_{\max} = 4$ . Sum up these  $M^k$ . Take the nonzero entries, the chosen pairs, of the sum. Run SimRank on the chosen pairs. Use pickle to store the graph, the ID-to-node hash tables, and the scores hash table.

The iterative gathering approach obtains tweets which are structurally similar to the filter, but does not restrict the data to only finding tweets that contain hashtags in the filter. This is better than blindly gathering Listener. We only demonstrate a sample with a small amount of data, so the results are not as strong. Also, since the data consists of new tweets, the results depends on what’s trending at the time of collection.

## References

- [1] J. O'shea, Z. Bandar, and K. Crockett. A new benchmark dataset with production methodology for short text semantic similarity algorithms. *ACM Trans. Speech Lang. Process.*, 10(4):19:1–19:63, Jan. 2014.