Homework-2-2

March 1, 2018

1 Clustering Yelp Restaurants

Part 2: To be completed INDIVIDUALLY and due on March 3 at 7pm.

In this assignment, we will continue to work with the Yelp dataset that we used in Homework 2-1.

We will continue to try to find culinary **districts** in Las Vegas. As a reminder from last time, these are characterized by **closeness** and **similarity** of restaurants. Use the "longitude" and "latitude" to cluster closeness.

However, in this analysis we will not use the Yelp-supplied "categories" to cluster for similarity as we did in Part 1. Instead, we will cluster the reviews themselves, extracting categories in an unsupervised fashion.

Specifically, you are to use Latent Semantic Analysis (LSA) on the Yelp reviews to cluster restaurants based off on their reviews. As a reminder, LSA consists of using PCA applied to the document-term matrix.

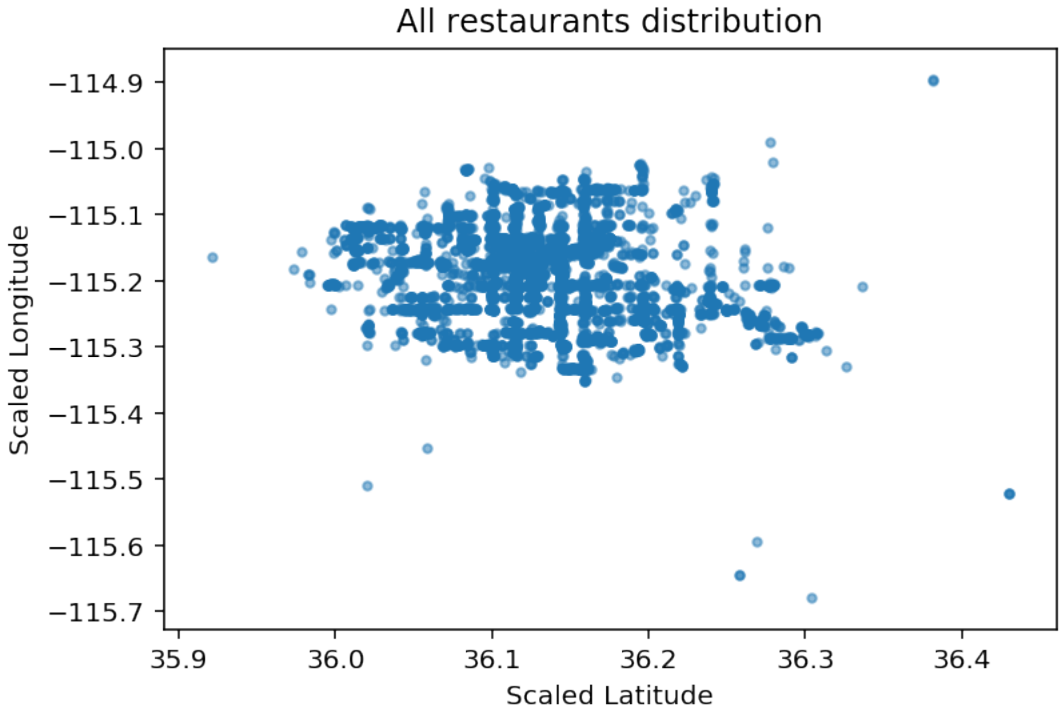
Now, your feature vectors will contain latitude, longitude and the most relatively important review terms.

You will apply PCA 3 times. Each time, you will take into account the first k reviews per business, where $k = \{10, 100, 1000\}$. Many businesses will have less than k, or even no reviews. In this case, simply assign to the business the maximum number of reviews it has. **(4 pts)**

```
In [1]: import json

        %matplotlib inline
        %config InlineBackend.figure_format='retina'
        # import libraries
        import numpy as np
        import matplotlib as mp
        import pandas as pd
        import matplotlib.pyplot as plt
        import pandas as pd
        #import slideUtilities as sl
        #import laUtilities as ut
        from importlib import reload
        from datetime import datetime
        from IPython.display import Image
        from IPython.display import display_html
        from IPython.display import display
        from IPython.display import Math
        from IPython.display import Latex
        from IPython.display import HTML
        import sklearn.datasets as sk_data
        import sklearn.metrics as metrics

        #import matplotlib as mpl
        import seaborn as sns
        print('')
```

```
In [2]: restaurant = {}
        with open('dataset/business.json') as bus:
            for line in bus:
                dic = json.loads(line)
                if dic["city"]=="Las Vegas":
                    if "Restaurants" in dic["categories"]:
        #                 kk[dic["business_id"]] = 0
                        restaurant[dic["business_id"]] = {"latitude":dic["latitude"], "longitu

        df = pd.DataFrame.from_dict(restaurant, orient='index')
        df.reset_index(level=0, inplace=True)
        df.head()

Out[2]:                     index   latitude   longitude
        0  --9e1ONYQuAa-CB_Rrw7Tw  36.123183 -115.169190
        1  --q7kSBRb0vWC8lSkXFByA  36.016693 -115.173115
        2  -153AjTW5luZPK4omEujWA  36.103001 -115.173516
        3  -1m9o3vGRA8IBPNvNqKLmA  36.104330 -115.175593
        4  -1vfRrlnNnNJ5boOVghMPA  36.281295 -115.286737
```

```
In [3]: latitude = df.latitude
        longitude = df.longitude
        location = np.array(list(zip(latitude, longitude)))

        plt.scatter(location[:, 0],location[:, 1], s=10, alpha = 0.5)
        plt.title('All restaurants distribution')
        plt.xlabel('Scaled Latitude')
        plt.ylabel('Scaled Longitude')

Out[3]: Text(0,0.5,'Scaled Longitude')
```



```
In [4]: from collections import defaultdict

        review_dic = {}


        with open('dataset/review.json') as f:
            for line in f:
                dic1 = json.loads(line)
                if dic1["business_id"] in restaurant:
                    if dic1["business_id"] in review_dic:
                        review_dic[dic1["business_id"]].append((dic1["text"]))
                    else:
                        review_dic[dic1["business_id"]] = [dic1["text"]]

In [5]: print(len(review_dic))
        print(len(review_dic['zpoZ6WyQUYff18-z4ZU1mA']))

        review10_dic = {}
        review10_str = {}
        review100_dic = {}
        review100_str = {}
        review1000_dic = {}
        review1000_str = {}
        for key in review_dic:
            m10 = min(len(review_dic[key]), 10)
            m100 = min(len(review_dic[key]), 100)
            m1000 = min(len(review_dic[key]), 1000)

            review10_dic[key] = review_dic[key][:m10]
            review10_str[key] = ' '.join(review10_dic[key])
            review100_dic[key] = review_dic[key][:m100]
            review100_str[key] = ' '.join(review100_dic[key])
            review1000_dic[key] = review_dic[key][:m1000]
            review1000_str[key] = ' '.join(review1000_dic[key])
```

```
5899
547
```

```
In [6]: # create separate lists of business_id, latitude, longitude and review, with the same
        business_id = []
        latitude = []
        longitude = []
        review10 = []
        review100 = []
        review1000 = []

        for key,val in restaurant.items():
            business_id.append(key)
            latitude.append(val.get('latitude'))
            longitude.append(val.get('longitude'))
            review10.append(review10_str[key])
            review100.append(review100_str[key])
            review1000.append(review1000_str[key])

        latitude = np.array(latitude)
        longitude = np.array(longitude)
```

```
In [7]: # strip digits from all reviews
        from string import digits
        remove_digits = str.maketrans("", "", digits)
        review10 = [rev.translate(remove_digits) for rev in review10]
        review100 = [rev.translate(remove_digits) for rev in review100]
        review1000 = [rev.translate(remove_digits) for rev in review1000]

        print(len(review10))
```

```
5899
```

```
In [8]: from nltk.stem.snowball import SnowballStemmer
        from nltk.tokenize import word_tokenize
        from nltk.tokenize import sent_tokenize


        review10 = [" ".join(SnowballStemmer("english", ignore_stopwords=True).stem(word)
                 for sent in sent_tokenize(message)
                for word in word_tokenize(sent))
                for message in review10]

In [9]: review100 = [" ".join(SnowballStemmer("english", ignore_stopwords=True).stem(word)
                 for sent in sent_tokenize(message)
                for word in word_tokenize(sent))
                for message in review100]
```

```
        ---------------------------------------------------------------------------

        KeyboardInterrupt                         Traceback (most recent call last)

        <ipython-input-9-403ecd5d8f48> in <module>()
          2          for sent in sent_tokenize(message)
          3         for word in word_tokenize(sent))
    ----> 4         for message in review100]
          5


        <ipython-input-9-403ecd5d8f48> in <listcomp>(.0)
          2          for sent in sent_tokenize(message)
          3         for word in word_tokenize(sent))
    ----> 4         for message in review100]
          5


        <ipython-input-9-403ecd5d8f48> in <genexpr>(.0)
          1 review100 = [" ".join(SnowballStemmer("english", ignore_stopwords=True).stem(word)
          2          for sent in sent_tokenize(message)
    ----> 3         for word in word_tokenize(sent))
          4         for message in review100]
          5


        /Library/Frameworks/Python.framework/Versions/3.6/lib/python3.6/site-packages/nltk/stem
         96             raise ValueError("The language '{0}' is not supported.".format(language
         97         stemmerclass = globals()[language.capitalize() + "Stemmer"]
    ---> 98         self.stemmer = stemmerclass(ignore_stopwords)
         99         self.stem = self.stemmer.stem
        100         self.stopwords = self.stemmer.stopwords
```

```
/Library/Frameworks/Python.framework/Versions/3.6/lib/python3.6/site-packages/nltk/ster
130                 try:
131                     for word in stopwords.words(language):
--> 132                         self.stopwords.add(word)
133                 except IOError:
134                     raise ValueError("{!r} has no list of stopwords. Please set"


KeyboardInterrupt:
```

```
In [ ]: review1000 = [" ".join(SnowballStemmer("english", ignore_stopwords=True).stem(word)
                  for sent in sent_tokenize(message)
                 for word in word_tokenize(sent))
                 for message in review1000]
```

```
In [185]: from sklearn.feature_extraction.text import TfidfVectorizer
          # min_df=4,max_df=0.8
          # max_df=0.18, min_df=0.009
          vectorizer = TfidfVectorizer(min_df=0.009,max_df=0.18, stop_words='english', sublinea
          DataReview10 = vectorizer.fit_transform(review10)
          terms10 = vectorizer.get_feature_names()

          print(type(DataReview10), DataReview10.shape)
          # terms10 = vectorizer.get_feature_names()
```

```
<class 'scipy.sparse.csr.csr_matrix'> (5899, 2591)
```

```
In [194]: DataReview100 = vectorizer.fit_transform(review100)
          terms100 = vectorizer.get_feature_names()

          print(type(DataReview100), DataReview100.shape)
```

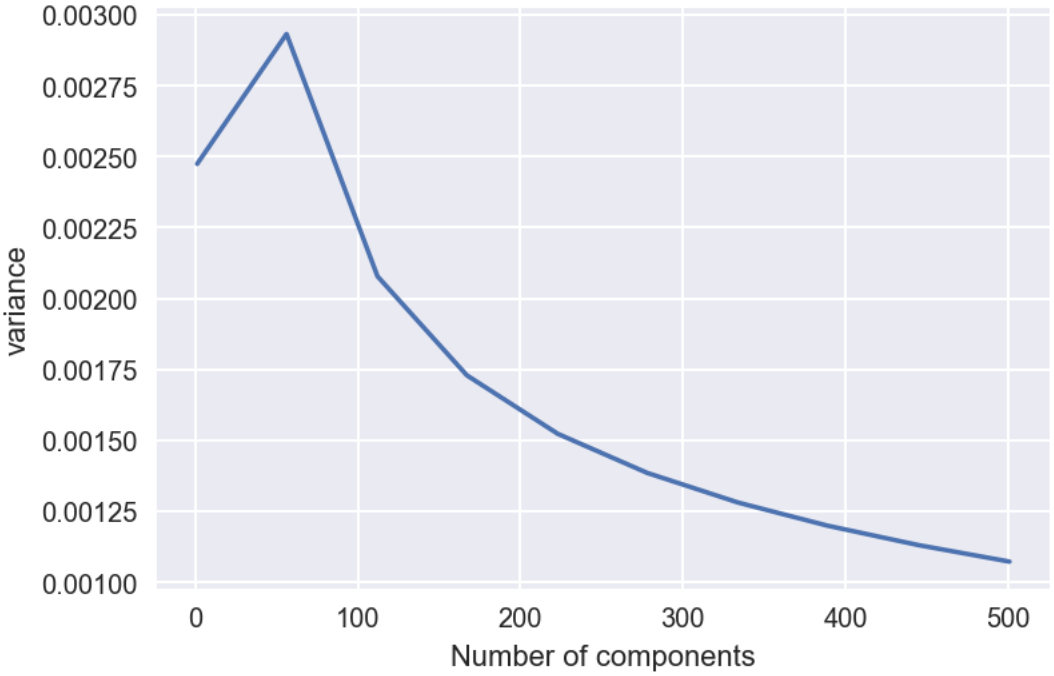
```
<class 'scipy.sparse.csr.csr_matrix'> (5899, 7982)
```

```
In [211]: DataReview1000 = vectorizer.fit_transform(review1000)
          terms1000 = vectorizer.get_feature_names()

          print(type(DataReview1000), DataReview1000.shape)
```

```
<class 'scipy.sparse.csr.csr_matrix'> (5899, 12465)
```

```
In [23]: from sklearn.decomposition import TruncatedSVD
         from sklearn.preprocessing import Normalizer
         # K = 10
         # apply LSA on reviews
```

```
variance = np.zeros(10)
ii = 0
for kk in np.linspace(1,501, 10, dtype='int16'):
    lsa = TruncatedSVD(kk, algorithm = 'arpack')
    DataReview10_lsa = lsa.fit(DataReview10)
    variance[ii] = DataReview10_lsa.explained_variance_ratio_.mean()
    ii += 1

plt.plot(np.linspace(1,501, 10, dtype='int16'),variance)
plt.xlabel('Number of components')
dummy = plt.ylabel('variance')
plt.show()
```



```
In [186]: from sklearn.decomposition import TruncatedSVD
          from sklearn.preprocessing import Normalizer
          # select 100 to apply to SVD
          lsa = TruncatedSVD(100, algorithm = 'arpack')
          review_lsa10 = lsa.fit_transform(DataReview10)
          review_lsa10 = Normalizer(copy=False).fit_transform(review_lsa10)
```

```
In [195]: lsa = TruncatedSVD(100, algorithm = 'arpack')
          review_lsa100 = lsa.fit_transform(DataReview100)
          review_lsa100 = Normalizer(copy=False).fit_transform(review_lsa100)
```

```
In [212]: lsa = TruncatedSVD(100, algorithm = 'arpack')
          review_lsa1000 = lsa.fit_transform(DataReview1000)
          review_lsa1000 = Normalizer(copy=False).fit_transform(review_lsa1000)
```

```
In [74]: location = 1000 * Normalizer(copy=False).fit_transform(np.column_stack((latitude, long

         feature10 = np.concatenate((review_lsa10, location), axis=1)
```

```
In [196]: feature100 = np.concatenate((review_lsa100, location), axis=1)
```

```
In [213]: feature1000 = np.concatenate((review_lsa1000, location), axis=1)
```

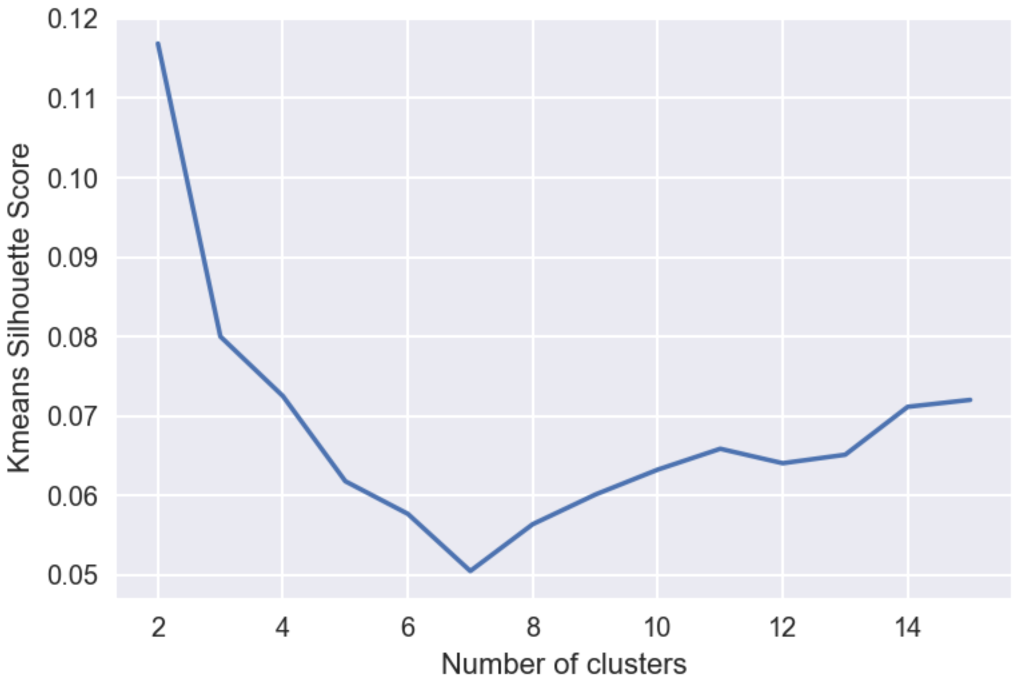
Find clusters using the 3 different techniques we discussed in class: k-means++, hierarchical, and GMM for **each** of the 3 feature vectors per business (remember you created feature vectors based on $k = \{10, 100, 1000\}$). Visualize the clusters by plotting the longitude/latitude of the restaurants in a scatter plot and label each cluster.

Note that to label each cluster, you will need to think about how to extract labels from the LSA results. **(4 pts)**

2 K=10: first 10 reviews per business

3 K-Means++ clusters

```
In [187]: from sklearn.cluster import KMeans
          from sklearn import metrics
          import numpy as np
          import seaborn as sns; sns.set()  # for plot styling

          max_clusters = 15
          s = np.zeros(max_clusters+1)

          for k in range(2,max_clusters+1):
              kmeans = KMeans(init='k-means++', n_clusters=k, n_init=10)
              kmeans.fit_predict(feature10)
              labels = kmeans.fit_predict(feature10)
              s[k] = metrics.silhouette_score(feature10,labels,metric='euclidean')

          plt.plot(range(2,len(s)),s[2:])
          plt.xlabel('Number of clusters')
          plt.ylabel('Kmeans Silhouette Score')
          plt.show()
```



```
In [76]: # select k=5 to cluster
         k_K10 = 5

         kmeans = KMeans(init='k-means++', n_clusters=k_K10, n_init=10)
         K_labels10 = kmeans.fit_predict(feature10)
         K_centroids10 = kmeans.cluster_centers_

         K_dic10 = {}
         for i in K_labels10:
             if i in K_dic10:
                 K_dic10[i] += 1
             else:
                 K_dic10[i] = 1

         # print(K_dic10)
         for i in range(k_K10):
             print('There are {} restautrants in cluster {}. '.format(K_dic10[i], i))
```

```
There are 795 restautrants in cluster 0.
There are 1070 restautrants in cluster 1.
There are 481 restautrants in cluster 2.
There are 1184 restautrants in cluster 3.
There are 2369 restautrants in cluster 4.
```

```
In [83]: K_centroids10 = kmeans.cluster_centers_
         K_ori_centers10 = lsa.inverse_transform(K_centroids10[:,:100])
         K_order_centroids10 = K_ori_centers10.argsort()[:, ::-1]

         print("Top words in each cluster by using K-means method:")
         print('')

         # print out the top 50 words with largest weight in each cluster
         for i in range(k_K10):
             print("Top 50 words in Cluster {}: ".format(i))
             for ind in K_order_centroids10[i, :50]:
         #         print('Top category is {}'.format(terms10[ind]))
                 print(' %s' % terms10[ind], end='')
             print("")
             print("")
```

```
Top words in each cluster by using K-means method:

Top 50 words in Cluster 0:
 noodl sushi chines thai bowl tea asian korean broth pho japanes curri tofu chef authent pad sp

Top 50 words in Cluster 1:
 wing taco bartend garlic bowl beer bbq deliveri game crust sushi ingredi sub play burrito reac

Top 50 words in Cluster 2:
 taco mexican salsa burrito asada carn chip tortilla enchilada guacamol authent roberto pastor

Top 50 words in Cluster 3:
 wing downtown taco deliveri beer bacon cashier bbq window phone card deliv subway job readi ca

Top 50 words in Cluster 4:
 hotel coffe beer casino bartend bacon waiter wing wine italian expens tomato buffet pasta cafe
```

So From top 50 words in each cluster, we can selects several key words as their labels.

Cluster 0 : noodles, sushi, Chinese

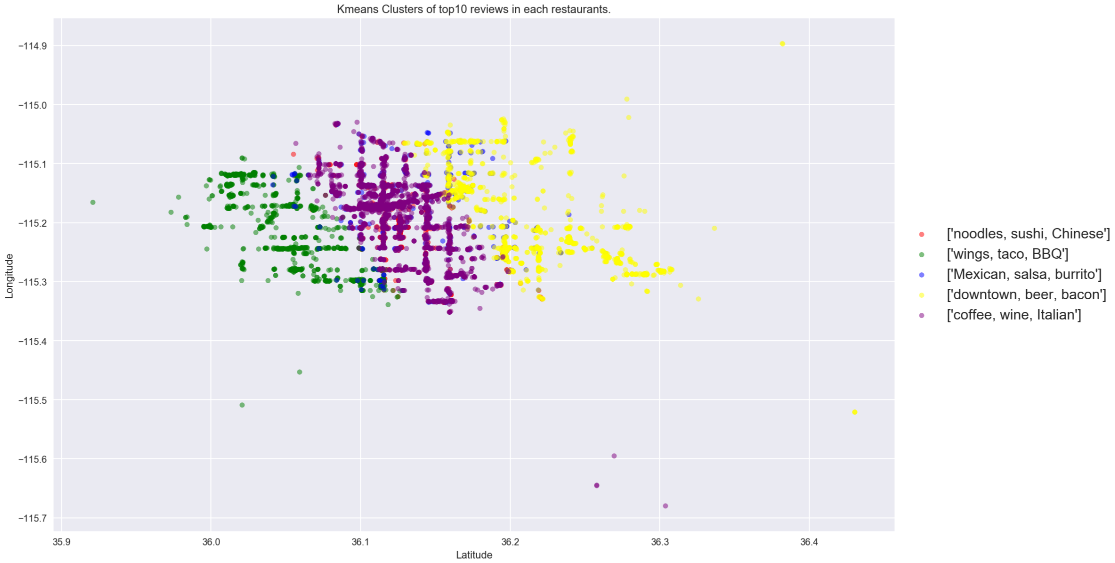
Cluster 1 : wings, taco, BBQ

Cluster 2 : Mexican, salsa, burrito

Cluster 3 : downtown, beer, bacon

Cluster 4 : coffee, wine, Italian

```
In [86]: K_cluster10_top = [['noodles, sushi, Chinese'],['wings, taco, BBQ'],['Mexican, salsa,

         c = ['r', 'g', 'blue', 'yellow', 'purple','darkseagreen','dimgray' ,  'pink','brown',

         plt.figure(figsize=(16,10))

         for i in range(k_K10):
             plt.scatter(latitude[K_labels10==i], longitude[K_labels10==i], s=25, color=c[i],
         #     points = np.array([location[j] for j in range(len(location)) if K_labels[j] ==
         #     plt.scatter(points[:, 0], points[:, 1], s=10, c=c[i], alpha = 0.5)

         plt.legend(loc='center left', bbox_to_anchor=(1, 0.5),prop={'size': 15})
         plt.title('Kmeans Clusters of top10 reviews in each restaurants.')
         plt.xlabel('Latitude')
         plt.ylabel('Longitude')

Out[86]: Text(0,0.5,'Longitude')
```

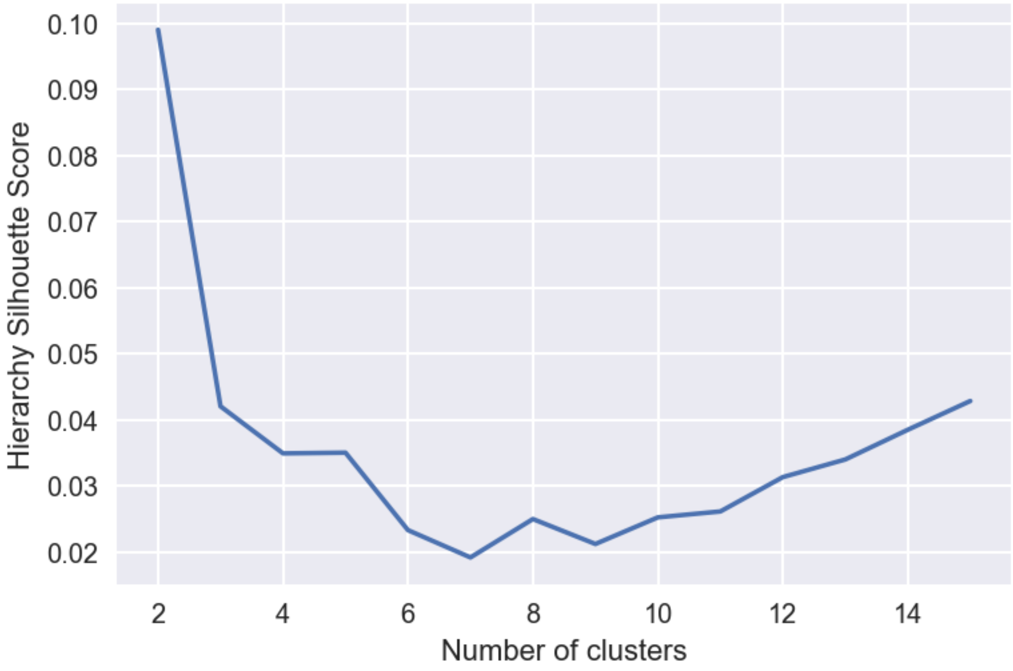


4 Hierarchical clusters

```
In [89]: import scipy.cluster
         import scipy.cluster.hierarchy as hierarchy
         import scipy.spatial.distance

         H_Z10 = hierarchy.linkage(feature10, method='ward', metric='euclidean')
```

```
s = np.zeros(max_clusters+1)
for k in range(2,max_clusters+1):
    clusters = hierarchy.fcluster(H_Z10, k, criterion='maxclust')
    s[k] = metrics.silhouette_score(feature10,clusters,metric='euclidean')
plt.plot(range(2,len(s)),s[2:])
plt.xlabel('Number of clusters')
plt.ylabel('Hierarchy Silhouette Score')
```

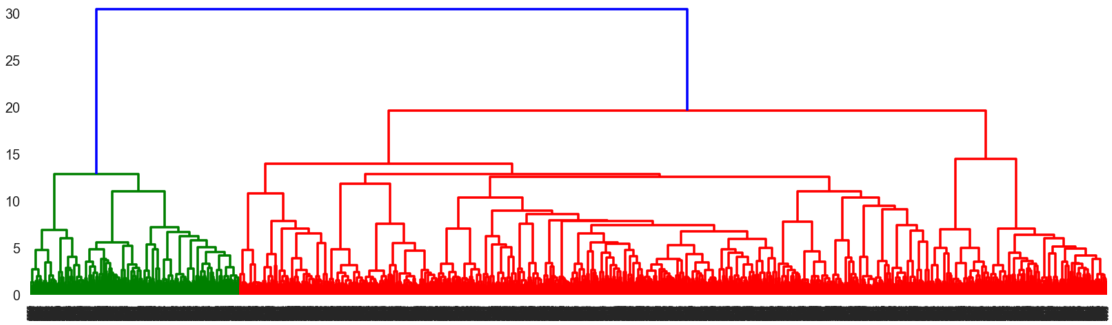
```
Out[89]: Text(0,0.5,'Hierarchy Silhouette Score')
```



```
In [90]: k_H10 = 5
         clusters10 = hierarchy.fcluster(H_Z10, k_H10, criterion='maxclust')

         H_dic10 = {}
         for i in clusters10:
             if i in H_dic10:
                 H_dic10[i] += 1
             else:
                 H_dic10[i] = 1

         for i in range(1,k_H10+1):
             print('There are {} restautrants in cluster {}. '.format(H_dic10[i], i))
```

```
There are 1151 restautrants in cluster 1.
There are 489 restautrants in cluster 2.
There are 3290 restautrants in cluster 3.
There are 330 restautrants in cluster 4.
There are 639 restautrants in cluster 5.
```

```
In [91]: plt.figure(figsize=(14,4))
         H_figure = hierarchy.dendrogram(H_Z10,  truncate_mode='level', show_leaf_counts=True)
```



```
In [103]: # Calculate the centroids in each cluster
          cluster_H10 = {}
          sum_H10 = []
          H_centroids10 = []
          sum_HH10 =  np.zeros(102)
          for i in range(k_H10):
              cluster_H10[i] = np.array([feature10[j] for j in range(len(location)) if cluster
              for k in range(len(cluster_H10[i])):
                  sum_HH10 = list(map(lambda x: x[0]+x[1], zip(sum_HH10, cluster_H10[i][k])))
              sum_H10.append(sum_HH10)
              center =  [(sum_HH10[j]/len(cluster_H10[i])) for j in range(len(sum_HH10))]
              H_centroids10.append(center)

          H_centroids10 = np.array(H_centroids10)
          H_ori_centers10 = lsa.inverse_transform(H_centroids10[:,:100])
          H_order_centroids10 = H_ori_centers10.argsort()[:, ::-1]

          print("Top words in each cluster by using Hierarchical method:")
          print('')

          # print out the top 50 words with largest weight in each cluster
          for i in range(k_H10):
              print("Top 50 words in Cluster {}: ".format(i+1))
              for ind in H_order_centroids10[i, :50]:
                  print(' %s' % terms10[ind], end='')
              print("")
              print("")
```

```
Top words in each cluster by using Hierarchical method:

Top 50 words in Cluster 1:
 taco mexican burrito salsa asada carn chip bartend beer tortilla truck downtown el wing bacon

Top 50 words in Cluster 2:
 chines taco noodl thai mexican burrito authent salsa asada deliveri curri bbq sour chip carn p

Top 50 words in Cluster 3:
 beer taco wing bartend noodl chines bbq waiter coffe bowl bacon garlic sushi hotel deliveri te

Top 50 words in Cluster 4:
 taco beer mexican chip burrito wing bartend waiter noodl bowl chines authent bbq salsa hotel

Top 50 words in Cluster 5:
 taco wing beer mexican chip burrito bowl bartend garlic coffe bacon bbq waiter sushi deliveri
```

From top 50 words in each cluster, we can selects several key words as their labels.

Cluster 0 : taco, Mexican, burrito

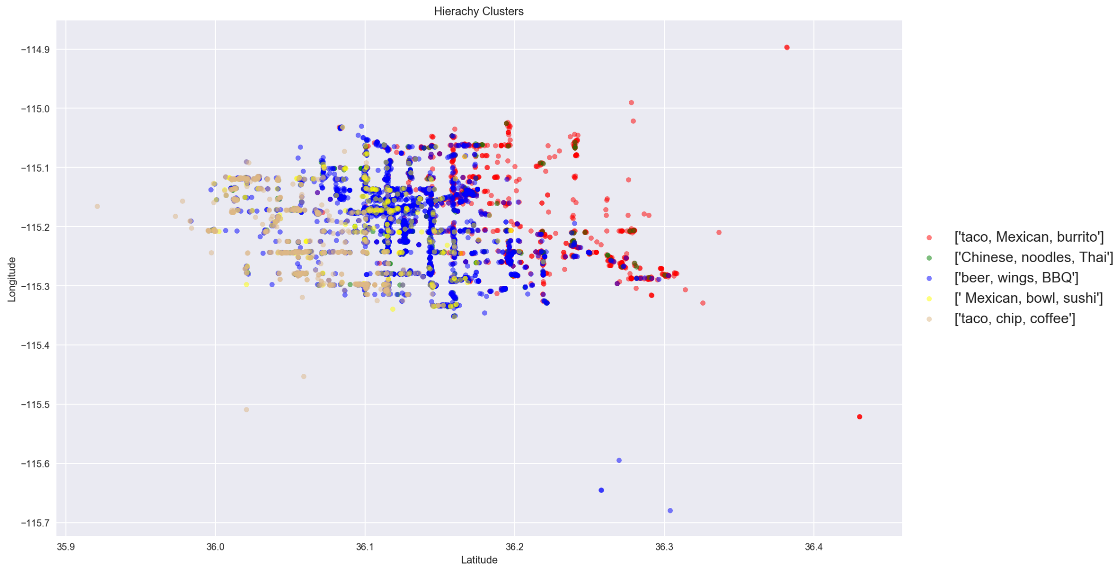
Cluster 1 : Chinese, noodles, Thai

Cluster 2 : beer, wings, BBQ

Cluster 3 : Mexican, bowl, sushi

Cluster 4 : taco, chip, coffee

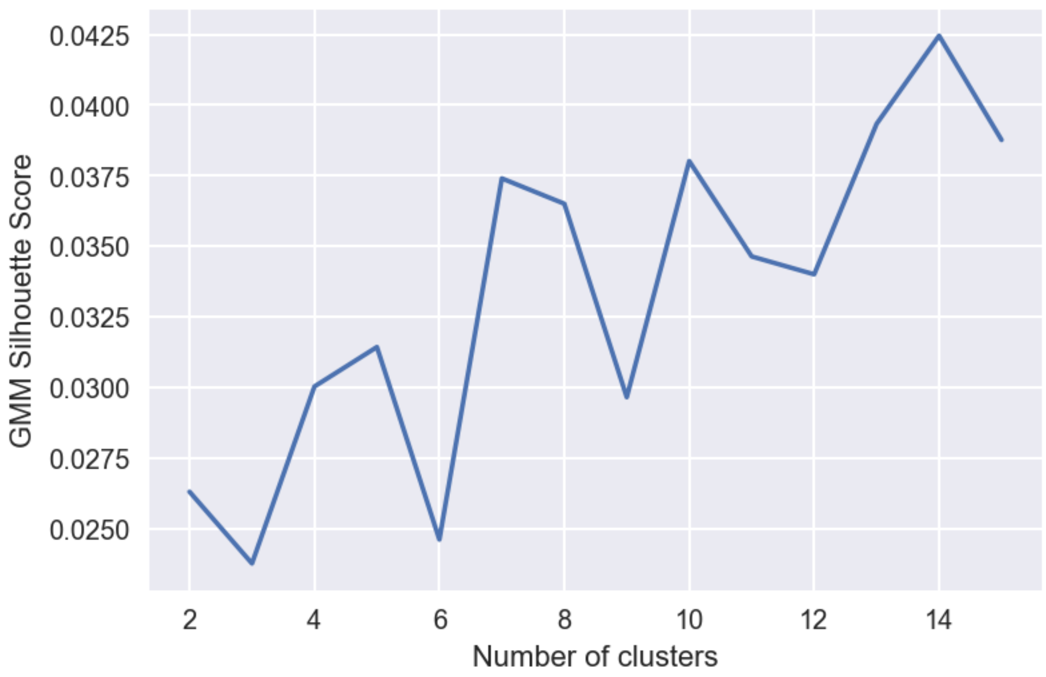
```
In [108]: H_cluster10_top = [['taco, Mexican, burrito'],['Chinese, noodles, Thai'],['beer, wing
          c = ['r', 'g', 'blue', 'yellow', 'burlywood','darkseagreen', 'beige', 'pink', 'orange

          plt.figure(figsize=(16,10))
          for i in range(k_H10):
              plt.scatter(latitude[clusters10==i+1], longitude[clusters10==i+1], s=25, color=c

          plt.legend(loc='center left', bbox_to_anchor=(1, 0.5),prop={'size': 15})
          plt.title('Hierachy Clusters')
          plt.xlabel('Latitude')
          plt.ylabel('Longitude')

Out[108]: Text(0,0.5,'Longitude')
```



5 GMM clusters

```
In [189]: s = np.zeros(max_clusters+1)
          for k in range(2,max_clusters+1):
              gmm = mixture.GaussianMixture(n_components=k, covariance_type='full')
              gmm.fit(feature10)
              y_pred = gmm.predict(feature10)
              s[k] = metrics.silhouette_score(feature10,y_pred,metric='euclidean')
          plt.plot(range(2,len(s)),s[2:])
          plt.xlabel('Number of clusters')
          plt.ylabel('GMM Silhouette Score')
```

```
Out[189]: Text(0,0.5,'GMM Silhouette Score')
```



In [193]:
```
k_G10 = 5
gmm = mixture.GaussianMixture(n_components=k_G10, covariance_type='tied')
gmm.fit(feature10)
y_pred10 = gmm.predict(feature10)

G_dic10 = {}
for i in y_pred10:
    if i in G_dic10:
        G_dic10[i] += 1
    else:
        G_dic10[i] = 1

for i in range(k_G10):
    print('There are {} restautrants in cluster {}. '.format(G_dic10[i], i))
```

```
There are 3293 restautrants in cluster 0.
There are 537 restautrants in cluster 1.
There are 529 restautrants in cluster 2.
There are 511 restautrants in cluster 3.
There are 1029 restautrants in cluster 4.
```

In [191]:
```
# Calculate the centroids in each cluster
cluster_G10 = {}
sum_G10 = []
```

```
G_centroids10 = []
sum_GG10 =  np.zeros(102)
for i in range(k_G10):
    cluster_G10[i] = np.array([feature10[j] for j in range(len(location)) if y_pred10
    for k in range(len(cluster_G10[i])):
        sum_GG10 = list(map(lambda x: x[0]+x[1], zip(sum_GG10, cluster_G10[i][k])))
    sum_G10.append(sum_GG10)
    center =  [(sum_GG10[j]/len(cluster_G10[i])) for j in range(len(sum_GG10))]
    G_centroids10.append(center)

G_centroids10 = np.array(G_centroids10)
G_ori_centers10 = lsa.inverse_transform(G_centroids10[:,:100])
G_order_centroids10 = G_ori_centers10.argsort()[:, ::-1]

print("Top words in each cluster by using GMM method:")
print('')

# print out the top 50 words with largest weight in each cluster
for i in range(k_G10):
    print("Top 50 words in Cluster {}: ".format(i))
    for ind in G_order_centroids10[i, :50]:
        print(' %s' % terms10[ind], end='')
    print("")
    print("")
```

```
Top words in each cluster by using GMM method:

Top 50 words in Cluster 0:
 sushi noodl thai curri chines bowl korean pho tea japanes broth ayc chef pad tempura tofu asi

Top 50 words in Cluster 1:
 sushi noodl subway thai sub bowl curri chines tea korean pho tuna japanes broth chef ayc pad

Top 50 words in Cluster 2:
 wing beer bartend garlic sushi bbq bowl noodl deliveri chines waiter chef bacon coffe tea rib

Top 50 words in Cluster 3:
 wing beer coffe garlic bbq bartend sushi bacon bowl noodl deliveri chines tea waiter chef rib

Top 50 words in Cluster 4:
 taco wing beer mexican chip burrito bowl bartend garlic coffe bacon bbq waiter sushi deliveri
```

From top 50 words in each cluster, we can selects several key words as their labels.

Cluster 0 : sushi, wine, lobster

Cluster 1 : taco, Mexican, salsa

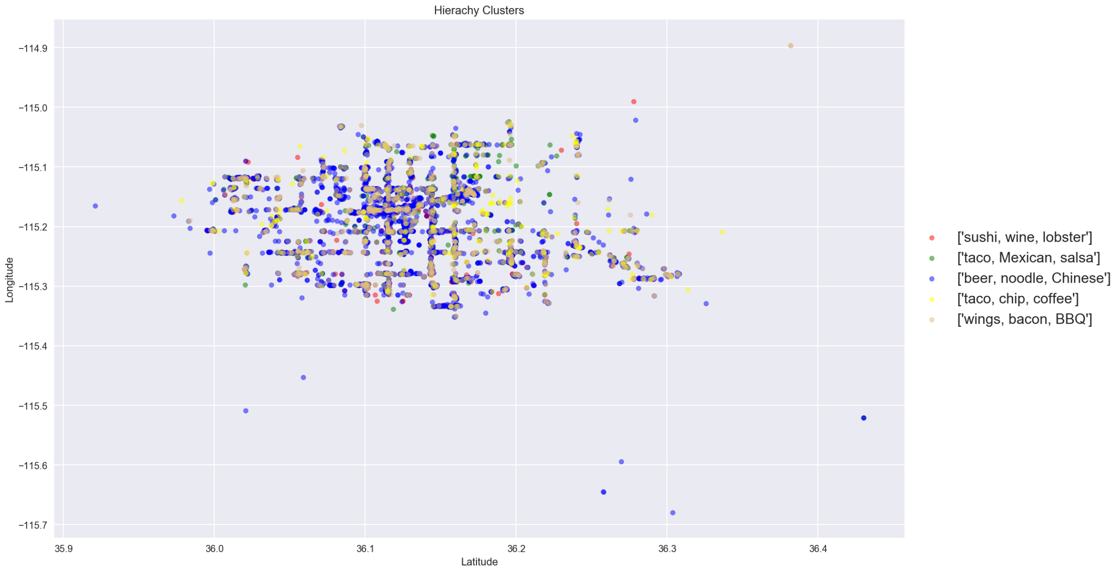
Cluster 2 : beer, noodle, Chinese

Cluster 3 : taco, chip, coffee

Cluster 4 : wings, bacon, BBQ

```
In [118]: G_cluster10_top = [['sushi, wine, lobster'],['taco, Mexican, salsa'],['beer, noodle,
          c = ['r', 'g', 'blue', 'yellow', 'burlywood','darkseagreen', 'beige', 'pink', 'orange

          plt.figure(figsize=(16,10))
          for i in range(k_G10):
              plt.scatter(latitude[y_pred10==i], longitude[y_pred10==i], s=25, color=c[i],label

          plt.legend(loc='center left', bbox_to_anchor=(1, 0.5),prop={'size': 15})
          plt.title('GMM Clusters')
          plt.xlabel('Latitude')
          plt.ylabel('Longitude')
```

```
Out[118]: Text(0,0.5,'Longitude')
```

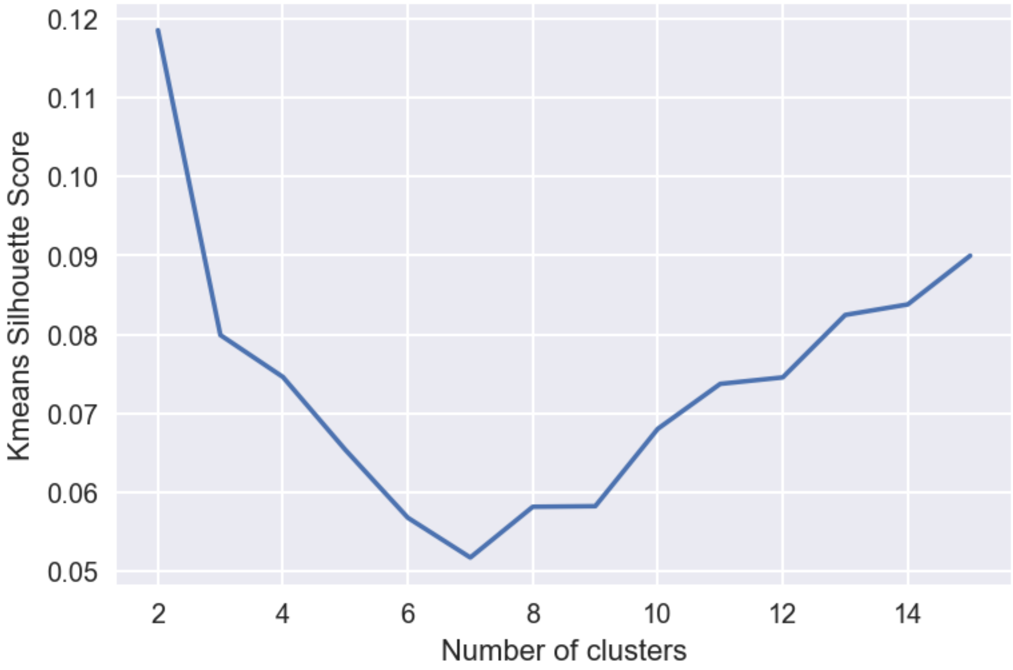


6 K=100: first 100 reviews per business

7 K-Means++ clusters

```
In [197]: max_clusters = 15
          s = np.zeros(max_clusters+1)
```

```
for k in range(2,max_clusters+1):
    kmeans = KMeans(init='k-means++', n_clusters=k, n_init=10)
    kmeans.fit_predict(feature100)
    labels = kmeans.fit_predict(feature100)
    s[k] = metrics.silhouette_score(feature100,labels,metric='euclidean')

plt.plot(range(2,len(s)),s[2:])
plt.xlabel('Number of clusters')
plt.ylabel('Kmeans Silhouette Score')
plt.show()
```



```
In [198]: # select k=5 to cluster
          k_K100 = 5

          kmeans = KMeans(init='k-means++', n_clusters=k_K100, n_init=10)
          K_labels100 = kmeans.fit_predict(feature100)
          K_centroids100 = kmeans.cluster_centers_

          K_dic100 = {}
          for i in K_labels100:
              if i in K_dic100:
                  K_dic100[i] += 1
              else:
                  K_dic100[i] = 1
```

```
        # print(K_dic10)
        for i in range(k_K100):
            print('There are {} restautrants in cluster {}. '.format(K_dic100[i], i))
```

```
There are 458 restautrants in cluster 0.
There are 1207 restautrants in cluster 1.
There are 1058 restautrants in cluster 2.
There are 836 restautrants in cluster 3.
There are 2340 restautrants in cluster 4.
```

```
In [199]: K_centroids100 = kmeans.cluster_centers_
          K_ori_centers100 = lsa.inverse_transform(K_centroids100[:,:100])
          K_order_centroids100 = K_ori_centers100.argsort()[:, ::-1]

          print("Top words in each cluster by using K-means method:")
          print('')

          # print out the top 50 words with largest weight in each cluster
          for i in range(k_K100):
              print("Top 50 words in Cluster {}: ".format(i))
              for ind in K_order_centroids100[i, :50]:
          #         print('Top category is {}'.format(terms10[ind]))
                  print(' %s' % terms100[ind], end='')
              print("")
              print("")
```

```
Top words in each cluster by using K-means method:

Top 50 words in Cluster 0:
 asada carne tortillas burritos guacamole pastor carnitas enchiladas el tortilla nachos salsas

Top 50 words in Cluster 1:
 downtown subway pizzas fremont mac pepperoni truck refund pie ribs bell fingers mcdonald subs

Top 50 words in Cluster 2:
 subway pizzas pepperoni mac bartenders fingers sushi buffalo teriyaki pie philly nachos bell i

Top 50 words in Cluster 3:
 sushi noodle tofu thai japanese broth curry korean chow mein tempura soy pad pho miso chinatow

Top 50 words in Cluster 4:
 court pizzas mac subway pepperoni caesar lobster pie york pool bartenders mashed dogs lamb has
```

From top 50 words in each cluster, we can selects several key words as their labels.

Cluster 0 : burritos, nachos, Mexican

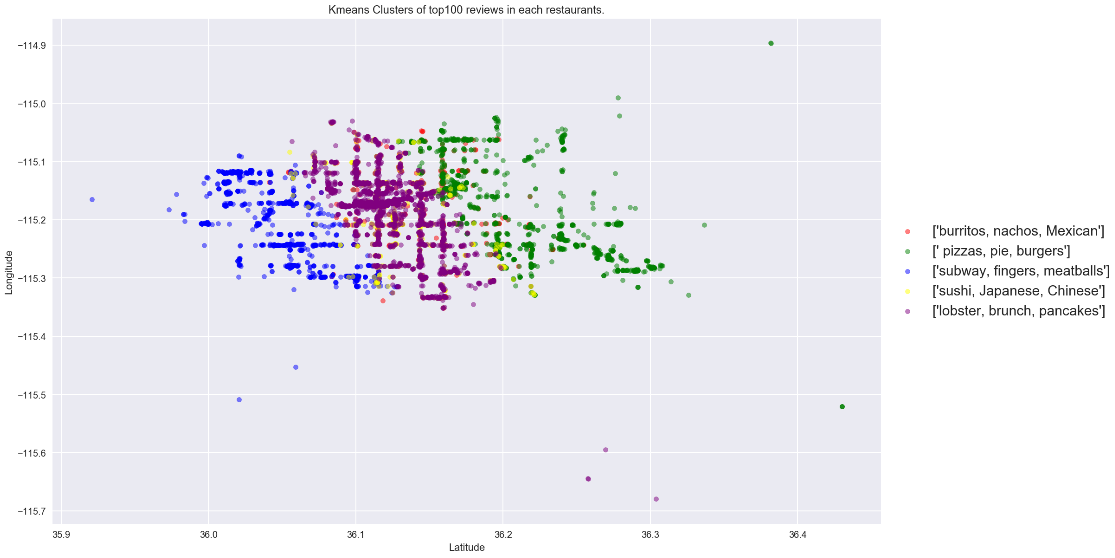
Cluster 1 : pizzas, pie, burgers

Cluster 2 : subway, fingers, meatballs

Cluster 3 : sushi, Japanese, Chinese

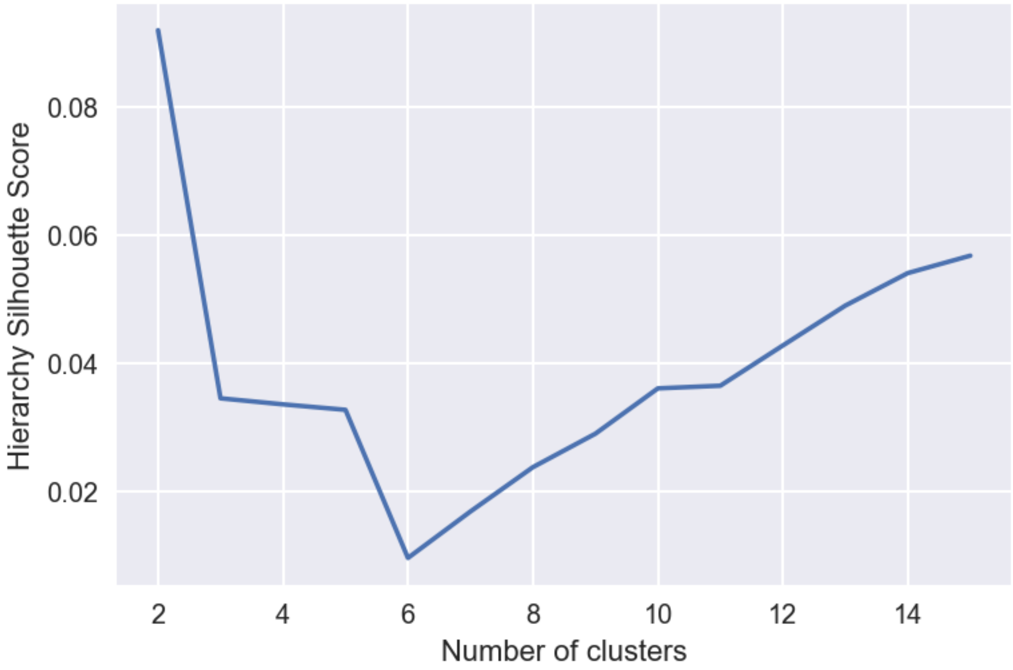
Cluster 4 : lobster, brunch, pancakes

```
In [200]: K_cluster100_top = [['burritos, nachos, Mexican'],[' pizzas, pie, burgers'],['subway

          c = ['r', 'g', 'blue', 'yellow', 'purple','darkseagreen','dimgray' ,  'pink','brown'

          plt.figure(figsize=(16,10))

          for i in range(k_K100):
              plt.scatter(latitude[K_labels100==i], longitude[K_labels100==i], s=25, color=c[i

          plt.legend(loc='center left', bbox_to_anchor=(1, 0.5),prop={'size': 15})
          plt.title('Kmeans Clusters of top100 reviews in each restaurants.')
          plt.xlabel('Latitude')
          plt.ylabel('Longitude')

Out[200]: Text(0,0.5,'Longitude')
```



8 Hierarchical clusters

```
In [201]: H_Z100 = hierarchy.linkage(feature100, method='ward', metric='euclidean')

          s = np.zeros(max_clusters+1)
          for k in range(2,max_clusters+1):
              clusters = hierarchy.fcluster(H_Z100, k, criterion='maxclust')
              s[k] = metrics.silhouette_score(feature100,clusters,metric='euclidean')
          plt.plot(range(2,len(s)),s[2:])
          plt.xlabel('Number of clusters')
          plt.ylabel('Hierarchy Silhouette Score')

Out[201]: Text(0,0.5,'Hierarchy Silhouette Score')
```



```
In [204]: k_H100 = 5
          clusters100 = hierarchy.fcluster(H_Z100, k_H100, criterion='maxclust')

          H_dic100 = {}
          for i in clusters100:
              if i in H_dic100:
                  H_dic100[i] += 1
              else:
                  H_dic100[i] = 1

          for i in range(1,k_H100+1):
              print('There are {} restautrants in cluster {}. '.format(H_dic100[i], i))
```

```
There are 403 restautrants in cluster 1.
There are 463 restautrants in cluster 2.
There are 835 restautrants in cluster 3.
There are 951 restautrants in cluster 4.
There are 3247 restautrants in cluster 5.
```

```
In [205]: # Calculate the centroids in each cluster
          cluster_H100 = {}
          sum_H100 = []
          H_centroids100 = []
          sum_HH100 =  np.zeros(102)
          for i in range(k_H100):
              cluster_H100[i] = np.array([feature100[j] for j in range(len(location)) if cluste
              for k in range(len(cluster_H100[i])):
                  sum_HH100 = list(map(lambda x: x[0]+x[1], zip(sum_HH100, cluster_H100[i][k]))
              sum_H100.append(sum_HH100)
              center =  [(sum_HH100[j]/len(cluster_H100[i])) for j in range(len(sum_HH100))]
              H_centroids100.append(center)

          H_centroids100 = np.array(H_centroids100)
          H_ori_centers100 = lsa.inverse_transform(H_centroids100[:,:100])
          H_order_centroids100 = H_ori_centers100.argsort()[:, ::-1]

          print("Top words in each cluster by using Hierarchical method:")
          print('')

          # print out the top 50 words with largest weight in each cluster
          for i in range(k_H100):
              print("Top 50 words in Cluster {}: ".format(i+1))
              for ind in H_order_centroids100[i, :50]:
                  print(' %s' % terms100[ind], end='')
              print("")
              print("")
```

```
Top words in each cluster by using Hierarchical method:

Top 50 words in Cluster 1:
 asada carne el pastor tortillas burritos carnitas horchata guacamole al salsas enchiladas tor

Top 50 words in Cluster 2:
 asada carne el tortillas burritos pastor truck guacamole tortilla nachos carnitas horchata al

Top 50 words in Cluster 3:
 asada carne burritos tortillas guacamole nachos tortilla el carnitas quesadilla enchiladas tru

Top 50 words in Cluster 4:
 asada carne sushi thai burritos noodle tortillas tofu guacamole curry nachos tortilla teriyaki
```

```
Top 50 words in Cluster 5:
 sushi subway pizzas asada nachos mac carne pepperoni ribs court thai lobster burritos noodle p
```

From top 50 words in each cluster, we can selects several key words as their labels.

Cluster 1 : burritos, Mexican, nachos

Cluster 2 : carne, pizzas, Spanish

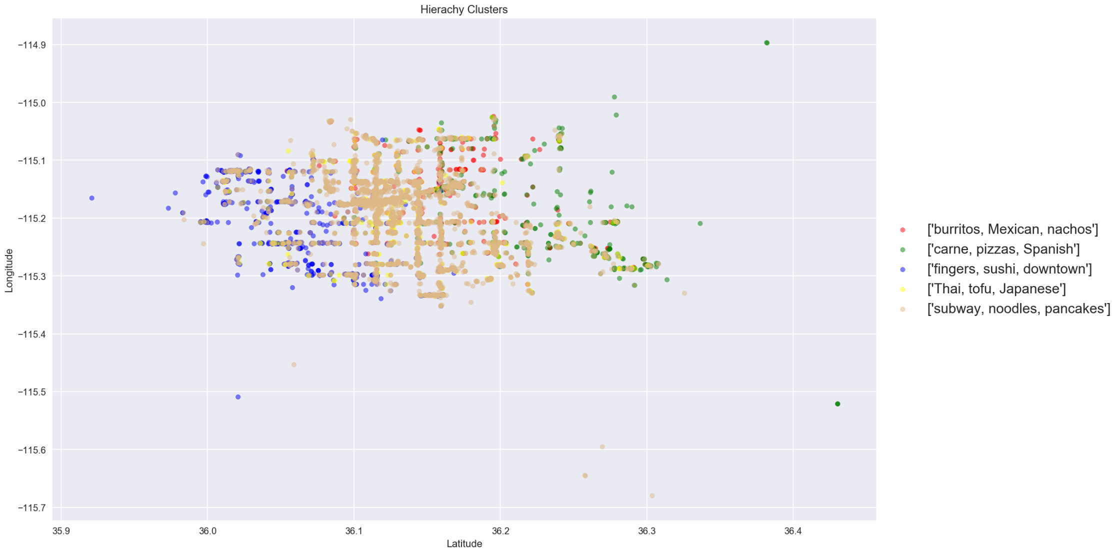
Cluster 3 : fingers, sushi, downtown

Cluster 4 : Thai, tofu, Japanese

Cluster 5 : subway, noodles, pancakes

```
In [206]: H_cluster100_top = [['burritos, Mexican, nachos'],['carne, pizzas, Spanish'],['finge
          c = ['r', 'g', 'blue', 'yellow', 'burlywood','darkseagreen', 'beige', 'pink', 'orang

          plt.figure(figsize=(16,10))
          for i in range(k_H100):
              plt.scatter(latitude[clusters100==i+1], longitude[clusters100==i+1], s=25, color

          plt.legend(loc='center left', bbox_to_anchor=(1, 0.5),prop={'size': 15})
          plt.title('Hierachy Clusters')
          plt.xlabel('Latitude')
          plt.ylabel('Longitude')
```

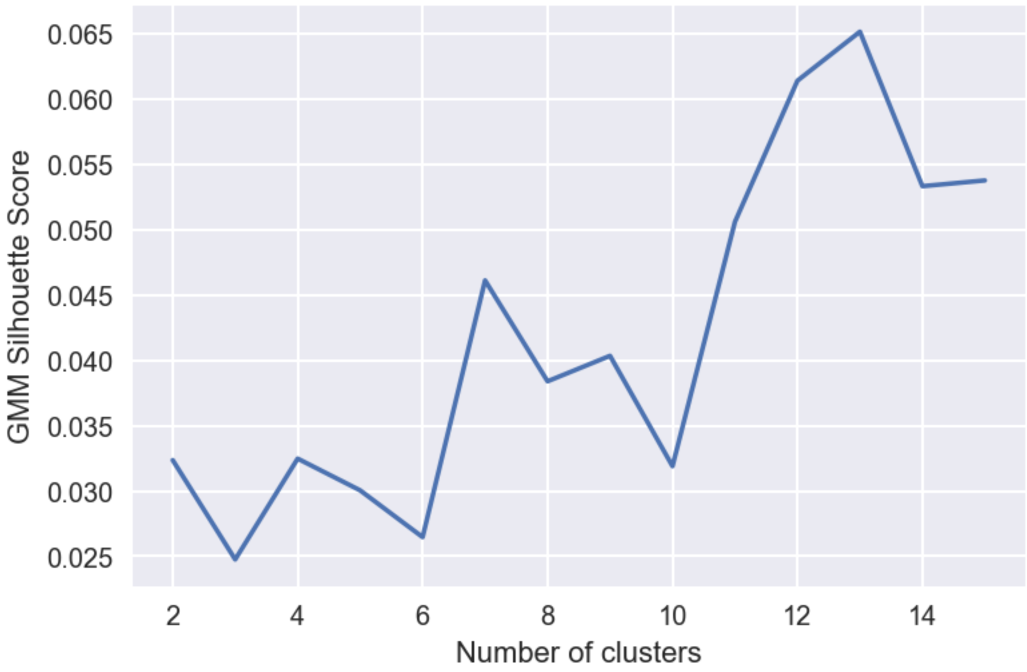
```
Out[206]: Text(0,0.5,'Longitude')
```



9 GMM clusters

```
In [207]: s = np.zeros(max_clusters+1)
          for k in range(2,max_clusters+1):
              gmm = mixture.GaussianMixture(n_components=k, covariance_type='full')
              gmm.fit(feature100)
              y_pred = gmm.predict(feature100)
              s[k] = metrics.silhouette_score(feature100,y_pred,metric='euclidean')
          plt.plot(range(2,len(s)),s[2:])
          plt.xlabel('Number of clusters')
          plt.ylabel('GMM Silhouette Score')
```

```
Out[207]: Text(0,0.5,'GMM Silhouette Score')
```



```
In [208]: k_G100 = 5
          gmm = mixture.GaussianMixture(n_components=k_G100, covariance_type='tied')
          gmm.fit(feature100)
          y_pred100 = gmm.predict(feature100)

          G_dic100 = {}
          for i in y_pred100:
              if i in G_dic100:
                  G_dic100[i] += 1
              else:
                  G_dic100[i] = 1

          for i in range(k_G100):
              print('There are {} restautrants in cluster {}. '.format(G_dic100[i], i))
```

```
There are 451 restautrants in cluster 0.
There are 3029 restautrants in cluster 1.
There are 584 restautrants in cluster 2.
There are 653 restautrants in cluster 3.
There are 1182 restautrants in cluster 4.
```

```
In [209]: # Calculate the centroids in each cluster
          cluster_G100 = {}
          sum_G100 = []
          G_centroids100 = []
          sum_GG100 =  np.zeros(102)
          for i in range(k_G100):
              cluster_G100[i] = np.array([feature100[j] for j in range(len(location)) if y_pre
              for k in range(len(cluster_G100[i])):
                  sum_GG100 = list(map(lambda x: x[0]+x[1], zip(sum_GG100, cluster_G100[i][k]))
              sum_G100.append(sum_GG100)
              center =  [(sum_GG100[j]/len(cluster_G100[i])) for j in range(len(sum_GG100))]
              G_centroids100.append(center)

          G_centroids100 = np.array(G_centroids100)
          G_ori_centers100 = lsa.inverse_transform(G_centroids100[:,:100])
          G_order_centroids100 = G_ori_centers100.argsort()[:, ::-1]

          print("Top words in each cluster by using GMM method:")
          print('')

          # print out the top 50 words with largest weight in each cluster
          for i in range(k_G100):
              print("Top 50 words in Cluster {}: ".format(i))
              for ind in G_order_centroids100[i, :50]:
                  print(' %s' % terms100[ind], end='')
              print("")
              print("")
```

```
Top words in each cluster by using GMM method:

Top 50 words in Cluster 0:
 pizzas pepperoni hut dough driver oven pie knots topping calzone pizzeria mozzarella papa domi

Top 50 words in Cluster 1:
 subway pizzas pepperoni court pie mac mcdonald refund driver dough dogs oven subs hash buffalo

Top 50 words in Cluster 2:
 subway asada pizzas carne pepperoni mac court pie nachos dogs refund el guacamole ribs dough r

Top 50 words in Cluster 3:
 subway asada pizzas nachos carne pepperoni burritos mac court tortilla guacamole pie refund bu

Top 50 words in Cluster 4:
 sushi subway pizzas asada nachos mac carne pepperoni ribs court thai lobster burritos noodle p
```

From top 50 words in each cluster, we can selects several key words as their labels.

Cluster 0 : pizzas, pie, meatballs

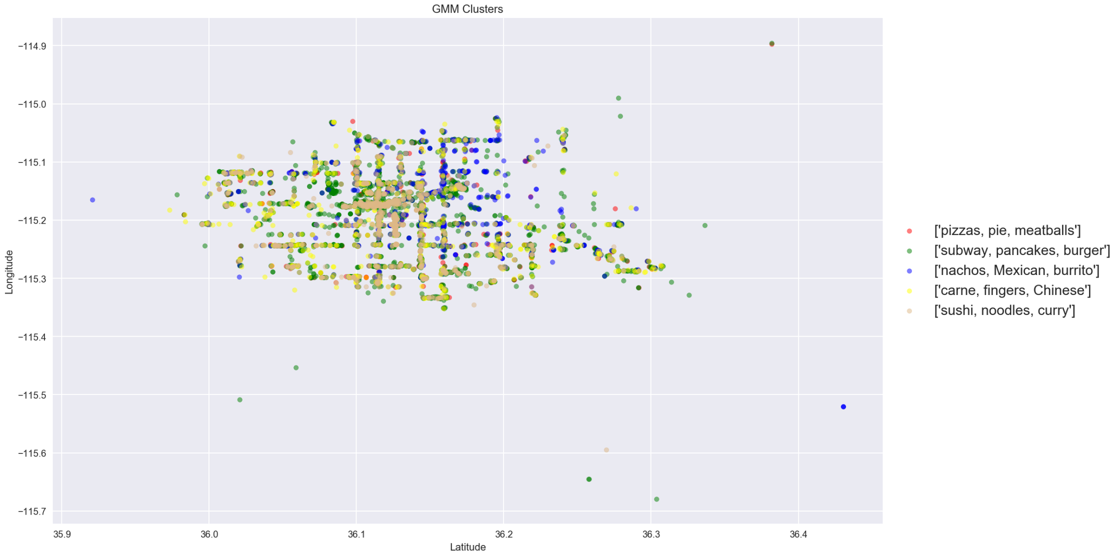
Cluster 1 : subway, pancakes, burger

Cluster 2 : nachos, Mexican, burrito

Cluster 3 : carne, fingers, Chinese

Cluster 4 : sushi, noodles, curry

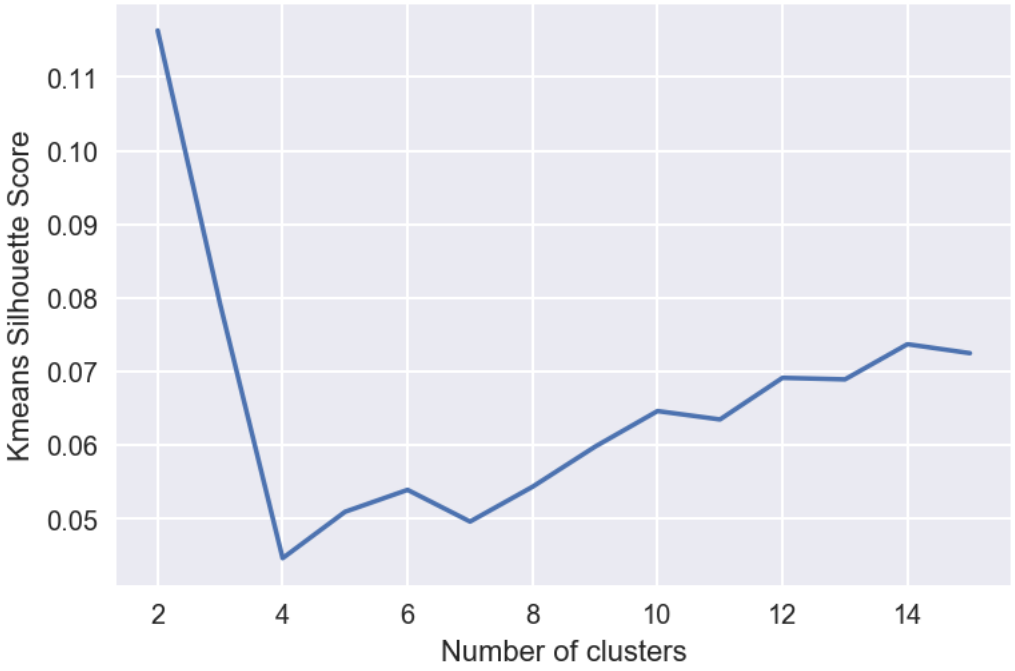
```
In [210]: G_cluster100_top = [['pizzas, pie, meatballs'],['subway, pancakes, burger'],['nachos
          c = ['r', 'g', 'blue', 'yellow', 'burlywood','darkseagreen', 'beige', 'pink', 'orange

          plt.figure(figsize=(16,10))
          for i in range(k_G100):
              plt.scatter(latitude[y_pred100==i], longitude[y_pred100==i], s=25, color=c[i],lab

          plt.legend(loc='center left', bbox_to_anchor=(1, 0.5),prop={'size': 15})
          plt.title('GMM Clusters')
          plt.xlabel('Latitude')
          plt.ylabel('Longitude')

Out[210]: Text(0,0.5,'Longitude')
```



10 K=1000: first 1000 reviews per business

11 K-Means++ clusters

```
In [166]: max_clusters = 15
          s = np.zeros(max_clusters+1)

          for k in range(2,max_clusters+1):
              kmeans = KMeans(init='k-means++', n_clusters=k, n_init=10)
              kmeans.fit_predict(feature1000)
              labels = kmeans.fit_predict(feature1000)
              s[k] = metrics.silhouette_score(feature1000,labels,metric='euclidean')

          plt.plot(range(2,len(s)),s[2:])
          plt.xlabel('Number of clusters')
          plt.ylabel('Kmeans Silhouette Score')
          plt.show()
```



```
In [216]: # select k=5 to cluster
          k_K1000 = 5

          kmeans = KMeans(init='k-means++', n_clusters=k_K1000, n_init=10)
          K_labels1000 = kmeans.fit_predict(feature1000)
          K_centroids1000 = kmeans.cluster_centers_

          K_dic1000 = {}
          for i in K_labels1000:
              if i in K_dic1000:
                  K_dic1000[i] += 1
              else:
                  K_dic1000[i] = 1

          # print(K_dic10)
          for i in range(k_K1000):
              print('There are {} restautrants in cluster {}. '.format(K_dic1000[i], i))
```

```
There are 1130 restautrants in cluster 0.
There are 1195 restautrants in cluster 1.
There are 2081 restautrants in cluster 2.
There are 1056 restautrants in cluster 3.
There are 437 restautrants in cluster 4.
```

```
In [217]: K_centroids1000 = kmeans.cluster_centers_
          K_ori_centers1000 = lsa.inverse_transform(K_centroids1000[:,:100])
          K_order_centroids1000 = K_ori_centers1000.argsort()[:, ::-1]

          print("Top words in each cluster by using K-means method:")
          print('')

          # print out the top 50 words with largest weight in each cluster
          for i in range(k_K1000):
              print("Top 50 words in Cluster {}: ".format(i))
              for ind in K_order_centroids1000[i, :50]:
          #         print('Top category is {}'.format(terms10[ind]))
                  print(' %s' % terms1000[ind], end='')
              print("")
              print("")
```

```
Top words in each cluster by using K-means method:

Top 50 words in Cluster 0:
 pizzas subway truck pepperoni fremont mcdonald dogs el driver pancakes hash burritos coupons

Top 50 words in Cluster 1:
 filet brunch calamari patio sliders pancakes lamb asparagus steaks bartenders hash parmesan s

Top 50 words in Cluster 2:
 court subway pizzas tofu pepperoni curry panda korean chow teriyaki dogs mein mcdonald subs d

Top 50 words in Cluster 3:
 pizzas pepperoni subway teriyaki nachos bartenders philly groupon chipotle subs games hawaiia

Top 50 words in Cluster 4:
 asada carne burritos tortillas pastor guacamole carnitas enchiladas salsas nachos el quesadil
```

From top 50 words in each cluster, we can selects several key words as their labels.

Cluster 0 : pizzas, pancakes, burritos

Cluster 1 : brunch, steaks, meatballs

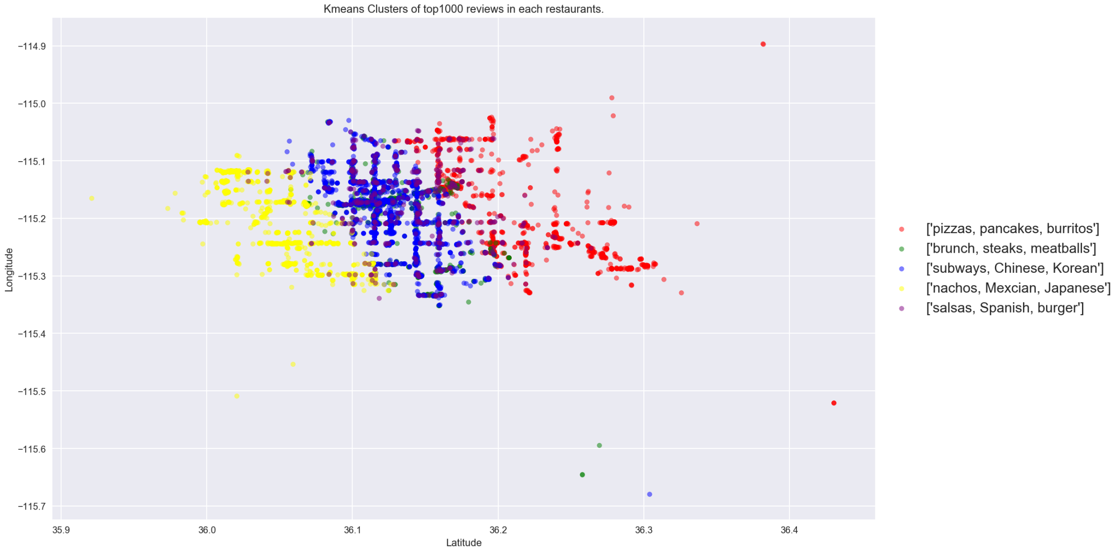
Cluster 2 : subways, Chinese, Korean

Cluster 3 : nachos, Mexcian, Japanese

Cluster 4 : salsas, Spanish, burger

```
In [218]: K_cluster1000_top = [['pizzas, pancakes, burritos'],['brunch, steaks, meatballs'],['

          c = ['r', 'g', 'blue', 'yellow', 'purple','darkseagreen','dimgray' ,  'pink','brown'

          plt.figure(figsize=(16,10))

          for i in range(k_K1000):
              plt.scatter(latitude[K_labels1000==i], longitude[K_labels1000==i], s=25, color=c

          plt.legend(loc='center left', bbox_to_anchor=(1, 0.5),prop={'size': 15})
          plt.title('Kmeans Clusters of top1000 reviews in each restaurants.')
          plt.xlabel('Latitude')
          plt.ylabel('Longitude')
```

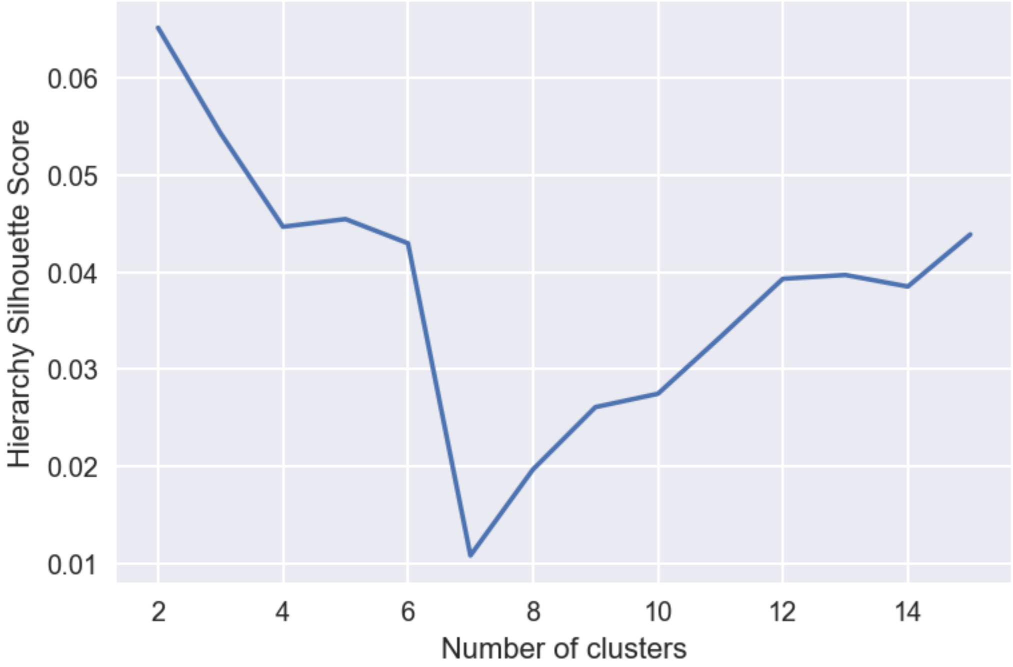
```
Out[218]: Text(0,0.5,'Longitude')
```



12 Hierarchical clusters

```
In [219]: H_Z1000 = hierarchy.linkage(feature1000, method='ward', metric='euclidean')

          s = np.zeros(max_clusters+1)
          for k in range(2,max_clusters+1):
              clusters = hierarchy.fcluster(H_Z1000, k, criterion='maxclust')
              s[k] = metrics.silhouette_score(feature1000,clusters,metric='euclidean')
          plt.plot(range(2,len(s)),s[2:])
          plt.xlabel('Number of clusters')
          plt.ylabel('Hierarchy Silhouette Score')
```

```
Out[219]: Text(0,0.5,'Hierarchy Silhouette Score')
```



```
In [220]: k_H1000 = 5
          clusters1000 = hierarchy.fcluster(H_Z1000, k_H1000, criterion='maxclust')

          H_dic1000 = {}
          for i in clusters1000:
              if i in H_dic1000:
                  H_dic1000[i] += 1
              else:
                  H_dic1000[i] = 1

          for i in range(1,k_H1000+1):
              print('There are {} restautrants in cluster {}. '.format(H_dic1000[i], i))

There are 1046 restautrants in cluster 1.
There are 420 restautrants in cluster 2.
There are 2555 restautrants in cluster 3.
There are 538 restautrants in cluster 4.
There are 1340 restautrants in cluster 5.
```

```
In [221]: # Calculate the centroids in each cluster
          cluster_H1000 = {}
          sum_H1000 = []
```

```
H_centroids1000 = []
sum_HH1000 =  np.zeros(102)
for i in range(k_H1000):
    cluster_H1000[i] = np.array([feature1000[j] for j in range(len(location)) if clus
    for k in range(len(cluster_H1000[i])):
        sum_HH1000 = list(map(lambda x: x[0]+x[1], zip(sum_HH1000, cluster_H1000[i][
    sum_H1000.append(sum_HH1000)
    center =  [(sum_HH1000[j]/len(cluster_H1000[i])) for j in range(len(sum_HH1000))]
    H_centroids1000.append(center)

H_centroids1000 = np.array(H_centroids1000)
H_ori_centers1000 = lsa.inverse_transform(H_centroids1000[:,:100])
H_order_centroids1000 = H_ori_centers1000.argsort()[:, ::-1]

print("Top words in each cluster by using Hierarchical method:")
print('')

# print out the top 50 words with largest weight in each cluster
for i in range(k_H1000):
    print("Top 50 words in Cluster {}: ".format(i+1))
    for ind in H_order_centroids1000[i, :50]:
        print(' %s' % terms1000[ind], end='')
    print("")
    print("")
```

```
Top words in each cluster by using Hierarchical method:

Top 50 words in Cluster 1:
 tofu curry mein chow panda teriyaki japanese tempura pad korean china wonton pho mongolian mis

Top 50 words in Cluster 2:
 pizzas pepperoni tofu curry mein chow panda teriyaki japanese driver tempura pad korean hut c

Top 50 words in Cluster 3:
 pizzas pepperoni curry tofu court bartenders philly lamb chow calamari panda teriyaki eggplan

Top 50 words in Cluster 4:
 pizzas asada nachos pepperoni carne court curry tofu burritos bartenders guacamole chow lamb

Top 50 words in Cluster 5:
 pizzas subway nachos pepperoni asada carne court burritos curry bartenders tofu teriyaki guaca
```

From top 50 words in each cluster, we can selects several key words as their labels.

Cluster 1 : curry, Chinese, Japanese

Cluster 2 : pizzas, tofu, Korean

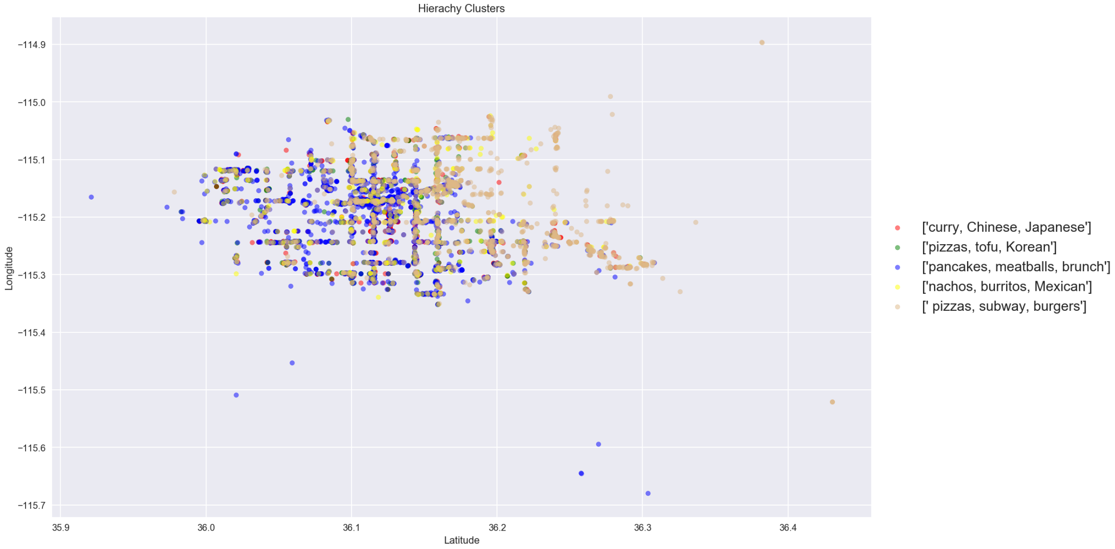
Cluster 3 : pancakes, meatballs, brunch

Cluster 4 : nachos, burritos, Mexican

Cluster 5 : pizzas, subway, burgers

```
In [222]: H_cluster1000_top = [['curry, Chinese, Japanese'],['pizzas, tofu, Korean'],['pancakes
          c = ['r', 'g', 'blue', 'yellow', 'burlywood','darkseagreen', 'beige', 'pink', 'orange

          plt.figure(figsize=(16,10))
          for i in range(k_H100):
              plt.scatter(latitude[clusters1000==i+1], longitude[clusters1000==i+1], s=25, colo

          plt.legend(loc='center left', bbox_to_anchor=(1, 0.5),prop={'size': 15})
          plt.title('Hierachy Clusters')
          plt.xlabel('Latitude')
          plt.ylabel('Longitude')
```

```
Out[222]: Text(0,0.5,'Longitude')
```

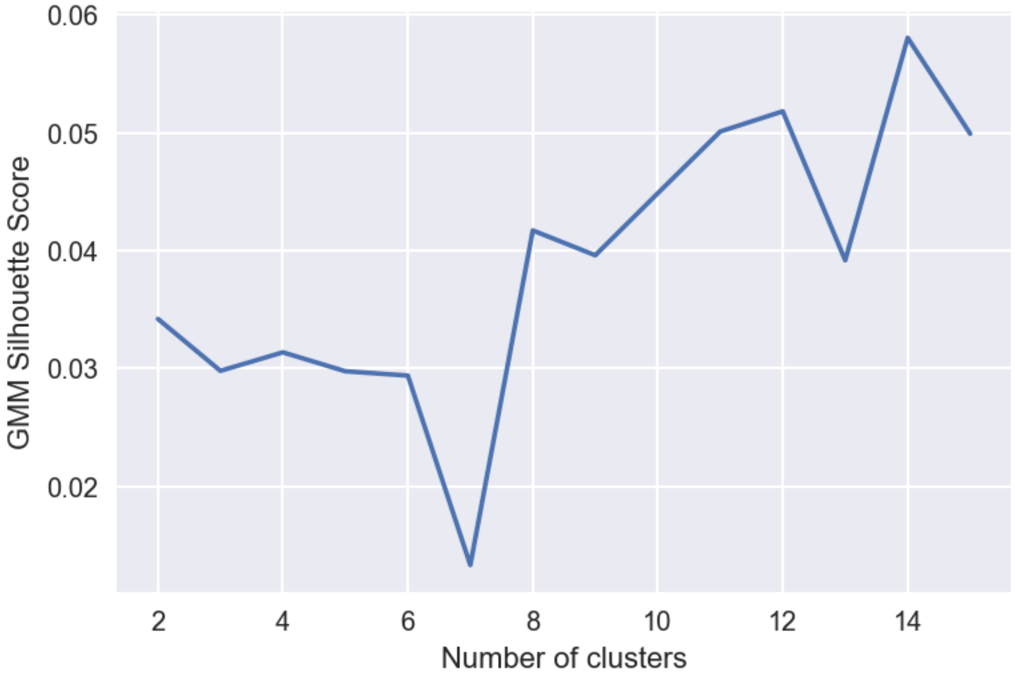


13 GMM clusters

```
In [179]: s = np.zeros(max_clusters+1)
          for k in range(2,max_clusters+1):
              gmm = mixture.GaussianMixture(n_components=k, covariance_type='full')
              gmm.fit(feature1000)
```

```
                y_pred = gmm.predict(feature1000)
                s[k] = metrics.silhouette_score(feature1000,y_pred,metric='euclidean')
            plt.plot(range(2,len(s)),s[2:])
            plt.xlabel('Number of clusters')
            plt.ylabel('GMM Silhouette Score')
```

```
Out[179]: Text(0,0.5,'GMM Silhouette Score')
```



```
In [223]: k_G1000 = 5
          gmm = mixture.GaussianMixture(n_components=k_G1000, covariance_type='tied')
          gmm.fit(feature1000)
          y_pred1000 = gmm.predict(feature1000)

          G_dic1000 = {}
          for i in y_pred1000:
              if i in G_dic1000:
                  G_dic1000[i] += 1
              else:
                  G_dic1000[i] = 1

          for i in range(k_G1000):
              print('There are {} restautrants in cluster {}. '.format(G_dic1000[i], i))
```

```
There are 531 restautrants in cluster 0.
There are 668 restautrants in cluster 1.
There are 471 restautrants in cluster 2.
There are 3663 restautrants in cluster 3.
There are 566 restautrants in cluster 4.
```

```
In [224]: # Calculate the centroids in each cluster
          cluster_G1000 = {}
          sum_G1000 = []
          G_centroids1000 = []
          sum_GG1000 =  np.zeros(102)
          for i in range(k_G1000):
              cluster_G1000[i] = np.array([feature1000[j] for j in range(len(location)) if y_p
              for k in range(len(cluster_G1000[i])):
                  sum_GG1000 = list(map(lambda x: x[0]+x[1], zip(sum_GG1000, cluster_G1000[i][
              sum_G1000.append(sum_GG1000)
              center =  [(sum_GG1000[j]/len(cluster_G1000[i])) for j in range(len(sum_GG1000))
              G_centroids1000.append(center)

          G_centroids1000 = np.array(G_centroids1000)
          G_ori_centers1000 = lsa.inverse_transform(G_centroids1000[:,:100])
          G_order_centroids1000 = G_ori_centers1000.argsort()[:, ::-1]

          print("Top words in each cluster by using GMM method:")
          print('')

          # print out the top 50 words with largest weight in each cluster
          for i in range(k_G1000):
              print("Top 50 words in Cluster {}: ".format(i))
              for ind in G_order_centroids1000[i, :50]:
                  print(' %s' % terms1000[ind], end='')
              print("")
              print("")
```

```
Top words in each cluster by using GMM method:

Top 50 words in Cluster 0:
 filet steakhouse steaks mignon calamari ravioli veal asparagus ribeye lamb olive scallops spag

Top 50 words in Cluster 1:
 bartenders nachos machines burritos poker gaming filet games chipotle steaks pt calamari vide

Top 50 words in Cluster 2:
 pizzas pepperoni bartenders hut meatballs mozzarella parmesan driver marinara knots machines

Top 50 words in Cluster 3:
 pizzas subway pepperoni court curry bartenders tofu nachos teriyaki mcdonald groupon pancakes

Top 50 words in Cluster 4:
 pizzas subway nachos pepperoni asada carne court burritos curry bartenders tofu teriyaki guaca
```

From top 50 words in each cluster, we can selects several key words as their labels.

Cluster 0 : steaks, meatballs, wines

Cluster 1 : nachos, Mexican, Hawaiian

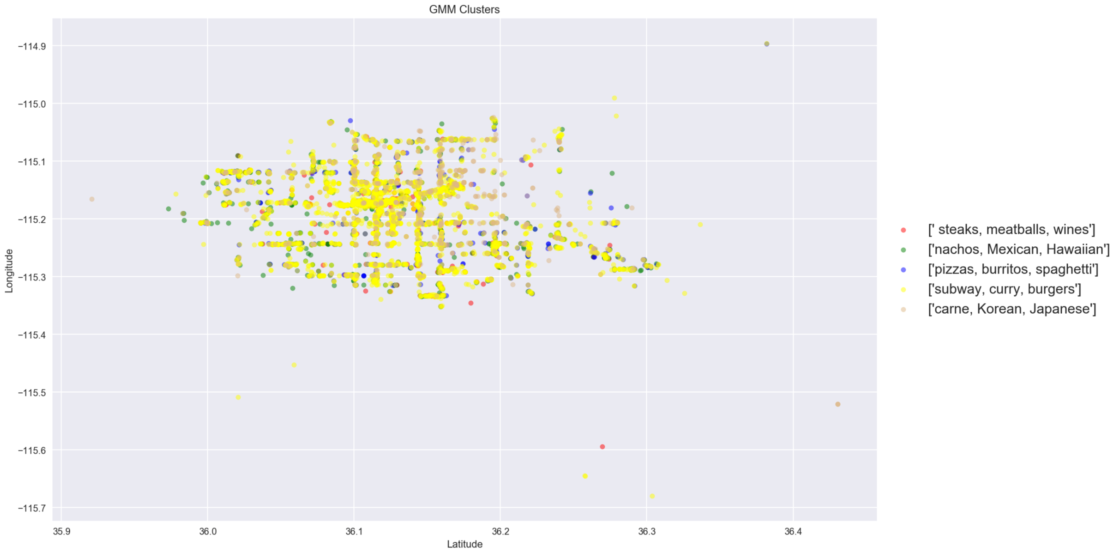
Cluster 2 : pizzas, burritos, spaghetti

Cluster 3 : subway, curry, burgers

Cluster 4 : carne, Korean, Japanese

```
In [225]: G_cluster1000_top = [[' steaks, meatballs, wines'],['nachos, Mexican, Hawaiian'],['pi
          c = ['r', 'g', 'blue', 'yellow', 'burlywood','darkseagreen', 'beige', 'pink', 'orange

          plt.figure(figsize=(16,10))
          for i in range(k_G1000):
              plt.scatter(latitude[y_pred1000==i], longitude[y_pred1000==i], s=25, color=c[i],l

          plt.legend(loc='center left', bbox_to_anchor=(1, 0.5),prop={'size': 15})
          plt.title('GMM Clusters')
          plt.xlabel('Latitude')
          plt.ylabel('Longitude')
```

```
Out[225]: Text(0,0.5,'Longitude')
```



What observations can you make regarding the different *k* values and clusterings? We are expecting comments on the labels of each cluster for the different *k*, on the districts created, on the results of each clustering e.t.c. In general, feel free to report any interesting findings you made. **(2 pts)**

13.0.1 Findings

1. It took me nearly 5 hours to run stemming of 100 or 1000 top reivews. So I gave up, only use the words which were not stemmed... I am so sorry about it.
2. When k=10, by using the stemmed information, we can get more precise high frequency key words in the all reviews because we eliminate the noises from the words endings (That's why "Mexican" frequency is much less in k=100 and k=1000 than k=10)
3. When k becomes larger, the distribution of clusters weight becomes more even.
4. From the scatter figures, the GMM method has most overlapping clusters.
5. Key words about Fast food tend to be high frequency key words in each clusters.
