

```
1 pip install --upgrade pip

Collecting pip
  Downloading https://files.pythonhosted.org/packages/ac/cf/0cc542fc93de2f3b9b53cb979c7
    |████████| 1.6MB 13.6MB/s
Installing collected packages: pip
  Found existing installation: pip 19.3.1
    Uninstalling pip-19.3.1:
      Successfully uninstalled pip-19.3.1
Successfully installed pip-21.1
```

```
1 pip install hdbscan
```

```
user = False
home = None
root = None
prefix = None
Installing build dependencies ... done

Getting requirements to build wheel ... done
  Preparing wheel metadata ... done
Requirement already satisfied: cython>=0.27 in /usr/local/lib/python3.7/dist-packages
Requirement already satisfied: six in /usr/local/lib/python3.7/dist-packages (from hdbscan)
Requirement already satisfied: scikit-learn>=0.20 in /usr/local/lib/python3.7/dist-packages
Requirement already satisfied: numpy>=1.16 in /usr/local/lib/python3.7/dist-packages
Requirement already satisfied: joblib>=1.0 in /usr/local/lib/python3.7/dist-packages
Requirement already satisfied: scipy>=1.0 in /usr/local/lib/python3.7/dist-packages
Building wheels for collected packages: hdbscan
  Building wheel for hdbscan (PEP 517) ... done
  Created wheel for hdbscan: filename=hdbscan-0.8.27-cp37-cp37m-linux_x86_64.whl size=1.6MB
  Stored in directory: /root/.cache/pip/wheels/73/5f/2f/9a259b84003b84847c259779206a
Successfully built hdbscan
Installing collected packages: hdbscan
  WARNING: Value for scheme platlib does not match. Please report this to <https://github.com/pypa/warehouse/blob/2.0.0/src/warehouse/toml.py#L110>
  distutils: /usr/local/lib/python3.7/dist-packages
  sysconfig: /usr/lib/python3.7/site-packages
  WARNING: Value for scheme purelib does not match. Please report this to <https://github.com/pypa/warehouse/blob/2.0.0/src/warehouse/toml.py#L110>
  distutils: /usr/local/lib/python3.7/dist-packages
  sysconfig: /usr/lib/python3.7/site-packages
  WARNING: Value for scheme headers does not match. Please report this to <https://github.com/pypa/warehouse/blob/2.0.0/src/warehouse/toml.py#L110>
  distutils: /usr/local/include/python3.7/hdbscan
  sysconfig: /usr/include/python3.7m/hdbscan
  WARNING: Value for scheme scripts does not match. Please report this to <https://github.com/pypa/warehouse/blob/2.0.0/src/warehouse/toml.py#L110>
  distutils: /usr/local/bin
  sysconfig: /usr/bin
  WARNING: Value for scheme data does not match. Please report this to <https://github.com/pypa/warehouse/blob/2.0.0/src/warehouse/toml.py#L110>
  distutils: /usr/local
  sysconfig: /usr
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[diff](#) [HOME](#) [None](#)

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root = None
prefix = None
WARNING: Value for scheme platlib does not match. Please report this to <https://github.com/pypa/warehouse/blob/2.0.0/src/warehouse/toml.py#L110>
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distutils: /usr/local/lib/python3.7/dist-packages
sysconfig: /usr/lib/python3.7/site-packages
WARNING: Value for scheme.purelib does not match. Please report this to <https://github.com>
distutils: /usr/local/lib/python3.7/dist-packages
sysconfig: /usr/lib/python3.7/site-packages
WARNING: Value for scheme.headers does not match. Please report this to <https://github.com>
distutils: /usr/local/include/python3.7/UNKNOWN
sysconfig: /usr/include/python3.7m
WARNING: Value for scheme.scripts does not match. Please report this to <https://github.com>
distutils: /usr/local/bin
sysconfig: /usr/bin
WARNING: Value for scheme.data does not match. Please report this to <https://github.com>
distutils: /usr/local
sysconfig: /usr
WARNING: Additional context:
user = False
home = None
root = None
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1 pip install folium

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WARNING: Value for scheme.platlib does not match. Please report this to <https://github.com>
distutils: /usr/local/lib/python3.7/dist-packages
sysconfig: /usr/lib/python3.7/site-packages
WARNING: Value for scheme.purelib does not match. Please report this to <https://github.com>
distutils: /usr/local/lib/python3.7/dist-packages
sysconfig: /usr/lib/python3.7/site-packages
WARNING: Value for scheme.headers does not match. Please report this to <https://github.com>
distutils: /usr/local/include/python3.7/UNKNOWN
sysconfig: /usr/include/python3.7m
WARNING: Value for scheme.scripts does not match. Please report this to <https://github.com>
distutils: /usr/local/bin
sysconfig: /usr/bin
WARNING: Value for scheme.data does not match. Please report this to <https://github.com>
distutils: /usr/local
sysconfig: /usr
WARNING: Additional context:
user = False
home = None
root = None
prefix = None
Requirement already satisfied: folium in /usr/local/lib/python3.7/dist-packages (0.8.3)
Requirement already satisfied: numpy in /usr/local/lib/python3.7/dist-packages (from folium)
Requirement already satisfied: jinja2 in /usr/local/lib/python3.7/dist-packages (from folium)
Requirement already satisfied: requests in /usr/local/lib/python3.7/dist-packages (from folium)
Requirement already satisfied: six in /usr/local/lib/python3.7/dist-packages (from folium)
Requirement already satisfied: branca>=0.3.0 in /usr/local/lib/python3.7/dist-packages
Requirement already satisfied: MarkupSafe>=0.23 in /usr/local/lib/python3.7/dist-packages
Requirement already satisfied: idna<3,>=2.5 in /usr/local/lib/python3.7/dist-packages
Requirement already satisfied: chardet<4,>=3.0.2 in /usr/local/lib/python3.7/dist-packages
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distutils: /usr/local/lib/python3.7/dist-packages
sysconfig: /usr/lib/python3.7/site-packages
WARNING: Value for scheme.purelib does not match. Please report this to <https://github.com>
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distutils: /usr/local/lib/python3.7/dist-packages
sysconfig: /usr/lib/python3.7/site-packages
WARNING: Value for scheme.headers does not match. Please report this to <https://github.com>
distutils: /usr/local/include/python3.7/UNKNOWN
sysconfig: /usr/include/python3.7m
WARNING: Value for scheme.scripts does not match. Please report this to <https://github.com>
distutils: /usr/local/bin
sysconfig: /usr/bin
WARNING: Value for scheme.data does not match. Please report this to <https://github.com>
distutils: /usr/local
sysconfig: /usr
WARNING: Additional context:
user = False
home = None
root = None
prefix = None
WARNING: Running pip as root will break packages and permissions. You should install pa
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1 import matplotlib
2 %matplotlib inline
3 %config InlineBackend.figure_format = 'svg'
4 import matplotlib.pyplot as plt
5 plt.style.use('ggplot')
6
7 import pandas as pd
8 import numpy as np
9
10 from tqdm import tqdm
11
12 from sklearn.cluster import KMeans, DBSCAN
13 from sklearn.metrics import silhouette_score, calinski_harabasz_score, davies_bouldin_score
14 from sklearn.datasets import make_blobs
15 from sklearn.neighbors import KNeighborsClassifier
16
17 from ipywidgets import interactive
18
19 from collections import defaultdict
20
21 import hdbscan
22 import folium
23 import re
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```

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Mounted at /content/drive

```
1 from tqam import tqam
2
3 from sklearn.cluster import KMeans, DBSCAN
4 from sklearn.metrics import silhouette_score
5 from sklearn.datasets import make_blobs
6 from sklearn.neighbors import KNeighborsClassifier
7
8 from ipywidgets import interactive
9
10 from collections import defaultdict
11
12 import folium
13 import re

1 cols=[ "user","check-in time", "latitude","longitude","location id"]
2 df = pd.read_csv(
3     "/content/drive/My Drive/CNN/Brightkite_totalCheckins.txt", delimiter="\t", header=1
4 )
5 df.head()
```

	user	check-in time	latitude	longitude	location id
0	0	2010-10-17T01:48:53Z	39.747652	-104.992510	88c46bf20db295831bd2d1718
1	0	2010-10-16T06:02:04Z	39.891383	-105.070814	7a0f88982aa015062b95e3b48
2	0	2010-10-16T03:18:51Z	39.891077	-105.068532	dd7cd3d264c2d063832db506f

```
1 df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 4747287 entries, 0 to 4747286
Data columns (total 5 columns):
 #   Column            Dtype  
 --- 
 0   user              int64  
 1   check-in time    object  
 2   latitude          float64 
 3   longitude         float64 
 4   location id      object  
dtypes: float64(2), int64(1), object(2)
memory usage: 181.1+ MB
```

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	user	latitude	longitude
count	4.747287e+06	4.747281e+06	4.747281e+06
mean	1.387181e+04	3.436971e+01	-4.213998e+01
std	1.335953e+04	1.739254e+01	8.466702e+01
min	0.000000e+00	-1.631933e+02	-1.798242e+02
25%	3.348000e+03	3.348218e+01	-9.861641e+01
50%	9.645000e+03	3.778241e+01	-7.955681e+01

```

1 df["user"].nunique()

51406
```

```

1 df.isna().values.any()

True
```

```

1 print(f'Before dropping NaNs \t:\t df.shape = {df.shape}')
2 df.dropna(inplace=True)
3 print(f'After dropping NaNs \t:\t df.shape = {df.shape}')

Before dropping NaNs      :      df.shape = (4747287, 5)
After dropping NaNs      :      df.shape = (4747281, 5)
```

```

1 X = np.array(df[["latitude","longitude"]], dtype='float64')
```

```

1 from sklearn.model_selection import train_test_split
2 X_train, X_test = train_test_split(X, test_size = 0.005, random_state = 0)
```

```

1 print(pd.DataFrame(X_test).info())
2 print(pd.DataFrame(X_test).describe())

<class 'pandas.core.frame.DataFrame'>
RangeIndex: 23737 entries, 0 to 23736
Data columns (total 2 columns):
 #   Column  Non-Null Count  Dtype  
---  --     --          --    
 0   0       23737 non-null   float64 
 1   1       23737 non-null   float64 
dtypes: float64(2)
memory usage: 371.0 KB
```

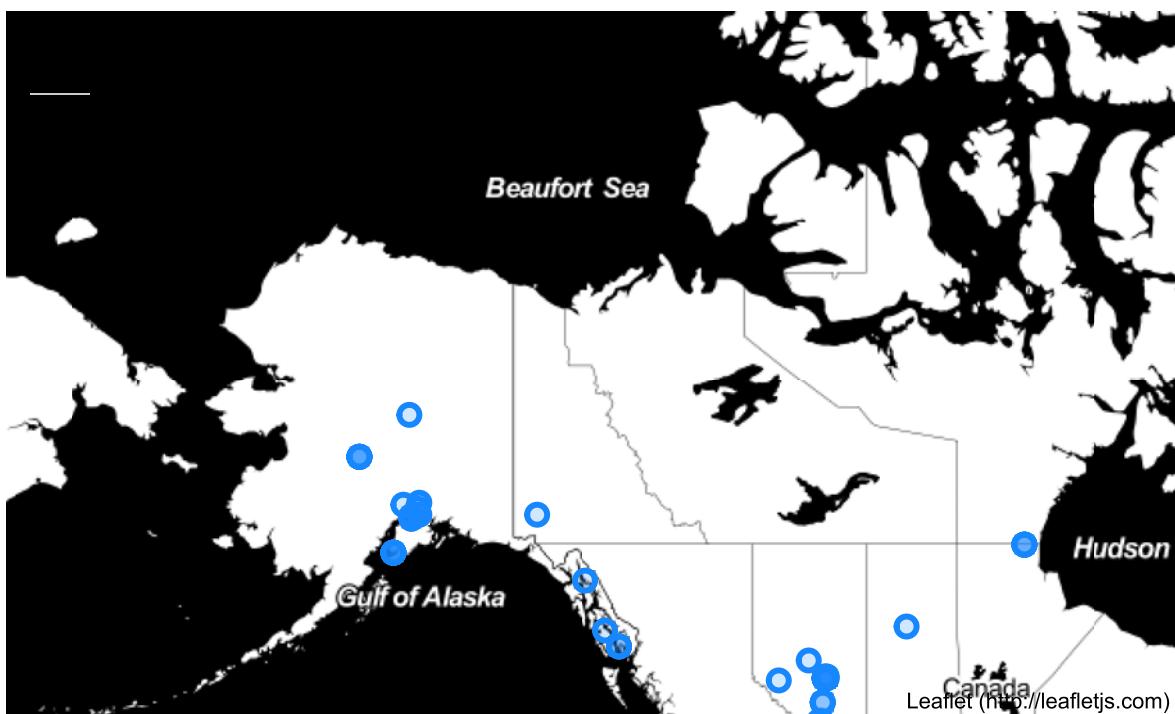
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mean	34.318984	-42.857492
std	17.420033	84.029079
min	-90.000000	-166.599692

25%	33.504479	-99.164130
50%	37.783171	-79.796294
75%	41.947969	0.000000
max	70.662689	175.783333

```
1 m = folium.Map(location=[X_test[:,0].mean(), X_test[:,1].mean()], zoom_start=9,
2                  tiles='Stamen Toner')
3
4 for i in range(0,23737):
5     folium.CircleMarker(
6         location=[X_test[i,0], X_test[i,1]],
7         radius=5,
8         color='#1787FE',
9         fill=True,
10        fill_colour='#1787FE'
11     ).add_to(m)
1
1 m
```

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```

1 wcss=[]
2 for i in range(1,15):
3     kmeans=KMeans(n_clusters=i,init='k-means++',max_iter=300,n_init=10,random_state=0)
4     kmeans.fit(X_test)
5     wcss.append(kmeans.inertia_)
6

1 pip install kneed
distutils: /usr/local
sysconfig: /usr
WARNING: Additional context:
user = False
home = None
root = None
prefix = None
Collecting kneed
    Downloading kneed-0.7.0-py2.py3-none-any.whl (9.4 kB)
Requirement already satisfied: numpy>=1.14.2 in /usr/local/lib/python3.7/dist-packages
Requirement already satisfied: scipy in /usr/local/lib/python3.7/dist-packages (from
Requirement already satisfied: matplotlib in /usr/local/lib/python3.7/dist-packages
Requirement already satisfied: cycler>=0.10 in /usr/local/lib/python3.7/dist-package
Requirement already satisfied: python-dateutil>=2.1 in /usr/local/lib/python3.7/dist
Requirement already satisfied: pyparsing!=2.0.4,!=2.1.2,!=2.1.6,>=2.0.1 in /usr/loc
Requirement already satisfied: kiwisolver>=1.0.1 in /usr/local/lib/python3.7/dist-pa
Requirement already satisfied: six in /usr/local/lib/python3.7/dist-packages (from c

```

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```

sysconfig: /usr/lib/python3.7/site-packages
WARNING: Value for scheme.purelib does not match. Please report this to <https://github.com>
distutils: /usr/local/lib/python3.7/dist-packages
sysconfig: /usr/lib/python3.7/site-packages

```

```
sysconfig: /usr/include/python3.7m/kneed
WARNING: Value for scheme.headers does not match. Please report this to <https://github.com/pypa/distutils>
distutils: /usr/local/include/python3.7/kneed
sysconfig: /usr/include/python3.7m/kneed
WARNING: Value for scheme.scripts does not match. Please report this to <https://github.com/pypa/distutils>
distutils: /usr/local/bin
sysconfig: /usr/bin
WARNING: Value for scheme.data does not match. Please report this to <https://github.com/pypa/distutils>
distutils: /usr/local
sysconfig: /usr
WARNING: Additional context:
user = False
home = None
root = None
prefix = None
WARNING: Value for scheme.platlib does not match. Please report this to <https://github.com/pypa/distutils>
distutils: /usr/local/lib/python3.7/dist-packages
sysconfig: /usr/lib/python3.7/site-packages
WARNING: Value for scheme.purelib does not match. Please report this to <https://github.com/pypa/distutils>
distutils: /usr/local/lib/python3.7/dist-packages
sysconfig: /usr/lib/python3.7/site-packages
WARNING: Value for scheme.headers does not match. Please report this to <https://github.com/pypa/distutils>
distutils: /usr/local/include/python3.7/UNKNOWN
sysconfig: /usr/include/python3.7m
WARNING: Value for scheme.scripts does not match. Please report this to <https://github.com/pypa/distutils>
distutils: /usr/local/bin
sysconfig: /usr/bin
WARNING: Value for scheme.data does not match. Please report this to <https://github.com/pypa/distutils>
distutils: /usr/local
sysconfig: /usr
WARNING: Additional context:
user = False
home = None
root = None
prefix = None
Successfully installed kneed-0.7.0
```

```
1 plt.plot(range(1,15),wcss,'bx-')
2 plt.title('The Elbow Method')
3 plt.xlabel('Number of clusters')
4 plt.ylabel('WCSS')
5 plt.show()
```

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The Elbow Method



```
1 from kneed import KneeLocator
2 kn = KneeLocator(range(1,15),wcss, curve='convex', direction='decreasing')
3 print(kn.knee)
```

3



```
1 k=3
2 model = KMeans(n_clusters=k, random_state=17).fit(X_test)
3 class_predictions = model.predict(X_test)
4 print(class_predictions)
```

```
[0 0 0 ... 0 0 2]
```

```
1 print(list(class_predictions).count(0))
2 print(list(class_predictions).count(1))
3 print(list(class_predictions).count(2))
```

```
15379
```

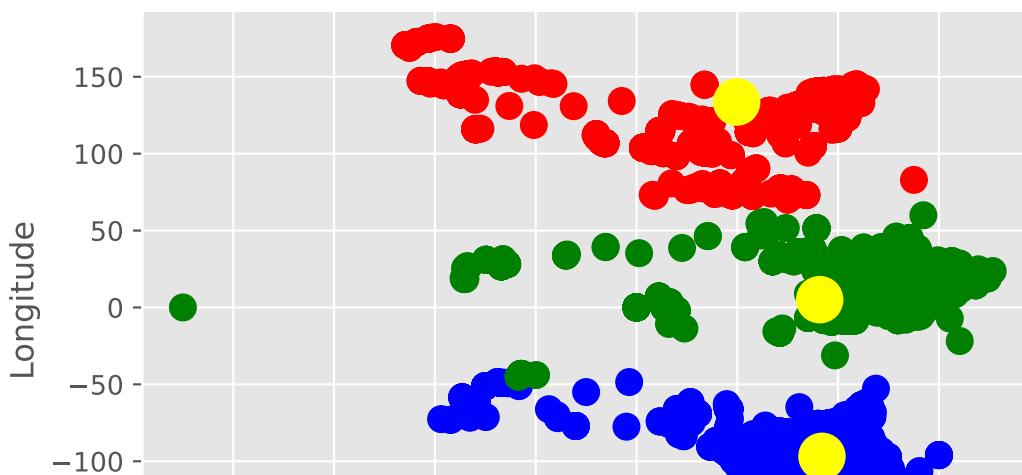
```
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```

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```

```
1 kmeans=KMeans(n_clusters=3,init='k-means++',max_iter=300,n_init=10,random_state=0)
2 y_kmeans=kmeans.fit_predict(X_test)
3
4
5 plt.scatter(X_test[y_kmeans==0,0],X_test[y_kmeans==0,1],s=100,c='red',label='cluster 1')
6 plt.scatter(X_test[y_kmeans==1,0],X_test[y_kmeans==1,1],s=100,c='blue',label='cluster 2')
7 plt.scatter(X_test[y_kmeans==2,0],X_test[y_kmeans==2,1],s=100,c='green',label='cluster 3')
8 plt.scatter(kmeans.cluster_centers_[:,0],kmeans.cluster_centers_[:,1],s=300,c='yellow',)
9 plt.title('Clusters of users')
10 plt.xlabel('Latitude')
11 plt.ylabel('Longitude')
12 plt.show()
```

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Clusters of users



```

1 best_silhouette, best_k = -1, 0
2
3 for k in tqdm(range(2, 10)):
4     model = KMeans(n_clusters=k, random_state=1).fit(X_test)
5     class_predictions = model.predict(X_test)
6
7     curr_silhouette = silhouette_score(X_test, class_predictions)
8     if curr_silhouette > best_silhouette:
9         best_k = k
10    best_silhouette = curr_silhouette
11
12 print(f'K={best_k}')
13 print(f'Silhouette Score: {best_silhouette}')

100%|██████████| 8/8 [01:05<00:00,  8.23s/it]K=3
Silhouette Score: 0.751058304924117

```

```

1 print(f'Calinski ignoring outliers: {calinski_harabasz_score(X_test[class_predictions!=
2
3 no_outliers = np.array([(counter+2)*x if x==1 else x for counter, x in enumerate(class_
4 print(f'Calinski outliers as singletons: {calinski_harabasz_score(X_test, no_outliers)')

Calinski ignoring outliers: 215308.6325502918
Calinski outliers as singletons: 215308.6325502918

```

```

1 print(f'Davies Bouldin ignoring outliers: {davies_bouldin_score(X_test[class_predictions!=
2
3 no_outliers = np.array([(counter+2)*x if x==1 else x for counter, x in enumerate(class_
4 print(f'Davies Bouldin as singletons: {davies_bouldin_score(X_test, no_outliers)')


```

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```

1 kmmeans_dat=pd.DataFrame(X_test)
2 kmmeans_dat['CLUSTER']=KMEANS['1']-1
kmmeans_dat

```

```

2 kmeans_dat['CLUSTERS_KMEANS'] = y_kmeans
3 kmeans_dat.head()

```

	0	1 CLUSTERS_KMEANS
0	34.046399	-118.448135
1	40.714269	-74.005973
2	40.707142	-74.013376
3	32.868831	-96.770719
4	42.883604	-78.872672

DBSCAN

```

1
2 model = DBSCAN(eps=0.01, min_samples=5).fit(X_test)
3 class_predictions = model.labels_

1 print(f'Number of clusters found: {len(np.unique(class_predictions))}')
2 print(f'Number of outliers found: {len(class_predictions[class_predictions== -1])}')
3
4 print(f'Silhouette ignoring outliers: {silhouette_score(X_test[class_predictions!= -1], ')
5
6 no_outliers = 0
7 no_outliers = np.array([(counter+2)*x if x== -1 else x for counter, x in enumerate(class_
8 print(f'Silhouette outliers as singletons: {silhouette_score(X_test, no_outliers)}')

Number of clusters found: 785
Number of outliers found: 11834
Silhouette ignoring outliers: 0.7661951430103257
Silhouette outliers as singletons: 0.2988007062481111

1 print(f'Calinski ignoring outliers: {calinski_harabasz_score(X_test[class_predictions!= -1])
2
3 no_outliers = np.array([(counter+2)*x if x== -1 else x for counter, x in enumerate(class_
4 print(f'Calinski outliers as singletons: {calinski_harabasz_score(X_test, no_outliers)')

Calinski ignoring outliers: 577981985.2748314
Calinski outliers as singletons: 68803410.67455058

1 print(f'Davies Bouldin ignoring outliers: {davies_bouldin_score(X_test[class_predictions!= -1])
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2
3 no_outliers = np.array([(counter+2)*x if x== -1 else x for counter, x in enumerate(class_
4 print(f'Davies Bouldin as singletons: {davies_bouldin_score(X_test, no_outliers)')

Davies Bouldin ignoring outliers: 0.14653707772832836

```

Davies Bouldin as singletons: 0.12403104775502434

```
1 dbSCAN_dat=pd.DataFrame(X_test)

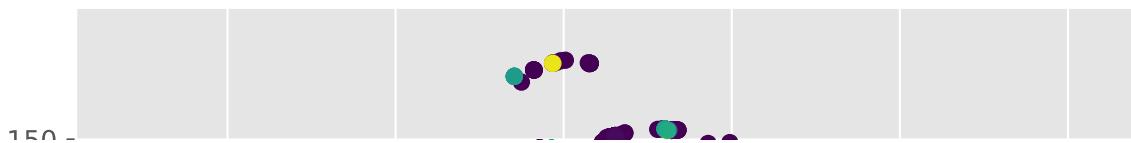
1 dbSCAN_dat[ 'CLUSTERS_DBSCAN' ] = class_predictions
2 dbSCAN_dat.head()
```

	0	1	CLUSTERS_DBSCAN
0	34.046399	-118.448135	0
1	40.714269	-74.005973	1
2	40.707142	-74.013376	1
3	32.868831	-96.770719	2
4	42.883604	-78.872672	3

```
1 plt.figure(figsize=(10, 8))
2 plt.scatter(X_test[:,0], X_test[:,1], c=model.labels_.astype(float))
```

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```
<matplotlib.collections.PathCollection at 0x7f17a5917390>
```



▼ HDBSCAN

```
1 model = hdbscan.HDBSCAN(min_cluster_size=5, min_samples=2,
2                           cluster_selection_epsilon=0.01)
3
4 class_predictions = model.fit_predict(X_test)

1 print(f'Number of clusters found: {len(np.unique(class_predictions))-1}')
2 print(f'Number of outliers found: {len(class_predictions[class_predictions== -1])}')
3
4 print(f'Silhouette ignoring outliers: {silhouette_score(X_test[class_predictions!= -1], (
5
6 no_outliers = np.array([(counter+2)*x if x== -1 else x for counter, x in enumerate(class_
7 print(f'Silhouette outliers as singletons: {silhouette_score(X_test, no_outliers)}')

Number of clusters found: 1485
Number of outliers found: 3801
Silhouette ignoring outliers: 0.6548991258646143
Silhouette outliers as singletons: 0.4596338355071577

1 print(f'Calinski ignoring outliers: {calinski_harabasz_score(X_test[class_predictions!= -1])
2
3 no_outliers = np.array([(counter+2)*x if x== -1 else x for counter, x in enumerate(class_
4 print(f'Calinski outliers as singletons: {calinski_harabasz_score(X_test, no_outliers)')

Calinski ignoring outliers: 456389.3477635357
Calinski outliers as singletons: 151607.63399134102

1 print(f'Davies Bouldin ignoring outliers: {davies_bouldin_score(X_test[class_predictions!= -1])
2
3 no_outliers = np.array([(counter+2)*x if x== -1 else x for counter, x in enumerate(class_
4 print(f'Davies Bouldin outliers as singletons: {davies_bouldin_score(X_test, no_outliers)')

Davies Bouldin ignoring outliers: 0.4204648261224274
Davies Bouldin outliers as singletons: 0.3548516344098311
```

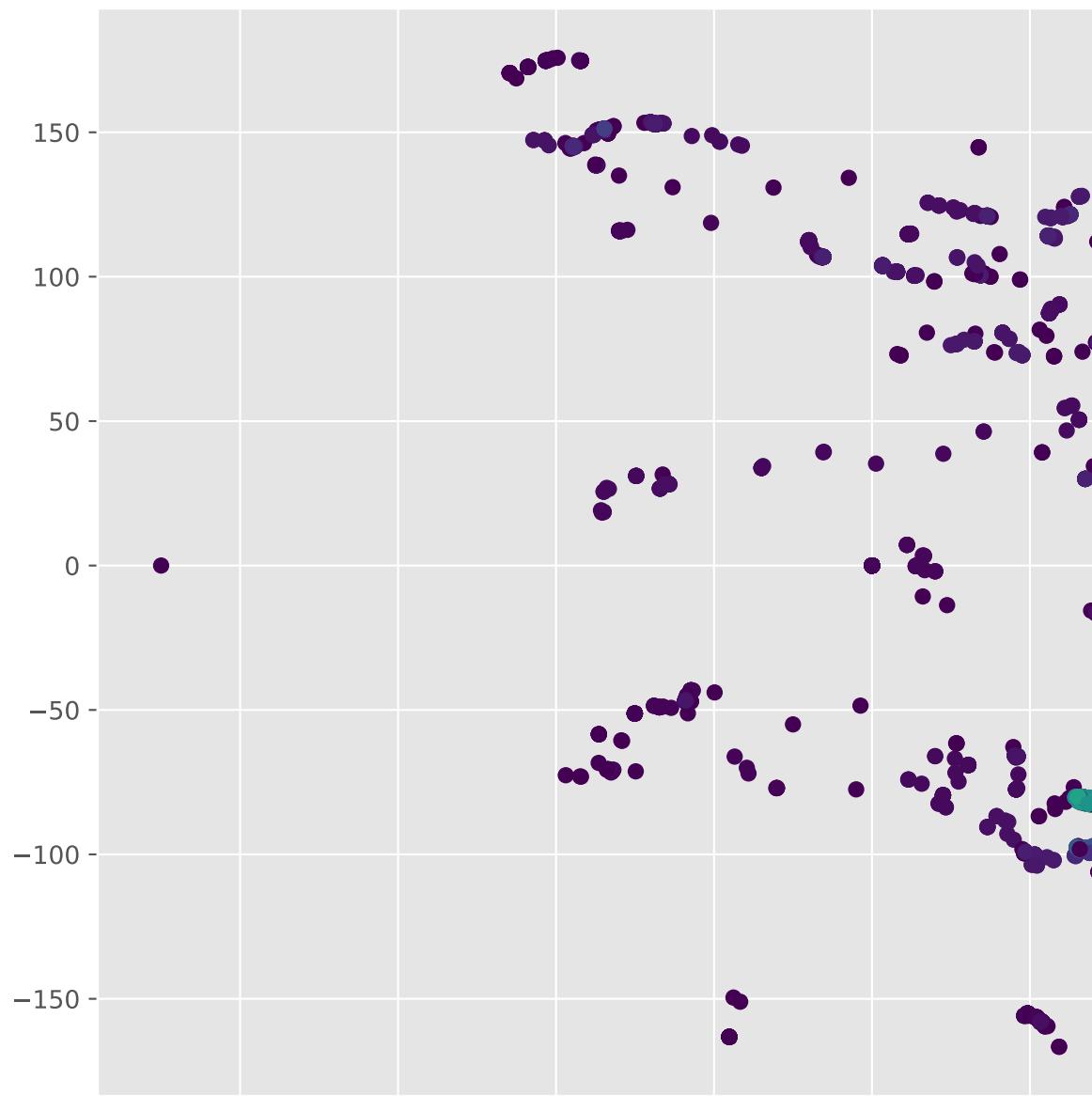
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[diff](#) `hdbscan_dat.head()`

	0	1	CLUSTERS_HDBSCAN
0	34.046399	-118.448135	1151
1	40.714269	-74.005973	1481
2	40.707142	-74.013376	1481
3	32.868831	-96.770719	968

```
1 plt.figure(figsize=(10, 8))
2 plt.scatter(X_test[:,0], X_test[:,1], c=model.labels_.astype(float))
```

```
<matplotlib.collections.PathCollection at 0x7f17a5917c10>
```



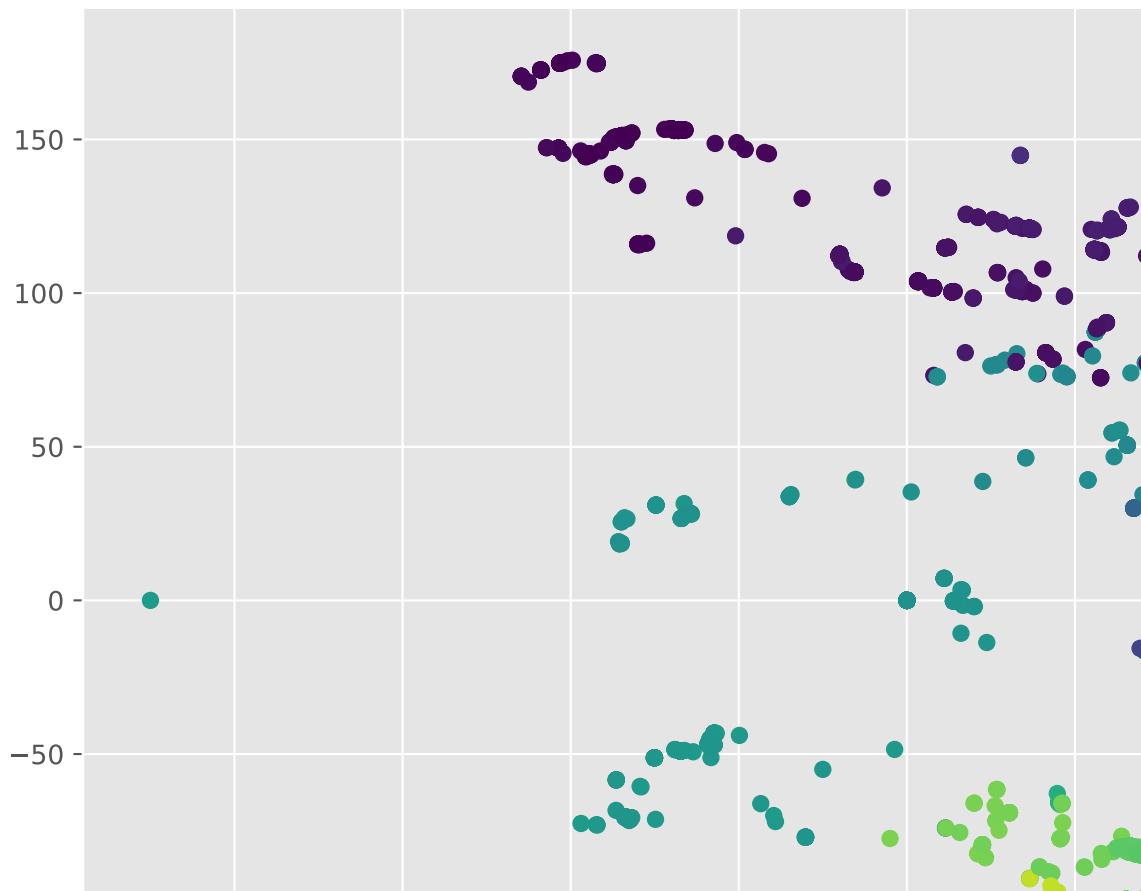
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▼ BIRCH

```
1 from sklearn.cluster import Birch  
  
1 brc = Birch(n_clusters=None)  
  
1 class_predictions=brc.fit_predict(X_test)  
  
1 print(f'Number of clusters found: {len(np.unique(class_predictions))-1}')  
2 print(f'Number of outliers found: {len(class_predictions[class_predictions== -1])}')  
3  
4 print(f'Silhouette ignoring outliers: {silhouette_score(X_test[class_predictions!= -1],  
5  
6 no_outliers = np.array([(counter+2)*x if x== -1 else x for counter, x in enumerate(class_  
7 print(f'Silhouette outliers as singletons: {silhouette_score(X_test, no_outliers)}')  
  
Number of clusters found: 875  
Number of outliers found: 0  
Silhouette ignoring outliers: 0.6563531735169894  
Silhouette outliers as singletons: 0.6563531735169894  
  
1 print(f'Calinski ignoring outliers: {calinski_harabasz_score(X_test[class_predictions!= -1])}')  
2  
3 no_outliers = np.array([(counter+2)*x if x== -1 else x for counter, x in enumerate(class_]  
4 print(f'Calinski outliers as singletons: {calinski_harabasz_score(X_test, no_outliers)}')  
  
Calinski ignoring outliers: 2869745.220027992  
Calinski outliers as singletons: 2869745.220027992  
  
1 print(f'Davies Bouldin ignoring outliers: {davies_bouldin_score(X_test[class_predictions!= -1])}')  
2  
3 no_outliers = np.array([(counter+2)*x if x== -1 else x for counter, x in enumerate(class_]  
4 print(f'Davies Bouldin as singletons: {davies_bouldin_score(X_test, no_outliers)}')  
  
Davies Bouldin ignoring outliers: 0.38315825945478854  
Davies Bouldin as singletons: 0.38315825945478854  
  
1 plt.figure(figsize=(10, 8))  
2 plt.scatter(X_test[:,0], X_test[:,1], c=brc.labels_.astype(float))
```

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```
<matplotlib.collections.PathCollection at 0x7f17a48a3450>
```



▼ OPTICS

```
1 from sklearn.cluster import OPTICS
2
3 model = OPTICS(min_samples=2)
4
5 class_predictions= model.fit_predict(X_test)

/usr/local/lib/python3.7/dist-packages/sklearn/cluster/_optics.py:802: RuntimeWarning:
ratio = reachability_plot[:-1] / reachability_plot[1:]
```

```
1 print(f'Number of clusters found: {len(np.unique(class_predictions))-1}')
2 print(f'Number of outliers found: {len(class_predictions[class_predictions== -1])}')
3
4 print(f'Silhouette ignoring outliers: {silhouette_score(X_test[class_predictions!= -1], (
```

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```
/n enumerate(class_
diff _predictions) as singletons: {silhouette_score(X_test, no_outliers)})'
```

Number of clusters found: 5463
Number of outliers found: 3076

```
Silhouette ignoring outliers: 0.791322364163566
Silhouette outliers as singletons: 0.6747560455330907
```

```
1 print(f'Calinski ignoring outliers: {calinski_harabasz_score(X_test[class_predictions!=
2
3 no_outliers = np.array([(counter+2)*x if x==1 else x for counter, x in enumerate(class_
4 print(f'Calinski outliers as singletons: {calinski_harabasz_score(X_test, no_outliers)}`

Calinski ignoring outliers: 971943.1093159069
Calinski outliers as singletons: 726856.1953551086

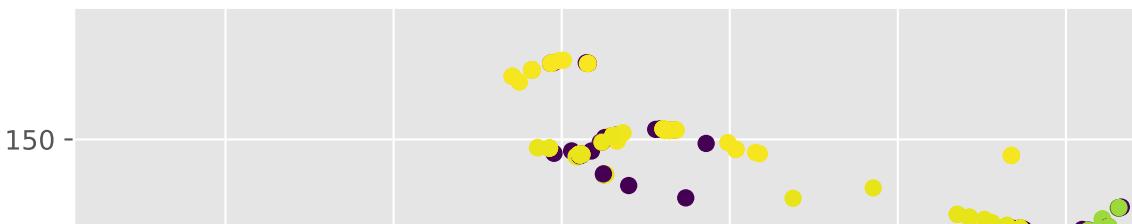
1 print(f'Davies Bouldin ignoring outliers: {davies_bouldin_score(X_test[class_predictions!=
2
3 no_outliers = np.array([(counter+2)*x if x==1 else x for counter, x in enumerate(class_
4 print(f'Davies Bouldin outliers as singletons: {davies_bouldin_score(X_test, no_outliers)}`

Davies Bouldin ignoring outliers: 0.33043150147184736
Davies Bouldin outliers as singletons: 0.29516973191501505

1 plt.figure(figsize=(10, 8))
2 plt.scatter(X_test[:,0], X_test[:,1], c=model.labels_.astype(float))
```

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```
<matplotlib.collections.PathCollection at 0x7f17a3e7f9d0>
```



▼ Gowalla

```
1 cols=[ "user", "check-in time", "latitude", "longitude", "location id"]
2 dataset = pd.read_csv(
3     "/content/drive/My Drive/CNN/Gowalla_totalCheckins.txt", delimiter="\t", header=None
4 )
5 dataset.head()
```

	user	check-in time	latitude	longitude	location id
0	0	2010-10-19T23:55:27Z	30.235909	-97.795140	22847
1	0	2010-10-18T22:17:43Z	30.269103	-97.749395	420315
2	0	2010-10-17T23:42:03Z	30.255731	-97.763386	316637
3	0	2010-10-17T19:26:05Z	30.263418	-97.757597	16516
4	0	2010-10-16T18:50:42Z	30.274292	-97.740523	5535878

```
1 X = np.array(dataset[["latitude", "longitude"]], dtype='float64')
```

```
1 from sklearn.model_selection import train_test_split
2 X_train, X_test = train_test_split(X, test_size = 0.005, random_state = 0)
```

```
1 pd.DataFrame(X_test).info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 32215 entries, 0 to 32214
Data columns (total 2 columns):
 #   Column  Non-Null Count  Dtype  
--- 
 0   0       32215 non-null   float64 
 1   1       32215 non-null   float64 
dtypes: float64(2)
memory usage: 503.5 KB
```

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	0	1
count	32215.000000	32215.000000
mean	40.493322	-47.877084
std	14.610465	65.970667
min	-45.871721	-159.467657
25%	33.393382	-97.664063
50%	39.839617	-78.765173
---	54.100000	10.000000

▼ OPTICS

```

1 model = OPTICS(min_samples=2)

1 class_predictions= model.fit_predict(X_test)

/usr/local/lib/python3.7/dist-packages/sklearn/cluster/_optics.py:802: RuntimeWarning:
ratio = reachability_plot[:-1] / reachability_plot[1:]

1 print(f'Number of clusters found: {len(np.unique(class_predictions))-1}')
2 print(f'Number of outliers found: {len(class_predictions[class_predictions== -1])}')
3
4 print(f'Silhouette ignoring outliers: {silhouette_score(X_test[class_predictions!= -1], (
5
6 no_outliers = np.array([(counter+2)*x if x== -1 else x for counter, x in enumerate(class_
7 print(f'Silhouette outliers as singletons: {silhouette_score(X_test, no_outliers)}')
8
9 print(f'Calinski ignoring outliers: {calinski_harabasz_score(X_test[class_predictions!= -1])
10
11 no_outliers = np.array([(counter+2)*x if x== -1 else x for counter, x in enumerate(class_
12 print(f'Calinski outliers as singletons: {calinski_harabasz_score(X_test, no_outliers)}')
13
14 print(f'Davies Bouldin ignoring outliers: {davies_bouldin_score(X_test[class_predictions!= -1])
15
16 no_outliers = np.array([(counter+2)*x if x== -1 else x for counter, x in enumerate(class_
17 print(f'Davies Bouldin as singletons: {davies_bouldin_score(X_test, no_outliers)}')

Number of clusters found: 9013
Number of outliers found: 5700

```

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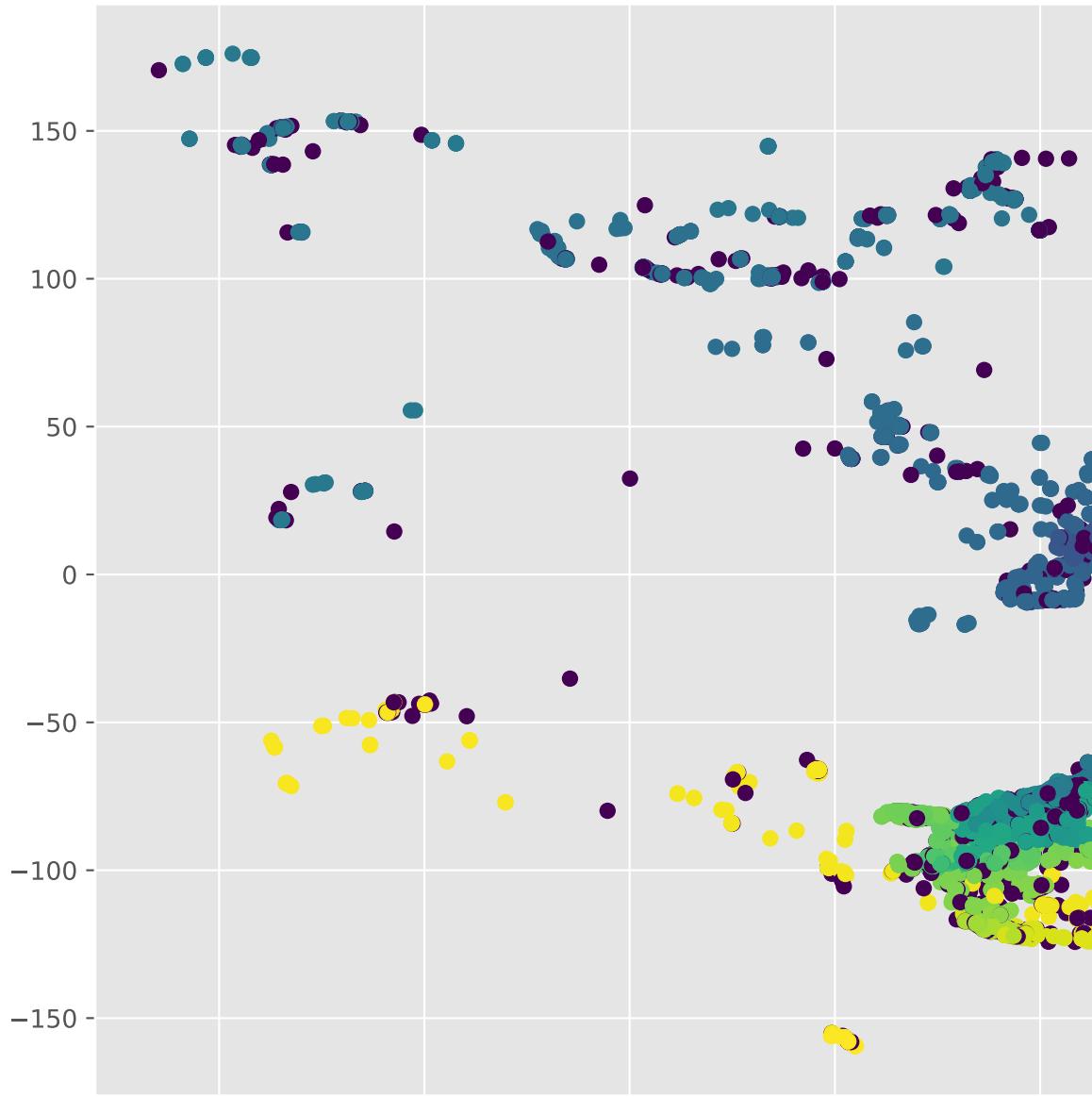
[diff](#)

Calinski ignoring outliers: 915006.6944089212

Calinski outliers as singletons: 688000.7410681586

```
Davies Bouldin ignoring outliers: 0.3736579135589328
Davies Bouldin ignoring outliers: 0.3736579135589328
1  plt.figure(figsize=(10, 8))
2  plt.scatter(X_test[:,0], X_test[:,1], c=model.labels_.astype(float))

<matplotlib.collections.PathCollection at 0x7f17a3d4eb10>
```



▼ DBSCAN

1

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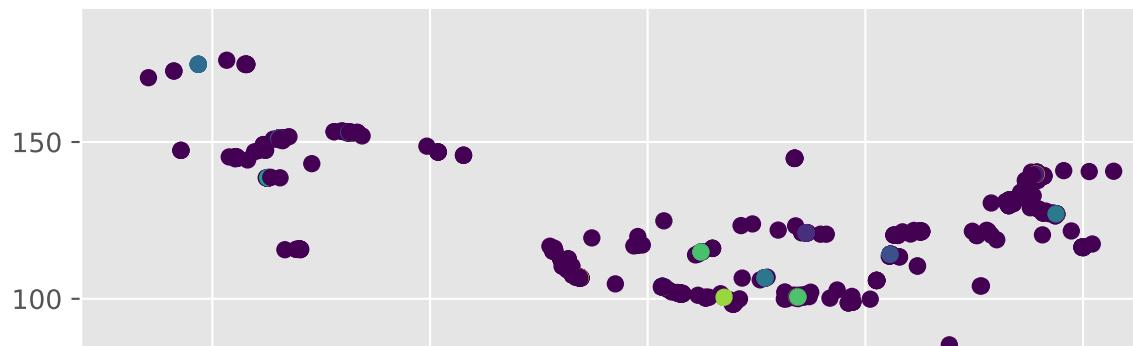
```
1  print(f'Number of clusters found: {len(np.unique(class_predictions))-1}')
2  print(f'Number of outliers found: {len(class_predictions[class_predictions== -1])}')
```

```
3  
4 print(f'Silhouette ignoring outliers: {silhouette_score(X_test[class_predictions!=-1],  
5  
6 no_outliers = np.array([(counter+2)*x if x==-1 else x for counter, x in enumerate(class_  
7 print(f'Silhouette outliers as singletons: {silhouette_score(X_test, no_outliers)})'  
8  
9 print(f'Calinski ignoring outliers: {calinski_harabasz_score(X_test[class_predictions!=-1]  
10 no_outliers = np.array([(counter+2)*x if x==-1 else x for counter, x in enumerate(class_  
11 print(f'Calinski outliers as singletons: {calinski_harabasz_score(X_test, no_outliers)}'  
12  
13 print(f'Davies Bouldin ignoring outliers: {davies_bouldin_score(X_test[class_predictions!=-1]  
14 no_outliers = np.array([(counter+2)*x if x==-1 else x for counter, x in enumerate(class_  
15 print(f'Davies Bouldin outliers as singletons: {davies_bouldin_score(X_test, no_outliers)}'  
16  
17 Number of clusters found: 770  
Number of outliers found: 16560  
Silhouette ignoring outliers: 0.5952262243383366  
Silhouette outliers as singletons: 0.13146048379479877  
Calinski ignoring outliers: 229765407.89558798  
Calinski outliers as singletons: 22426541.654199768  
Davies Bouldin ignoring outliers: 0.24912855423904723  
Davies Bouldin as singletons: 0.11772929911226311
```

```
1 plt.figure(figsize=(10, 8))  
2 plt.scatter(X_test[:,0], X_test[:,1], c=model.labels_.astype(float))
```

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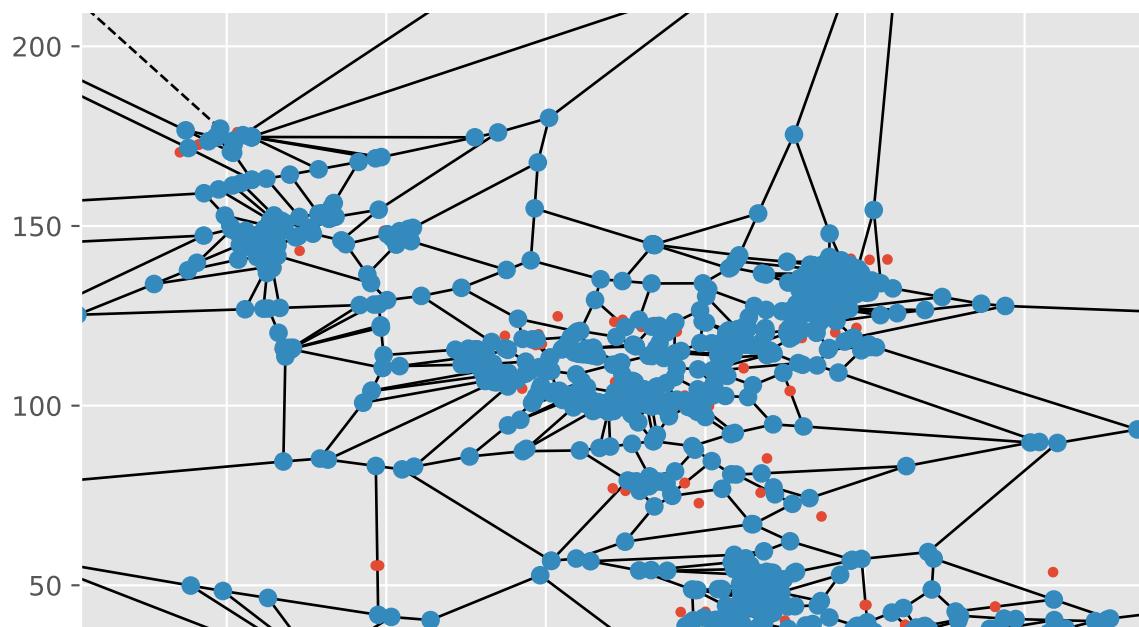
```
<matplotlib.collections.PathCollection at 0x7f17a3d4ea50>
```



▼ VORONOI DIAGRAM

```
1 from scipy.spatial import Voronoi, voronoi_plot_2d  
  
1 from scipy.spatial import Voronoi, voronoi_plot_2d  
2 vor = Voronoi(X_test)  
  
1 fig = voronoi_plot_2d(vor)  
2 fig.set_figheight(10)  
3 fig.set_figwidth(8)  
4 plt.show()
```

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```

1 fig = voronoi_plot_2d(vor, show_vertices=False, line_colors='orange',
2                         line_width=2, line_alpha=0.6, point_size=2)
3 plt.show()

```



```

1 vor.regions
[2982, 1011, 1065, 100, 101, 2205, 2981],
[2986, 2984, 2985],
[2986, 2210, 2209, 2212, 2213, 2985],
[2988, 2211, 1094, 1096, 2987],
[2994, 2214, 1100, 1622, 1620, 1099, 1619, 2993],
[3003, 3001, 3002],
[3003, 2222, 1632, 1631, 3001],
[3002, 2221, 779, 780, 1631, 3001],
[3003, 2222, 2224, 2223, 2221, 3002],
[3006, 507, 1123, 1656, 2226, 3005],
[3007, 1125, 2428, 2432, 2430, 571, 507, 3006],
[3009, 2227, 1654, 785, 796, 795, 311, 312, 310, 786, 3008],
[3011, 1661, 1662, 3010],
[3012, 2228, 510, 791, 1661, 3011],
[3015, 3013, 3014],
[3015, 2230, 1664, 1135, 1132, 1131, 3013],
[3014, 2231, 1285, 510, 2228, 2229, 1657, 1660, 1659, 1131, 3013],
[3015, 2230, 2439, 2440, 2232, 2231, 3014],
[3020, 2240, 1673, 1674, 1675, 3019],
[3021, 2243, 2242, 2241, 2239, 2240, 3020],
[3025, 3023, 3024],
[3025, 2245, 1678, 2247, 2249, 3023],
[3024, 2246, 1167, 1680, 2250, 2249, 3023],

```

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[diff](#)

```

[3037, 3035, 3034, 3036],
[3036, 1691, 2260, 2261, 2263, 2262, 1693, 1692, 3034],
[3035, 2256, 1153, 806, 521, 1692, 3034],
[3037 2257 2256 3034]

```

```
[3037, 2257, 1152, 802, 316, 1179, 1691, 3036],
[3046, 1984, 1983, 2265, 3045],
[3048, 1978, 1395, 1393, 1976, 1985, 1984, 3046],
[3053, 2653, 2664, 2665, 3052],
[3056, 3054, 3055],
[3061, 3058, 3057, 3059, 3060],
[3059, 3056, 3054, 3057],
[3061, 2275, 2274, 3058],
[3061, 2275, 2277, 2276, 1148, 1147, 2271, 2272, 3060],
[3065, 2278, 2687, 2686, 1701, 3064],
[3076, 3074, 3072, 3073, 3075],
[3075, 3067, 3068, 3073],
[3076, 3070, 3071, 3069, 3074],
[3076, 3070, 1193, 1187, 1698, 3066, 3067, 3075],
[3083, 3081, 3080, 3079, 3082],
[3082, 3077, 1703, 1702, 3079],
[3080, 1726, 826, 822, 1196, 1702, 3079],
[3081, 2282, 1727, 1726, 3080],
[3083, 3078, 2281, 2282, 3081],
[3083, 3078, 3077, 3082],
[3089, 3084, 1199, 1198, 3088],

[3091, 2287, 1456, 1457, 983, 3090],
[3096, 3094, 3093, 3095],
[3094, 2286, 1708, 1707, 2283, 3093],
[3096, 3092, 3091, 2287, 2288, 2289, 2286, 3094],
[3099, 3097, 3098],
[3099, 2292, 1711, 1710, 1709, 3097],
[3098, 2290, 527, 324, 325, 1709, 3097],
[3099, 2292, 2291, 2290, 3098],
[3100, 3107, 3108]
```

1 vor.vertices

```
array([[ 592.94570217,    225.91359725],
       [-1256.29761491,     2.80940194],
       [ 148.91512435,   120.00058698],
       ...,
       [   30.26663329,   -97.73944915],
       [   30.26662173,   -97.7396132 ],
       [   30.26674696,   -97.73990186]])
```

1 vor.ridge_points

```
array([[20779, 15140],
       [20779, 11903],
       [20779, 19332],
       ...,
       [ 9842, 16020],
       [ 6537, 7770],
```

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1 vor.ridge_vertices

```
[ 400, 415],
```

```
[414, 985],  
[676, 677],  
[676, 984],  
[984, 985],  
[987, 988],  
[987, 991],  
[988, 989],  
[989, 990],  
[990, 991],  
[400, 987],  
[673, 988],  
[673, 675],  
[675, 677],  
[413, 991],  
[224, 674],  
[227, 990],  
[674, 989],  
[992, 994],  
[992, 993],  
[993, 995],  
[994, 995],  
[406, 408],  
[406, 992],  
[408, 409],  
[409, 994],  
[671, 995],  
[671, 672],  
[672, 674],  
[673, 993],  
[407, 409],  
[407, 671],  
[406, 664],  
[663, 664],  
[663, 996],  
[675, 997],  
  
[996, 997],  
[998, 1001],  
[998, 999],  
[999, 1000],  
[1000, 1003],  
[1001, 1002],  
[1002, 1003],  
[424, 1001],  
[425, 998],  
[684, 999],  
[685, 1000],  
[436, 1002],  
[160, 1003],  
[435, 690],  
[480, 688],  
[688, 690],
```

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[diff](#)

```
[1007, 1009],  
[1010, 1011],  
[1010, 1013],  
[1011, 1011]
```

```
| 1011, 1014 |,
```

```
1 vor.furthest_site
```

```
False
```

✓ 1s completed at 4:56 PM



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