ml_project

March 2, 2020

```
In [38]: import pandas as pd
         import numpy as np
         import scipy.linalg as la
         import scipy.stats as stats
         import statsmodels.api as sm
         from sklearn import linear_model, model_selection, metrics
         import sklearn
         import plotly.graph_objs as go
         import matplotlib.pyplot as plt
         from sklearn.datasets import load_breast_cancer, load_digits, load_diabetes
         from sklearn.model_selection import train_test_split
         from sklearn.discriminant_analysis import LinearDiscriminantAnalysis as LDA
         from sklearn.neighbors import KNeighborsClassifier as KNC
         from sklearn.discriminant_analysis import QuadraticDiscriminantAnalysis as GDA
         from sklearn.metrics import roc_auc_score as RAS
         from sklearn.metrics import roc_curve as ROC
         import seaborn as sns
         from sklearn.manifold import TSNE
         import umap
```

```
   jupyter nbconvert --to latex "Race and Incarceration in America.ipynb"
--TagRemovePreprocessor.remove_input_tags='{"hide_input"}'; pdflatex "Race and
Incarceration in America"
```

1 Introduction

Last semester I took a look a data set containing the information of more than 7.5 million individuals that have been processed by the criminal justice system. I found that racial minorities were more likely to receive extreme sentences, agreeing with existing research around bias in the criminal justice system. In this project I will be exploring the data from a machine learning perspective. My goal is to determine if this data can be classified in such a way that is predictive of race.

2 Possible questions

can we use ml techniques to correctly classify this data? which ones fail and why? can we create a predictive model for sentence lengths? should sentencing be offloaded to a ml algorithm.

```
In [14]: chunksize = 100000
         rdf = pd.read_csv('regression_df.csv', chunksize=chunksize)
```

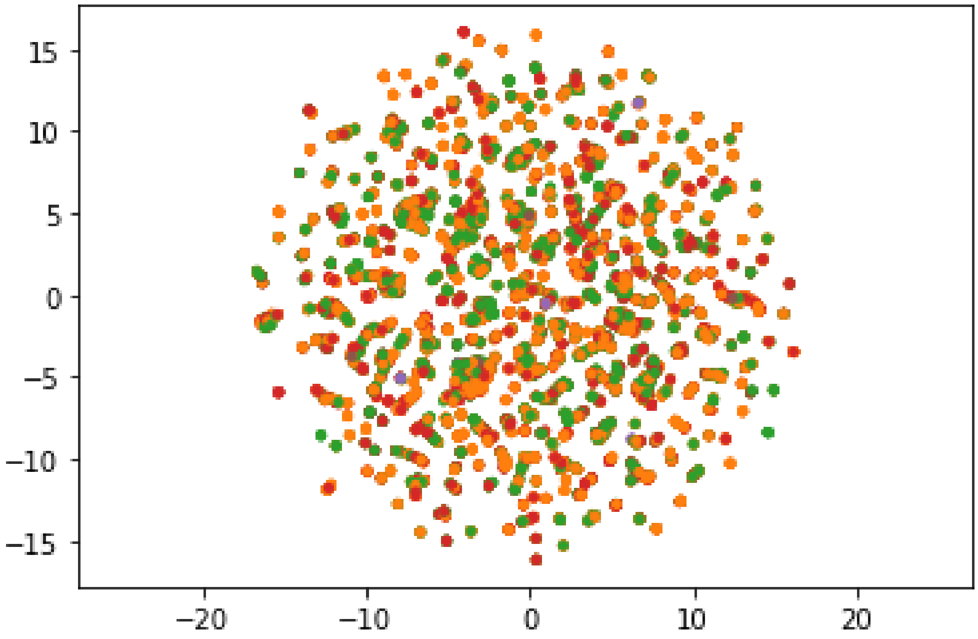
```
In [39]: # reducer = umap.UMAP()
         # i = 0
         # for item in rdf:
         #     if i > 3:
         #         break
         #     else:
         #         i += 1

         #     data = item.drop(['Unnamed: 0','IDENTIFIER','LATEST ADMISSION DATE'], axis=1)
         #     target = data[['AMER IND','ASIAN','BLACK','HISPANIC']]
         #     data = data.drop(['AMER IND','ASIAN','BLACK','HISPANIC'], axis=1)
         #     trans = reducer.fit_transform(data)

         # #     create maskings
         #     black = target.BLACK == 1
         #     asian = target.ASIAN == 1
         #     hisp = target.HISPANIC == 1
         #     ind = target['AMER IND'] == 1
         #     white = ~(black + asian + hisp)

         #     plt.scatter(trans[:,0][black],trans[:,1][black],label='black',marker='.')
         # #     plt.legend()
         # #     plt.show()
         #     plt.scatter(trans[:,0][white],trans[:,1][white],label='white',marker='.')
         # #     plt.legend()
         # #     plt.show()
         #     plt.scatter(trans[:,0][hisp],trans[:,1][hisp],label='hisp',marker='.')
         # #     plt.legend()
         # #     plt.show()
         #     plt.scatter(trans[:,0][ind],trans[:,1][ind],label='ind',marker='.')
         # #     plt.legend()
         # #     plt.show()
         #     plt.scatter(trans[:,0][asian],trans[:,1][asian],label='asian',marker='.')
         #     plt.legend()
         #     plt.show()
```

```
In [29]: cols = ['RACE','GENDER','AGE','OFFENSE','FACILITY','DETAINER','SENTENCE DAYS']
         df = pd.read_csv('individuals.csv',usecols=cols)
```

```
In [45]: samp = df.sample(20000)
         samp.RACE = pd.factorize(samp['RACE'])[0] + 1
         samp.GENDER = pd.factorize(samp['GENDER'])[0] + 1
         samp.OFFENSE = pd.factorize(samp['OFFENSE'])[0] + 1
         samp.DETAINER = pd.factorize(samp['DETAINER'])[0] + 1
         samp.FACILITY = pd.factorize(samp['FACILITY'])[0] + 1
```

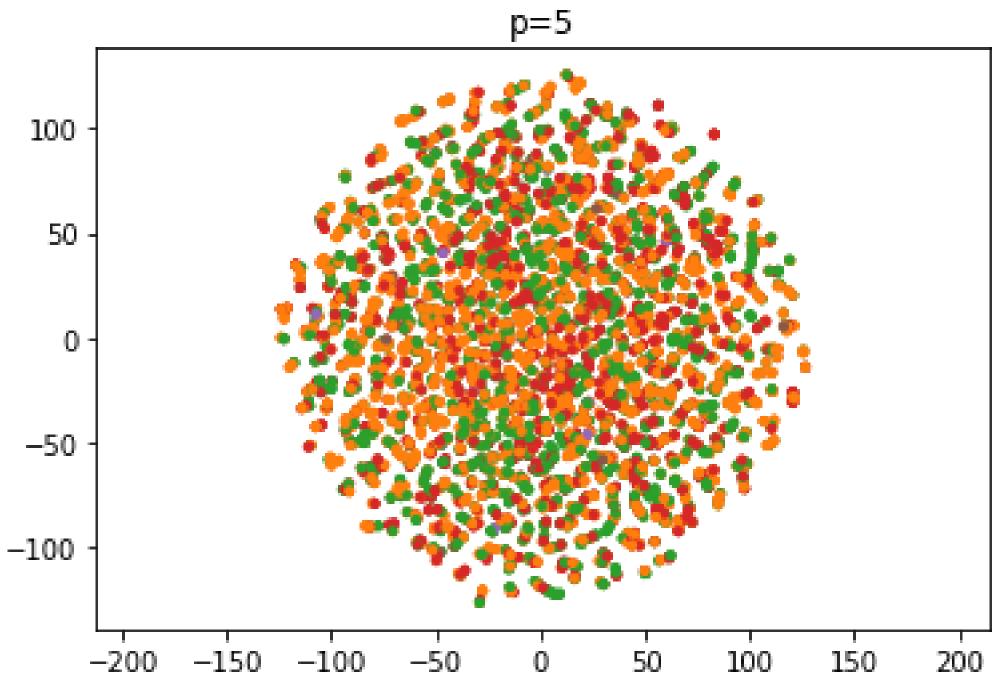
```
samp_y = samp.RACE
samp_X = samp[['GENDER','AGE','OFFENSE','FACILITY','DETAINER','SENTENCE DAYS']]

trans = reducer.fit_transform(samp_X)

plt.scatter(trans[:, 0], trans[:, 1], c=[sns.color_palette()[x] for x in samp_y], marl
plt.gca().set_aspect('equal', 'datalim')
plt.show()
```

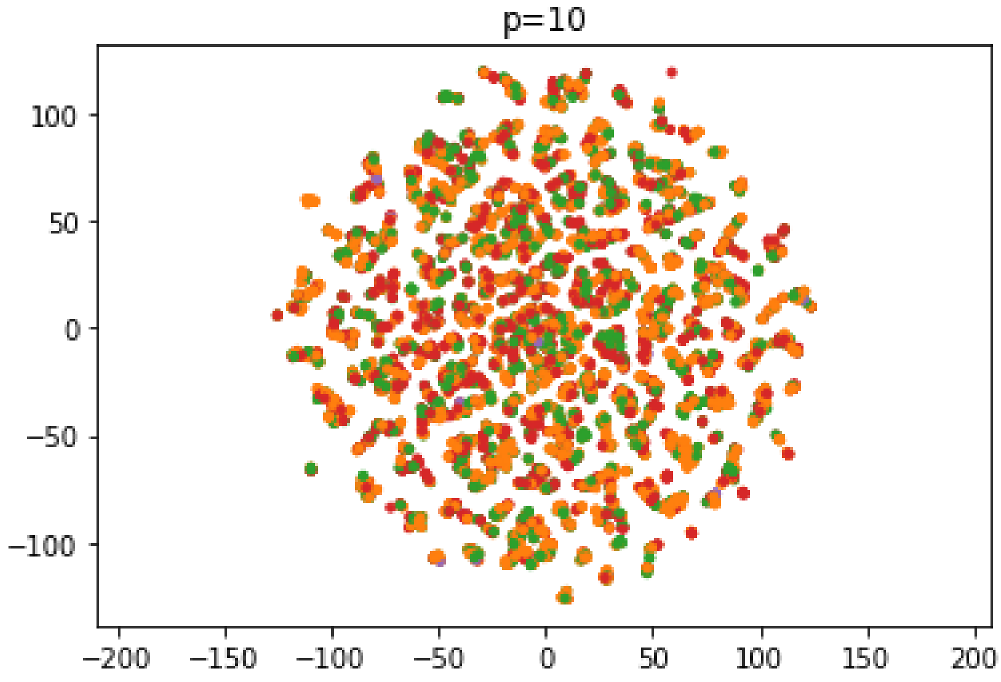
```
/home/ethan/.local/lib/python3.7/site-packages/numba/compiler.py:602: NumbaPerformanceWarning:


The keyword argument 'parallel=True' was specified but no transformation for parallel executior

To find out why, try turning on parallel diagnostics, see http://numba.pydata.org/numba-doc/lat

File "../../../.local/lib/python3.7/site-packages/umap/nndescent.py", line 47:
    @numba.njit(parallel=True)
    def nn_descent(
    ^



/home/ethan/.local/lib/python3.7/site-packages/umap/spectral.py:229: UserWarning:

Embedding a total of 50 separate connected components using meta-embedding (experimental)

/home/ethan/.local/lib/python3.7/site-packages/sklearn/manifold/spectral_embedding_.py:235: Use

Graph is not fully connected, spectral embedding may not work as expected.
```

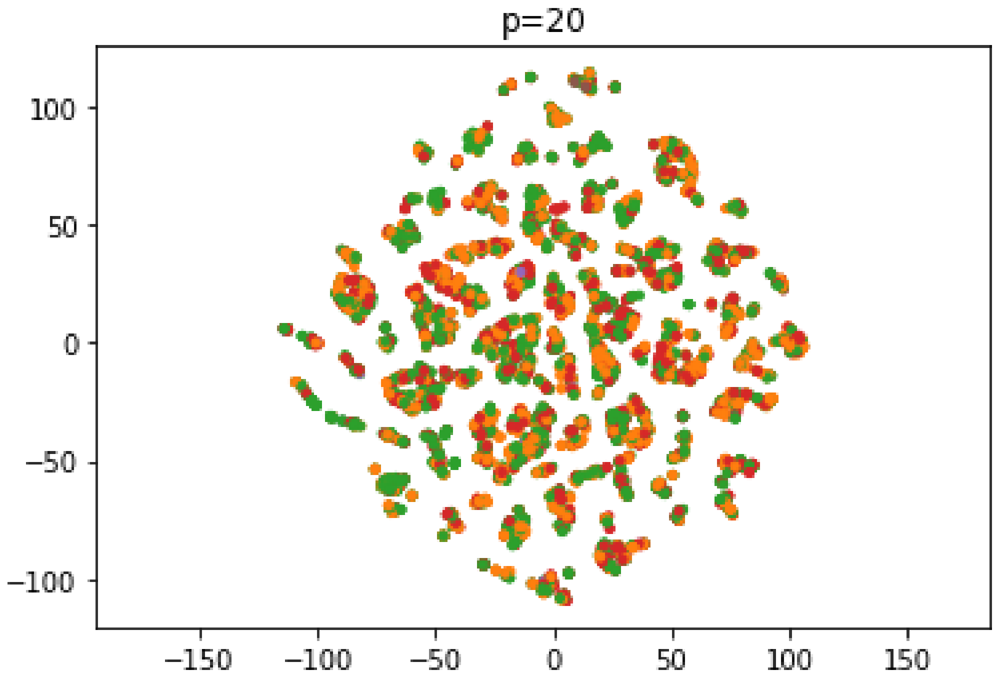


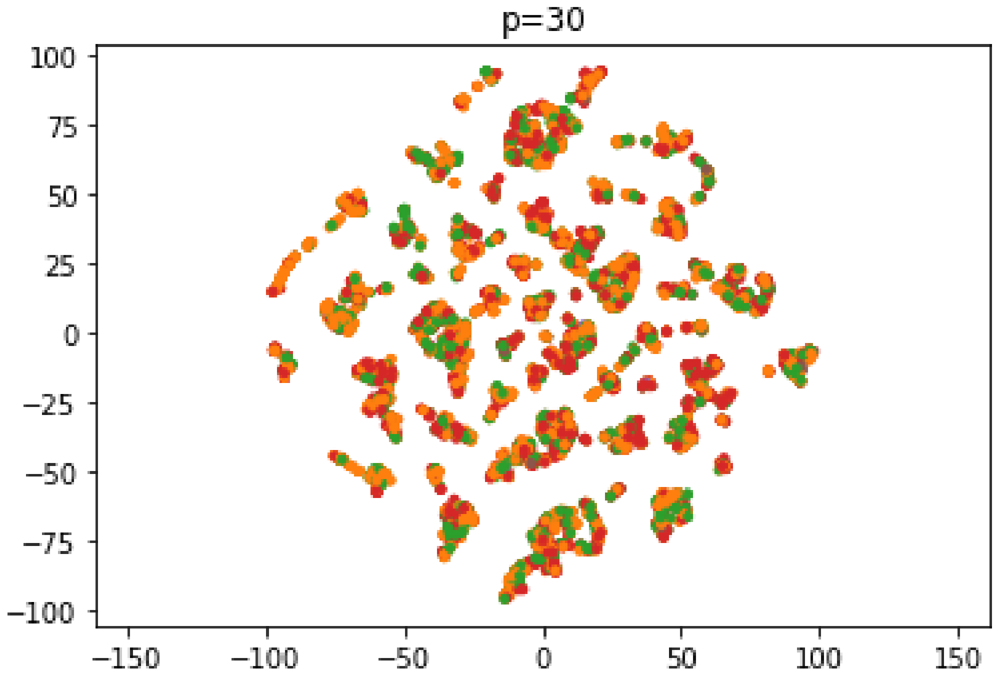
It seems that UMAP doesnt work

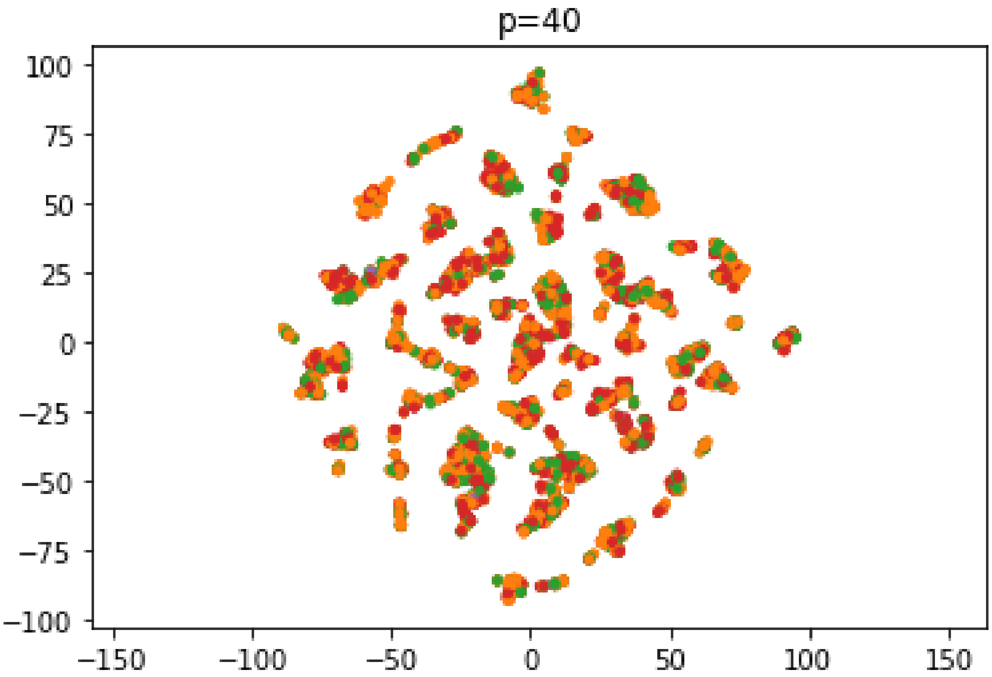
```
In [47]: # params
         ps = [5,10,20,30,40,50,60,70,80,90,100,110,120,130,140,150,160,170,180,190,200]

         for p in ps:

             samp = df.sample(8000)
             samp.RACE = pd.factorize(samp['RACE'])[0] + 1
             samp.GENDER = pd.factorize(samp['GENDER'])[0] + 1
             samp.OFFENSE = pd.factorize(samp['OFFENSE'])[0] + 1
             samp.DETAINER = pd.factorize(samp['DETAINER'])[0] + 1
             samp.FACILITY = pd.factorize(samp['FACILITY'])[0] + 1
             samp_y = samp.RACE
             samp_X = samp[['GENDER','AGE','OFFENSE','FACILITY','DETAINER','SENTENCE DAYS']]



             trans = TSNE(perplexity=p).fit_transform(samp_X)

             plt.scatter(trans[:, 0], trans[:, 1], c=[sns.color_palette()[x] for x in samp_y],
             plt.gca().set_aspect('equal', 'datalim')
             plt.title(f'p={p}')
             plt.show()
```

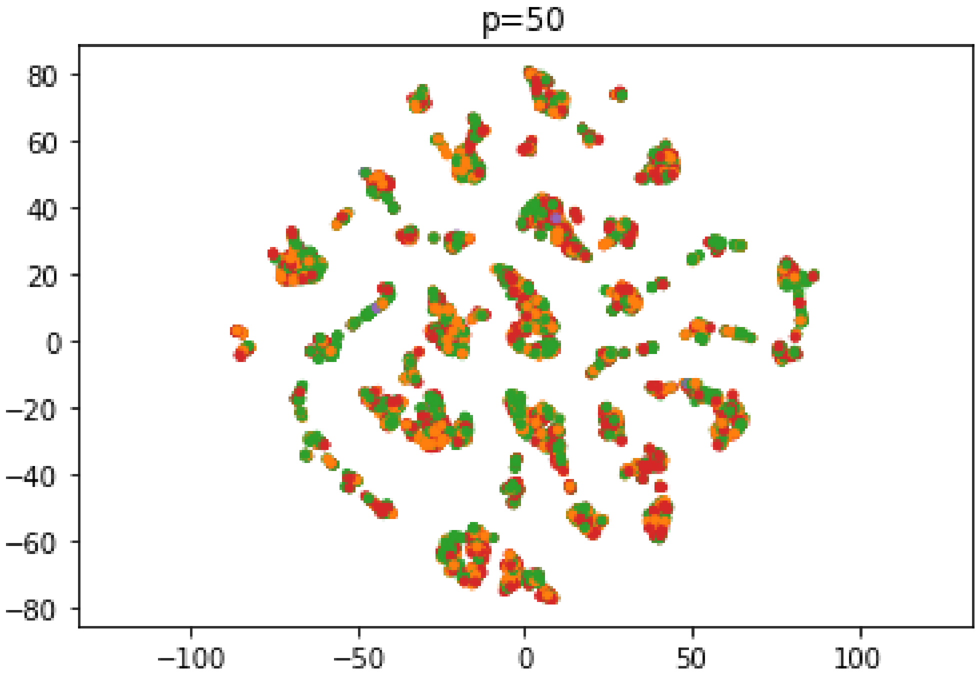

p=5
100
50
0
−50
−100
−200
−150
−100
−50
0
50
100
150
200

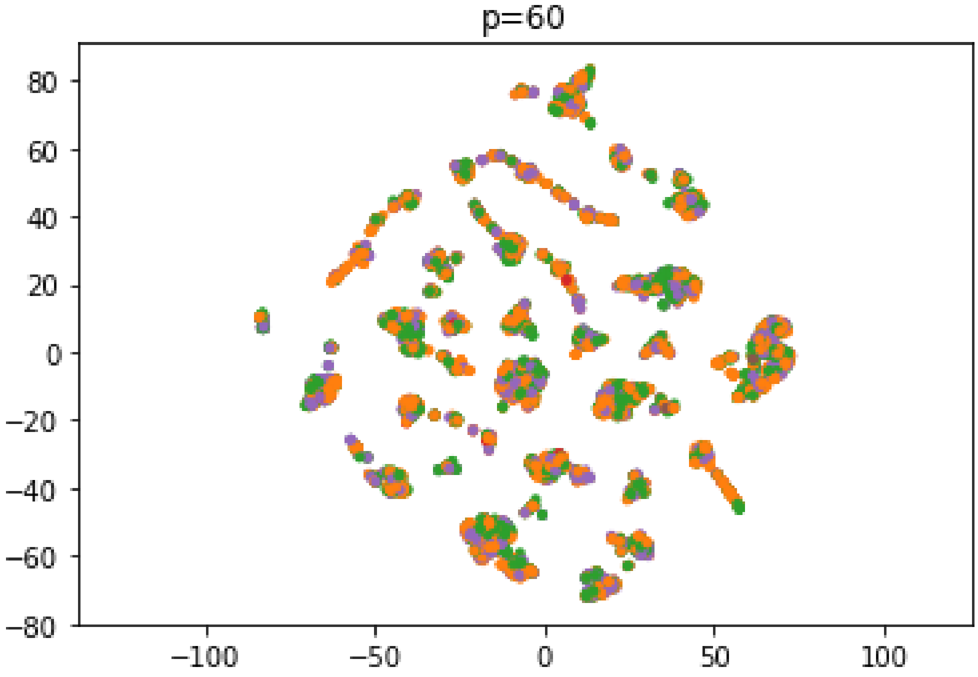

p=10
100
50
0
−50
−100
−200
−150
−100
−50
0
50
100
150
200

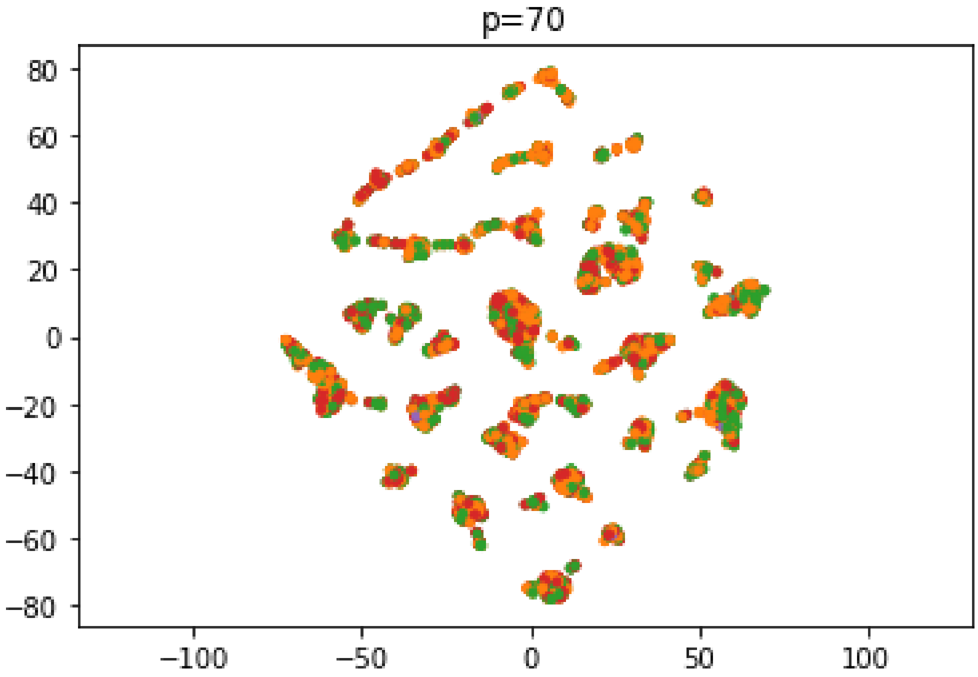

p=20
100
50
0
−50
−100
−150
−100
−50
0
50
100
150

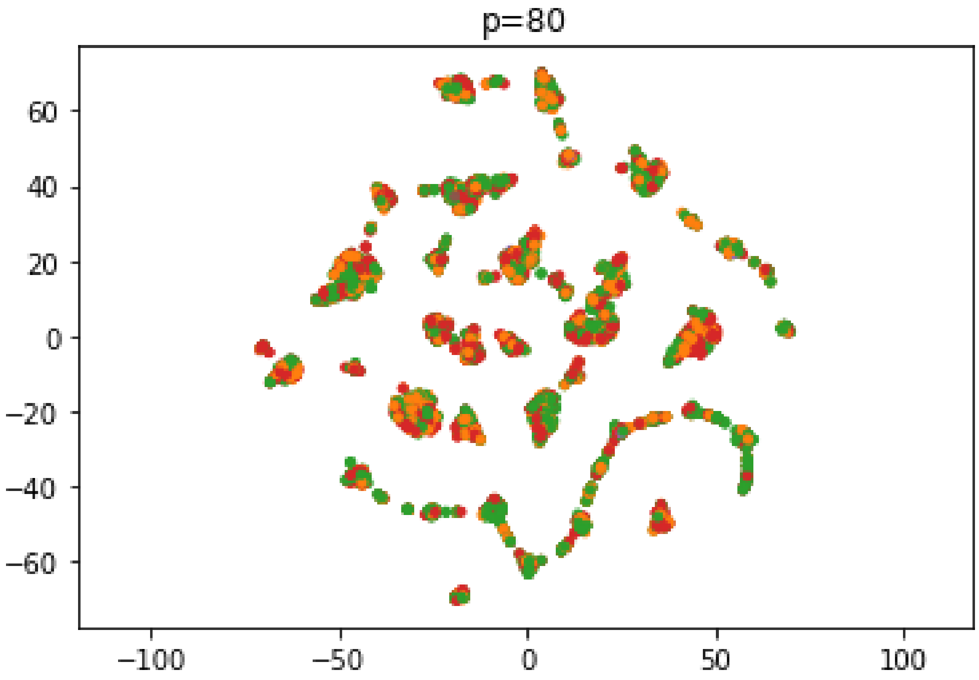

p=30
100
75
50
25
0
−25
−50
−75
−100
−150
−100
−50
0
50
100
150

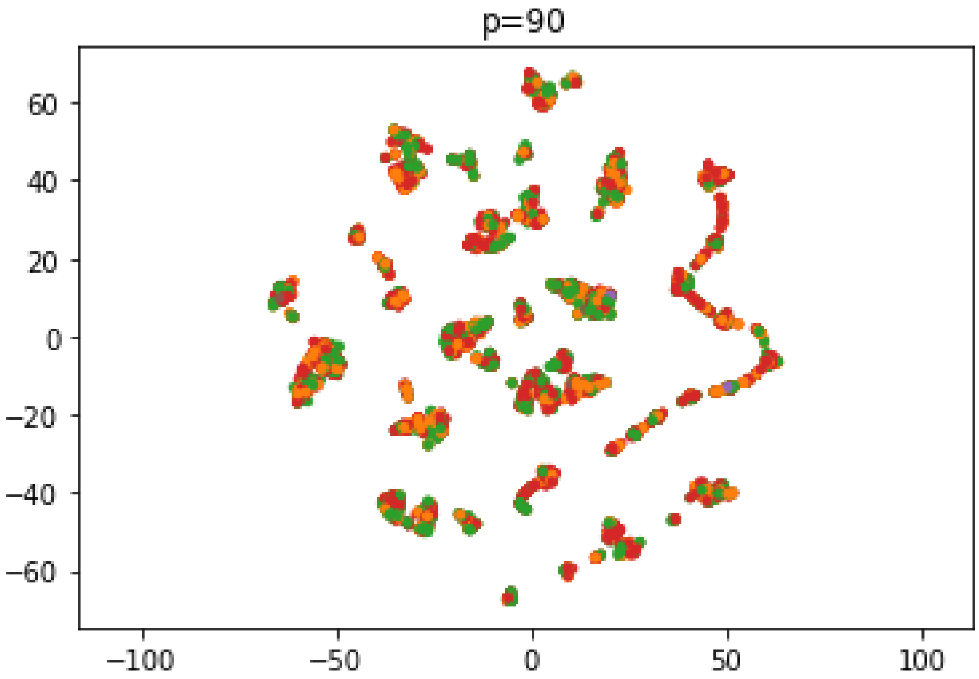

p=40
100
75
50
25
0
−25
−50
−75
−100
−150
−100
−50
0
50
100
150

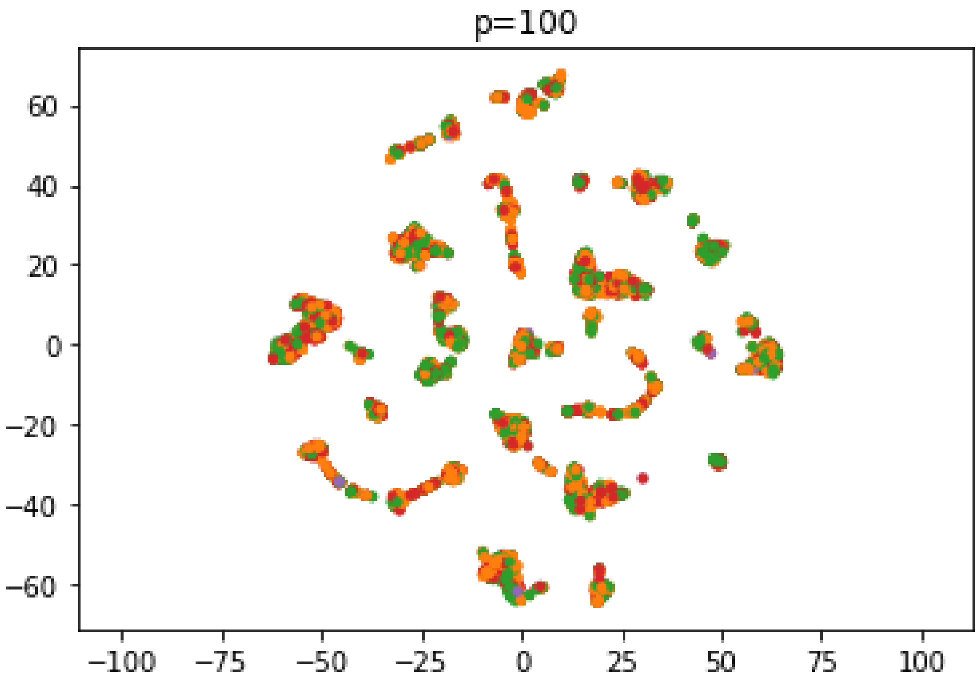

p=50
80
60
40
20
0
−20
−40
−60
−80
−100
−50
0
50
100

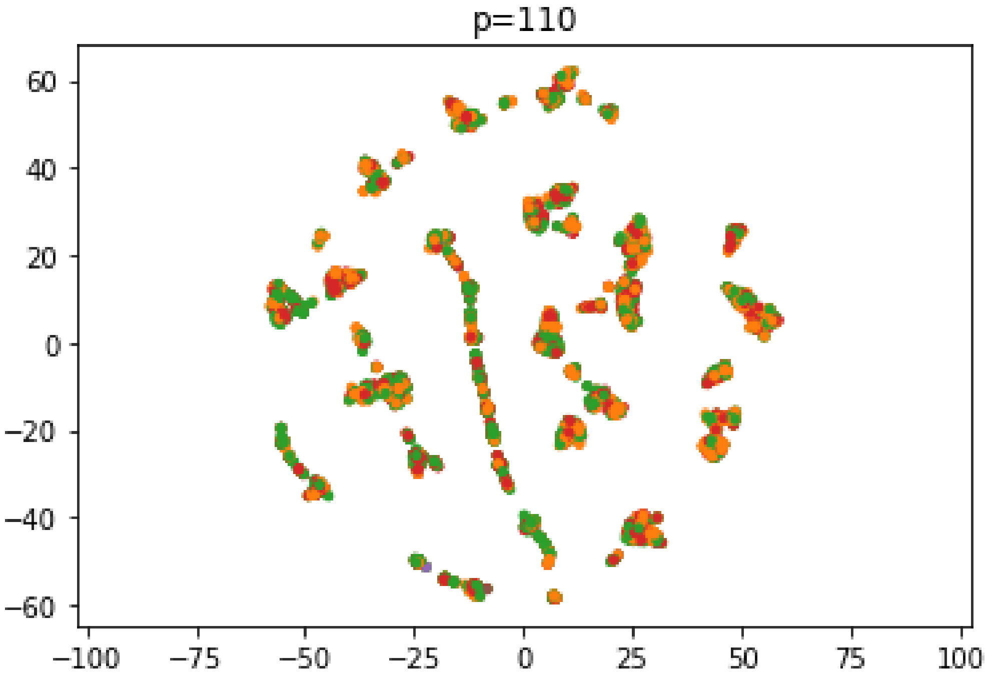

p=60
80
60
40
20
0
−20
−40
−60
−80
−100
−50
0
50
100

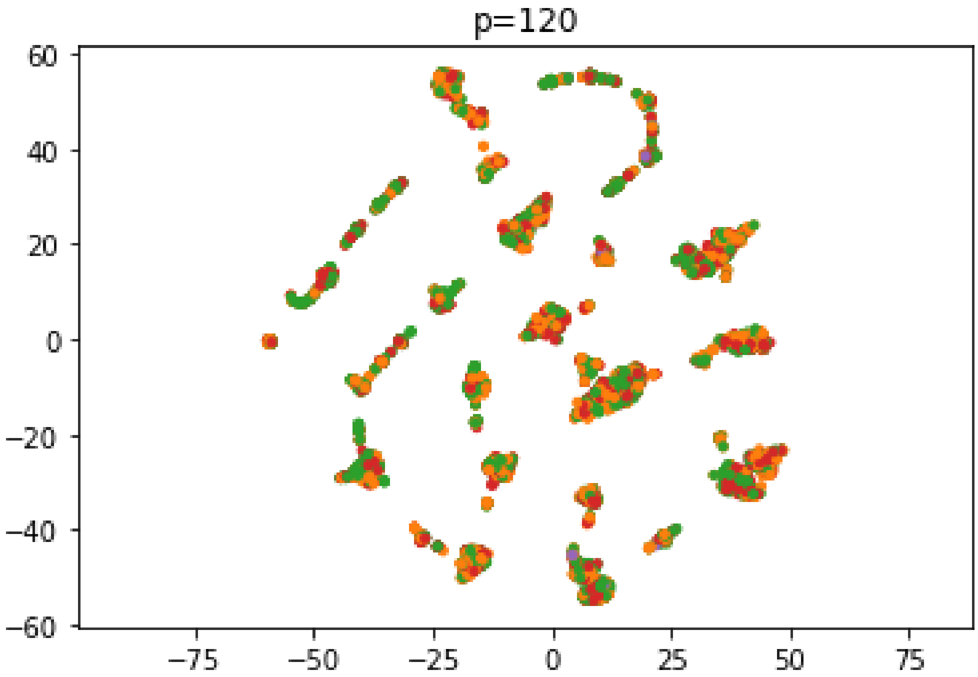

p=70
80
60
40
20
0
−20
−40
−60
−80
−100
−50
0
50
100

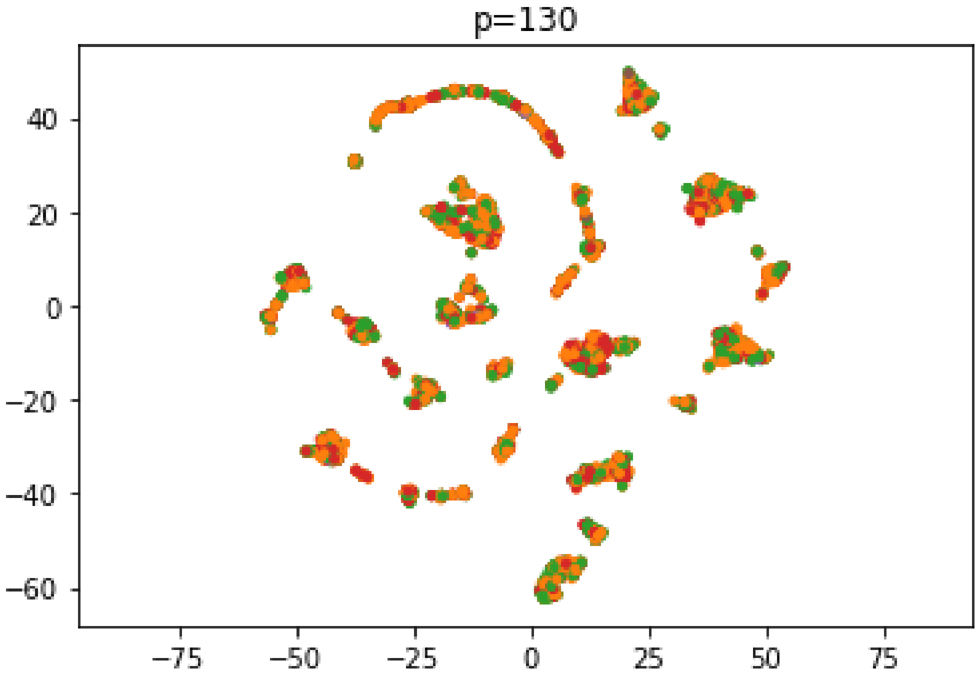

p=80
60
40
20
0
−20
−40
−60
−100
−50
0
50
100

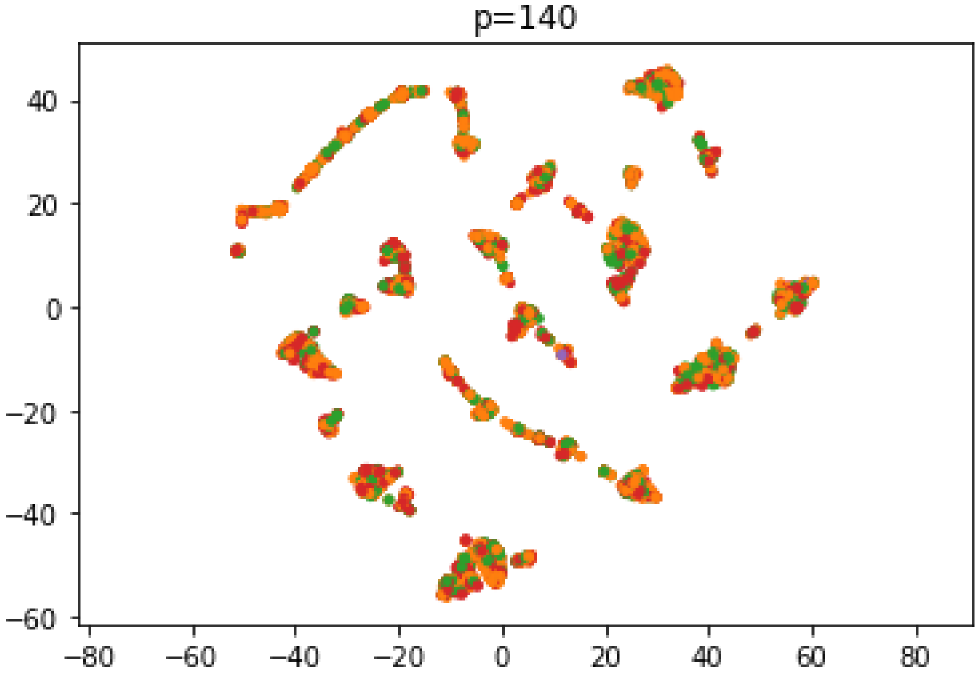

p=90
60
40
20
0
−20
−40
−60
−100
−50
0
50
100

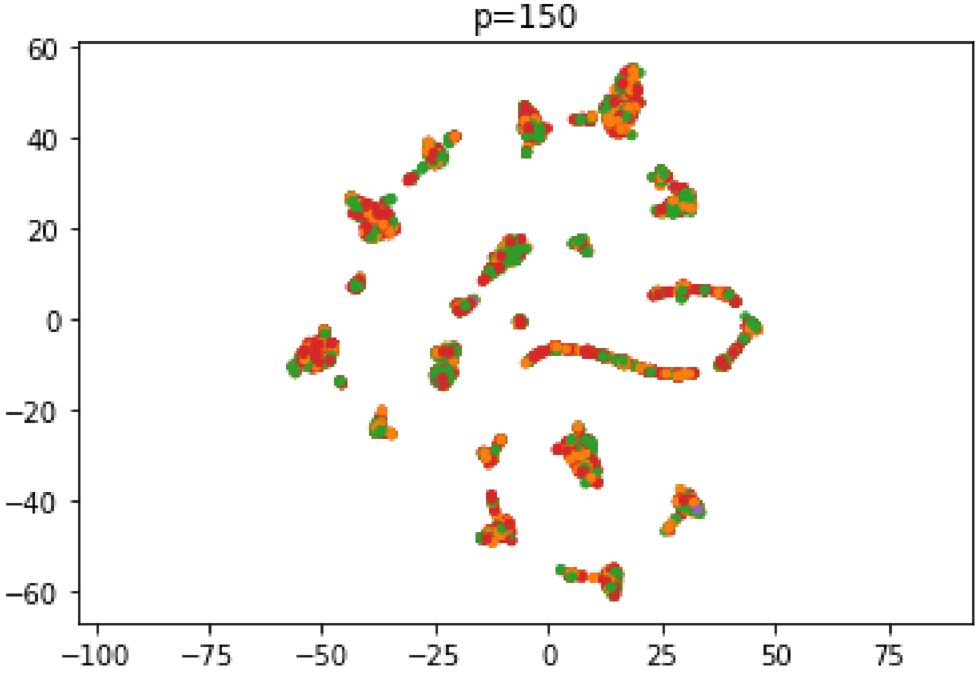

p=100
60
40
20
0
−20
−40
−60
−100
−75
−50
−25
0
25
50
75
100

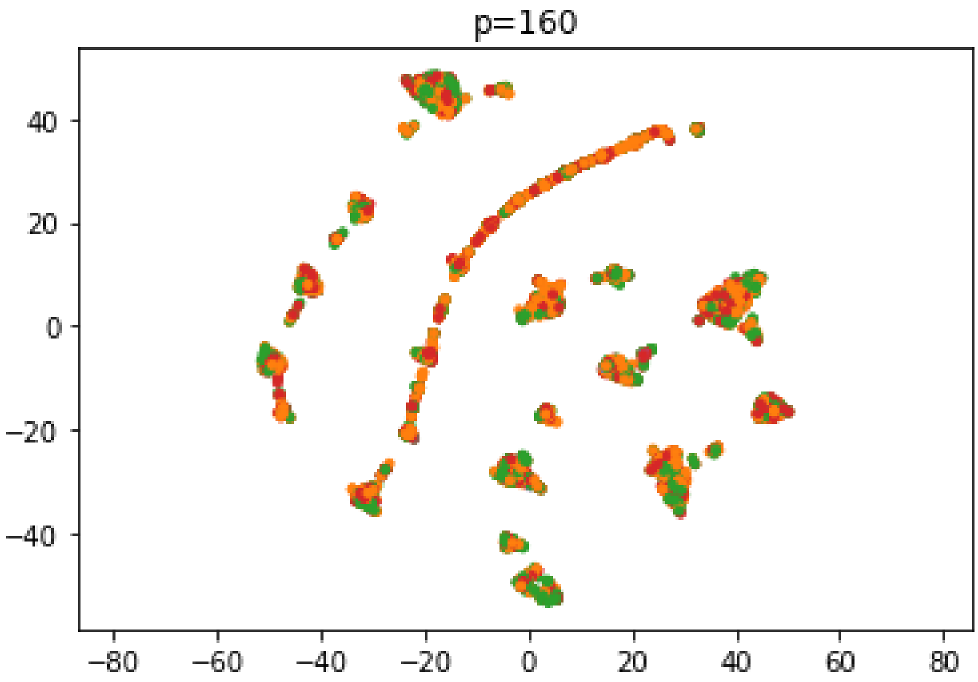

p=110
60
40
20
0
−20
−40
−60
−100
−75
−50
−25
0
25
50
75
100

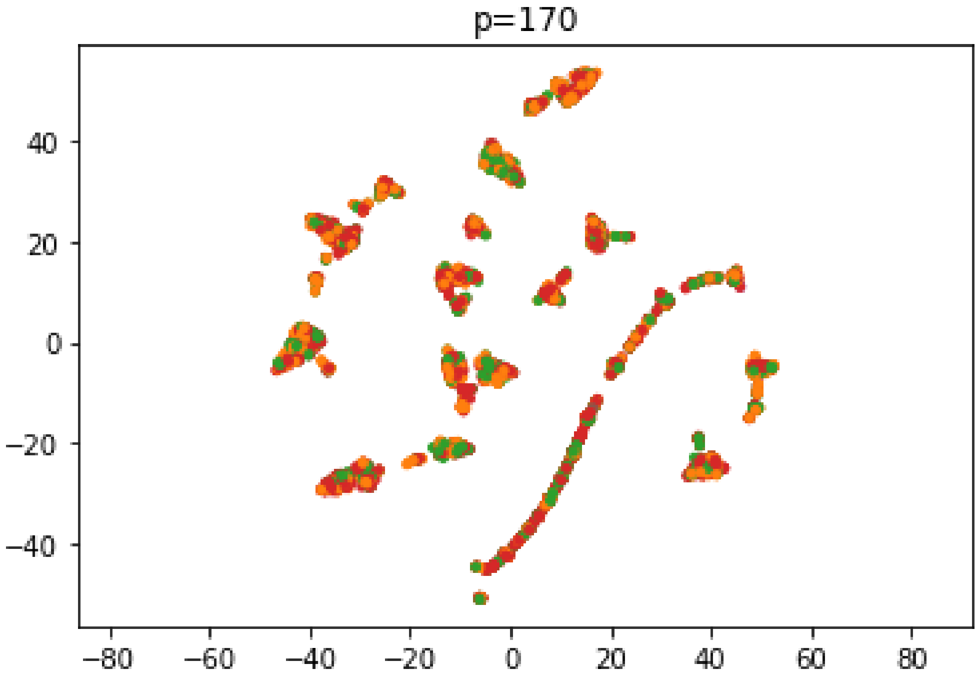

p=120
60
40
20
0
−20
−40
−60
−75
−50
−25
0
25
50
75

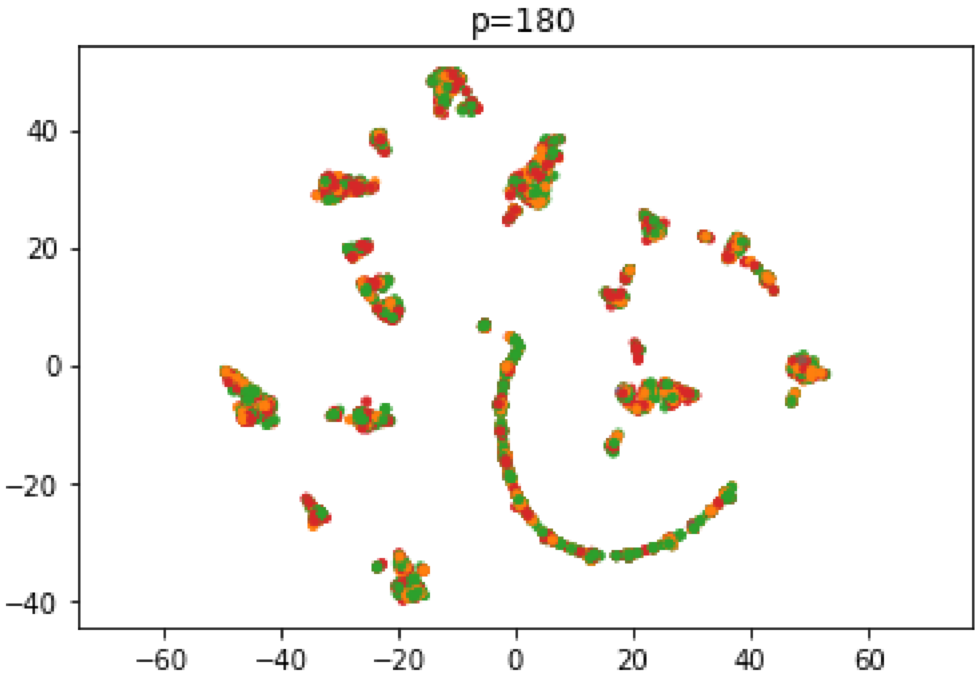

p=130
40
20
0
−20
−40
−60
−75
−50
−25
0
25
50
75

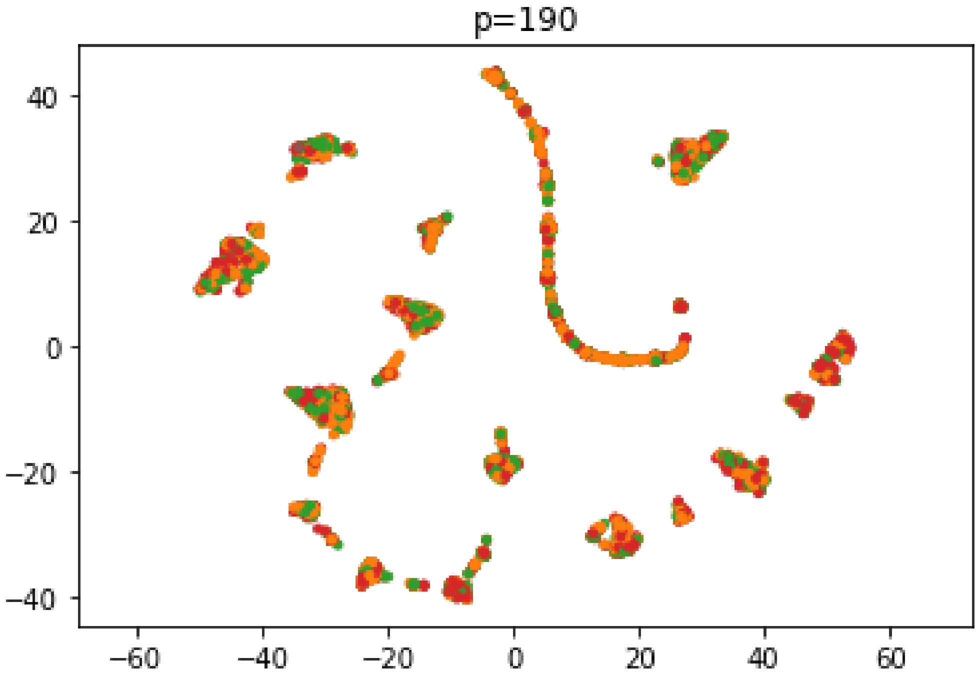

p=140
40
20
0
−20
−40
−60
−80
−60
−40
−20
0
20
40
60
80

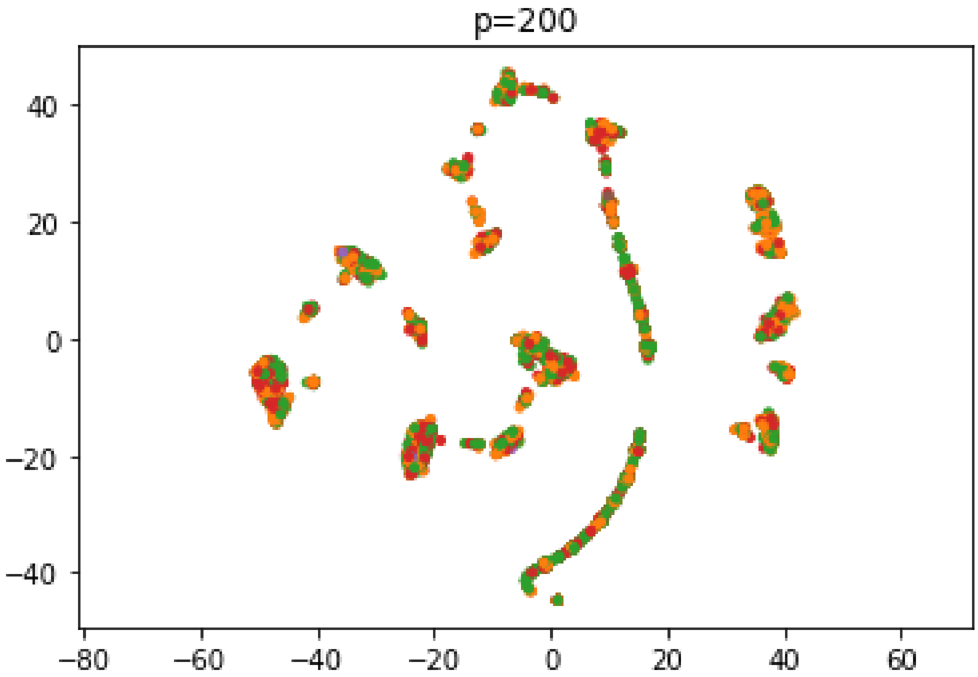

p=150
60
40
20
0
−20
−40
−60
−100
−75
−50
−25
0
25
50
75


p=160
40
20
0
−20
−40
−80
−60
−40
−20
0
20
40
60
80


p=170
40
20
0
−20
−40
−80
−60
−40
−20
0
20
40
60
80


p=180
40
20
0
−20
−40
−60
−40
−20
0
20
40
60

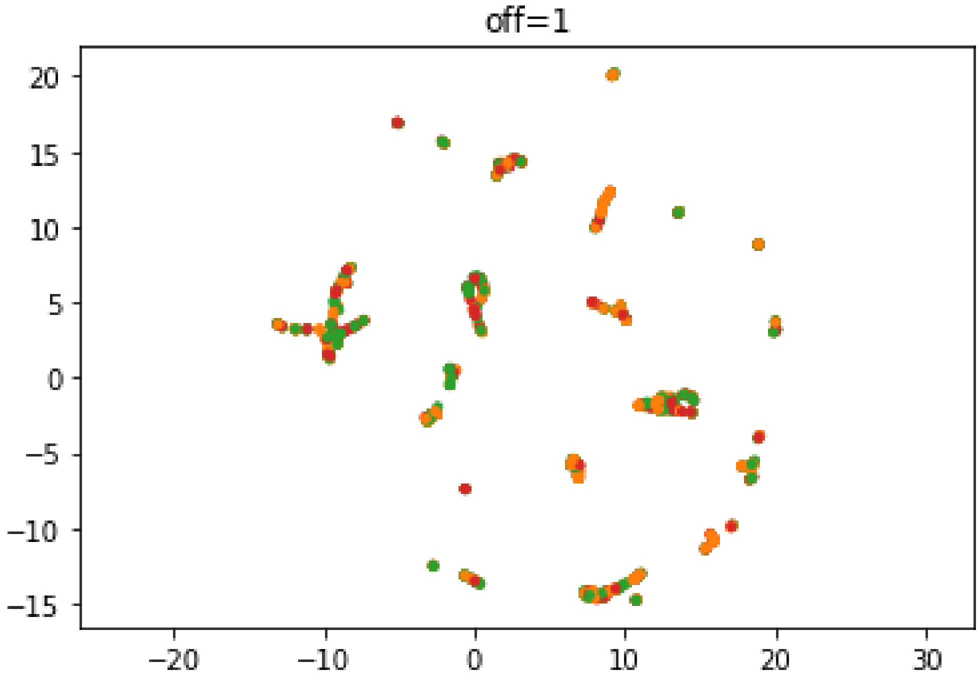

p=190
40
20
0
−20
−40
−60
−40
−20
0
20
40
60



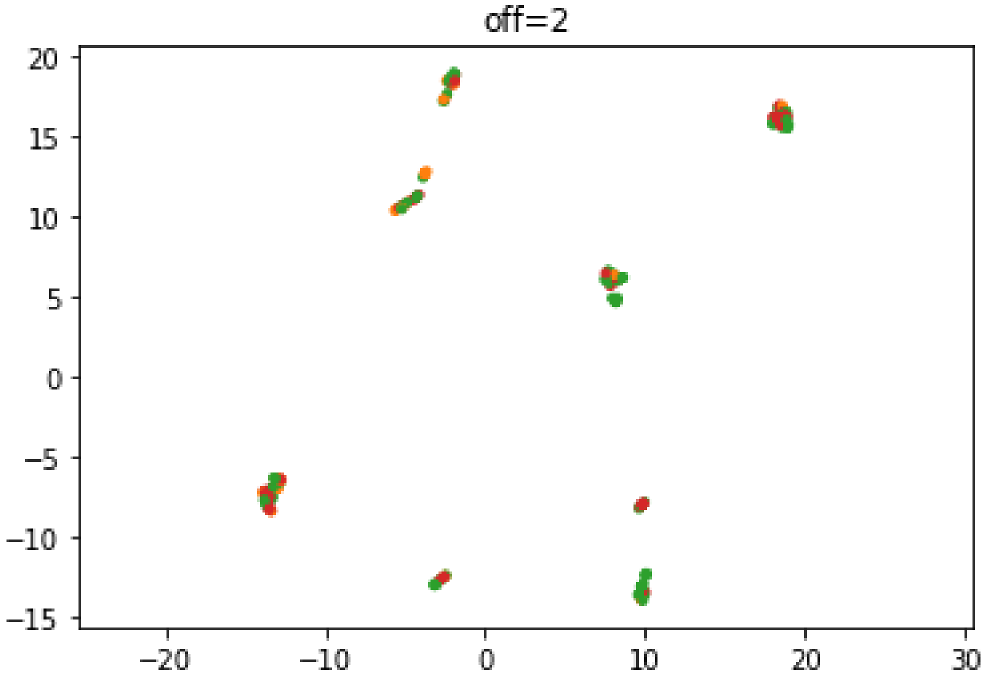
```
In [70]: for off in set(samp.OFFENSE):

             mask = samp_X.OFFENSE == off

             data = samp_X[mask]

         #     trans = TSNE(perplexity=20).fit_transform(data)
             try:
                 trans = reducer.fit_transform(data.values)

                 plt.scatter(trans[:, 0], trans[:, 1], c=[sns.color_palette()[x] for x in samp_
                 plt.gca().set_aspect('equal', 'datalim')
                 plt.title(f'off={off}')
                 plt.show()
             except:

                 continue
```

```
/home/ethan/.local/lib/python3.7/site-packages/umap/spectral.py:229: UserWarning:

Embedding a total of 5 separate connected components using meta-embedding (experimental)

/home/ethan/.local/lib/python3.7/site-packages/sklearn/manifold/spectral_embedding_.py:235: Us
```

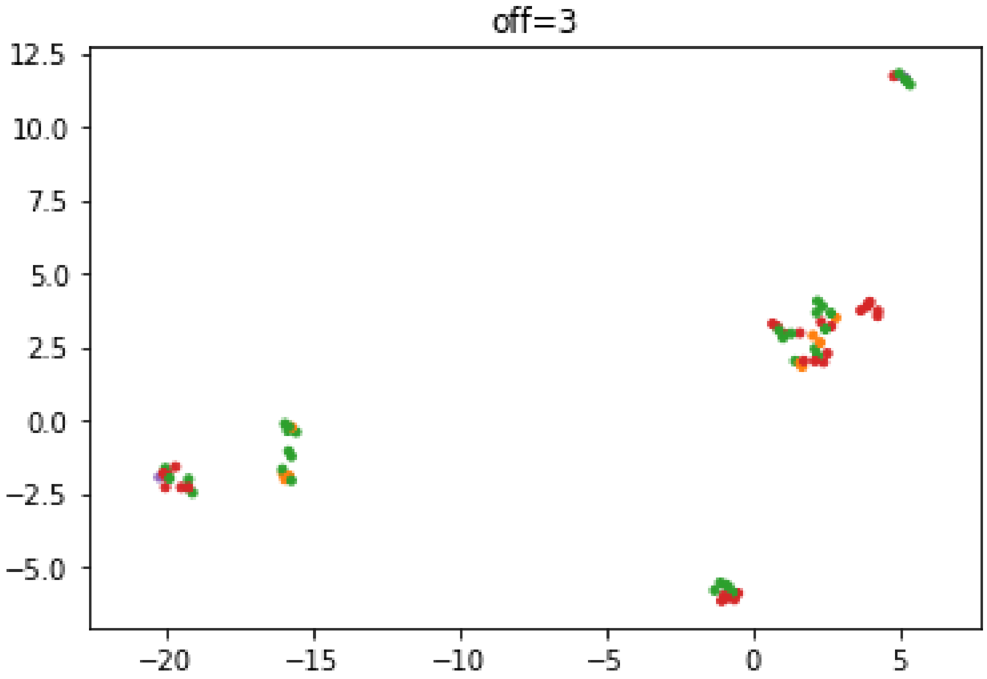
```
Graph is not fully connected, spectral embedding may not work as expected.
```



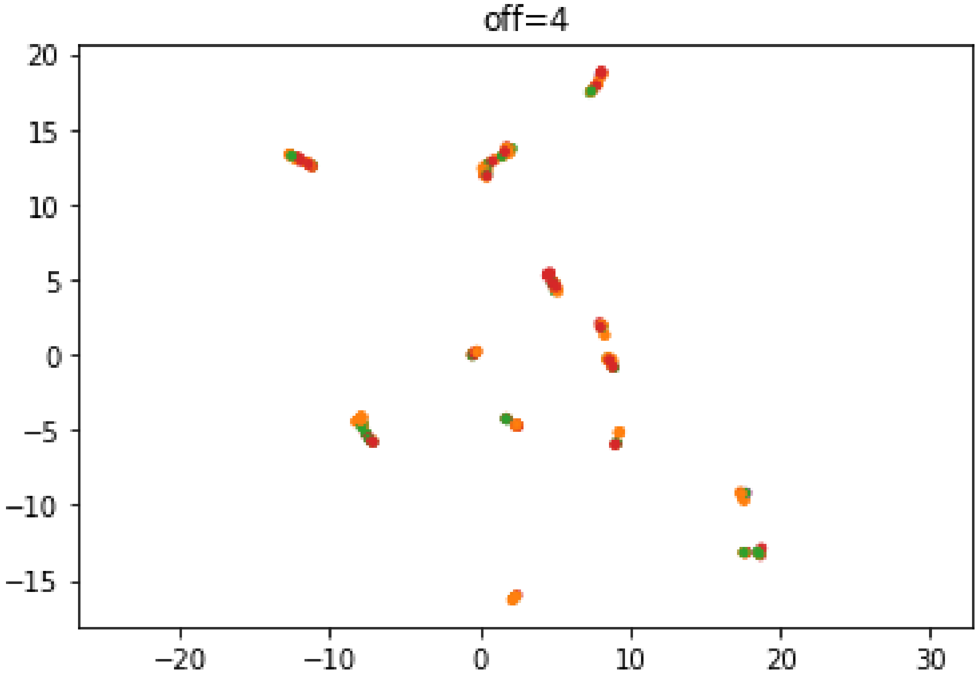
```
/home/ethan/.local/lib/python3.7/site-packages/umap/spectral.py:229: UserWarning:

Embedding a total of 4 separate connected components using meta-embedding (experimental)
```

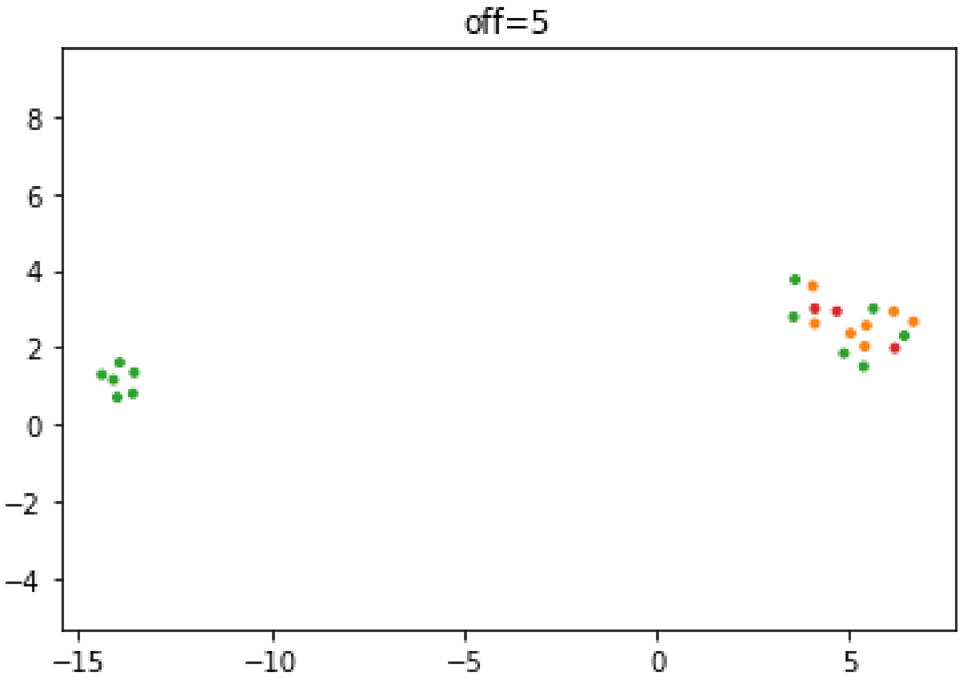


```
/home/ethan/.local/lib/python3.7/site-packages/umap/spectral.py:229: UserWarning:

Embedding a total of 2 separate connected components using meta-embedding (experimental)
```

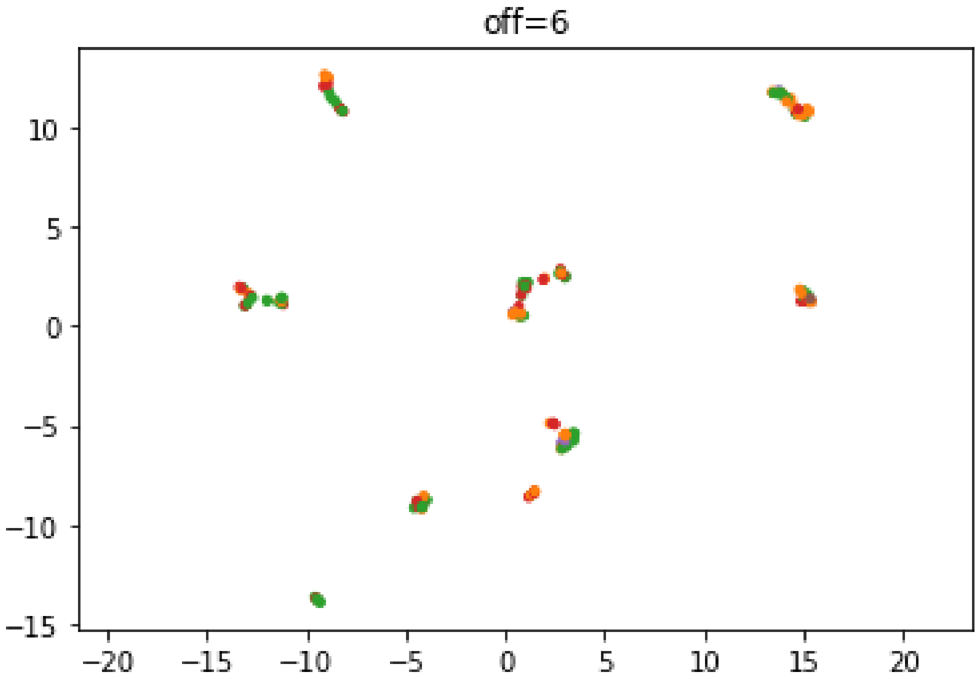


```
/home/ethan/.local/lib/python3.7/site-packages/umap/spectral.py:229: UserWarning:

Embedding a total of 4 separate connected components using meta-embedding (experimental)
```

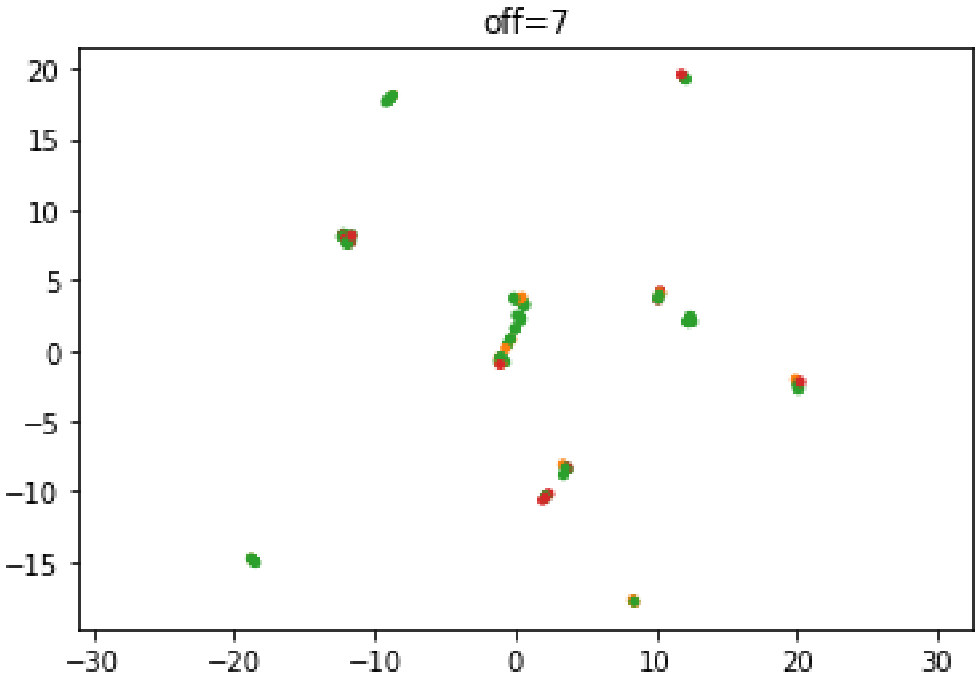




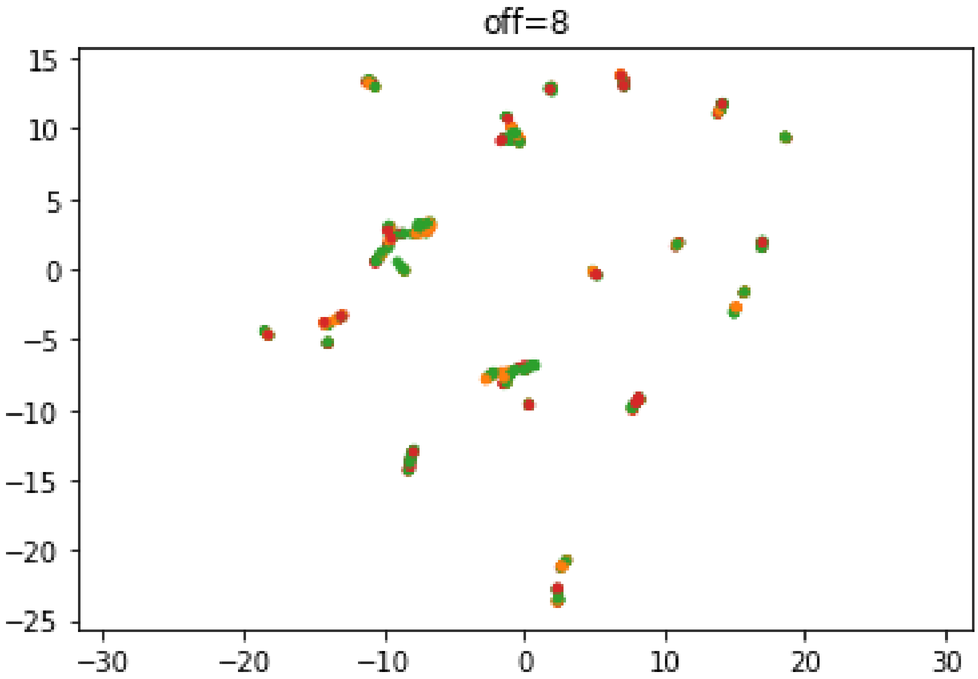
```
/home/ethan/.local/lib/python3.7/site-packages/umap/spectral.py:229: UserWarning:

Embedding a total of 6 separate connected components using meta-embedding (experimental)

/home/ethan/.local/lib/python3.7/site-packages/sklearn/manifold/spectral_embedding_.py:235: Use

Graph is not fully connected, spectral embedding may not work as expected.
```



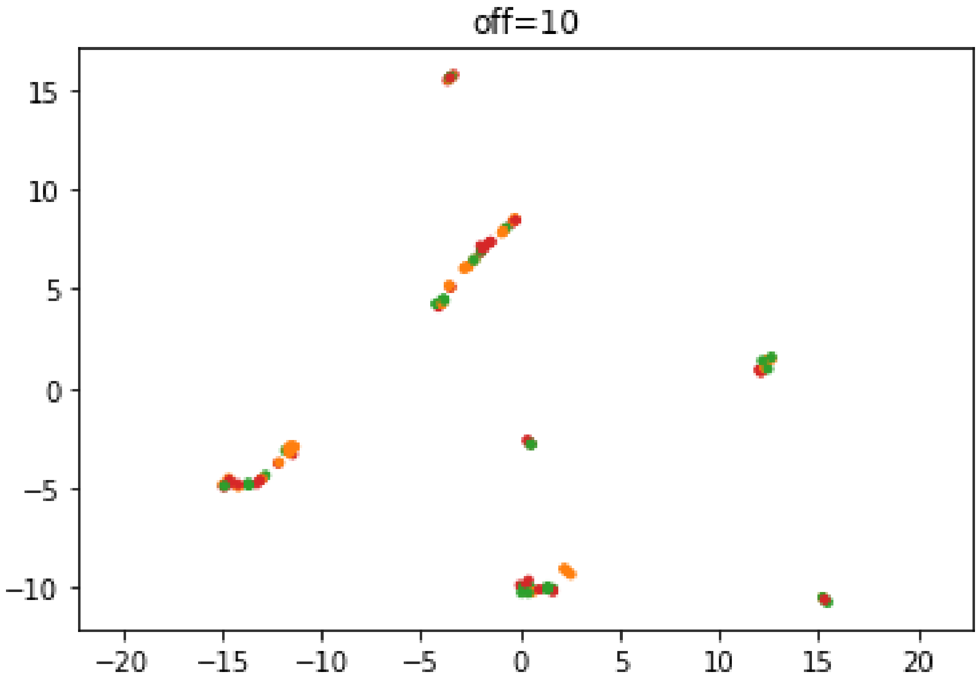
```
/home/ethan/.local/lib/python3.7/site-packages/umap/spectral.py:229: UserWarning:

Embedding a total of 8 separate connected components using meta-embedding (experimental)

/home/ethan/.local/lib/python3.7/site-packages/sklearn/manifold/spectral_embedding_.py:235: Us

Graph is not fully connected, spectral embedding may not work as expected.
```



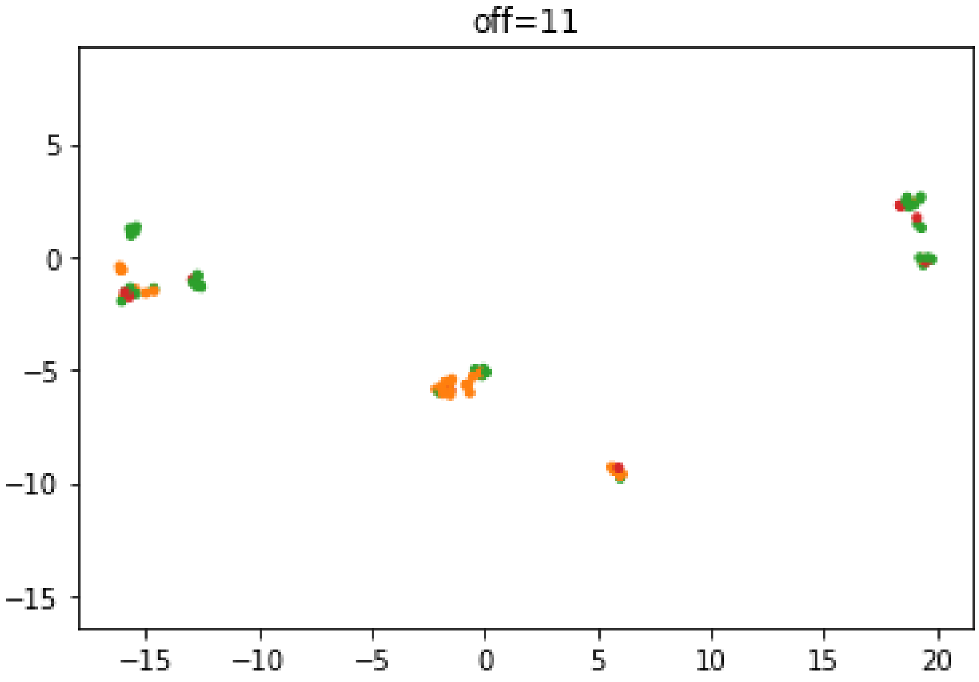
```
/home/ethan/.local/lib/python3.7/site-packages/umap/spectral.py:229: UserWarning:

Embedding a total of 9 separate connected components using meta-embedding (experimental)

/home/ethan/.local/lib/python3.7/site-packages/sklearn/manifold/spectral_embedding_.py:235: Us

Graph is not fully connected, spectral embedding may not work as expected.
```



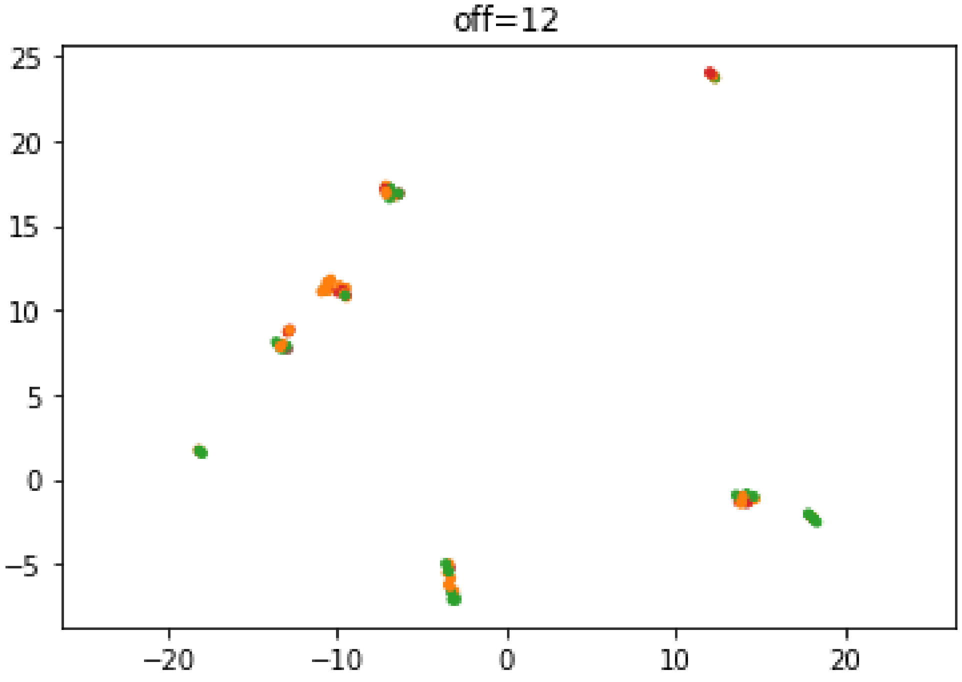
```
/home/ethan/.local/lib/python3.7/site-packages/umap/umap_.py:1383: UserWarning:

n_neighbors is larger than the dataset size; truncating to X.shape[0] - 1

/home/ethan/.local/lib/python3.7/site-packages/scipy/sparse/linalg/eigen/arpack/arpack.py:1592

k >= N for N * N square matrix. Attempting to use scipy.linalg.eigh instead.

/home/ethan/.local/lib/python3.7/site-packages/umap/spectral.py:229: UserWarning:

Embedding a total of 3 separate connected components using meta-embedding (experimental)
```



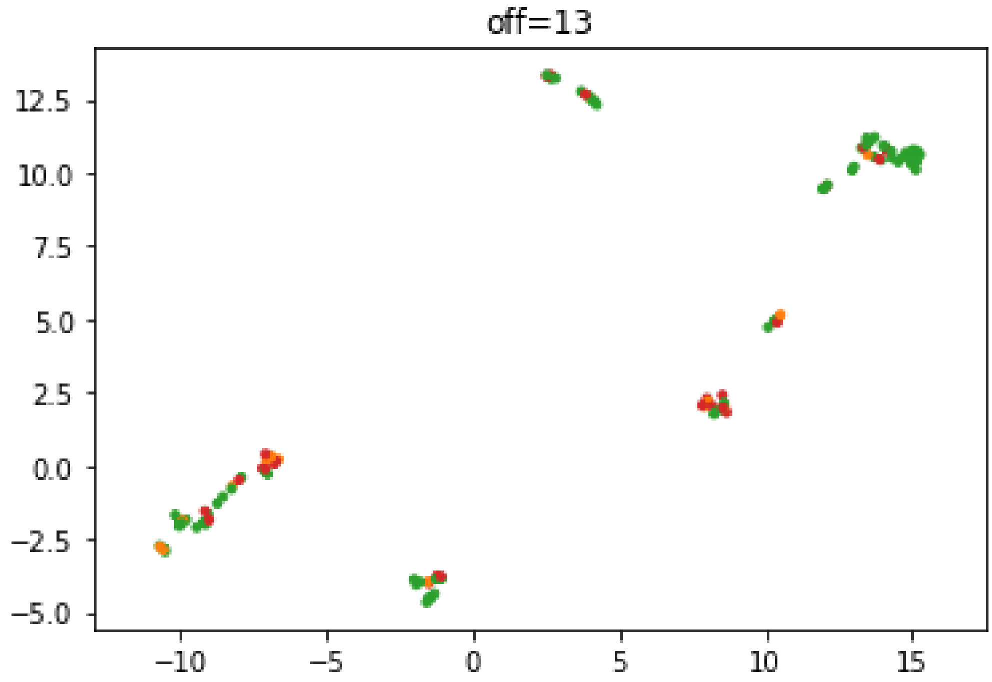
```
/home/ethan/.local/lib/python3.7/site-packages/umap/spectral.py:229: UserWarning:

Embedding a total of 2 separate connected components using meta-embedding (experimental)
```



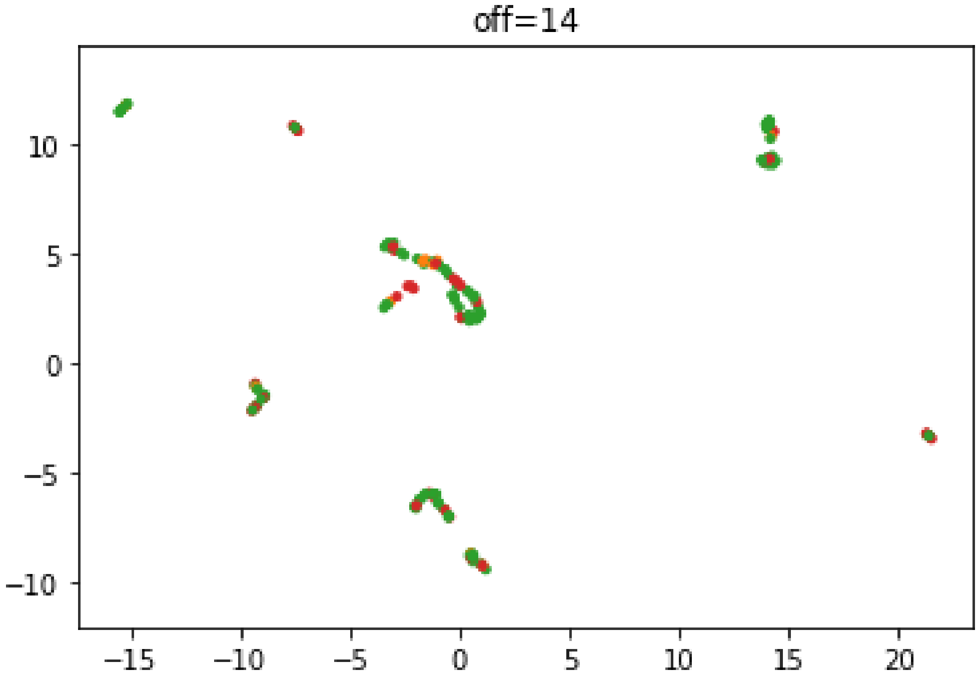
```
/home/ethan/.local/lib/python3.7/site-packages/umap/spectral.py:229: UserWarning:

Embedding a total of 5 separate connected components using meta-embedding (experimental)

/home/ethan/.local/lib/python3.7/site-packages/sklearn/manifold/spectral_embedding_.py:235: Us

Graph is not fully connected, spectral embedding may not work as expected.
```



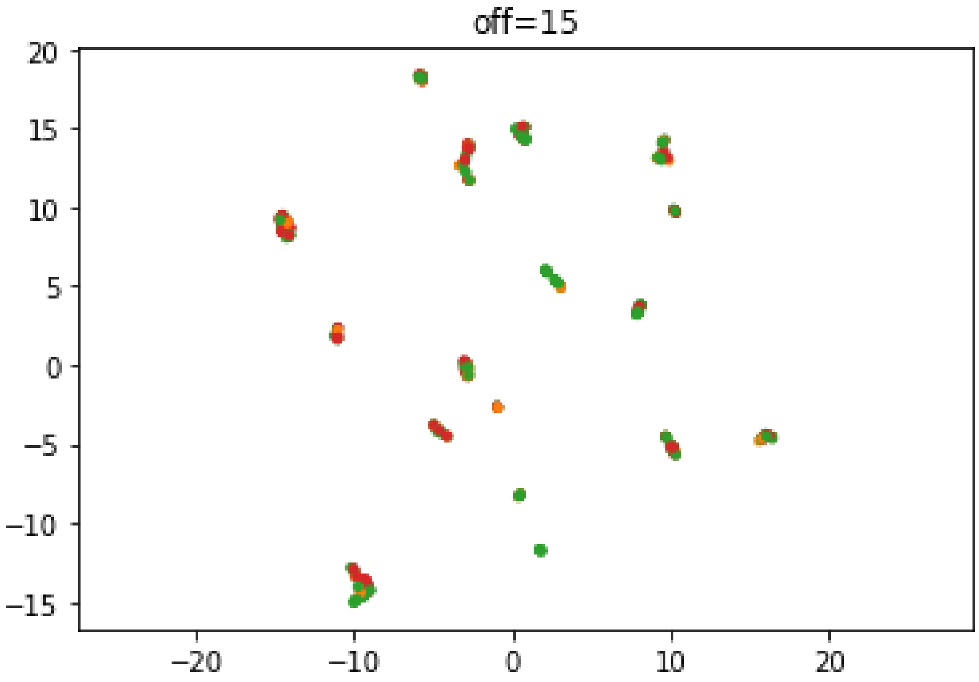
```
/home/ethan/.local/lib/python3.7/site-packages/umap/spectral.py:229: UserWarning:

Embedding a total of 2 separate connected components using meta-embedding (experimental)
```



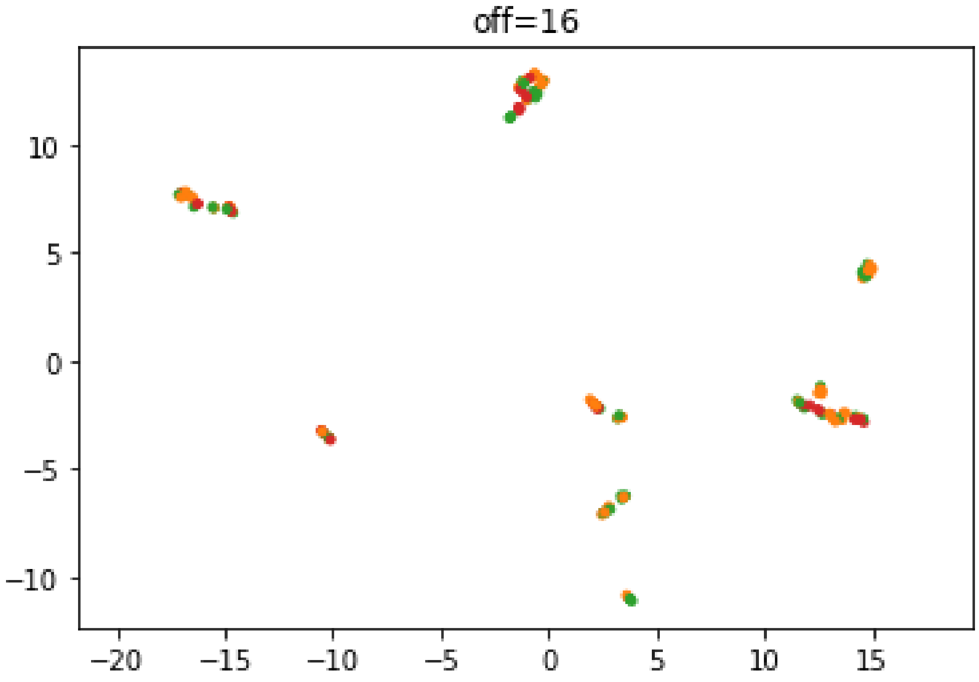
```
/home/ethan/.local/lib/python3.7/site-packages/umap/spectral.py:229: UserWarning:

Embedding a total of 5 separate connected components using meta-embedding (experimental)

/home/ethan/.local/lib/python3.7/site-packages/sklearn/manifold/spectral_embedding_.py:235: Use

Graph is not fully connected, spectral embedding may not work as expected.
```

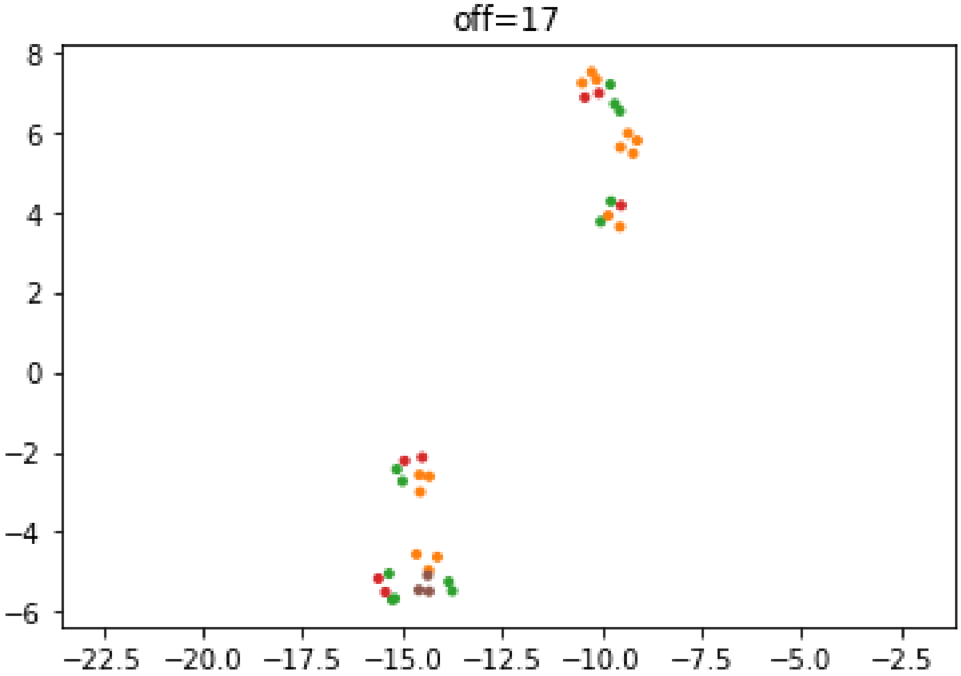


```
/home/ethan/.local/lib/python3.7/site-packages/umap/spectral.py:229: UserWarning:

Embedding a total of 7 separate connected components using meta-embedding (experimental)

/home/ethan/.local/lib/python3.7/site-packages/sklearn/manifold/spectral_embedding_.py:235: Use

Graph is not fully connected, spectral embedding may not work as expected.
```

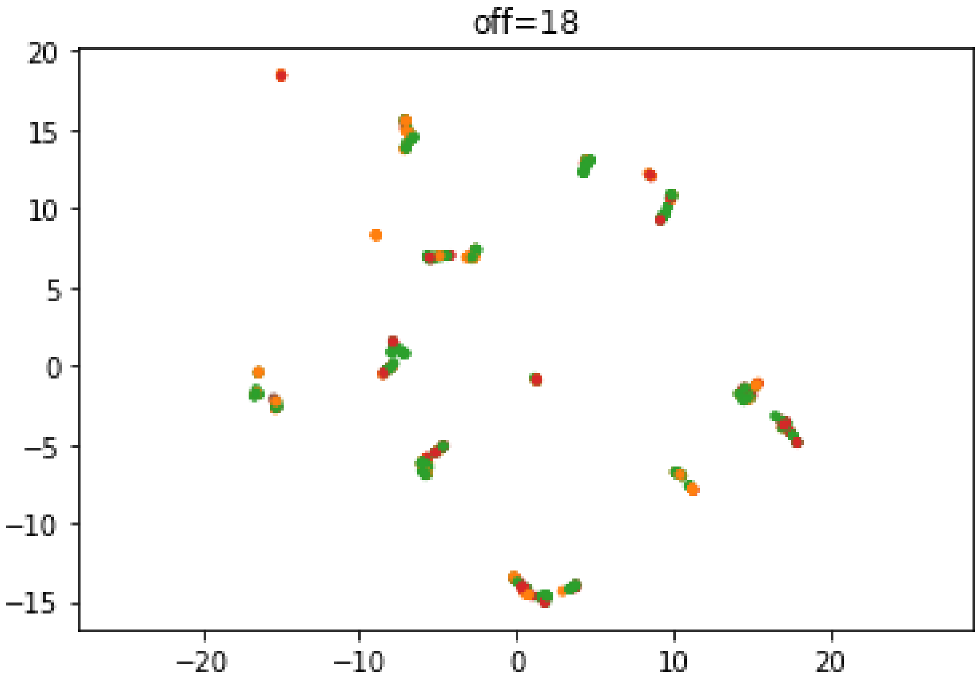


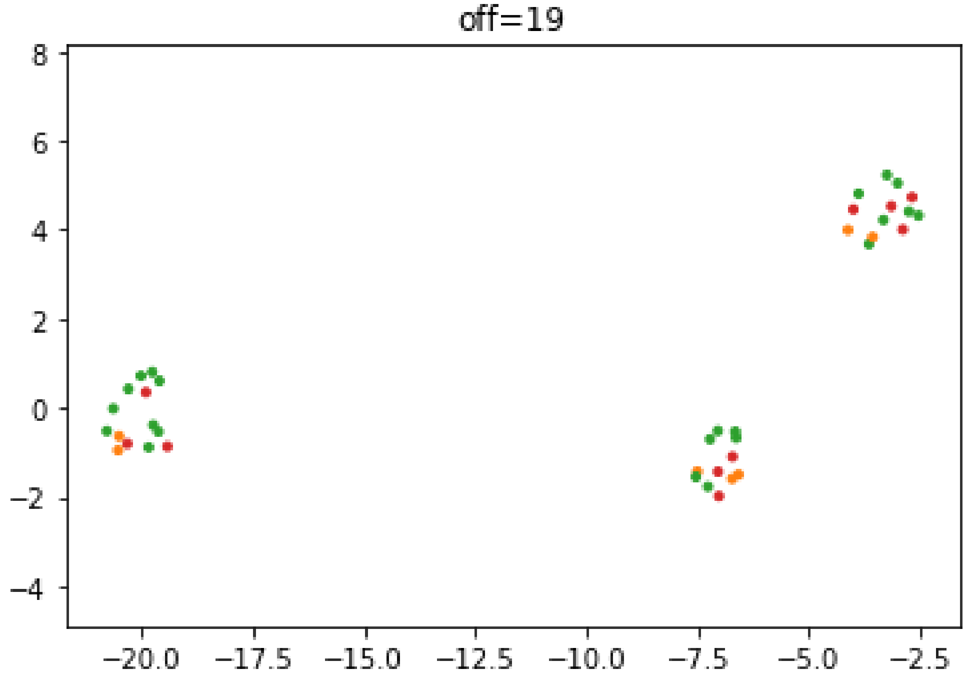
```
/home/ethan/.local/lib/python3.7/site-packages/umap/spectral.py:229: UserWarning:

Embedding a total of 3 separate connected components using meta-embedding (experimental)
```





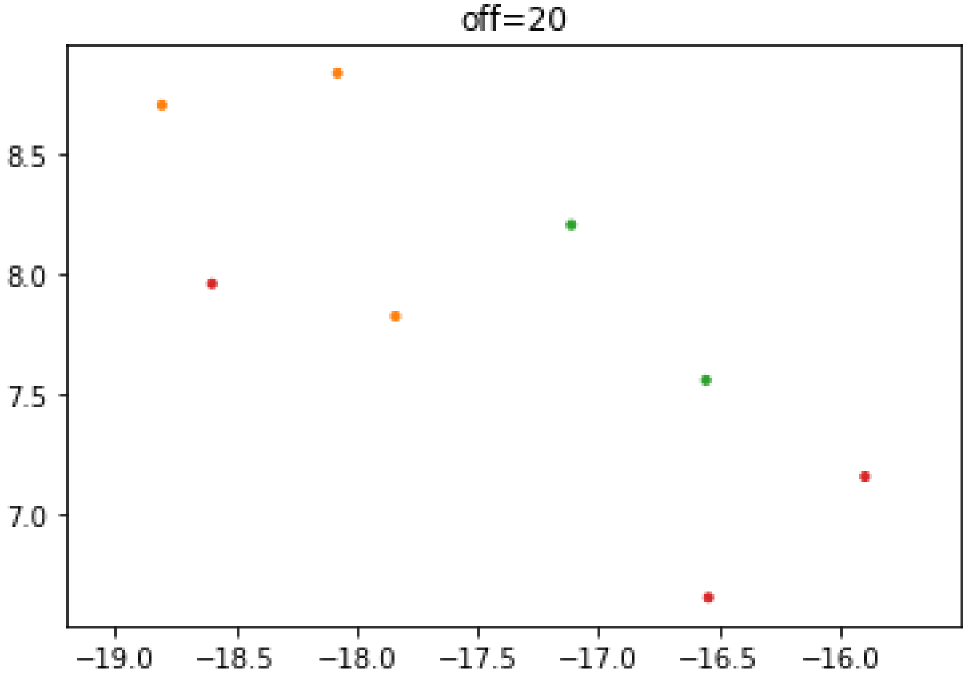
```
/home/ethan/.local/lib/python3.7/site-packages/umap/spectral.py:229: UserWarning:

Embedding a total of 8 separate connected components using meta-embedding (experimental)

/home/ethan/.local/lib/python3.7/site-packages/sklearn/manifold/spectral_embedding_.py:235: Use

Graph is not fully connected, spectral embedding may not work as expected.
```

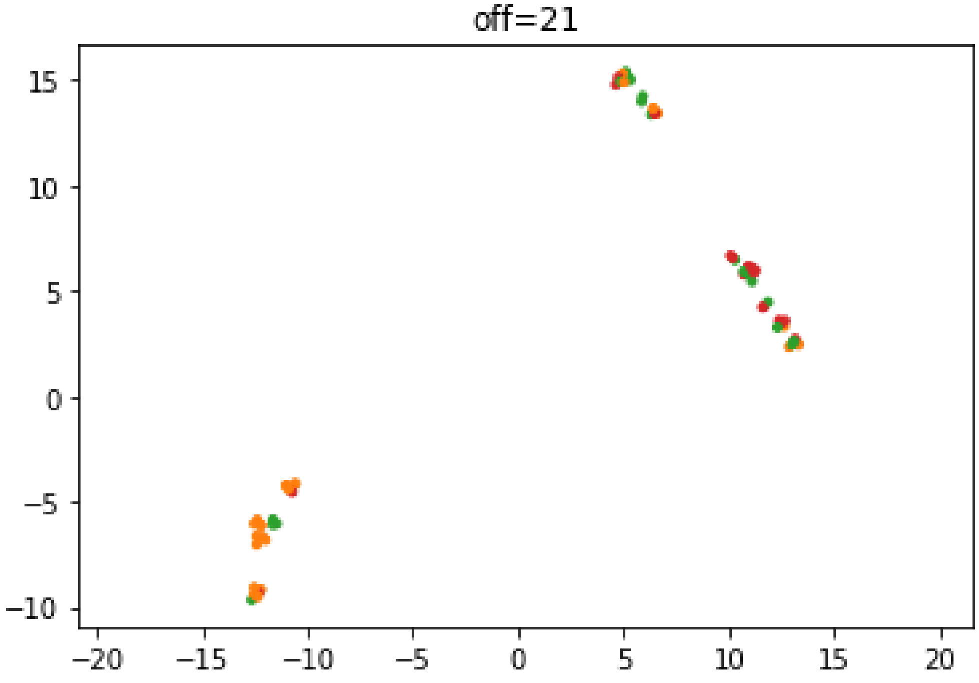


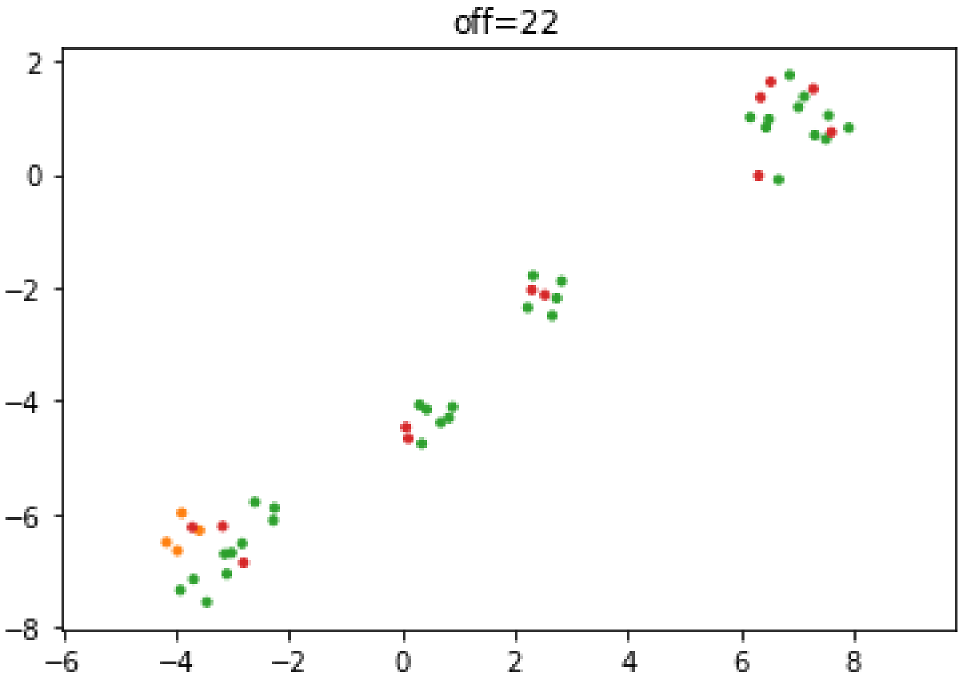


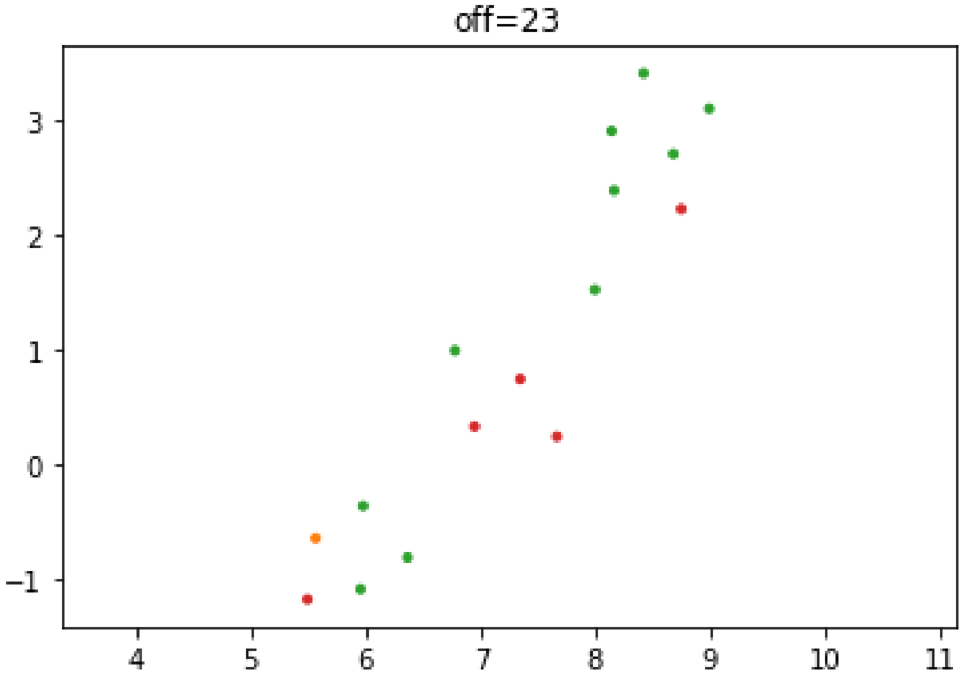
```
/home/ethan/.local/lib/python3.7/site-packages/umap/umap_.py:1383: UserWarning:
```

```
n_neighbors is larger than the dataset size; truncating to X.shape[0] - 1
```



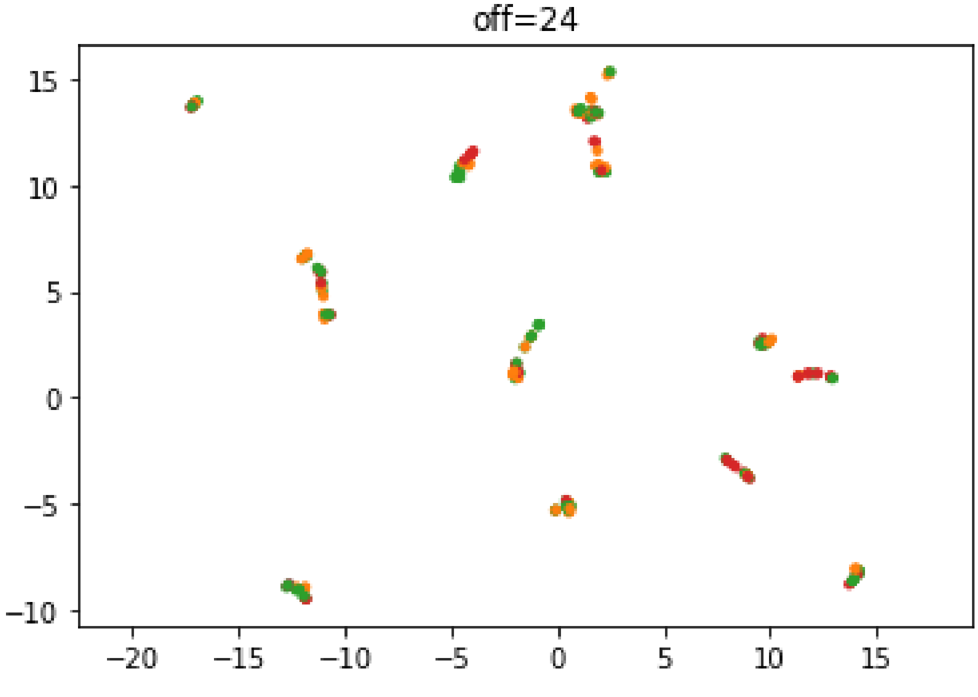




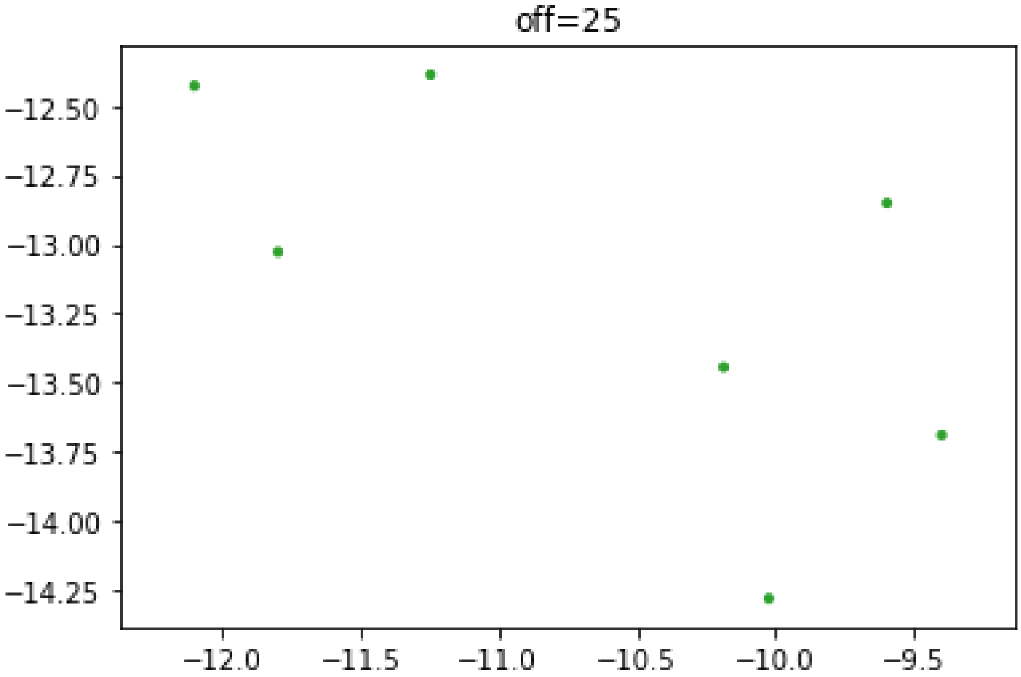


```
/home/ethan/.local/lib/python3.7/site-packages/umap/spectral.py:229: UserWarning:
```

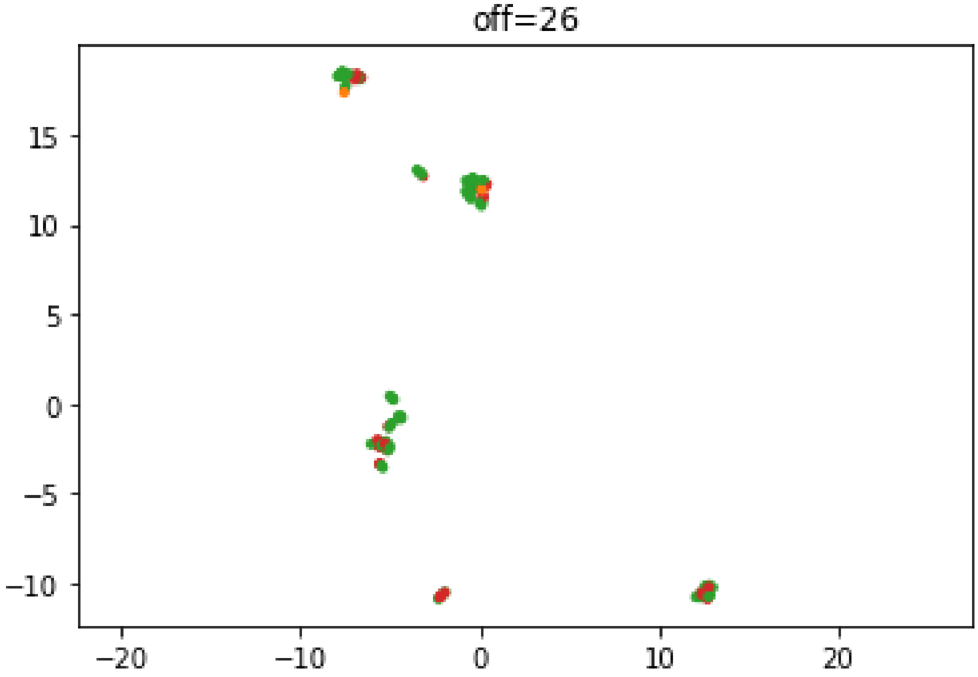
```
Embedding a total of 4 separate connected components using meta-embedding (experimental)
```



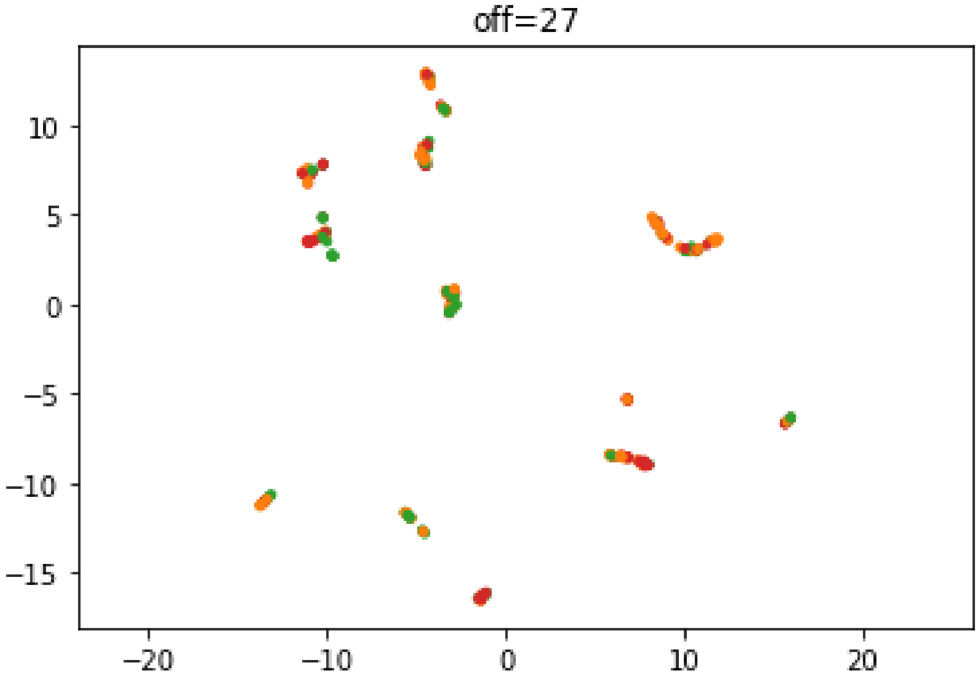
```
/home/ethan/.local/lib/python3.7/site-packages/umap/umap_.py:1383: UserWarning:

n_neighbors is larger than the dataset size; truncating to X.shape[0] - 1
```

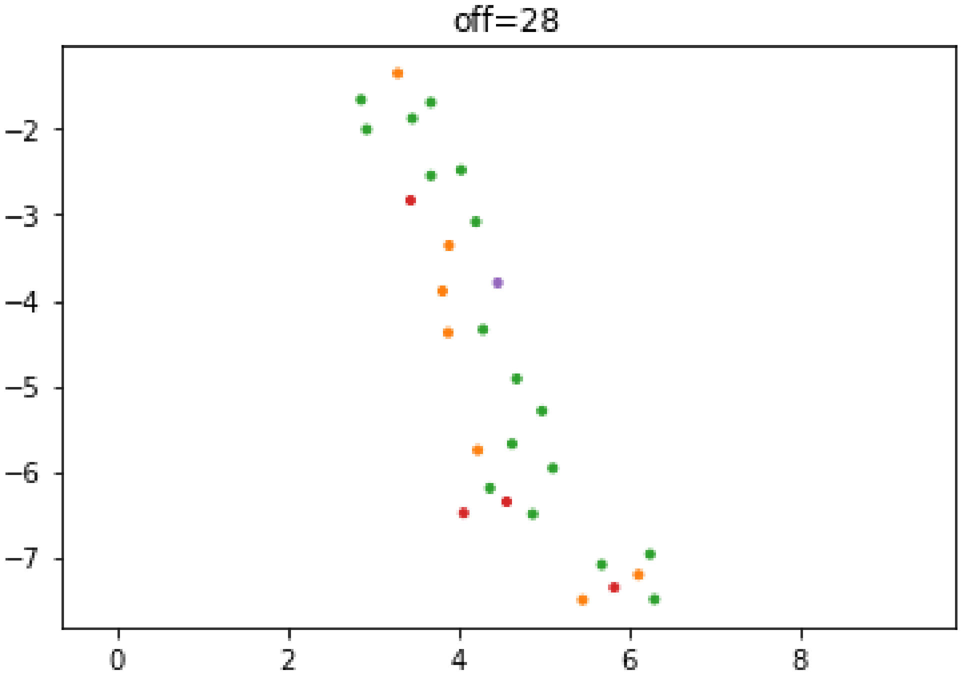


```
/home/ethan/.local/lib/python3.7/site-packages/umap/spectral.py:229: UserWarning:

Embedding a total of 4 separate connected components using meta-embedding (experimental)
```



```
/home/ethan/.local/lib/python3.7/site-packages/umap/spectral.py:229: UserWarning:

Embedding a total of 4 separate connected components using meta-embedding (experimental)
```

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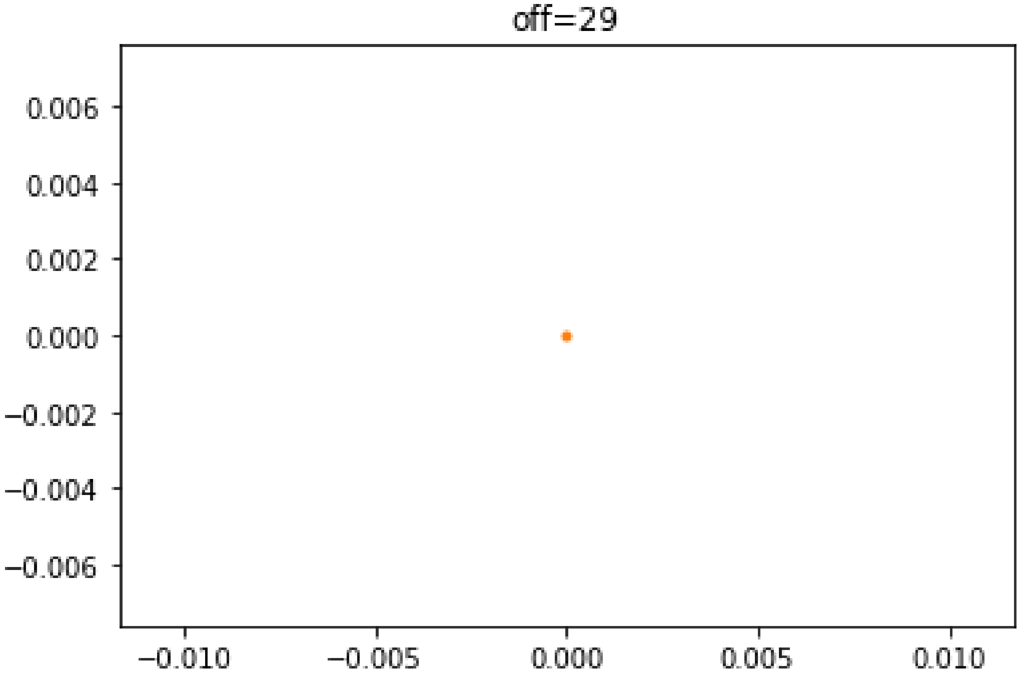
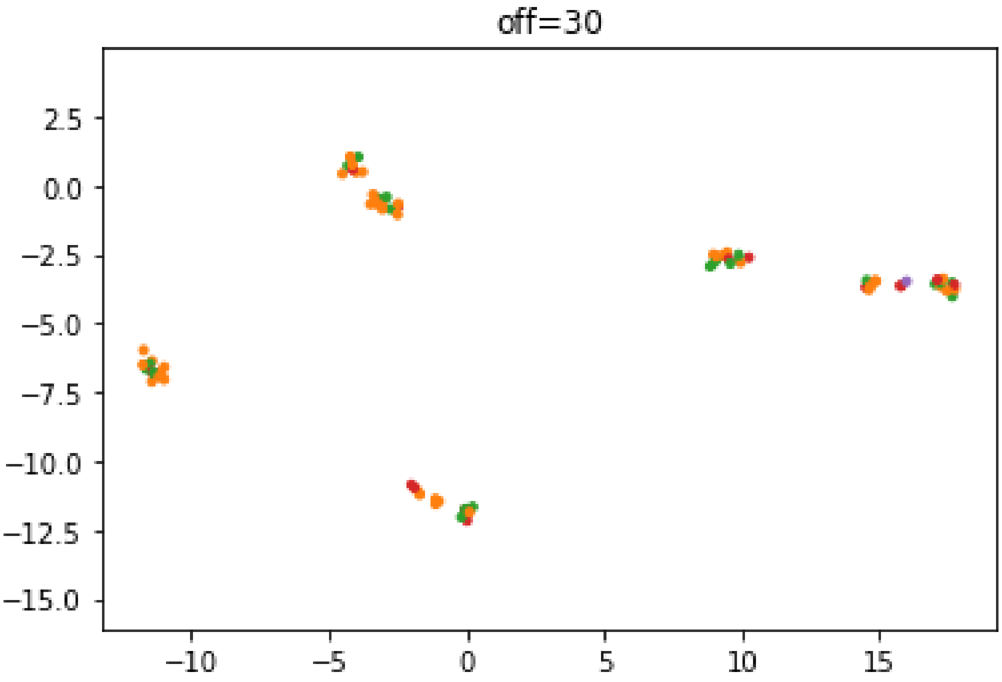
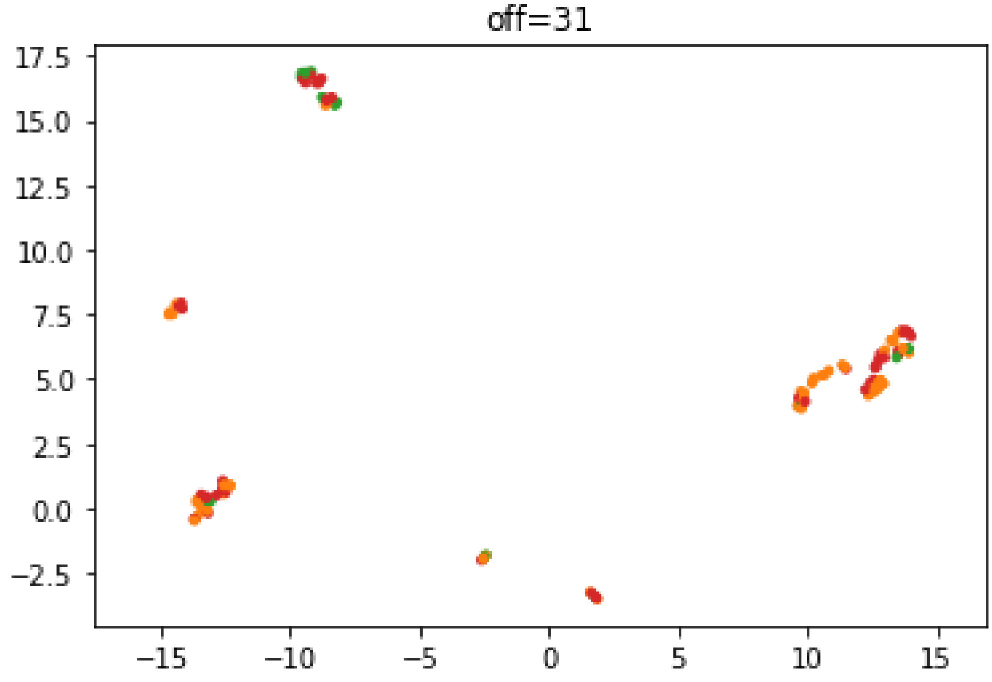
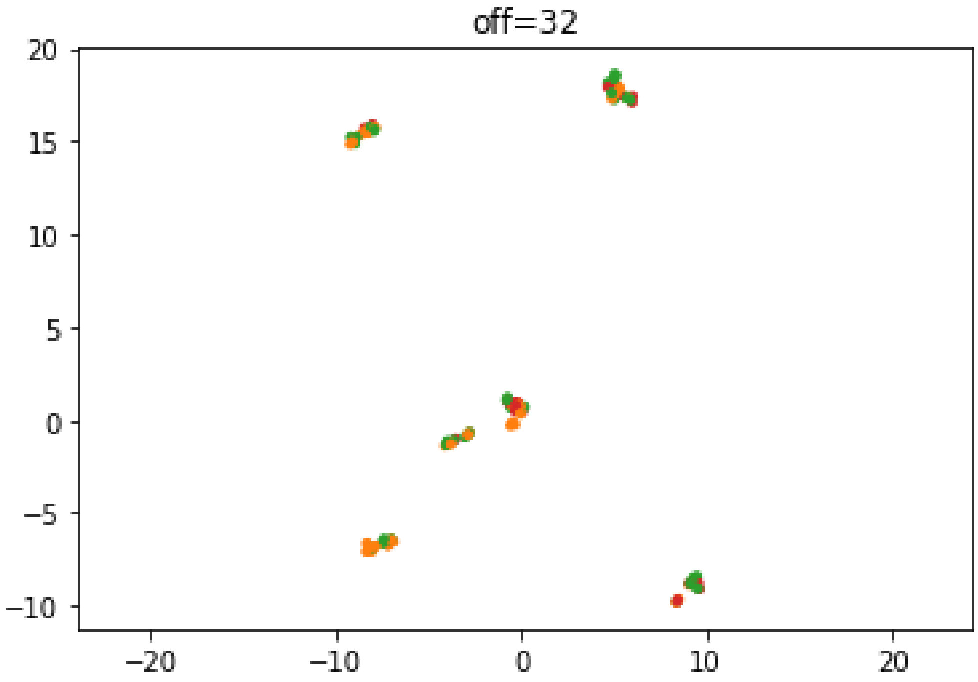
−3
−4
−5
−6
−7
0
2
4
6
8


off=29
0.006
0.004
0.002
0.000
−0.002
−0.004
−0.006
−0.010
−0.005
0.000
0.005
0.010


off=30
2.5
0.0
−2.5
−5.0
−7.5
−10.0
−12.5
−15.0
−10
−5
0
5
10
15


off=31
17.5
15.0
12.5
10.0
7.5
5.0
2.5
0.0
−2.5
−15
−10
−5
0
5
10
15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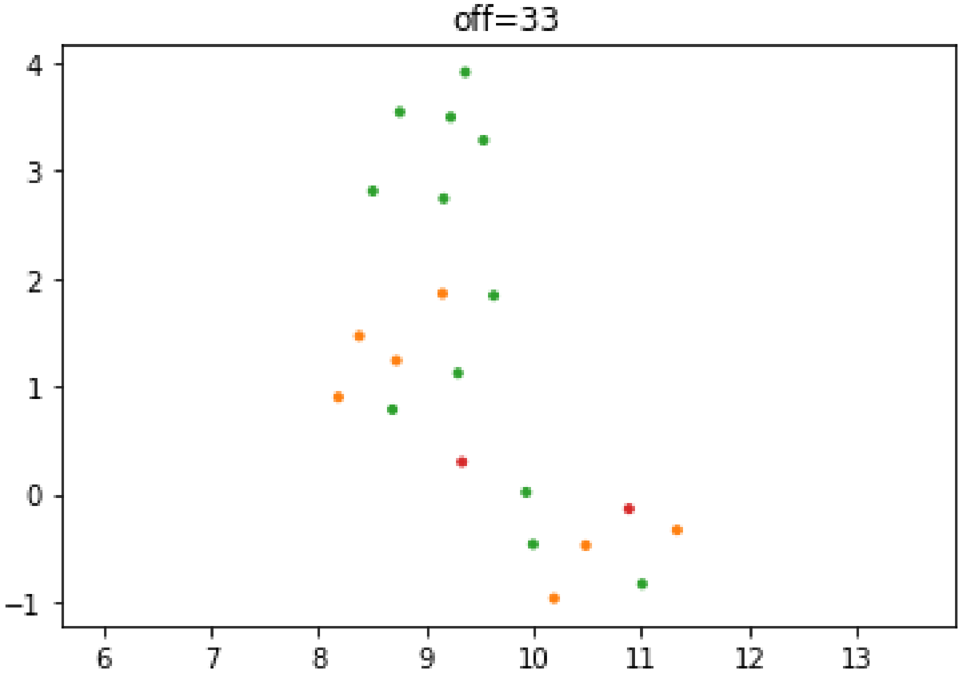
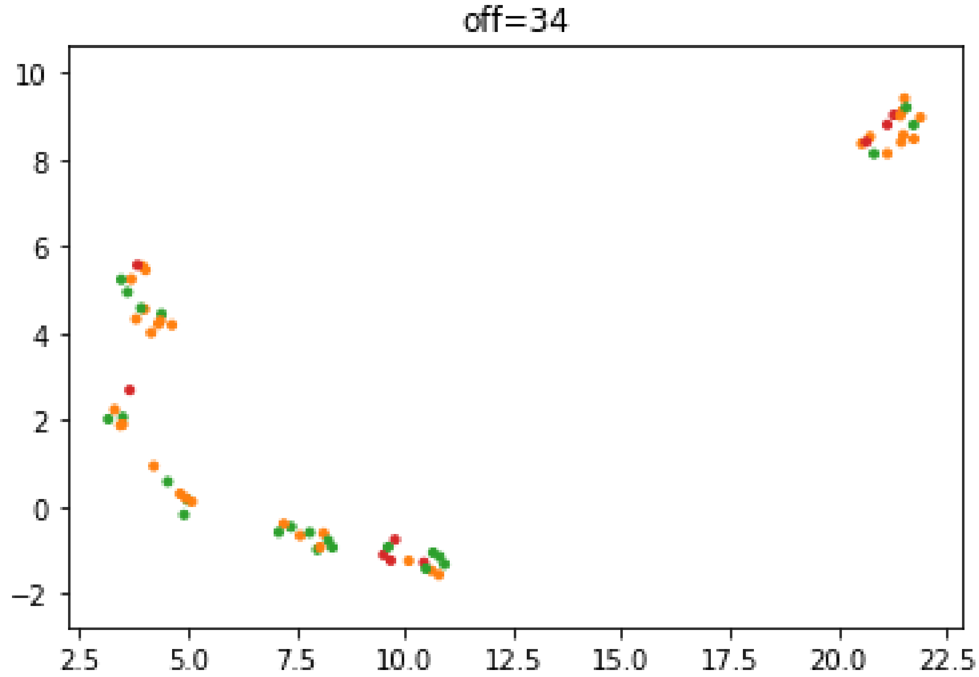
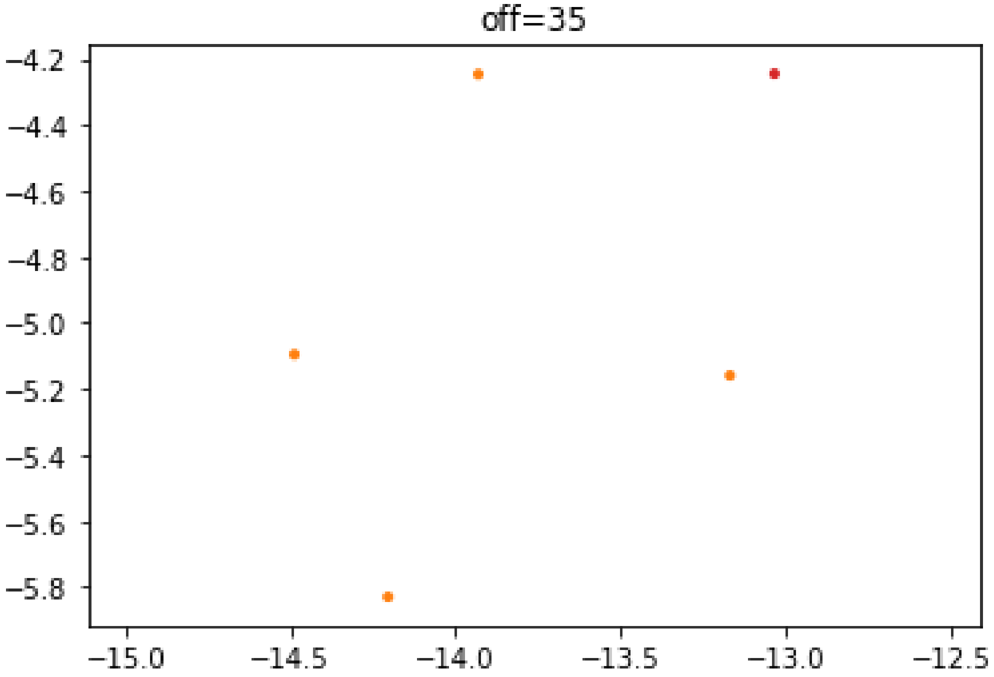
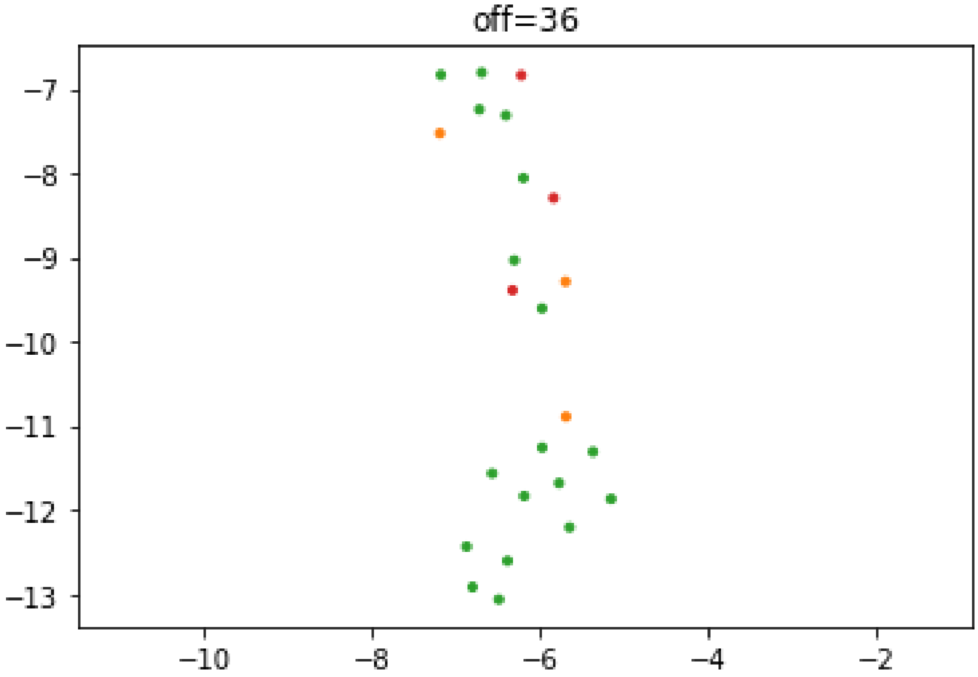
15
10
5
0
−5
−10
−20
−10
0
10
20


off=33
4
3
2
1
0
−1
6
7
8
9
10
11
12
13



```
/home/ethan/.local/lib/python3.7/site-packages/umap/umap_.py:1383: UserWarning:
n_neighbors is larger than the dataset size; truncating to X.shape[0] - 1
```




off=36
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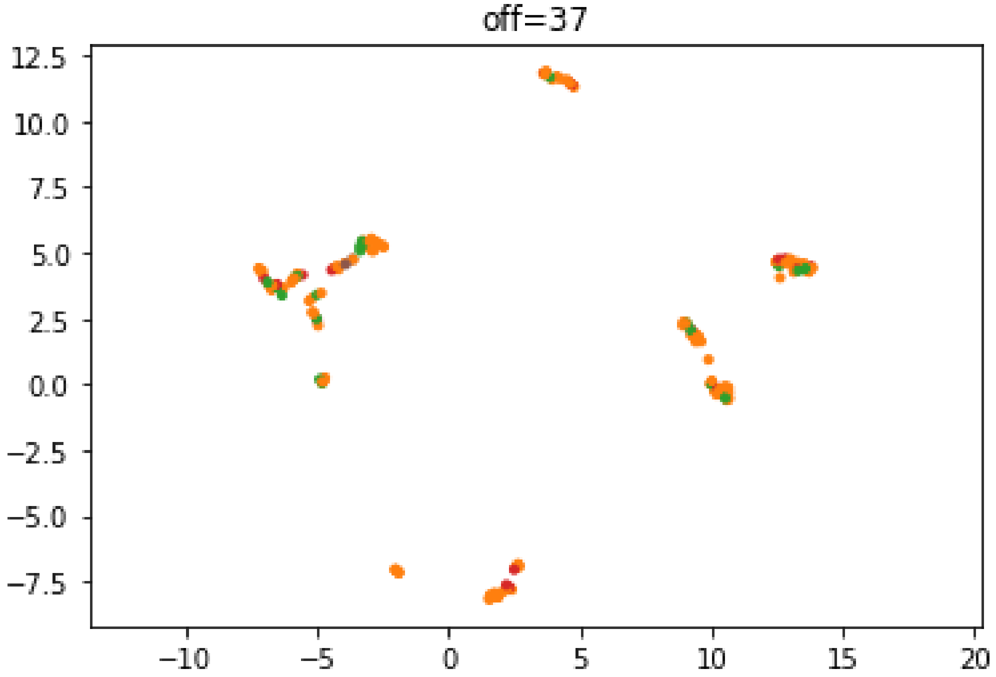
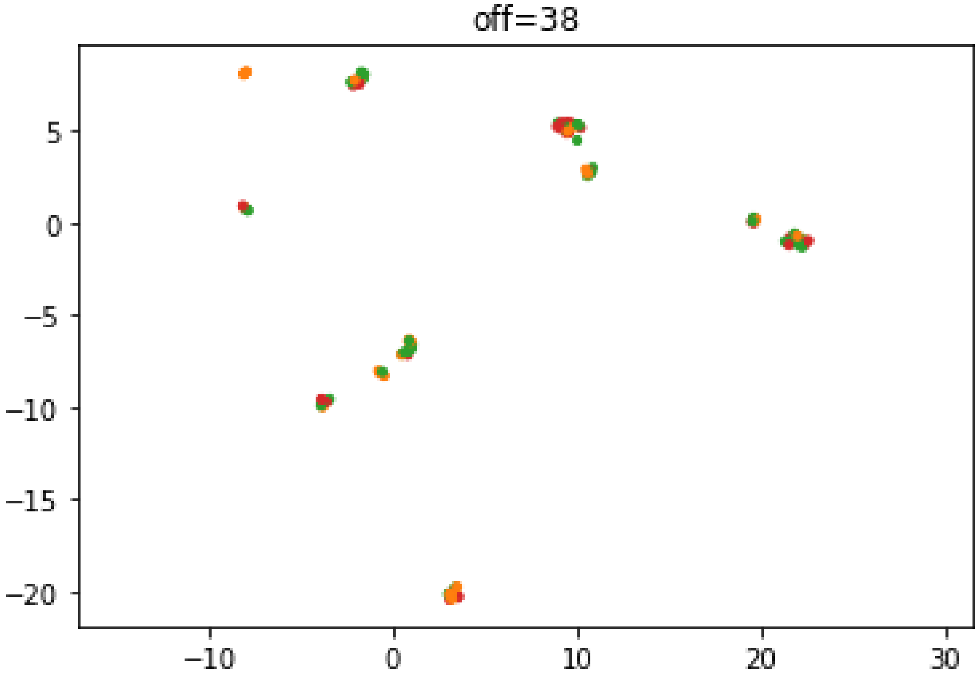
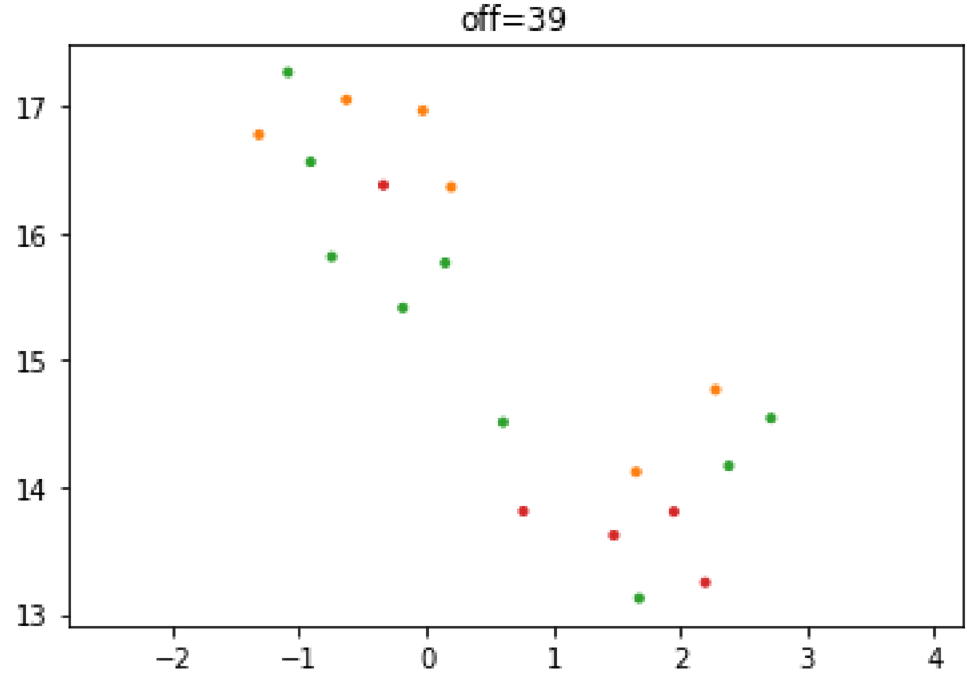
−8
−9
−10
−11
−12
−13
−10
−8
−6
−4
−2

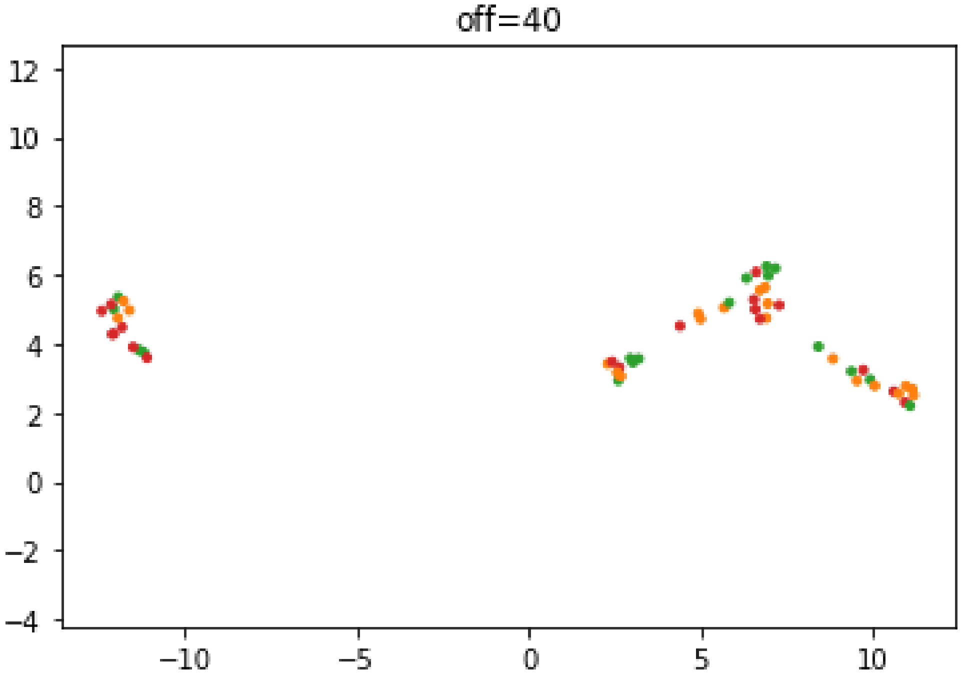

off=37
12.5
10.0
7.5
5.0
2.5
0.0
−2.5
−5.0
−7.5
−10
−5
0
5
10
15
20

```
/home/ethan/.local/lib/python3.7/site-packages/umap/spectral.py:229: UserWarning:

Embedding a total of 2 separate connected components using meta-embedding (experimental)
```



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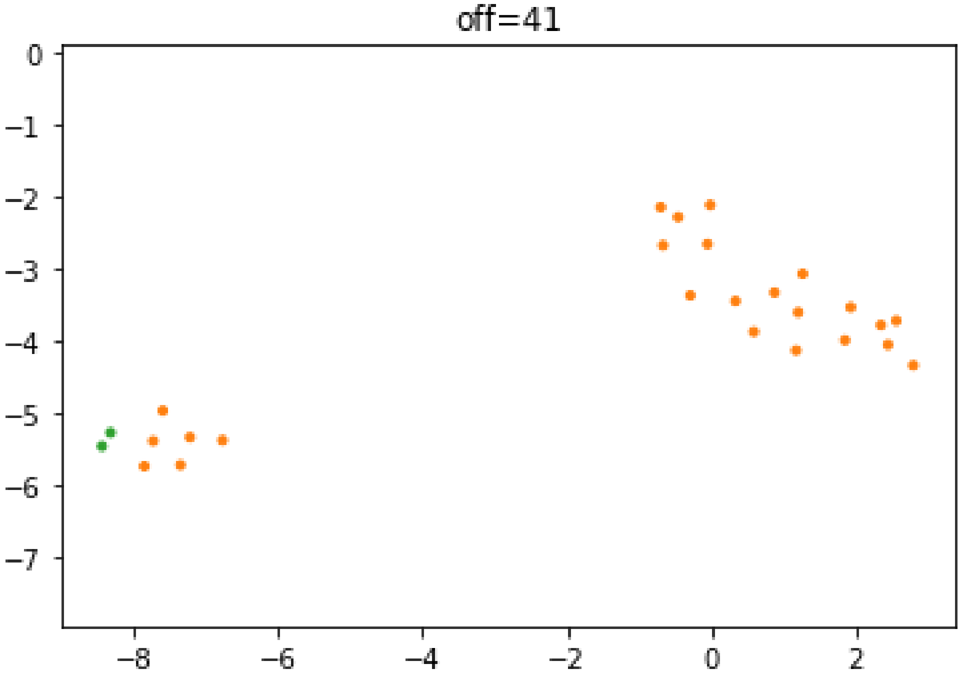
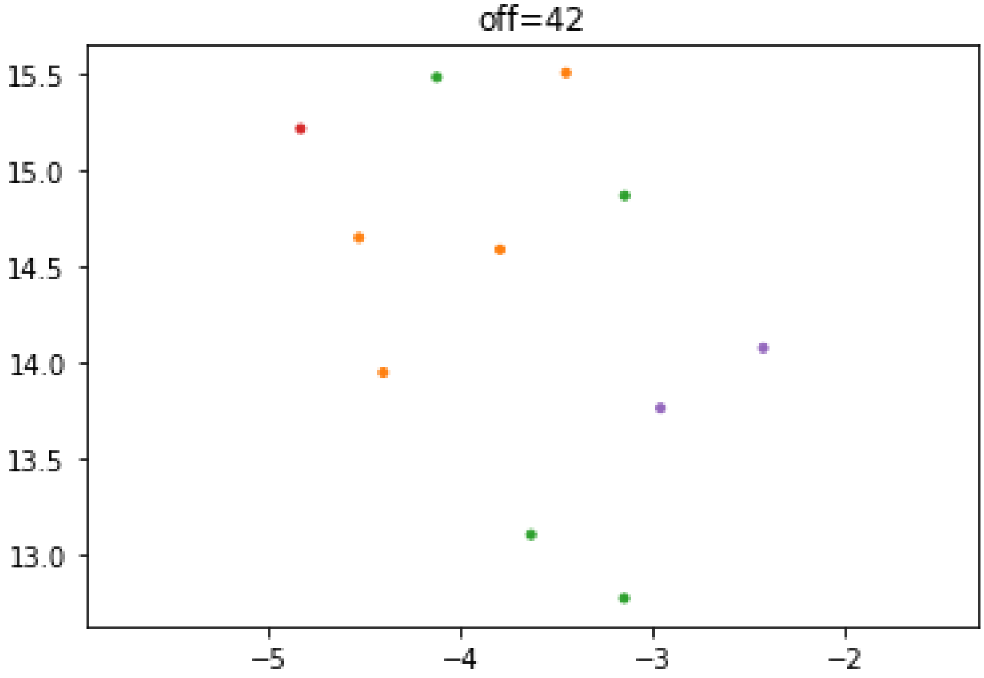
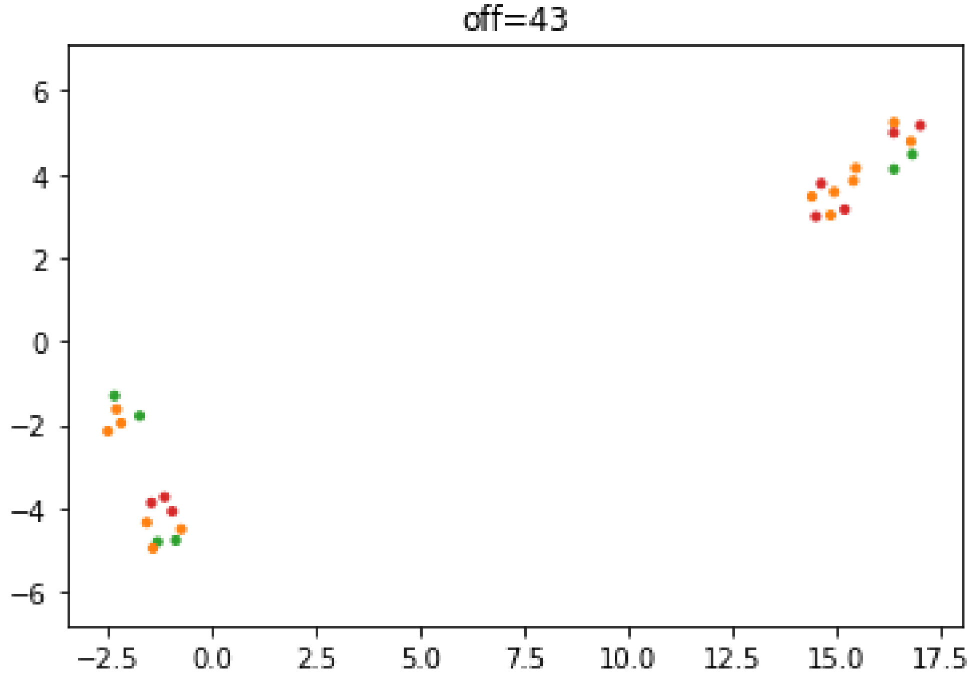
12
10
8
6
4
2
0
−2
−4
−10
−5
0
5
10

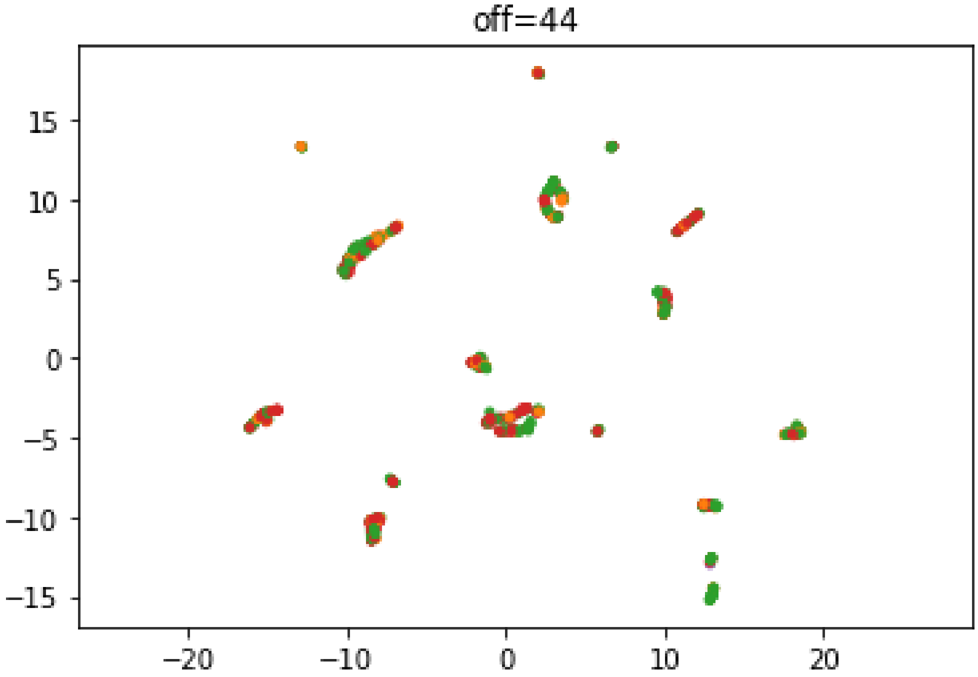

off=41
0
−1
−2
−3
−4
−5
−6
−7
−8
−6
−4
−2
0
2

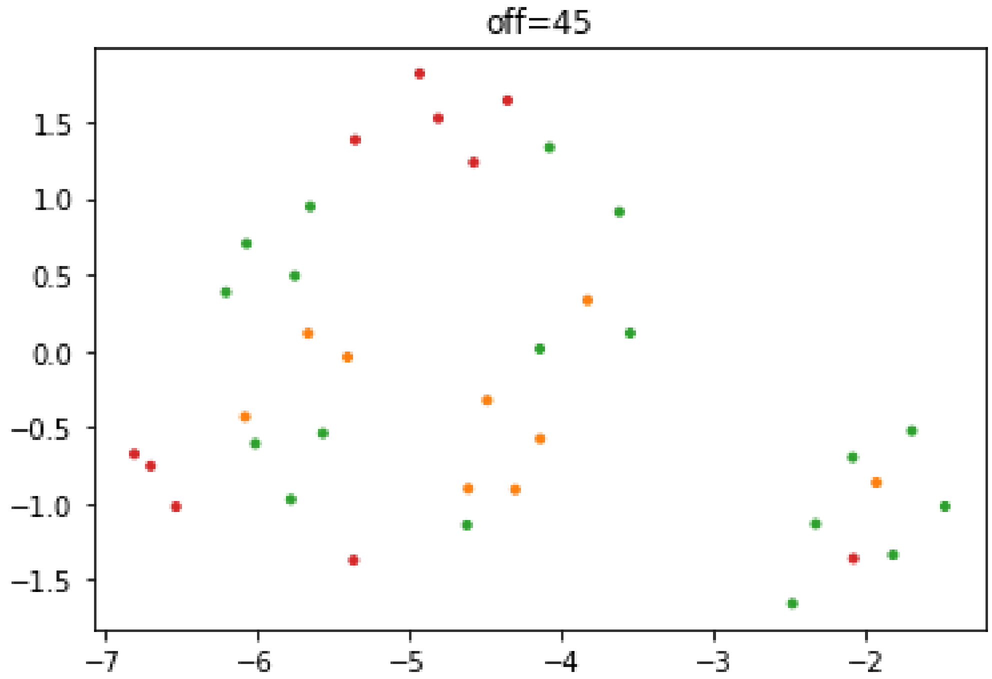
```
/home/ethan/.local/lib/python3.7/site-packages/umap/umap_.py:1383: UserWarning:

n_neighbors is larger than the dataset size; truncating to X.shape[0] - 1
```



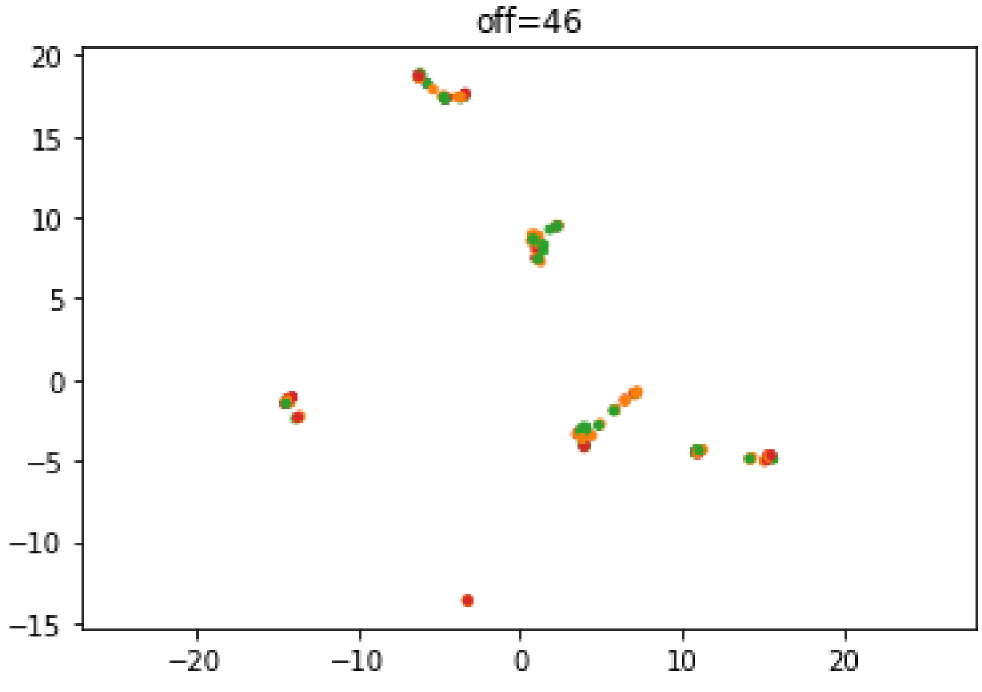


```
/home/ethan/.local/lib/python3.7/site-packages/umap/spectral.py:229: UserWarning:

Embedding a total of 8 separate connected components using meta-embedding (experimental)

/home/ethan/.local/lib/python3.7/site-packages/sklearn/manifold/spectral_embedding_.py:235: Use

Graph is not fully connected, spectral embedding may not work as expected.
```

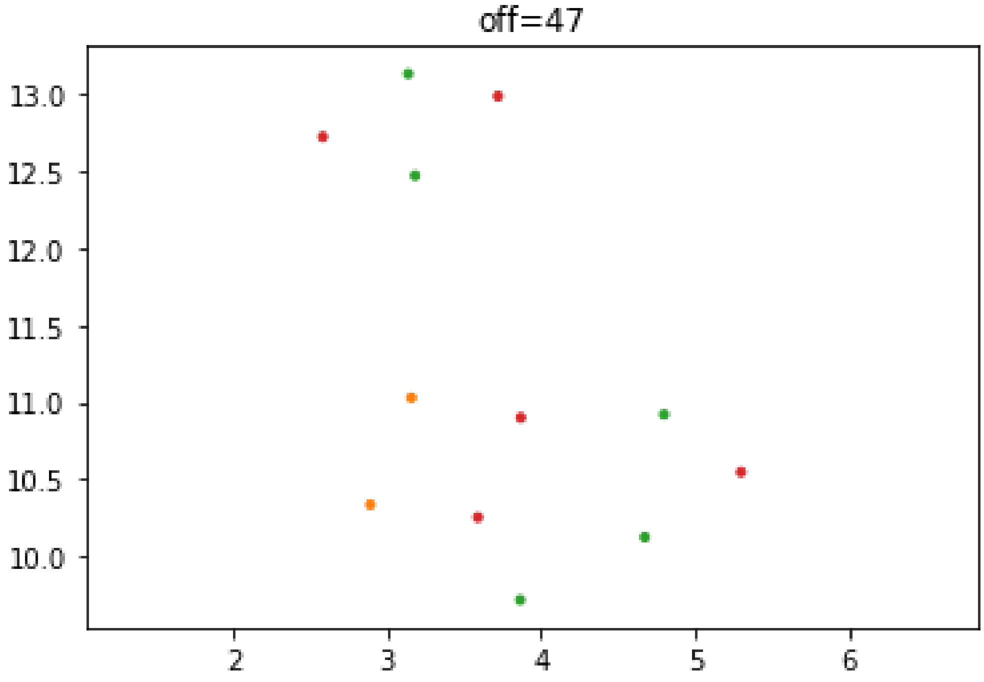




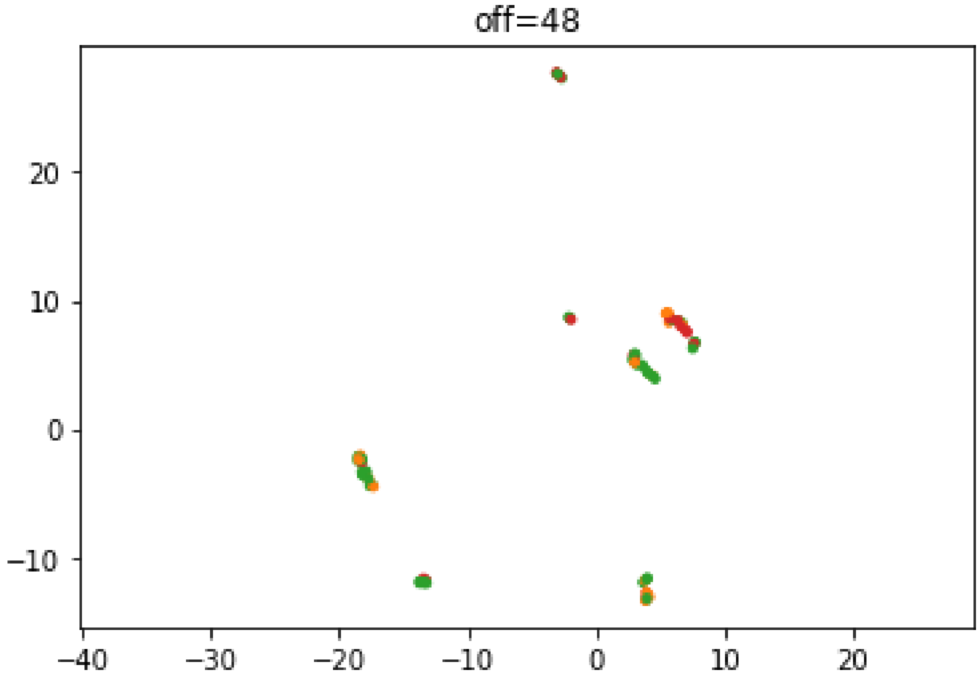
```
/home/ethan/.local/lib/python3.7/site-packages/umap/spectral.py:229: UserWarning:

Embedding a total of 3 separate connected components using meta-embedding (experimental)
```



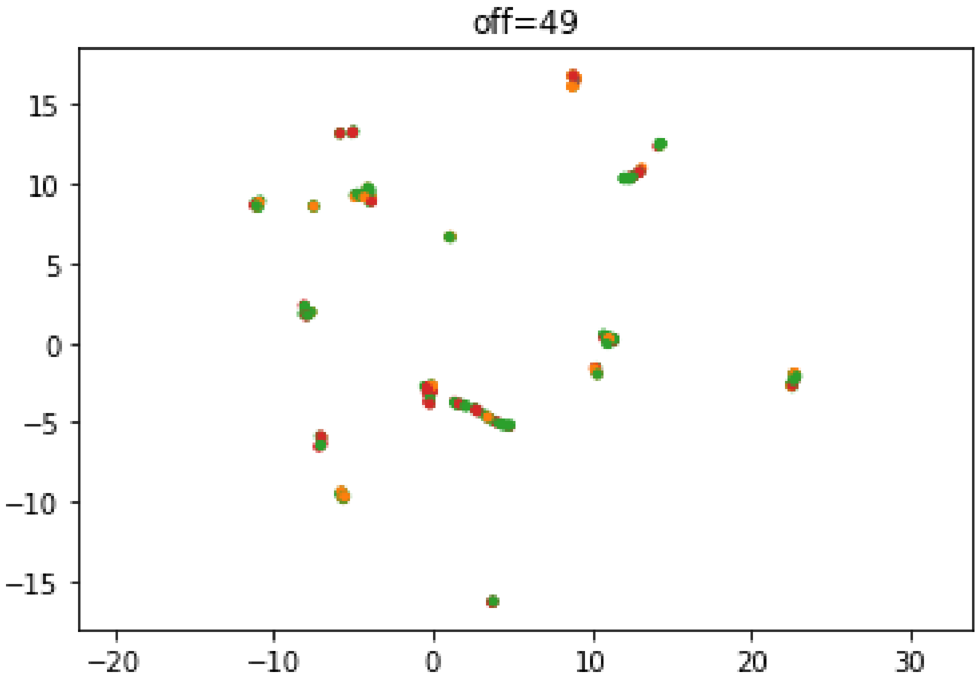
```
/home/ethan/.local/lib/python3.7/site-packages/umap/umap_.py:1383: UserWarning:

n_neighbors is larger than the dataset size; truncating to X.shape[0] - 1
```



```
/home/ethan/.local/lib/python3.7/site-packages/umap/spectral.py:229: UserWarning:

Embedding a total of 3 separate connected components using meta-embedding (experimental)
```



```
/home/ethan/.local/lib/python3.7/site-packages/umap/spectral.py:229: UserWarning:

Embedding a total of 6 separate connected components using meta-embedding (experimental)

/home/ethan/.local/lib/python3.7/site-packages/sklearn/manifold/spectral_embedding_.py:235: Use

Graph is not fully connected, spectral embedding may not work as expected.
```


off=49
15
10
5
0
−5
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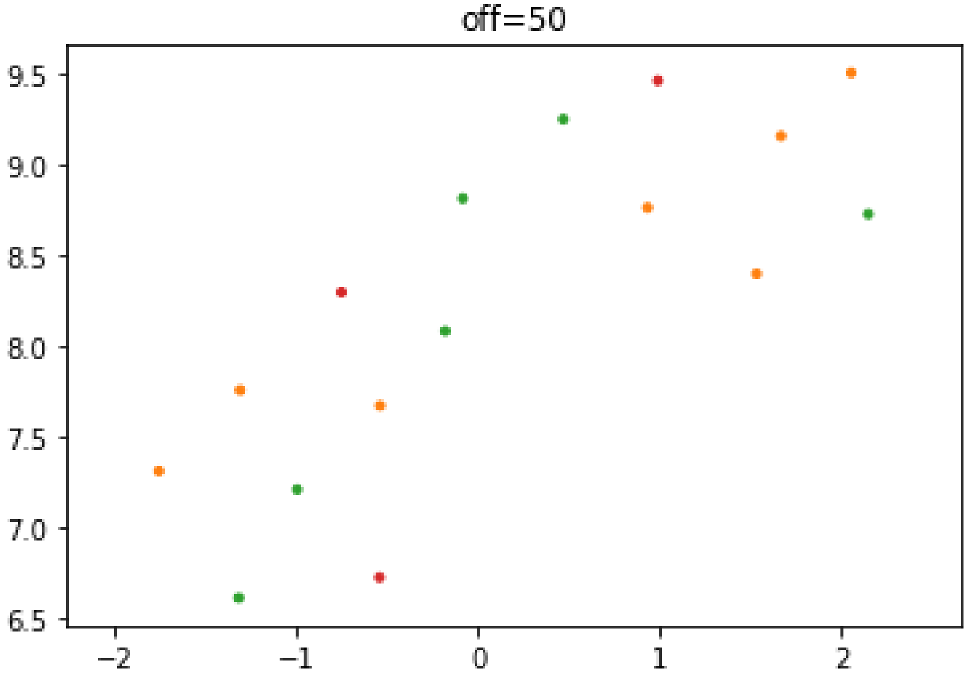
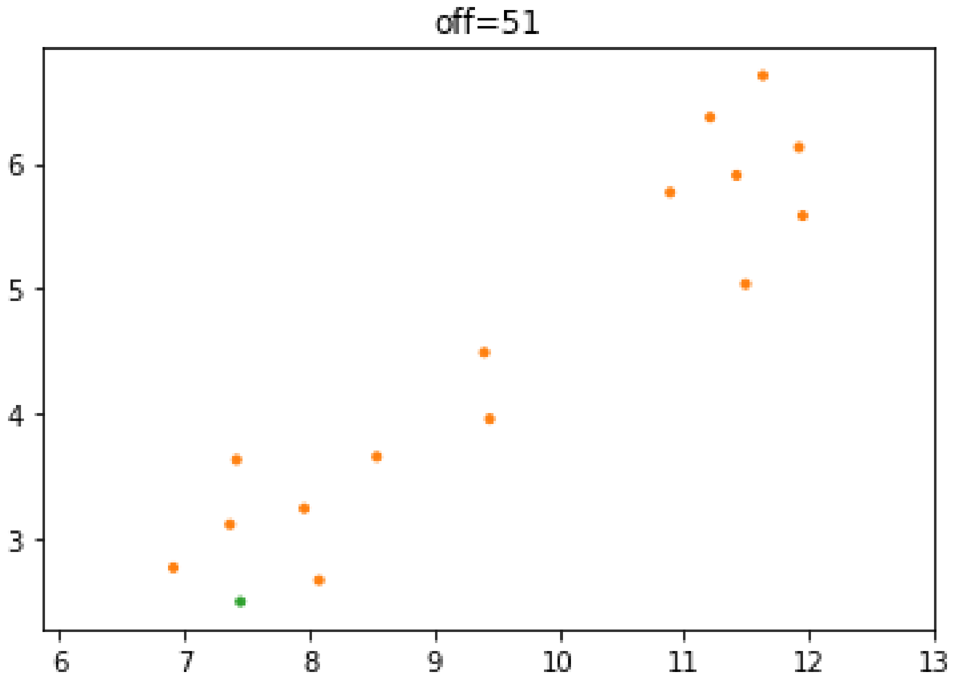
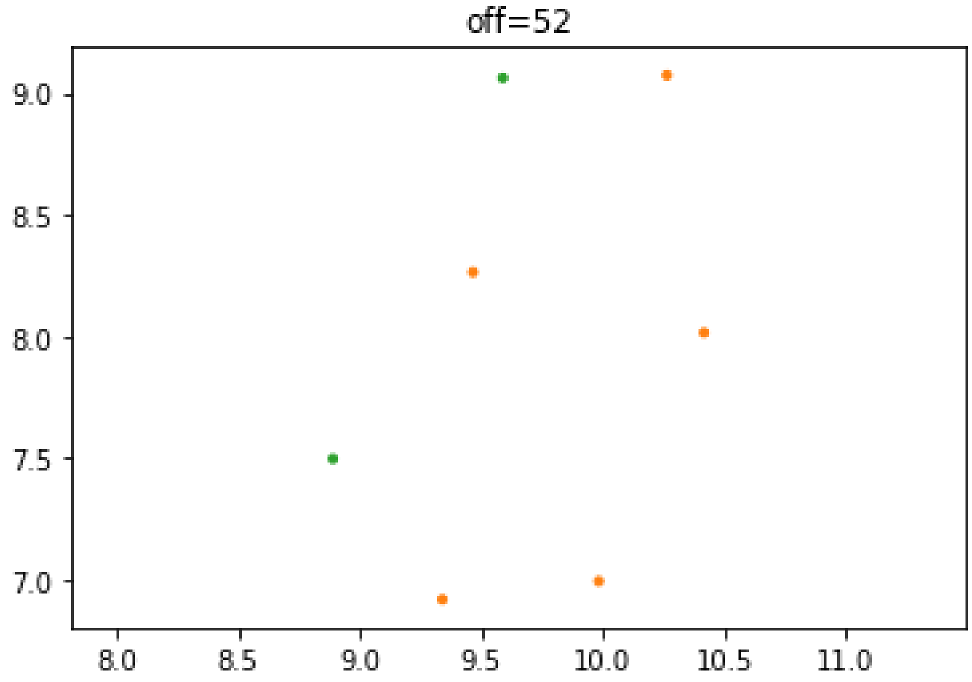
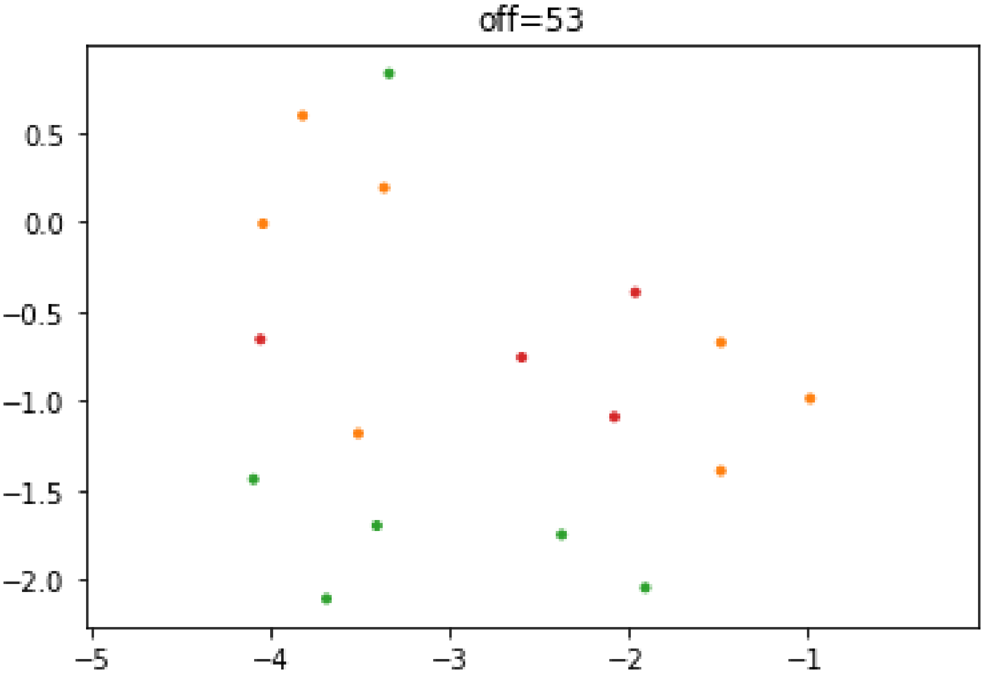
−15
−20
−10
0
10
20
30


off=50
9.5
9.0
8.5
8.0
7.5
7.0
6.5
−2
−1
0
1
2

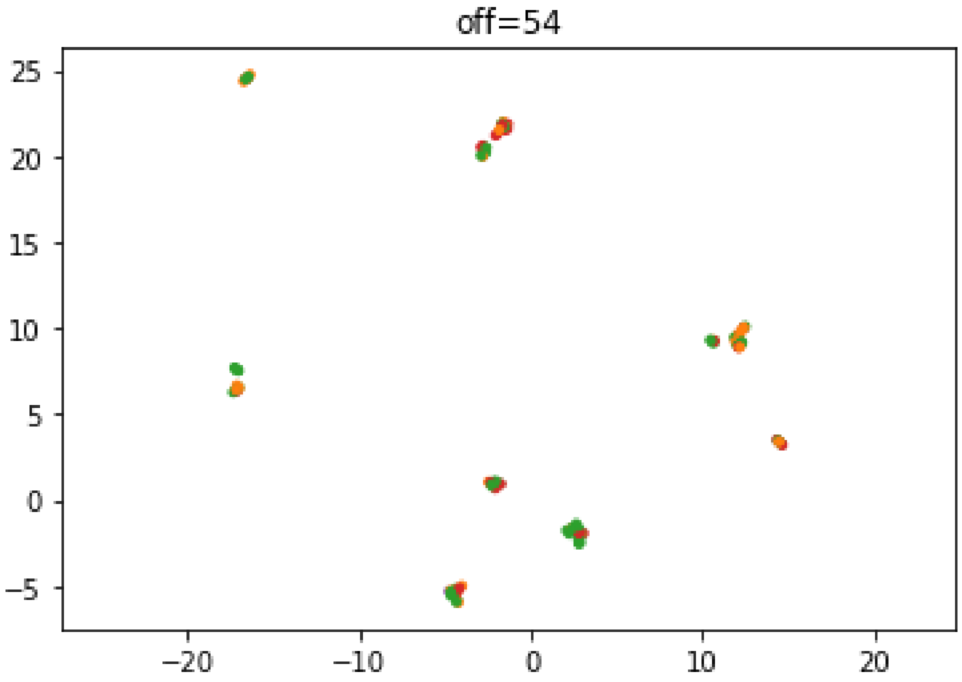


```
/home/ethan/.local/lib/python3.7/site-packages/umap/umap_.py:1383: UserWarning:
n_neighbors is larger than the dataset size; truncating to X.shape[0] - 1
```

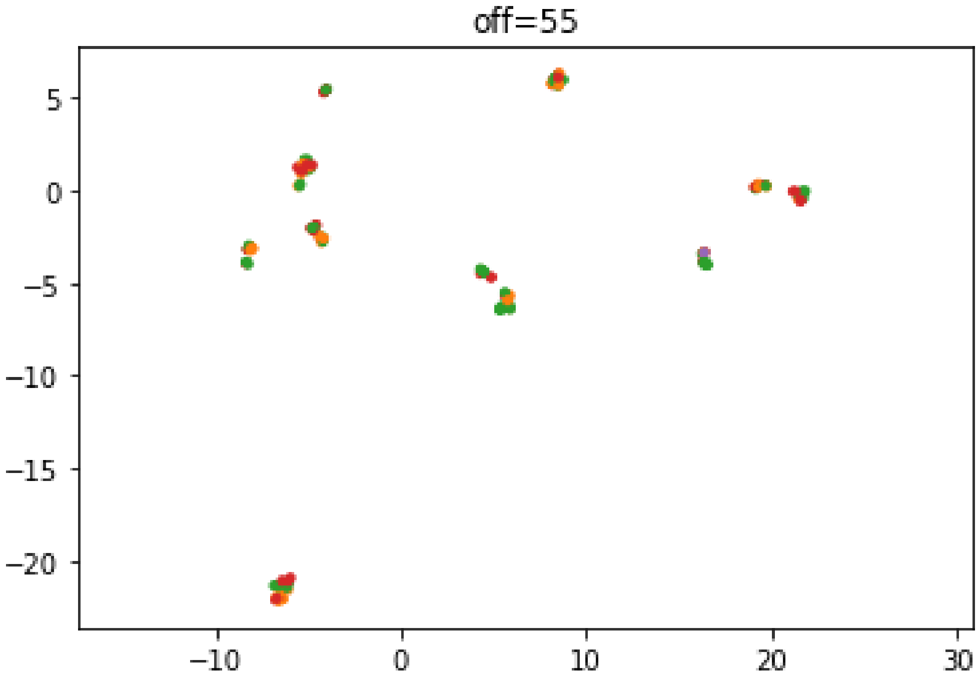


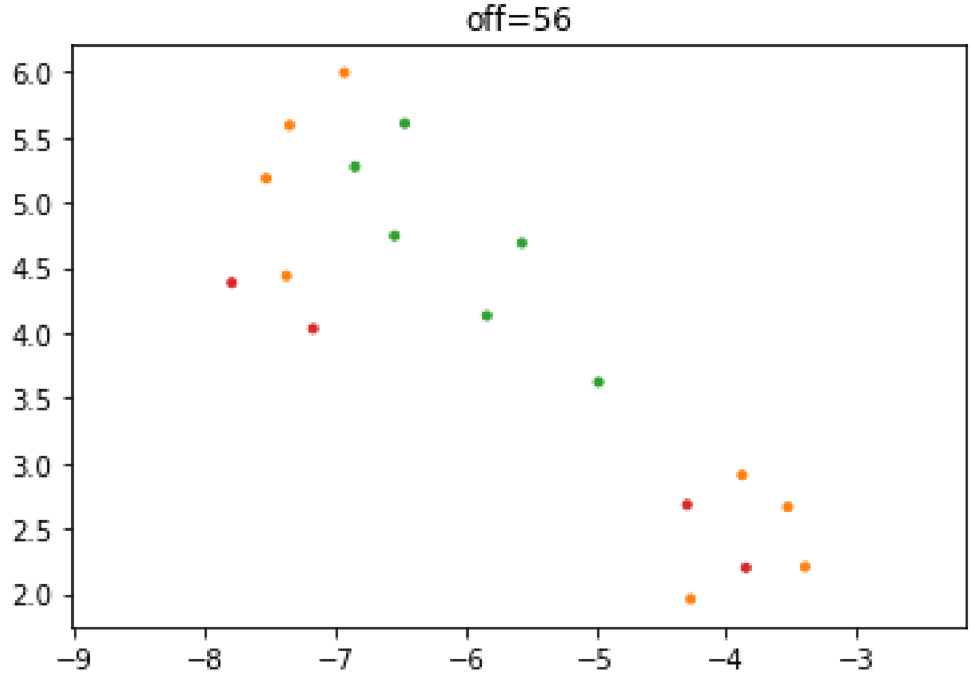


```
/home/ethan/.local/lib/python3.7/site-packages/umap/spectral.py:229: UserWarning:

Embedding a total of 3 separate connected components using meta-embedding (experimental)
```

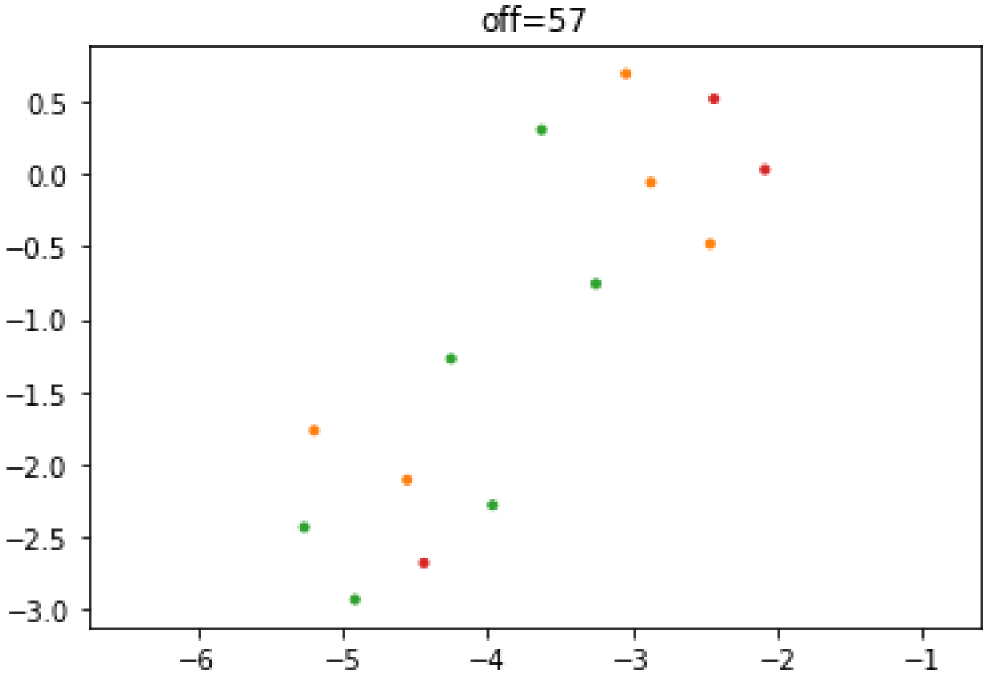


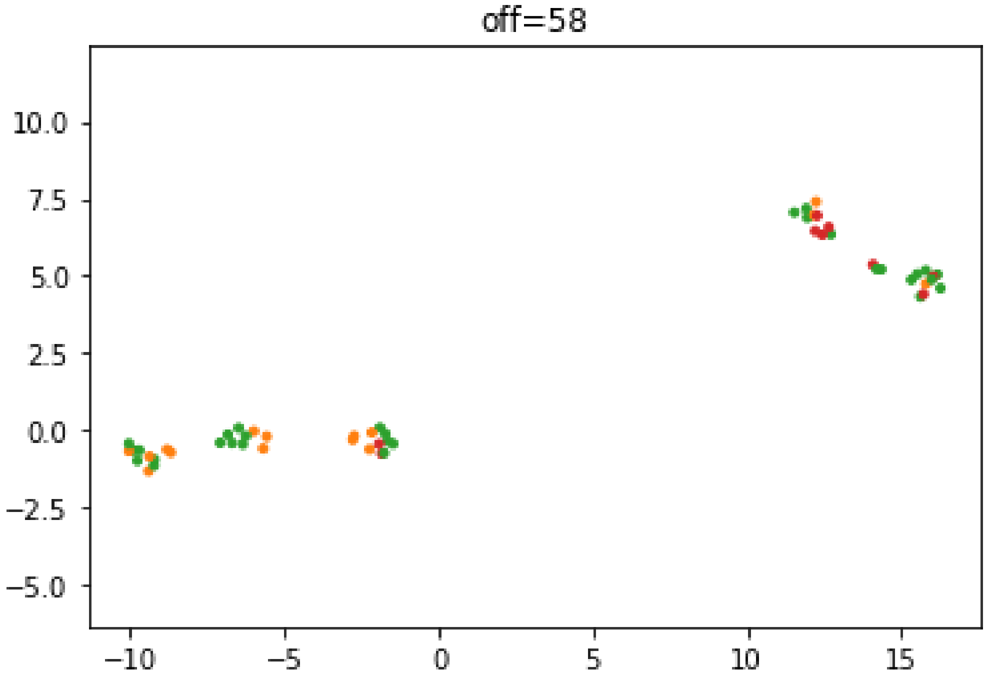
```
/home/ethan/.local/lib/python3.7/site-packages/umap/spectral.py:229: UserWarning:

Embedding a total of 2 separate connected components using meta-embedding (experimental)
```





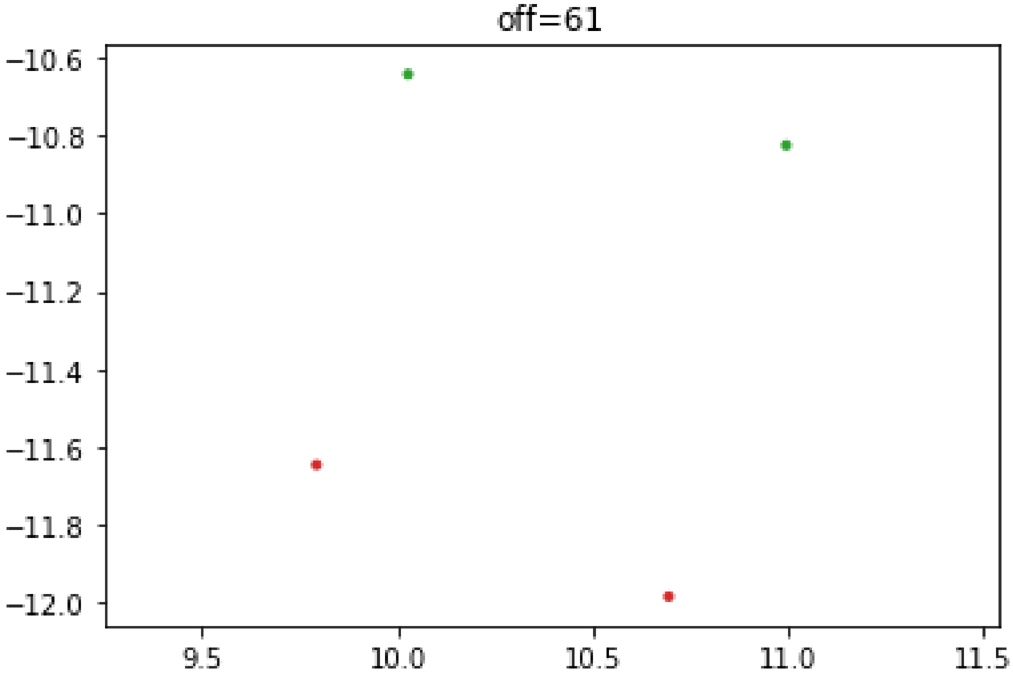
```
/home/ethan/.local/lib/python3.7/site-packages/umap/umap_.py:1383: UserWarning:
n_neighbors is larger than the dataset size; truncating to X.shape[0] - 1
```

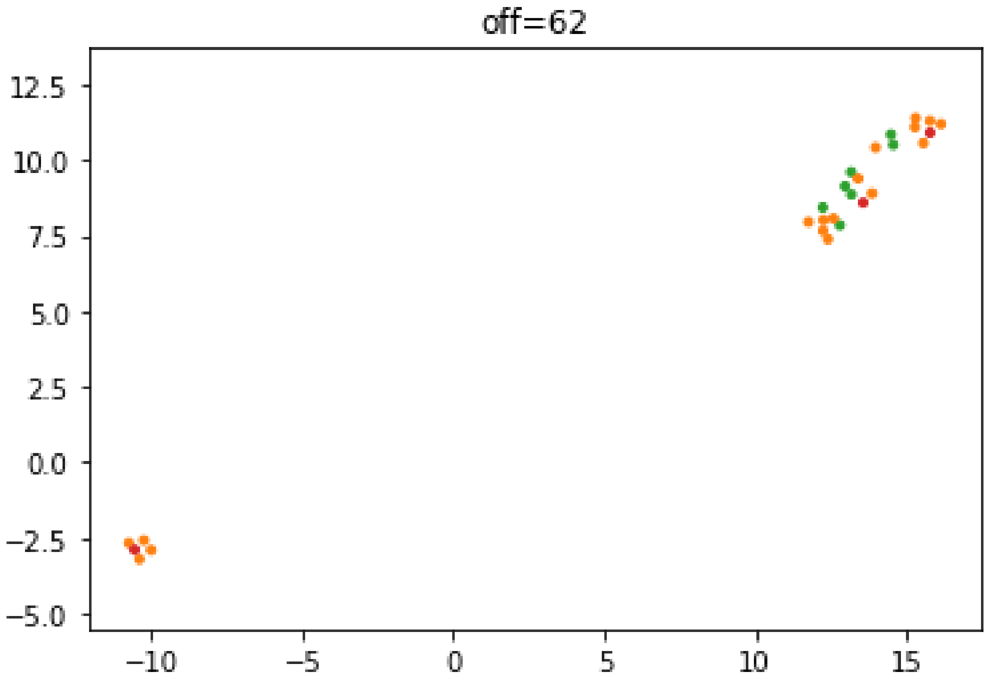




```
/home/ethan/.local/lib/python3.7/site-packages/umap/umap_.py:1383: UserWarning:
```

```
n_neighbors is larger than the dataset size; truncating to X.shape[0] - 1
/home/ethan/.local/lib/python3.7/site-packages/scipy/sparse/linalg/eigen/arpack/arpack.py:1592
k >= N for N * N square matrix. Attempting to use scipy.linalg.eigh instead.
/home/ethan/.local/lib/python3.7/site-packages/umap/umap_.py:1383: UserWarning:
n_neighbors is larger than the dataset size; truncating to X.shape[0] - 1
/home/ethan/.local/lib/python3.7/site-packages/scipy/sparse/linalg/eigen/arpack/arpack.py:1592
k >= N for N * N square matrix. Attempting to use scipy.linalg.eigh instead.
/home/ethan/.local/lib/python3.7/site-packages/umap/umap_.py:1383: UserWarning:
n_neighbors is larger than the dataset size; truncating to X.shape[0] - 1
```

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5.0
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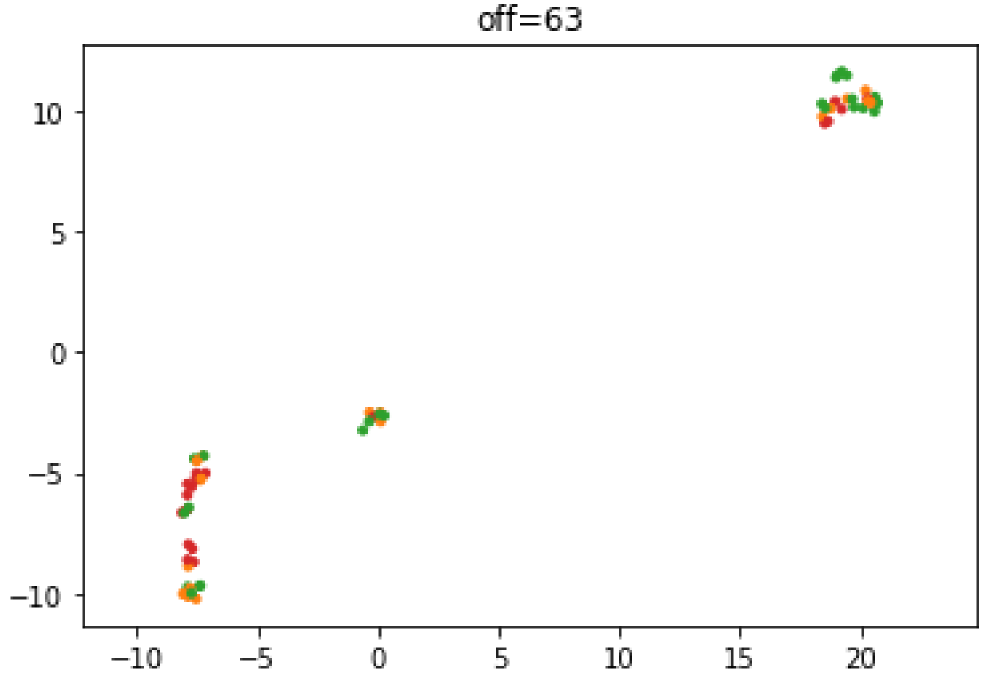
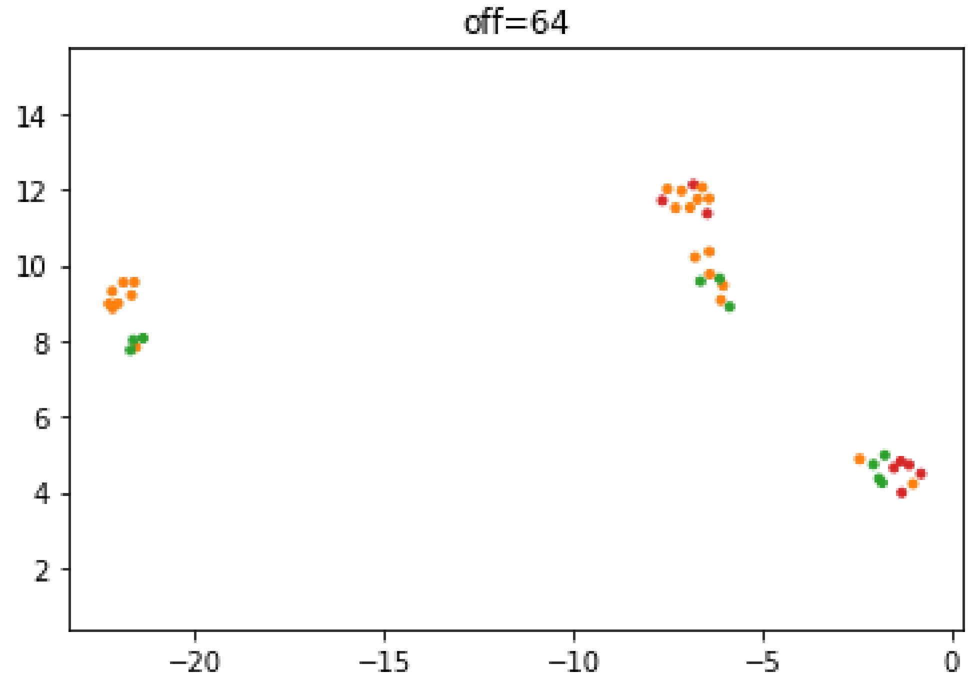
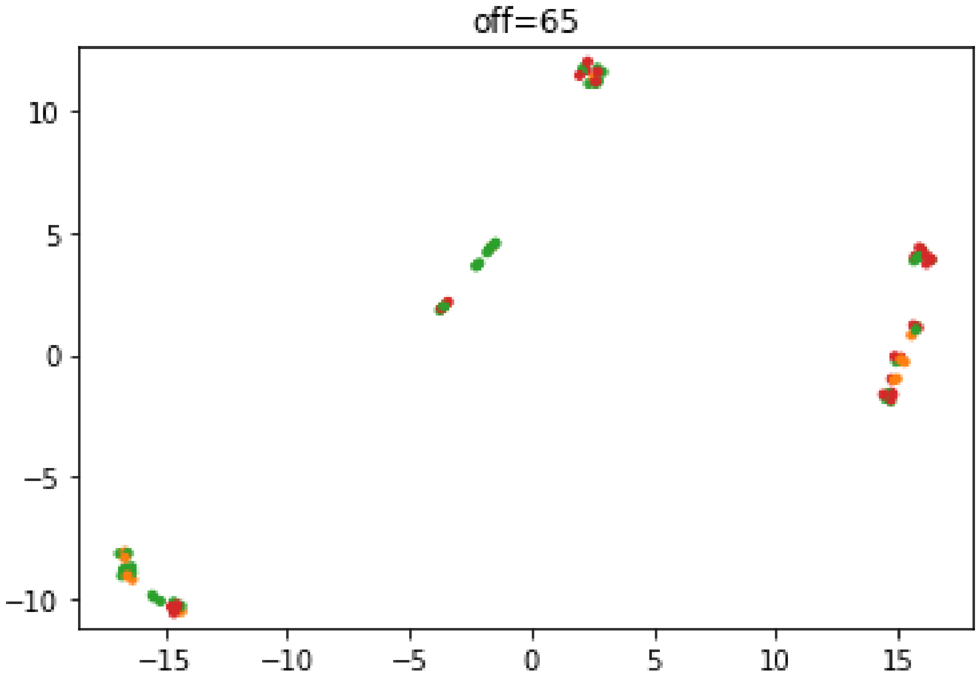
−2.5
−5.0
−10
−5
0
5
10
15

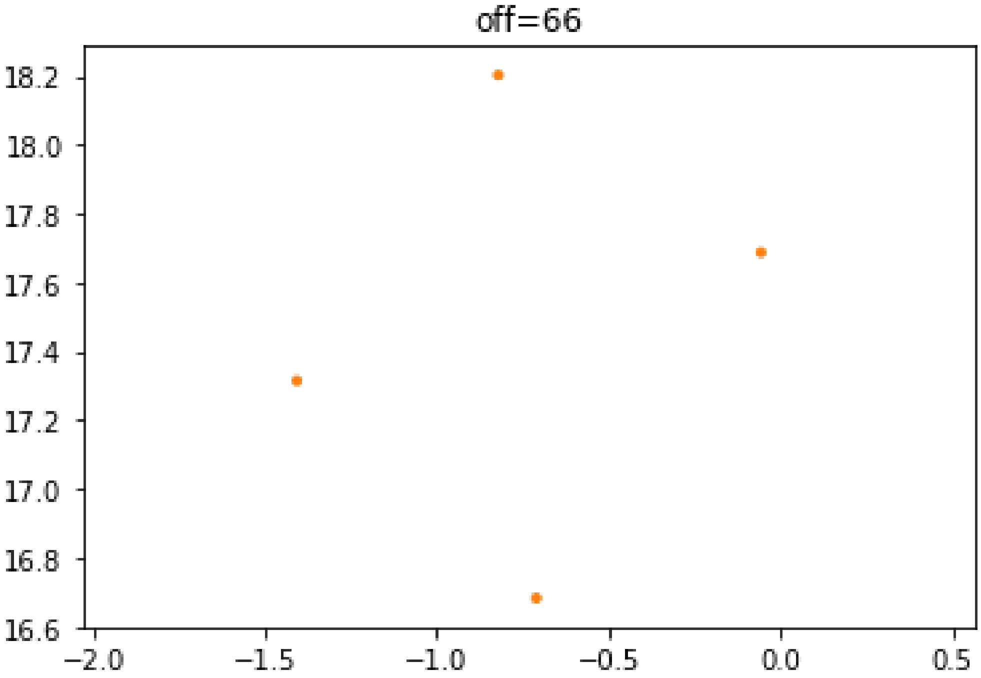

off=63
10
5
0
−5
−10
−10
−5
0
5
10
15
20



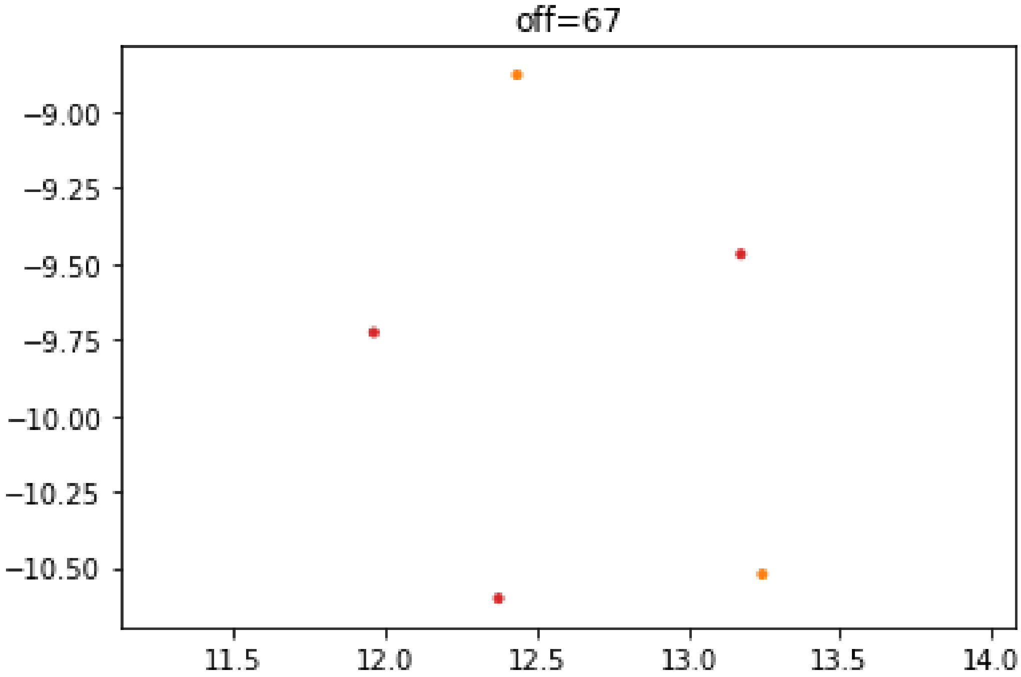
```
/home/ethan/.local/lib/python3.7/site-packages/umap/spectral.py:229: UserWarning:

Embedding a total of 3 separate connected components using meta-embedding (experimental)
```

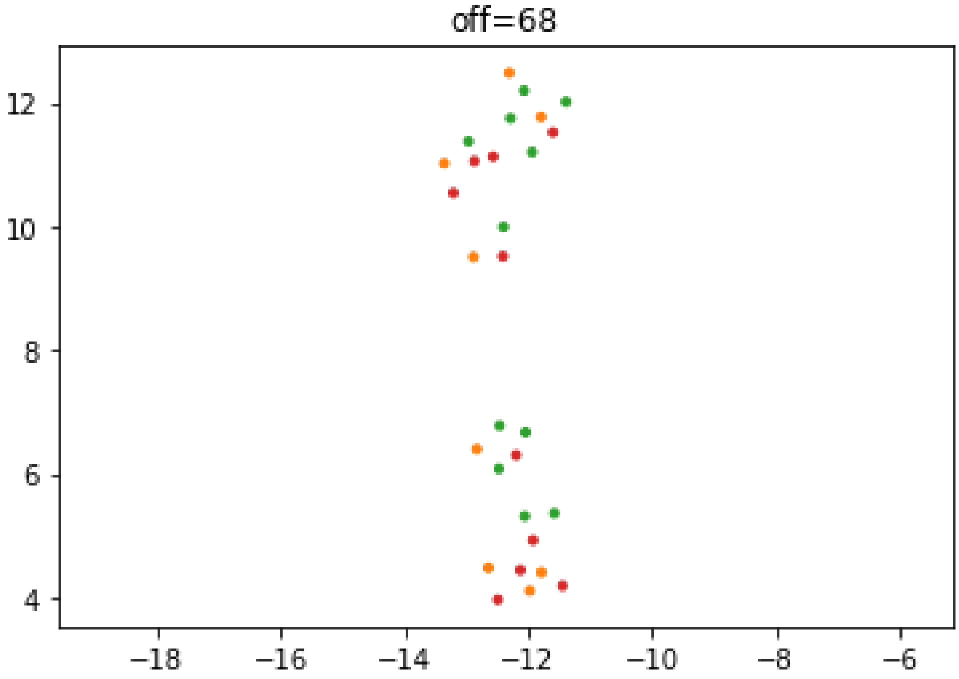


```
/home/ethan/.local/lib/python3.7/site-packages/umap/umap_.py:1383: UserWarning:

n_neighbors is larger than the dataset size; truncating to X.shape[0] - 1
```



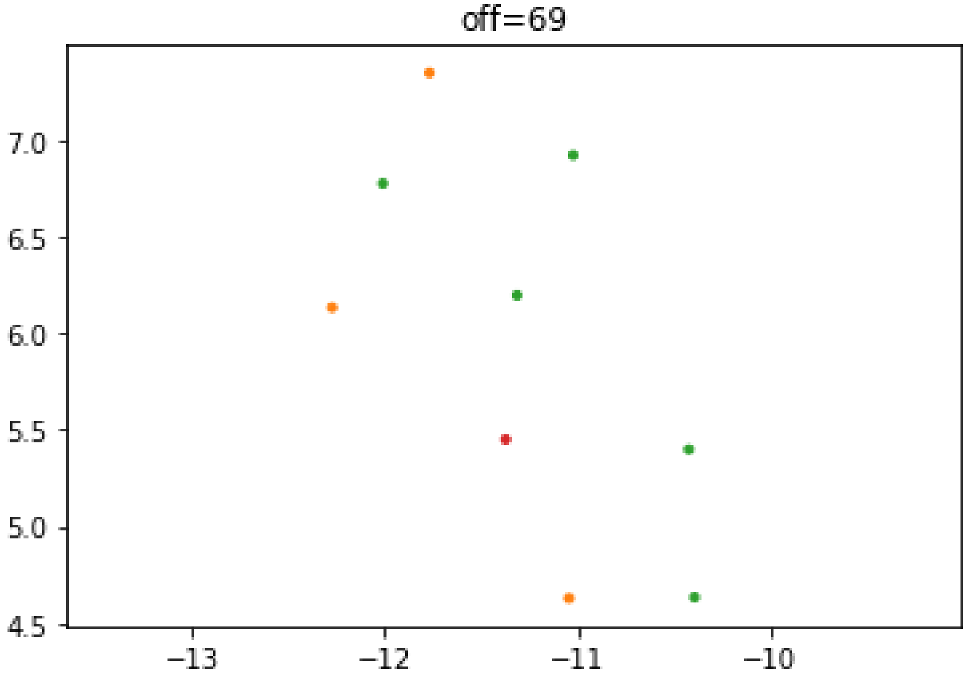
```
/home/ethan/.local/lib/python3.7/site-packages/umap/umap_.py:1383: UserWarning:

n_neighbors is larger than the dataset size; truncating to X.shape[0] - 1
```



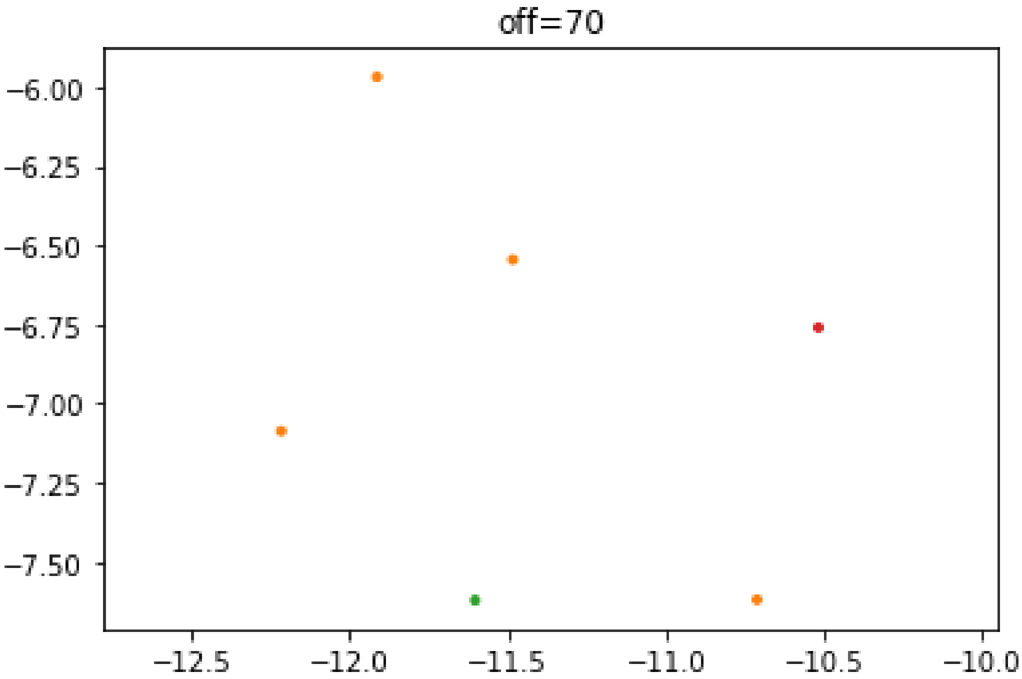


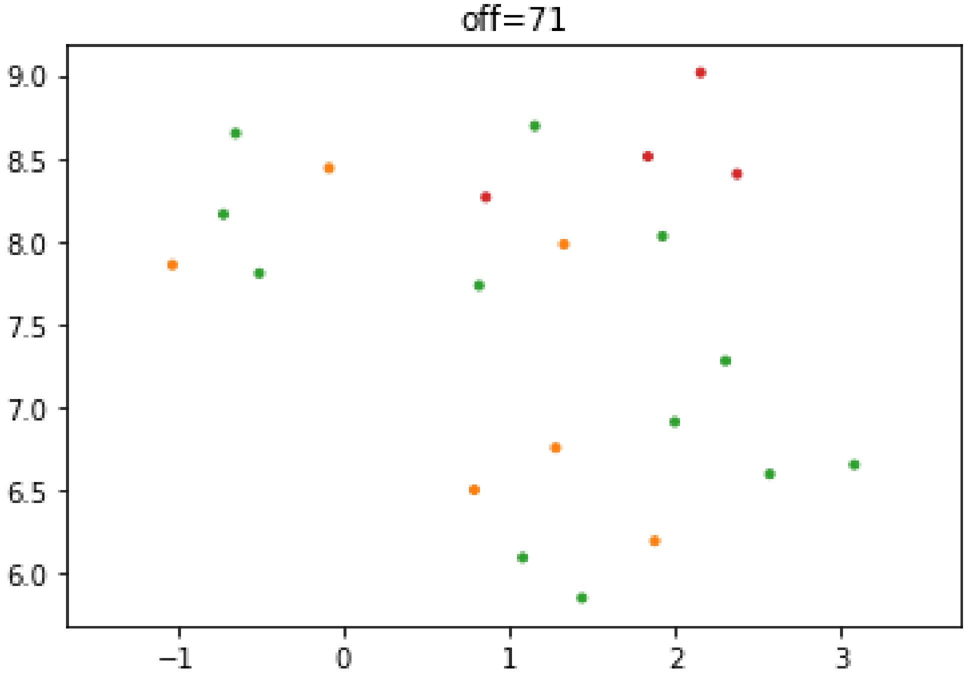
```
/home/ethan/.local/lib/python3.7/site-packages/umap/umap_.py:1383: UserWarning:
```

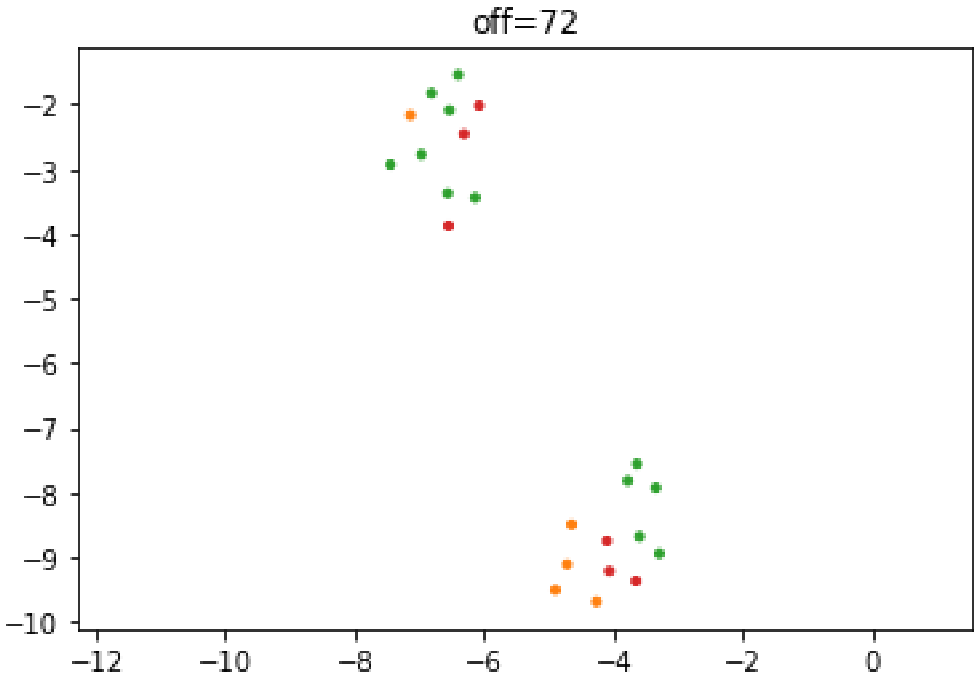
```
n_neighbors is larger than the dataset size; truncating to X.shape[0] - 1
```

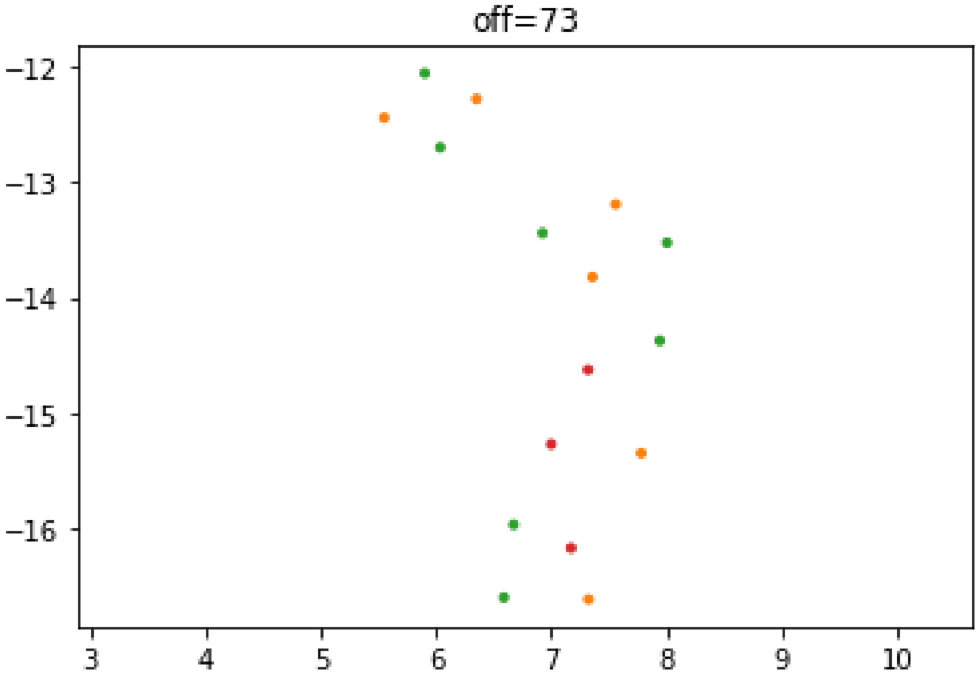


```
/home/ethan/.local/lib/python3.7/site-packages/umap/umap_.py:1383: UserWarning:
n_neighbors is larger than the dataset size; truncating to X.shape[0] - 1
```


off=70
−6.00
−6.25
−6.50
−6.75
−7.00
−7.25
−7.50
−12.5
−12.0
−11.5
−11.0
−10.5
−10.0

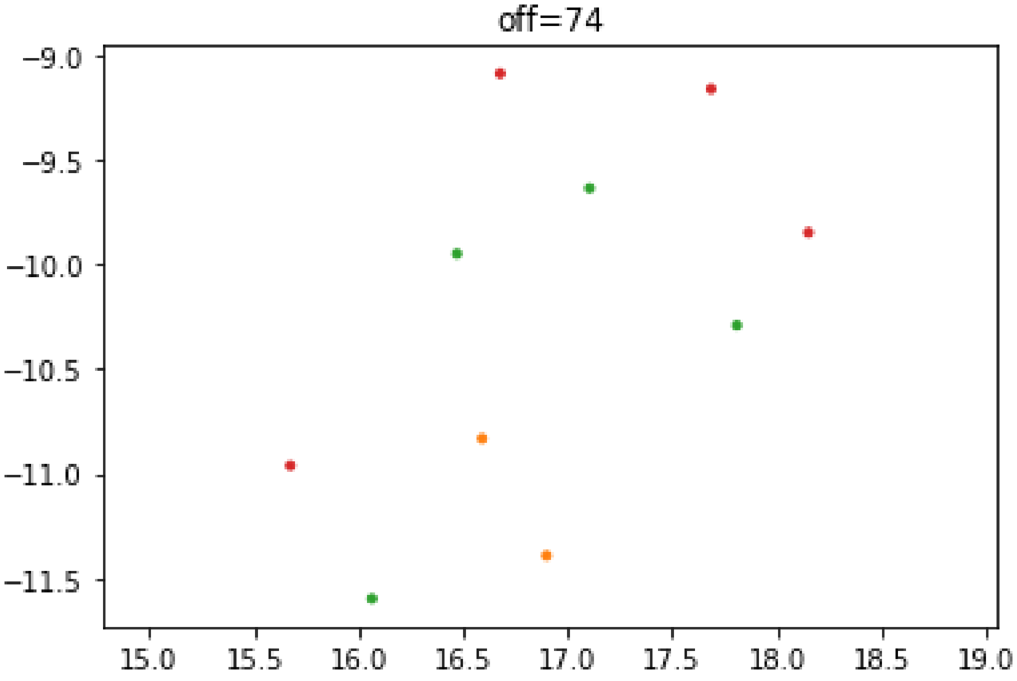

off=71
9.0
8.5
8.0
7.5
7.0
6.5
6.0
−1
0
1
2
3

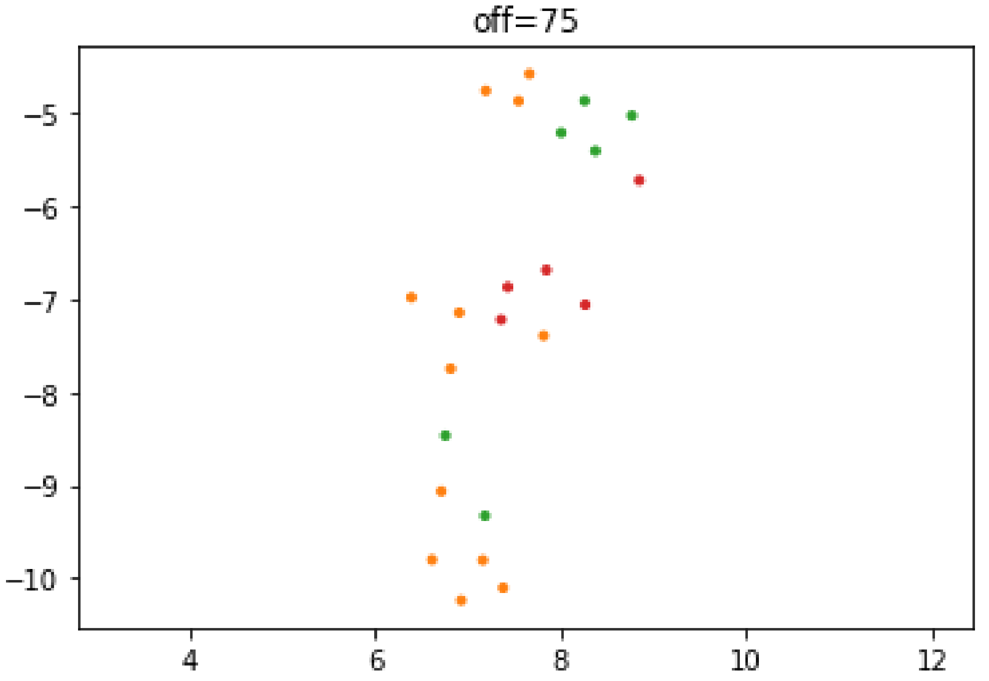




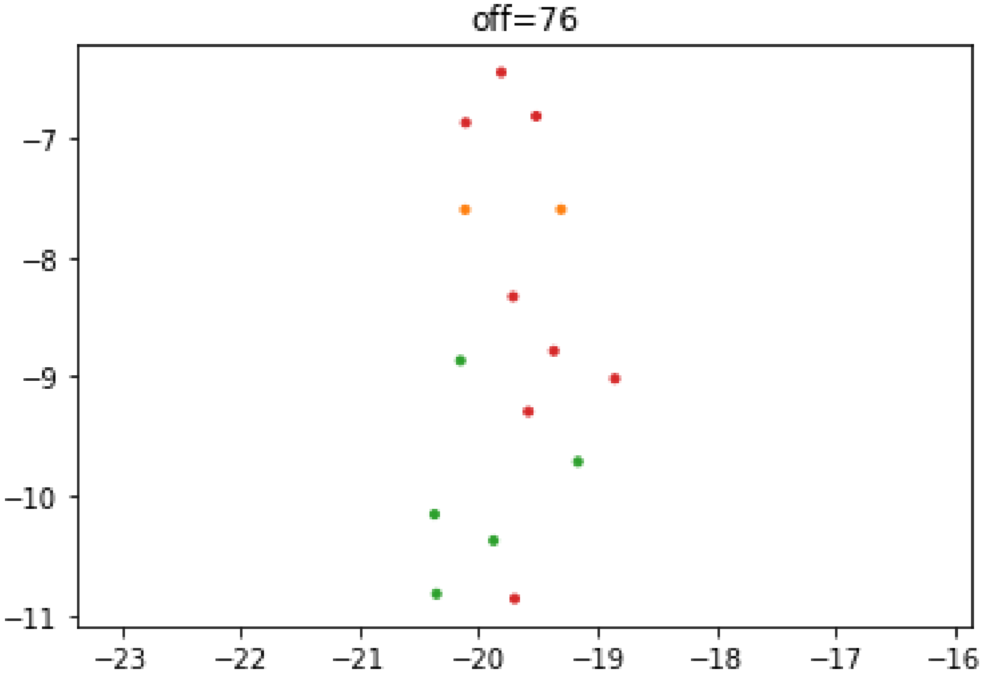
```
/home/ethan/.local/lib/python3.7/site-packages/umap/umap_.py:1383: UserWarning:
```

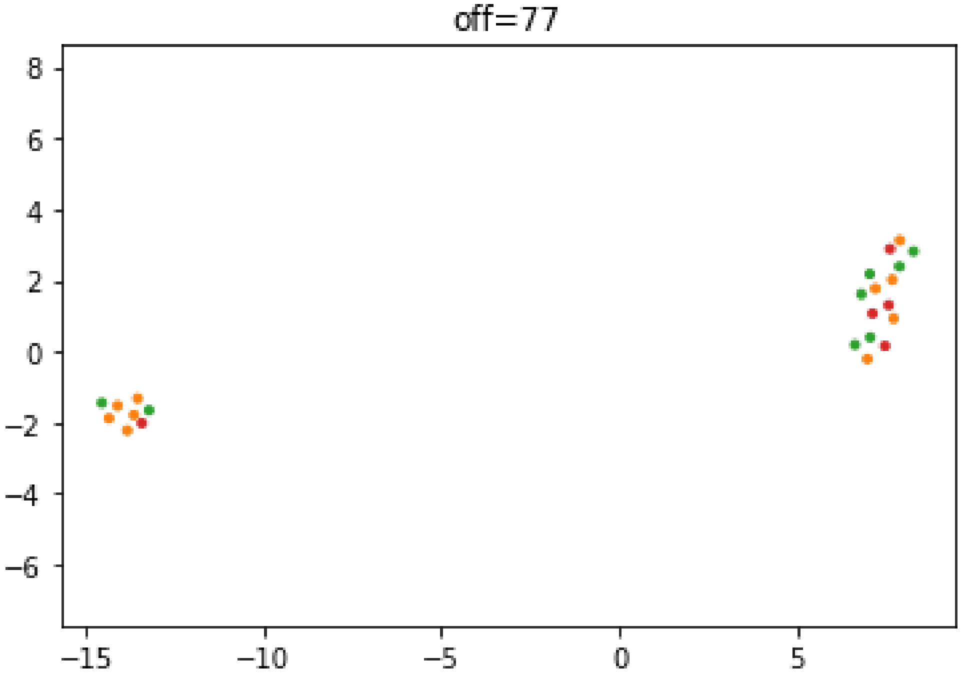
```
n_neighbors is larger than the dataset size; truncating to X.shape[0] - 1
```



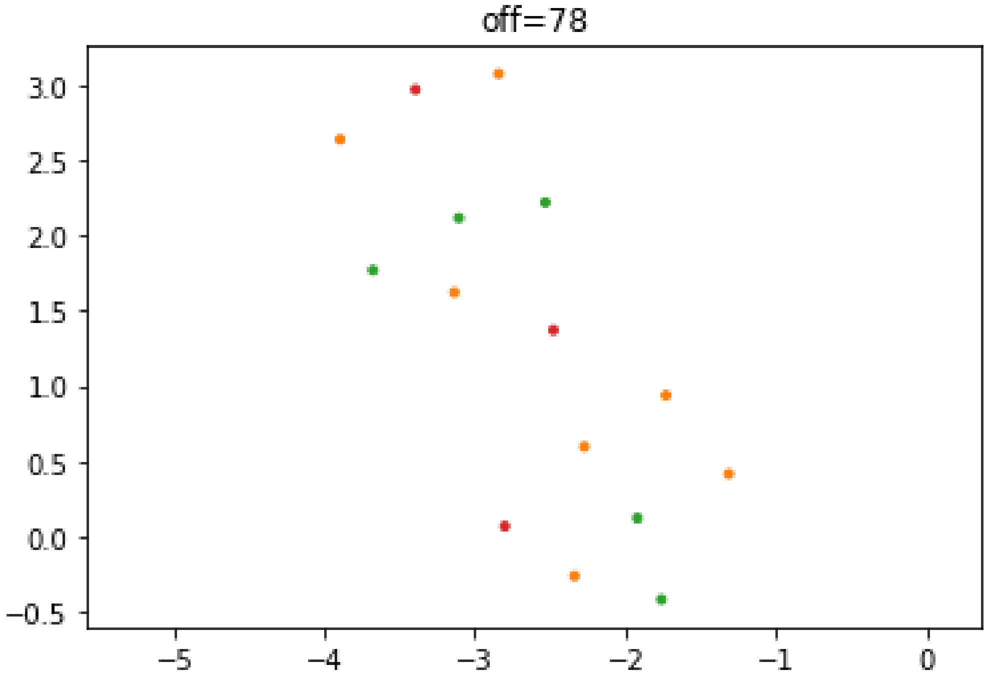


```
/home/ethan/.local/lib/python3.7/site-packages/umap/umap_.py:1383: UserWarning:

n_neighbors is larger than the dataset size; truncating to X.shape[0] - 1
```

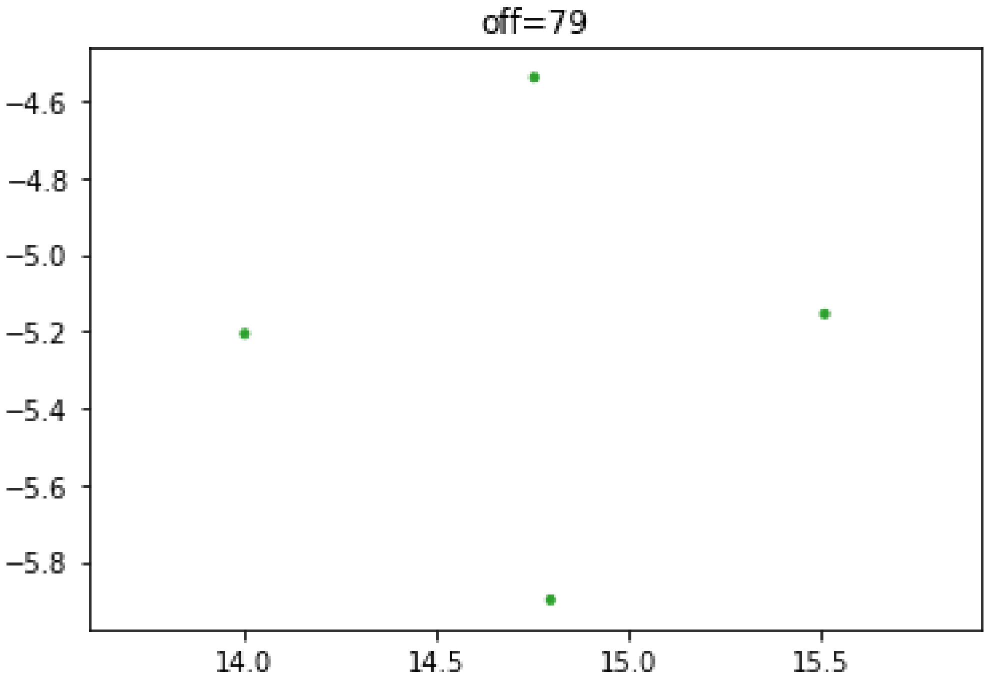




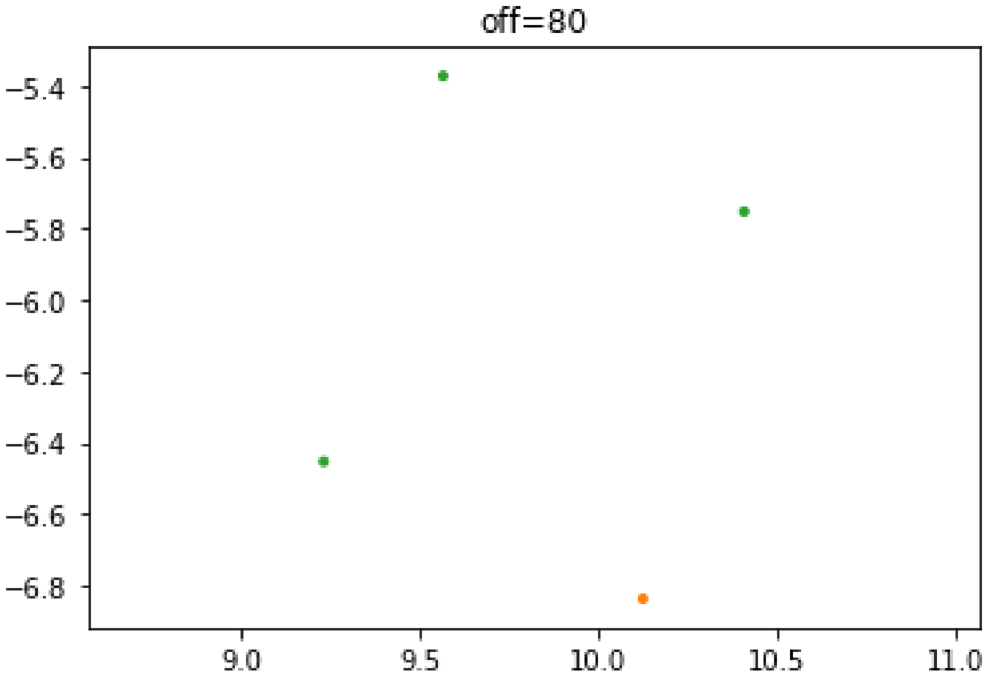
```
/home/ethan/.local/lib/python3.7/site-packages/umap/umap_.py:1383: UserWarning:
n_neighbors is larger than the dataset size; truncating to X.shape[0] - 1
```



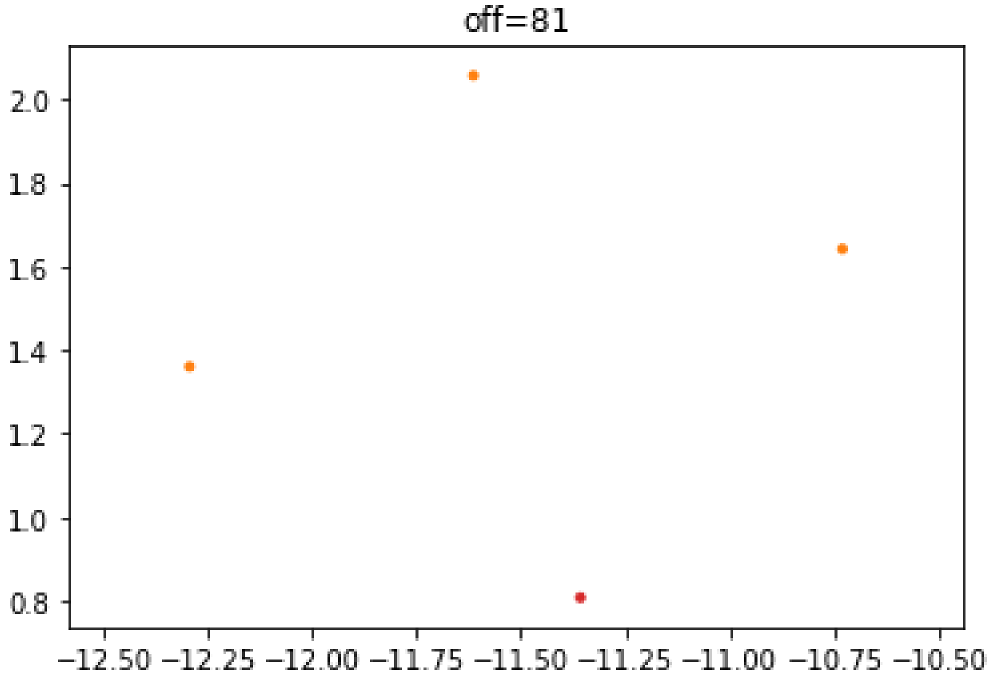
```
/home/ethan/.local/lib/python3.7/site-packages/umap/umap_.py:1383: UserWarning:
n_neighbors is larger than the dataset size; truncating to X.shape[0] - 1
```

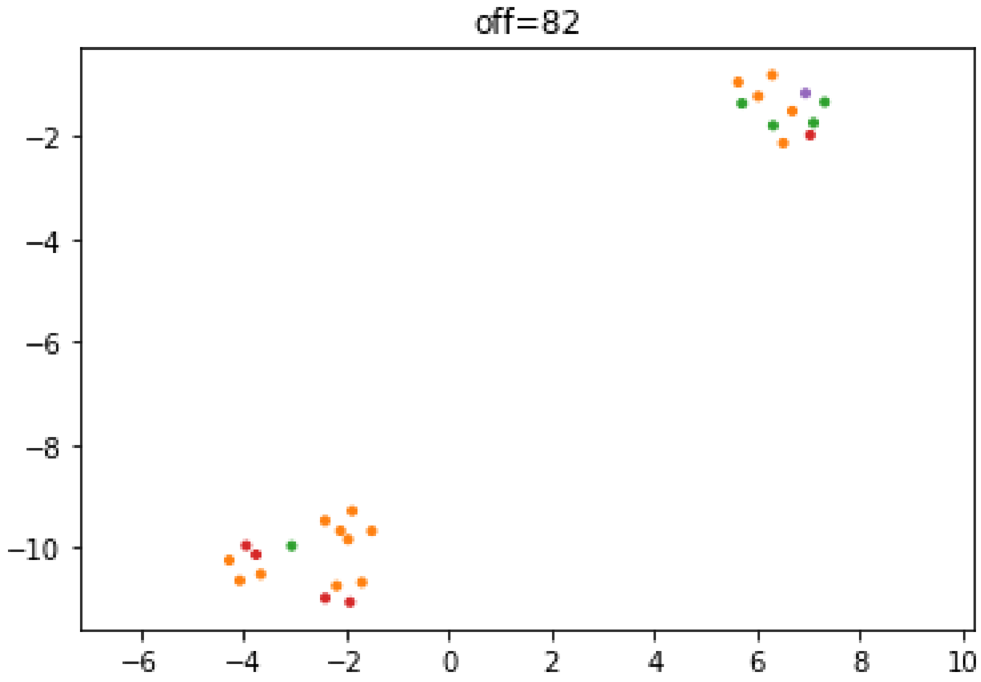


```
/home/ethan/.local/lib/python3.7/site-packages/umap/umap_.py:1383: UserWarning:
n_neighbors is larger than the dataset size; truncating to X.shape[0] - 1
```



```
/home/ethan/.local/lib/python3.7/site-packages/umap/umap_.py:1383: UserWarning:
n_neighbors is larger than the dataset size; truncating to X.shape[0] - 1
```





```
/home/ethan/.local/lib/python3.7/site-packages/umap/umap_.py:1383: UserWarning:

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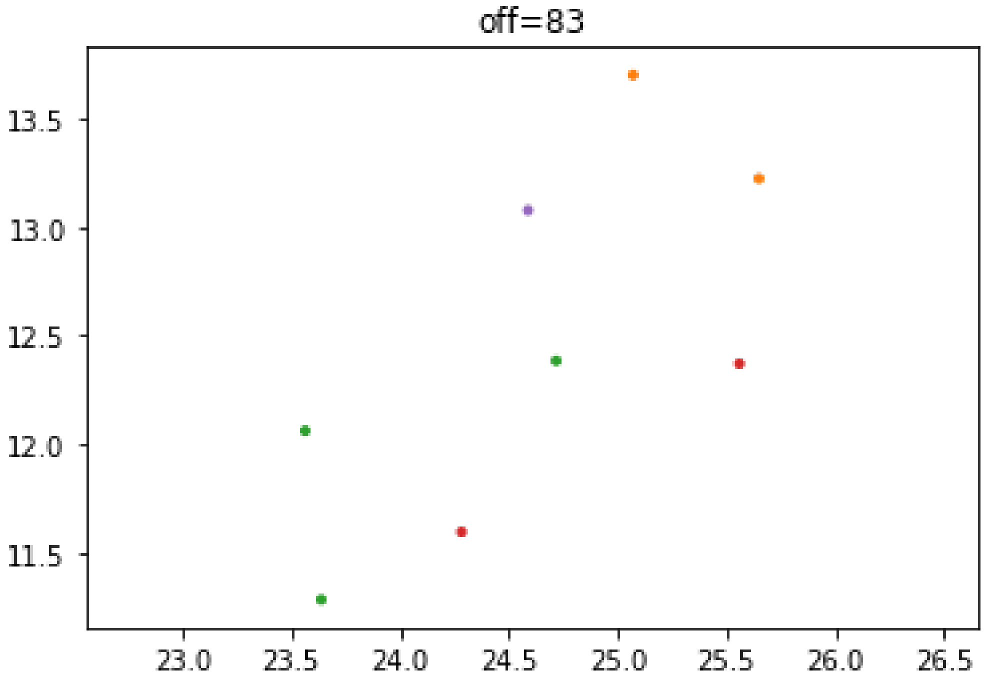
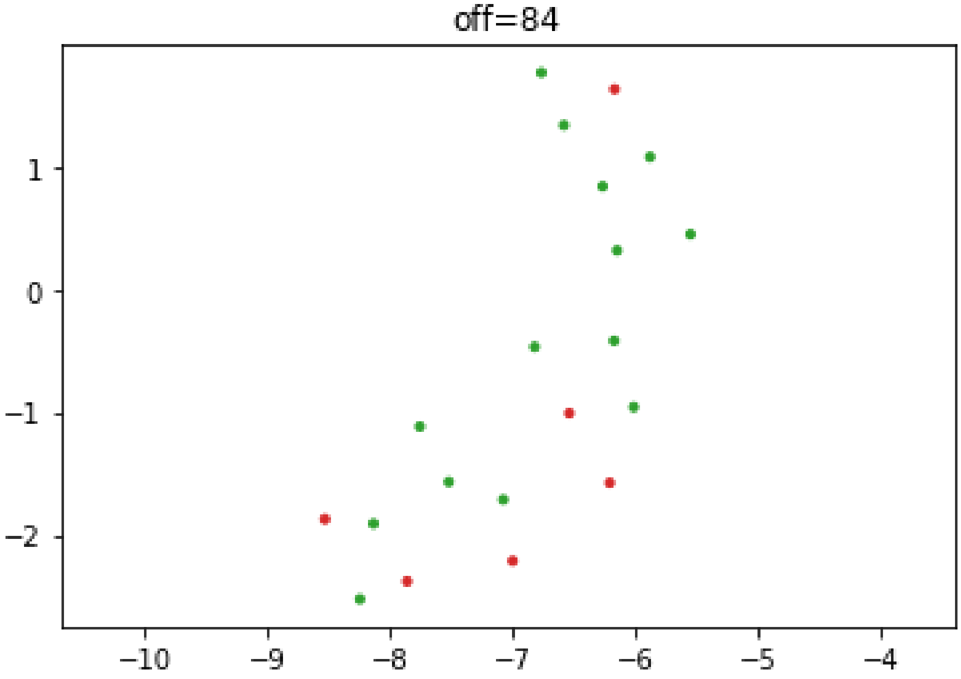
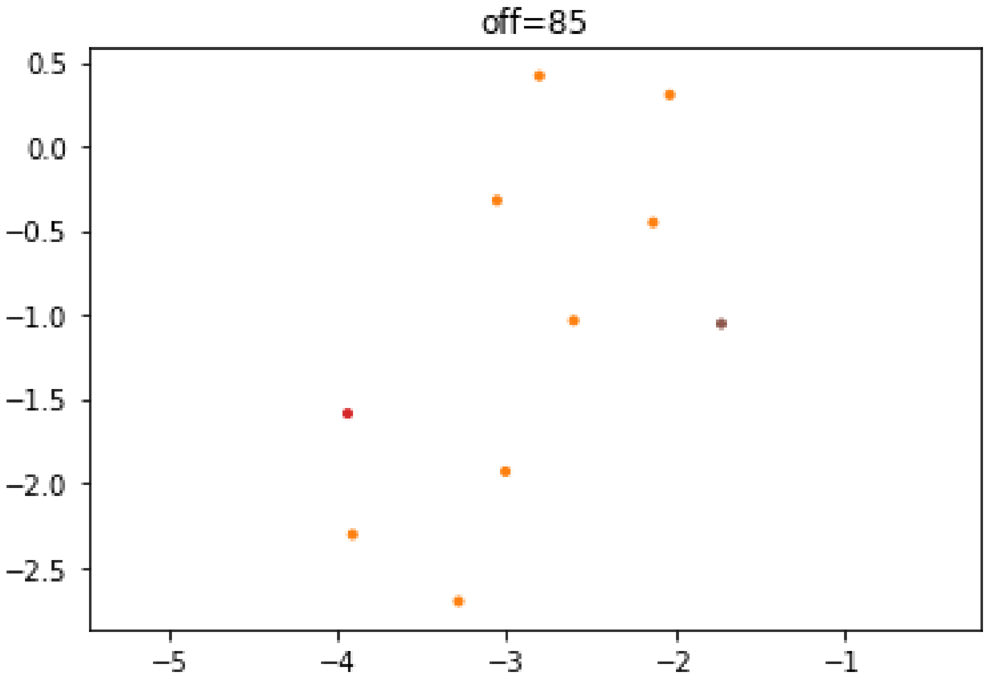


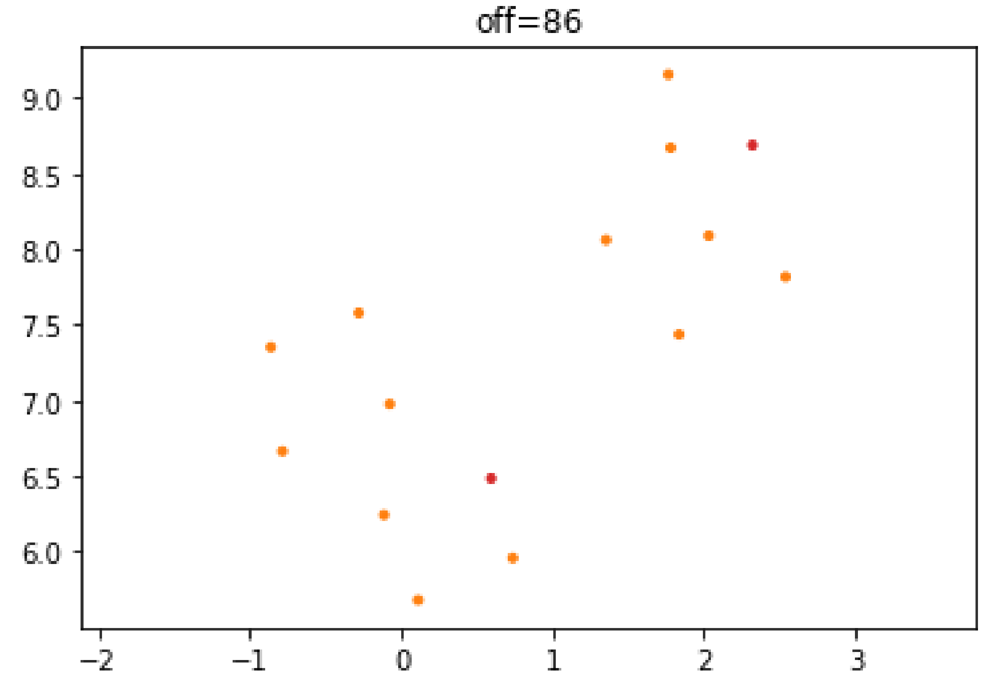


```
/home/ethan/.local/lib/python3.7/site-packages/umap/umap_.py:1383: UserWarning:
n_neighbors is larger than the dataset size; truncating to X.shape[0] - 1
```

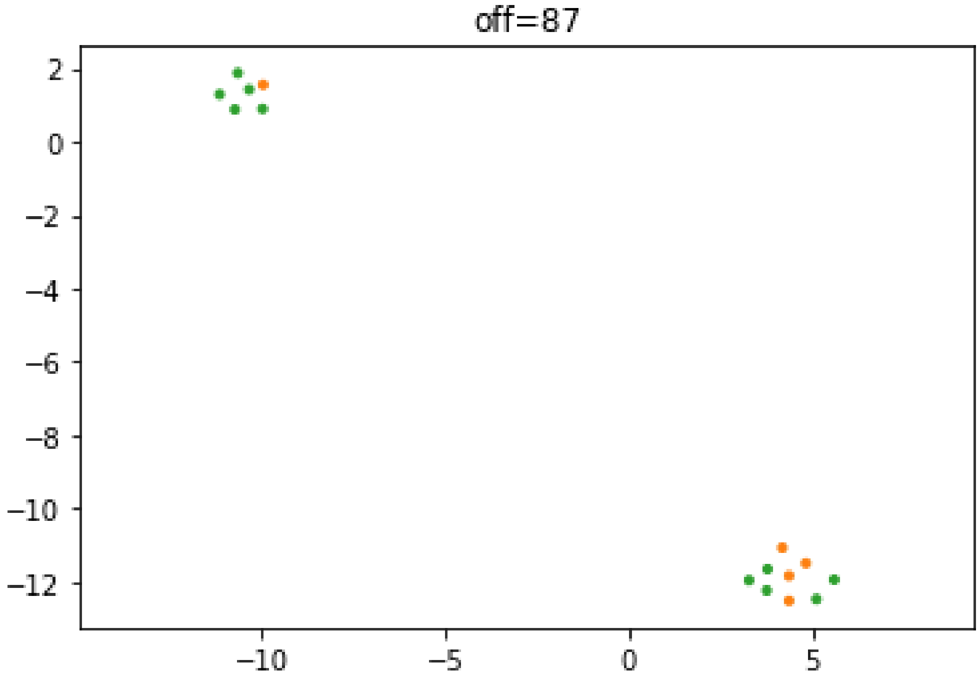


```
/home/ethan/.local/lib/python3.7/site-packages/umap/umap_.py:1383: UserWarning:

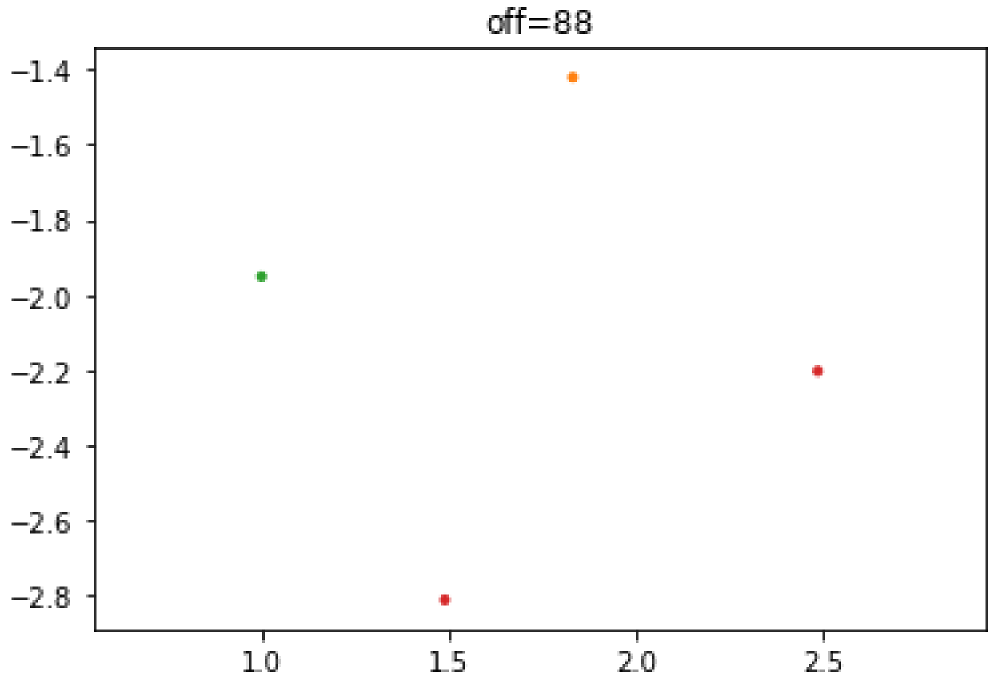
n_neighbors is larger than the dataset size; truncating to X.shape[0] - 1
```



```
/home/ethan/.local/lib/python3.7/site-packages/umap/umap_.py:1383: UserWarning:
n_neighbors is larger than the dataset size; truncating to X.shape[0] - 1
```

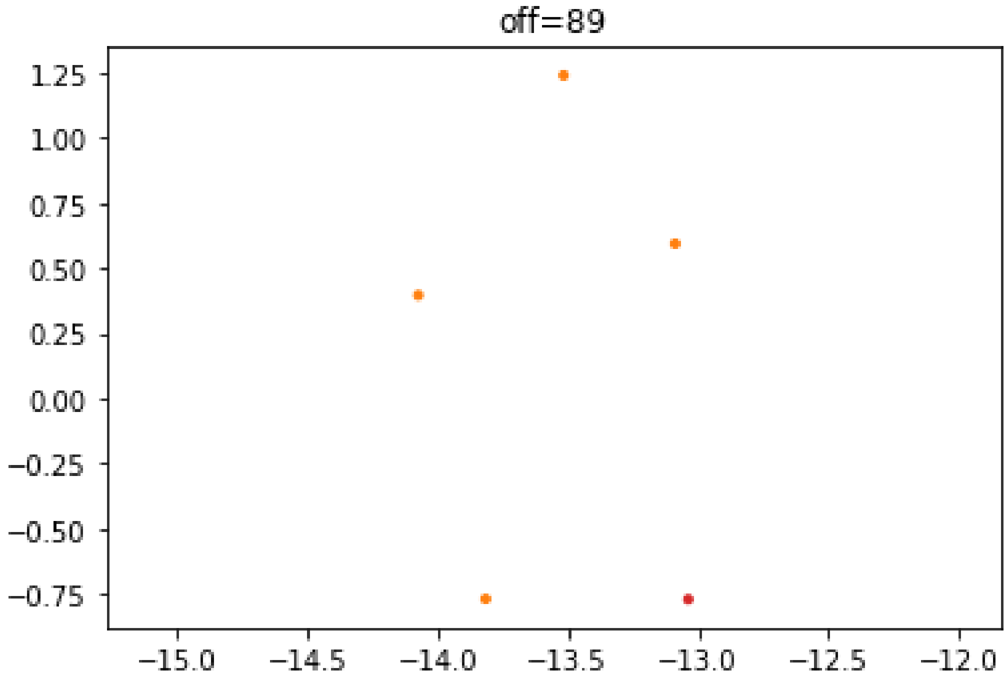


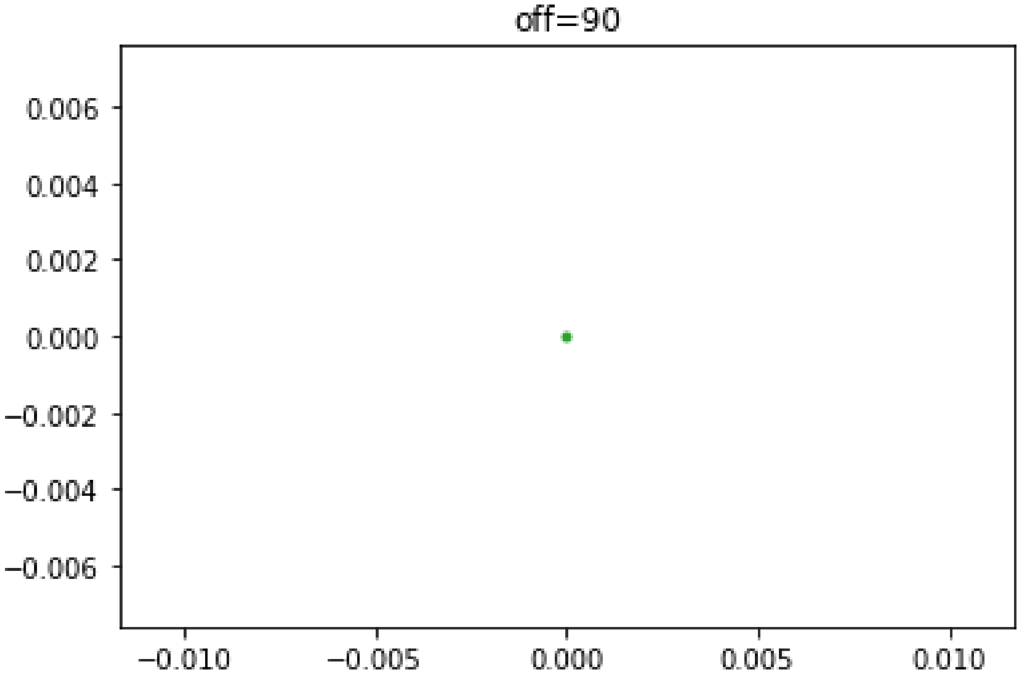
```
/home/ethan/.local/lib/python3.7/site-packages/umap/umap_.py:1383: UserWarning:
n_neighbors is larger than the dataset size; truncating to X.shape[0] - 1
```

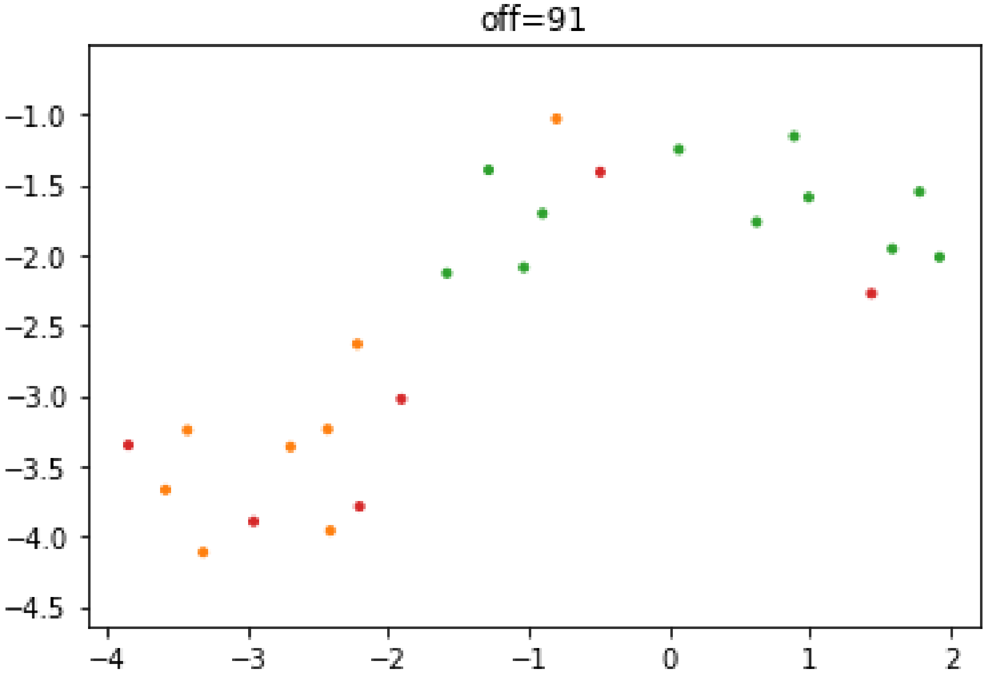


```
/home/ethan/.local/lib/python3.7/site-packages/umap/umap_.py:1383: UserWarning:

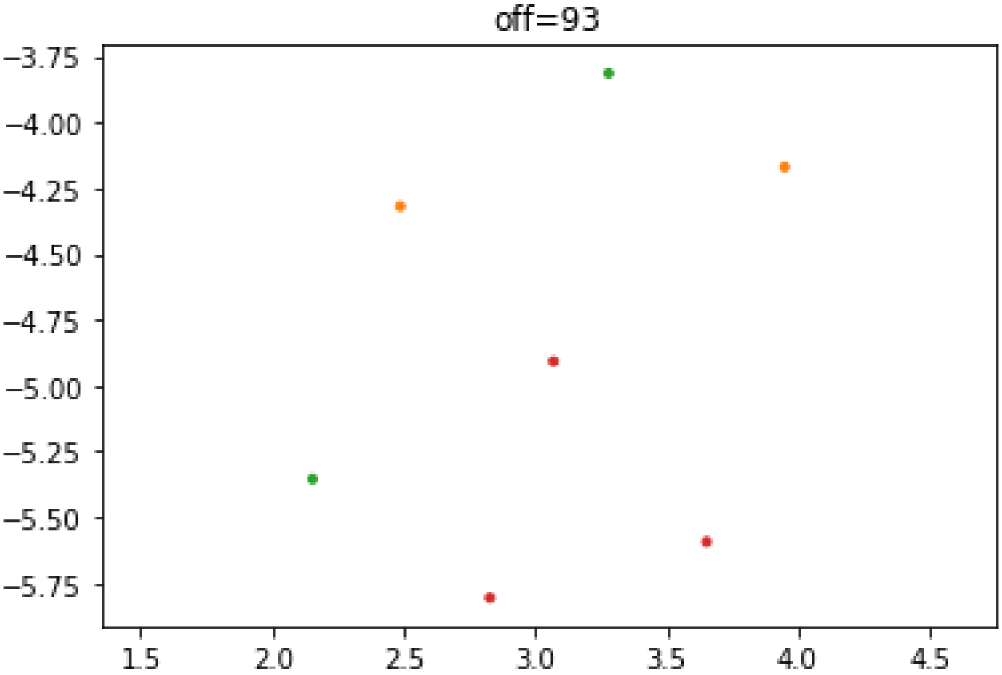
n_neighbors is larger than the dataset size; truncating to X.shape[0] - 1
```



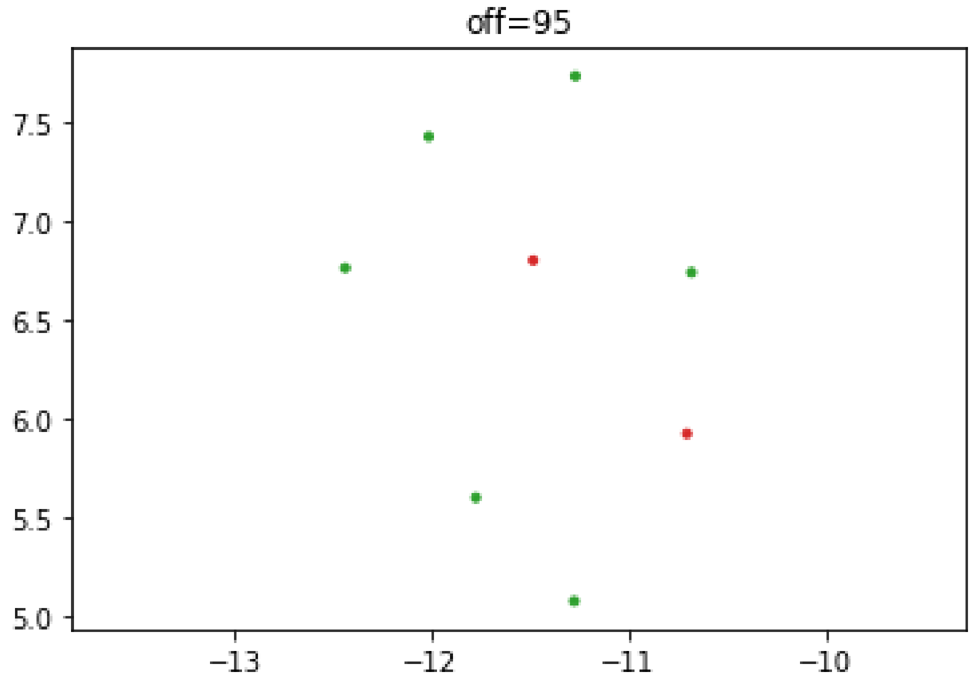

off=90
0.006
0.004
0.002
0.000
−0.002
−0.004
−0.006
−0.010
−0.005
0.000
0.005
0.010


off=91
−1.0
−1.5
−2.0
−2.5
−3.0
−3.5
−4.0
−4.5
−4
−3
−2
−1
0
1
2

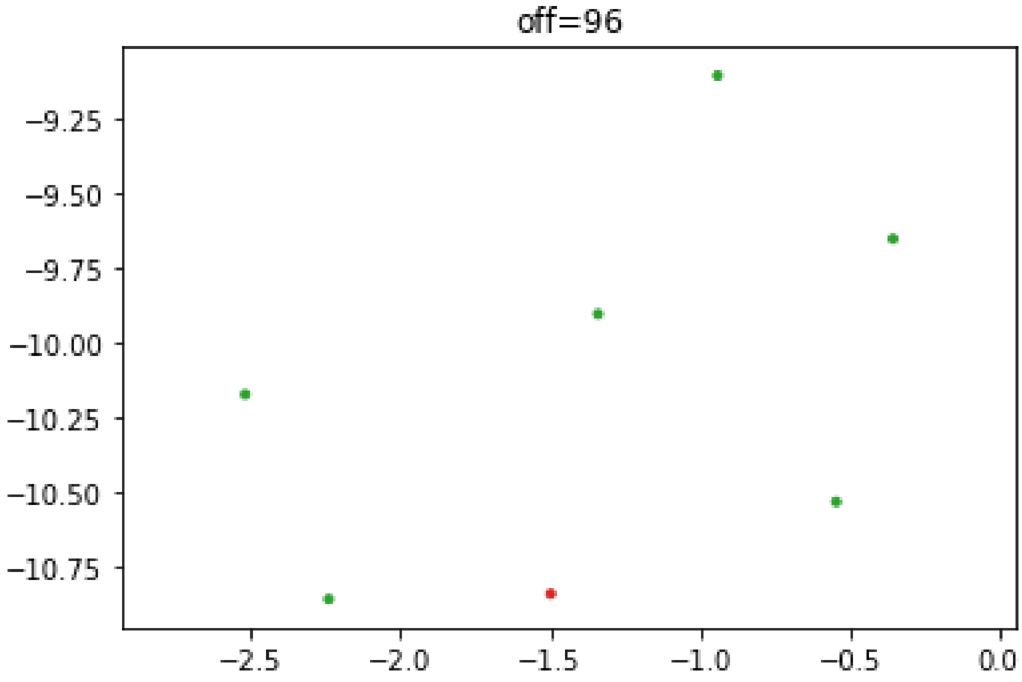
```
/home/ethan/.local/lib/python3.7/site-packages/umap/umap_.py:1383: UserWarning:
n_neighbors is larger than the dataset size; truncating to X.shape[0] - 1
/home/ethan/.local/lib/python3.7/site-packages/scipy/sparse/linalg/eigen/arpack/arpack.py:1592
k >= N for N * N square matrix. Attempting to use scipy.linalg.eigh instead.
/home/ethan/.local/lib/python3.7/site-packages/umap/umap_.py:1383: UserWarning:
n_neighbors is larger than the dataset size; truncating to X.shape[0] - 1
```



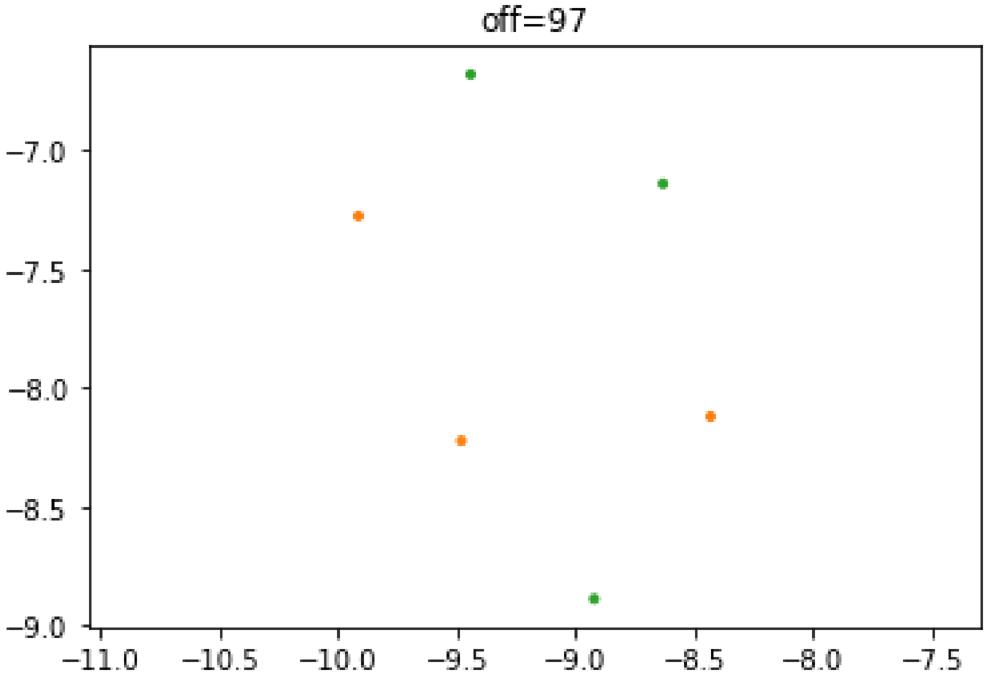
```
/home/ethan/.local/lib/python3.7/site-packages/umap/umap_.py:1383: UserWarning:
n_neighbors is larger than the dataset size; truncating to X.shape[0] - 1
/home/ethan/.local/lib/python3.7/site-packages/umap/umap_.py:1383: UserWarning:
n_neighbors is larger than the dataset size; truncating to X.shape[0] - 1
```



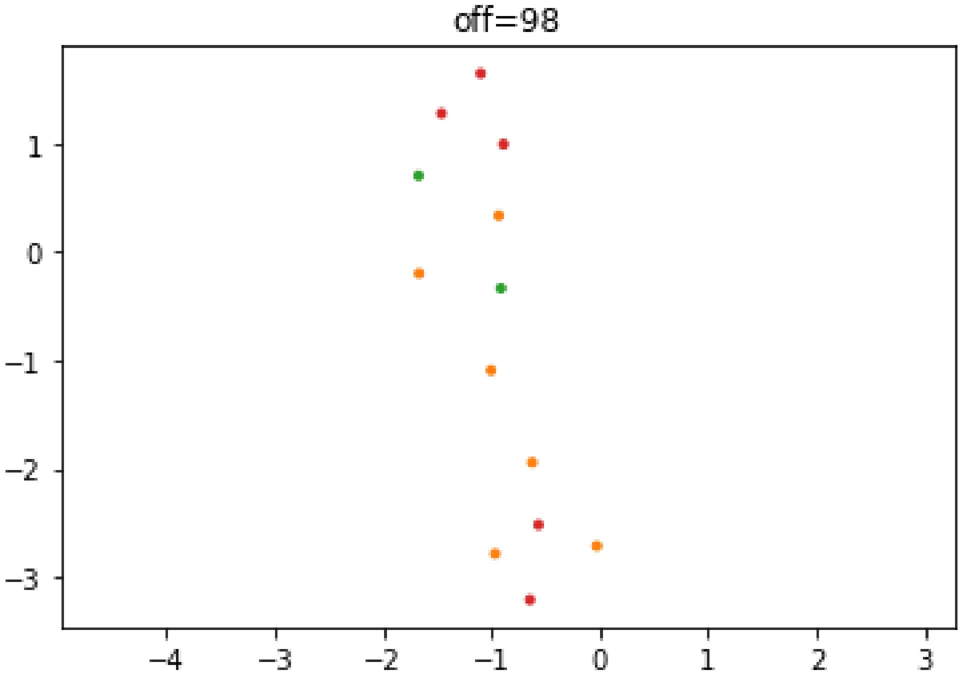
```
/home/ethan/.local/lib/python3.7/site-packages/umap/umap_.py:1383: UserWarning:
n_neighbors is larger than the dataset size; truncating to X.shape[0] - 1
```



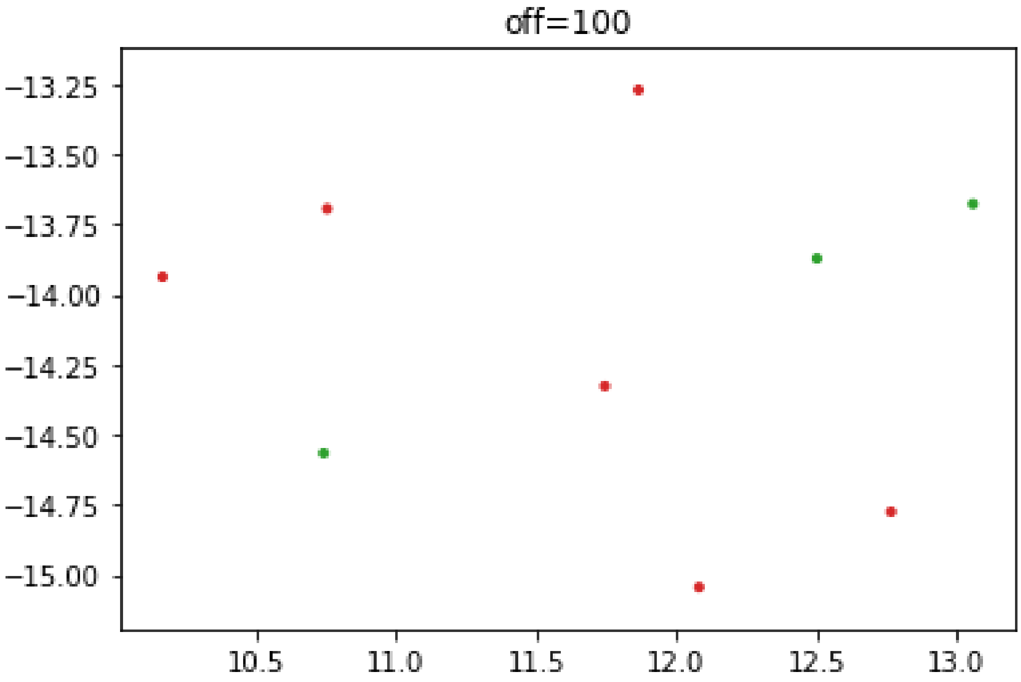
```
/home/ethan/.local/lib/python3.7/site-packages/umap/umap_.py:1383: UserWarning:
n_neighbors is larger than the dataset size; truncating to X.shape[0] - 1
```



```
/home/ethan/.local/lib/python3.7/site-packages/umap/umap_.py:1383: UserWarning:
n_neighbors is larger than the dataset size; truncating to X.shape[0] - 1
```



```
/home/ethan/.local/lib/python3.7/site-packages/umap/umap_.py:1383: UserWarning:
n_neighbors is larger than the dataset size; truncating to X.shape[0] - 1
/home/ethan/.local/lib/python3.7/site-packages/umap/umap_.py:1383: UserWarning:
n_neighbors is larger than the dataset size; truncating to X.shape[0] - 1
```

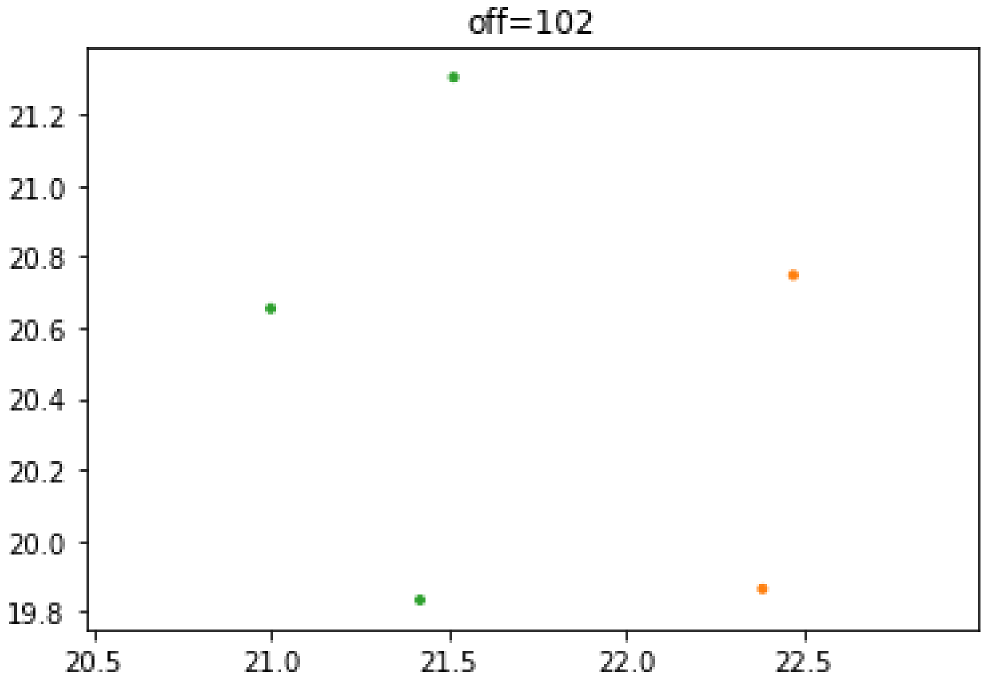


```
/home/ethan/.local/lib/python3.7/site-packages/umap/umap_.py:1383: UserWarning:

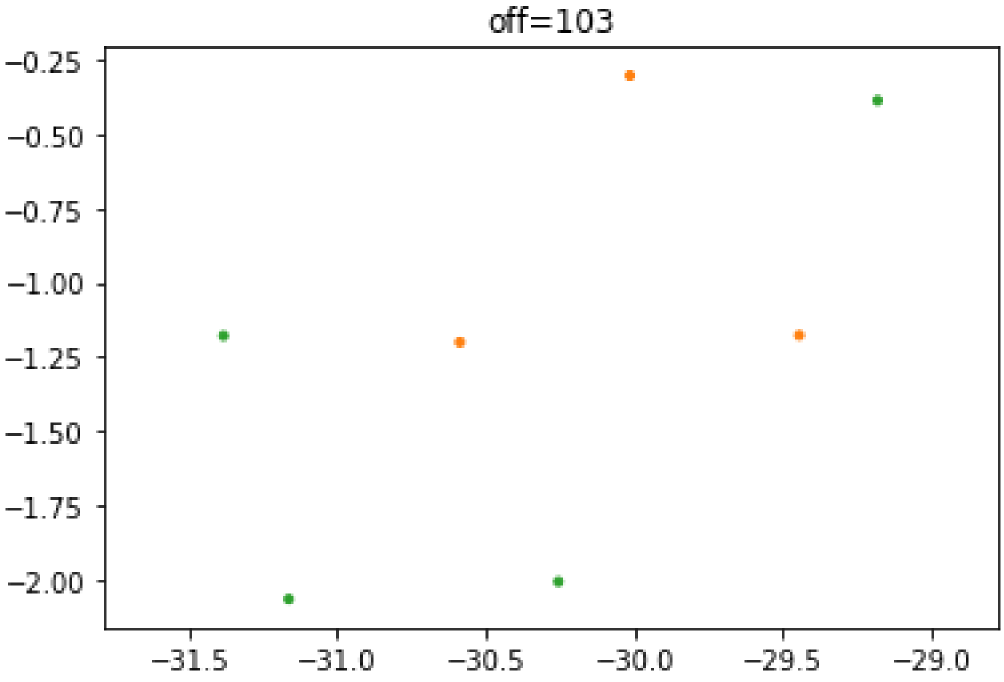
n_neighbors is larger than the dataset size; truncating to X.shape[0] - 1

/home/ethan/.local/lib/python3.7/site-packages/umap/umap_.py:1383: UserWarning:

n_neighbors is larger than the dataset size; truncating to X.shape[0] - 1
```



```
/home/ethan/.local/lib/python3.7/site-packages/umap/umap_.py:1383: UserWarning:
n_neighbors is larger than the dataset size; truncating to X.shape[0] - 1
```



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/home/ethan/.local/lib/python3.7/site-packages/umap/umap_.py:1383: UserWarning:
n_neighbors is larger than the dataset size; truncating to X.shape[0] - 1
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/home/ethan/.local/lib/python3.7/site-packages/umap/umap_.py:1383: UserWarning:
n_neighbors is larger than the dataset size; truncating to X.shape[0] - 1
```
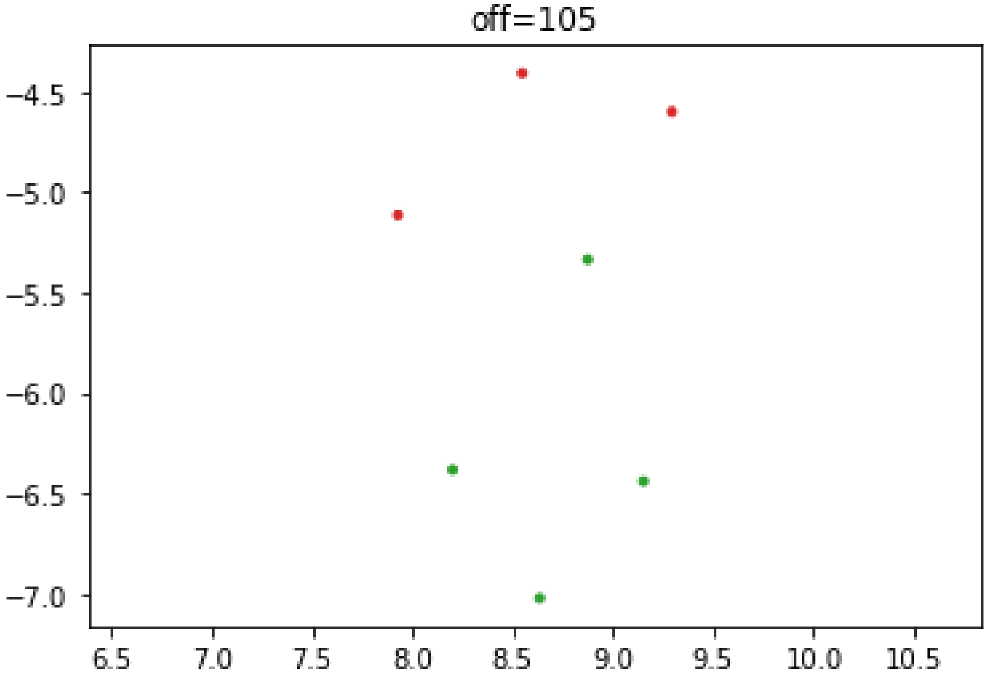
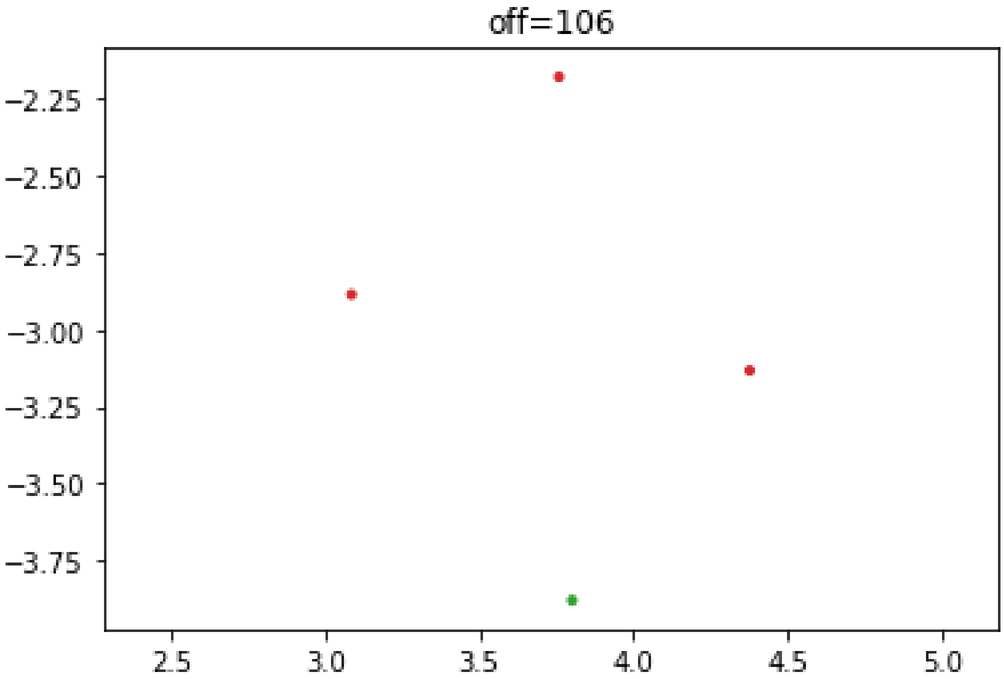



```
/home/ethan/.local/lib/python3.7/site-packages/umap/umap_.py:1383: UserWarning:
n_neighbors is larger than the dataset size; truncating to X.shape[0] - 1
```



```
/home/ethan/.local/lib/python3.7/site-packages/umap/umap_.py:1383: UserWarning:
n_neighbors is larger than the dataset size; truncating to X.shape[0] - 1
/home/ethan/.local/lib/python3.7/site-packages/scipy/sparse/linalg/eigen/arpack/arpack.py:1592
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n_neighbors is larger than the dataset size; truncating to X.shape[0] - 1
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n_neighbors is larger than the dataset size; truncating to X.shape[0] - 1
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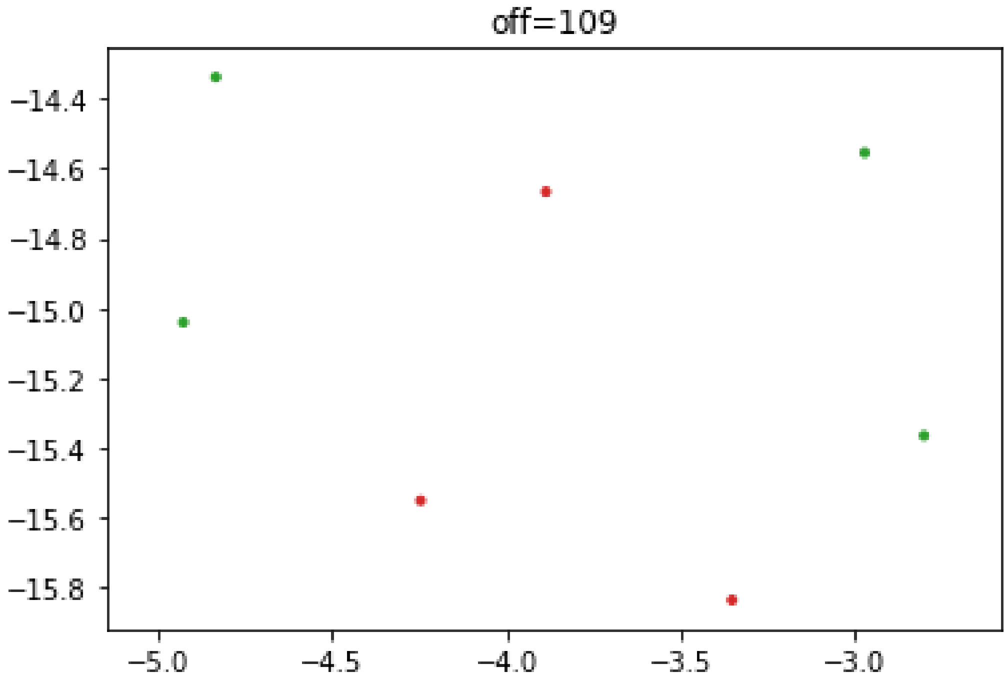
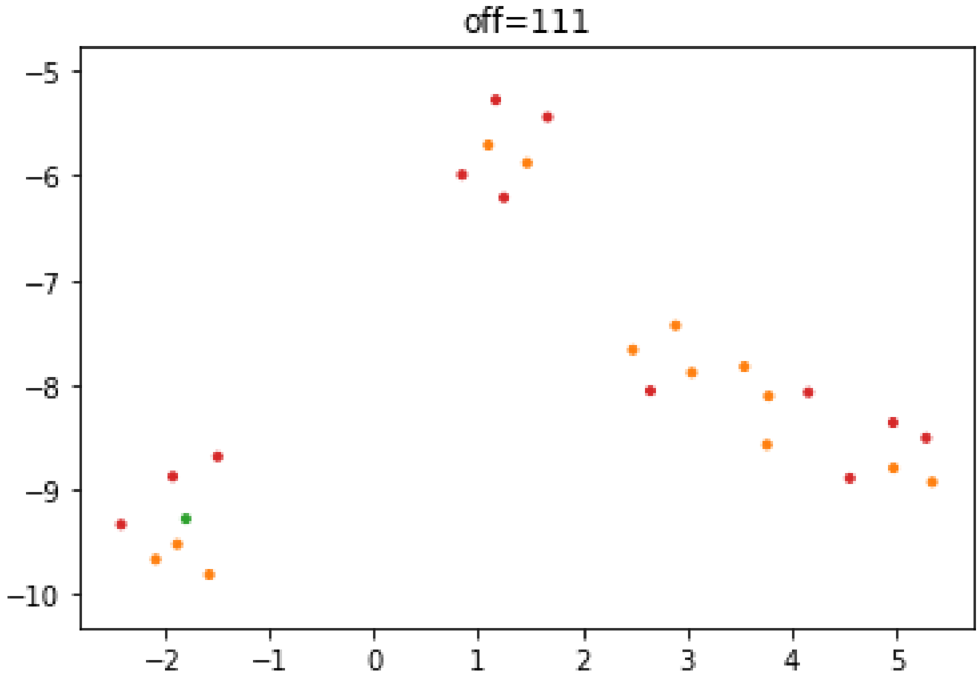
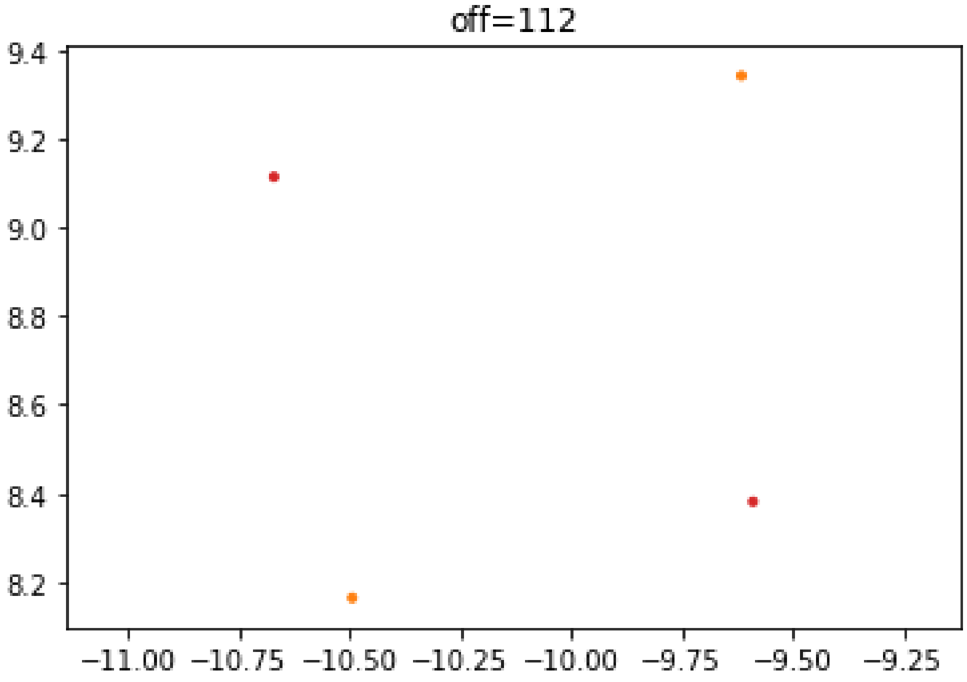


```
/home/ethan/.local/lib/python3.7/site-packages/umap/umap_.py:1383: UserWarning:

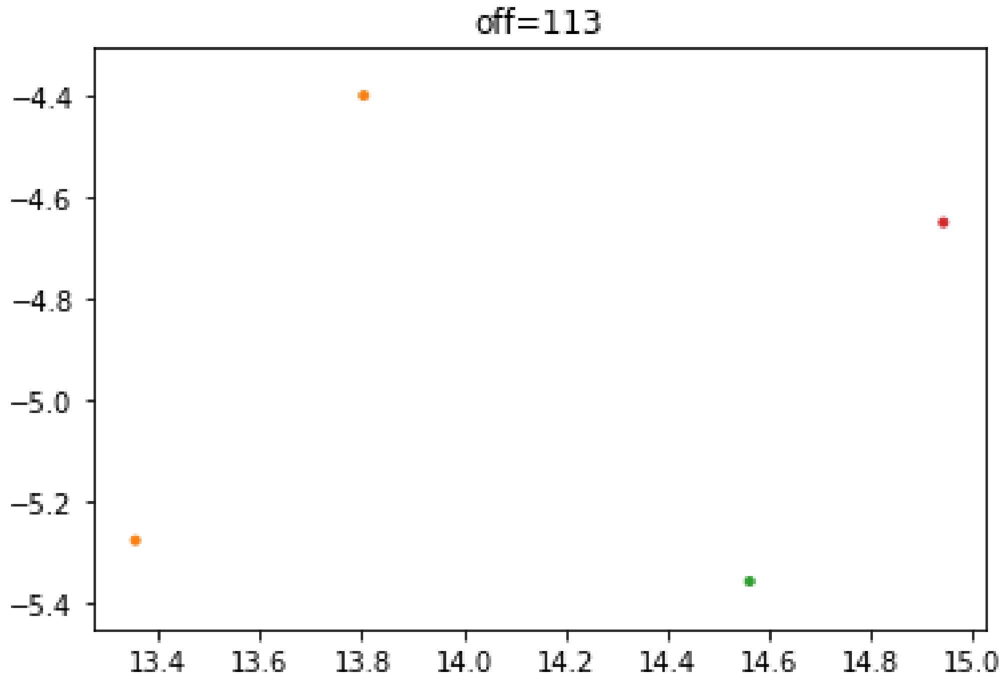
n_neighbors is larger than the dataset size; truncating to X.shape[0] - 1
```



```
/home/ethan/.local/lib/python3.7/site-packages/umap/umap_.py:1383: UserWarning:
n_neighbors is larger than the dataset size; truncating to X.shape[0] - 1
```

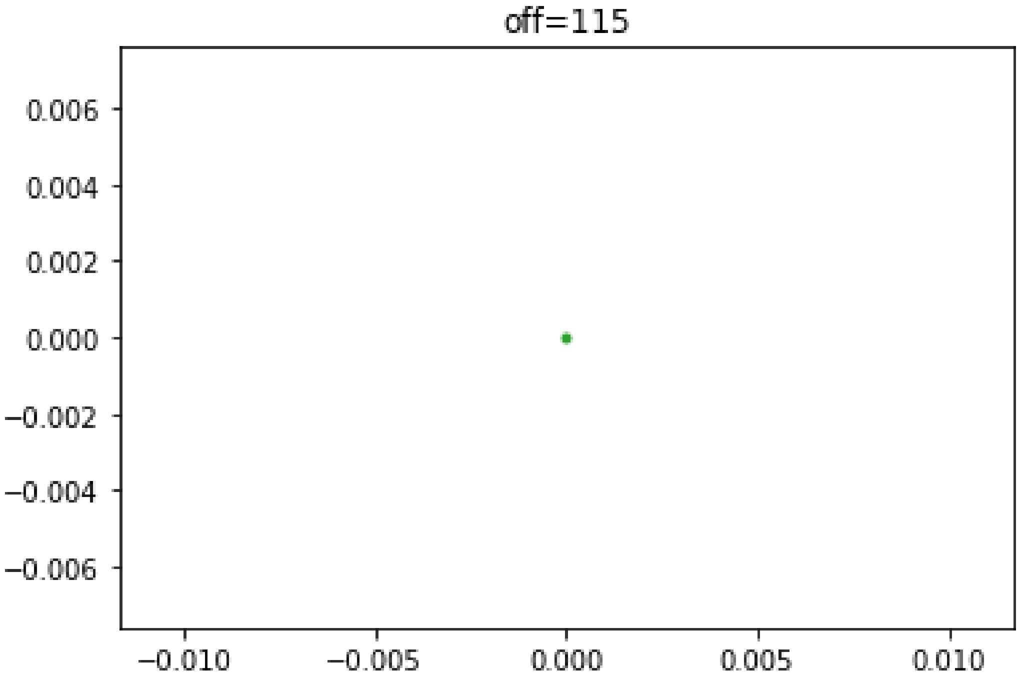


```
/home/ethan/.local/lib/python3.7/site-packages/umap/umap_.py:1383: UserWarning:
n_neighbors is larger than the dataset size; truncating to X.shape[0] - 1
```



```
/home/ethan/.local/lib/python3.7/site-packages/umap/umap_.py:1383: UserWarning:

n_neighbors is larger than the dataset size; truncating to X.shape[0] - 1
```



```
/home/ethan/.local/lib/python3.7/site-packages/umap/umap_.py:1383: UserWarning:
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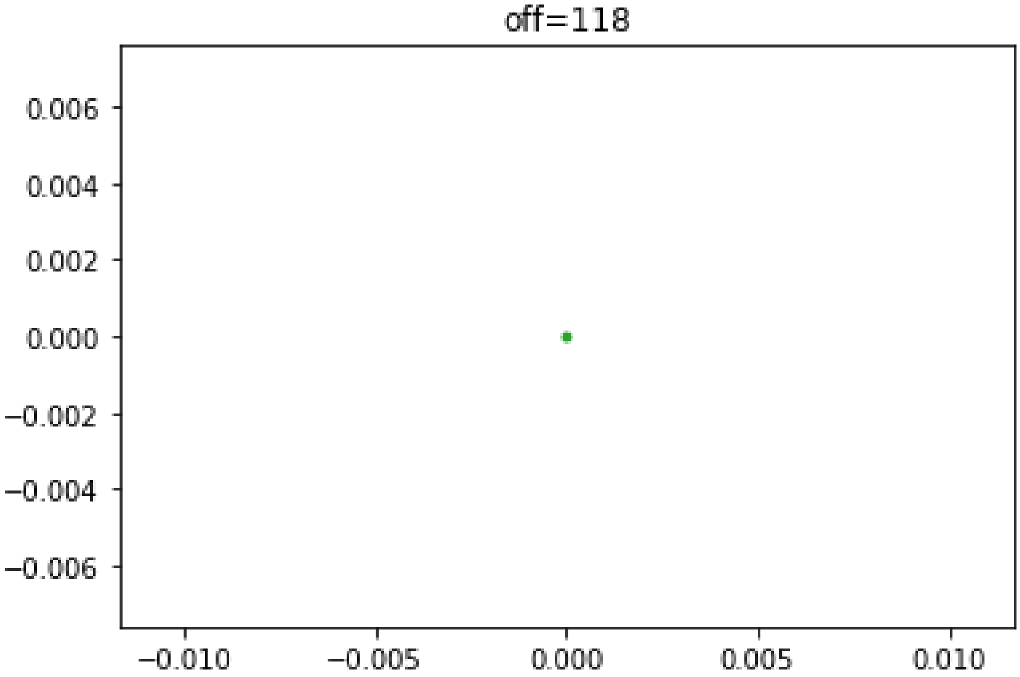
```



```
/home/ethan/.local/lib/python3.7/site-packages/umap/umap_.py:1383: UserWarning:
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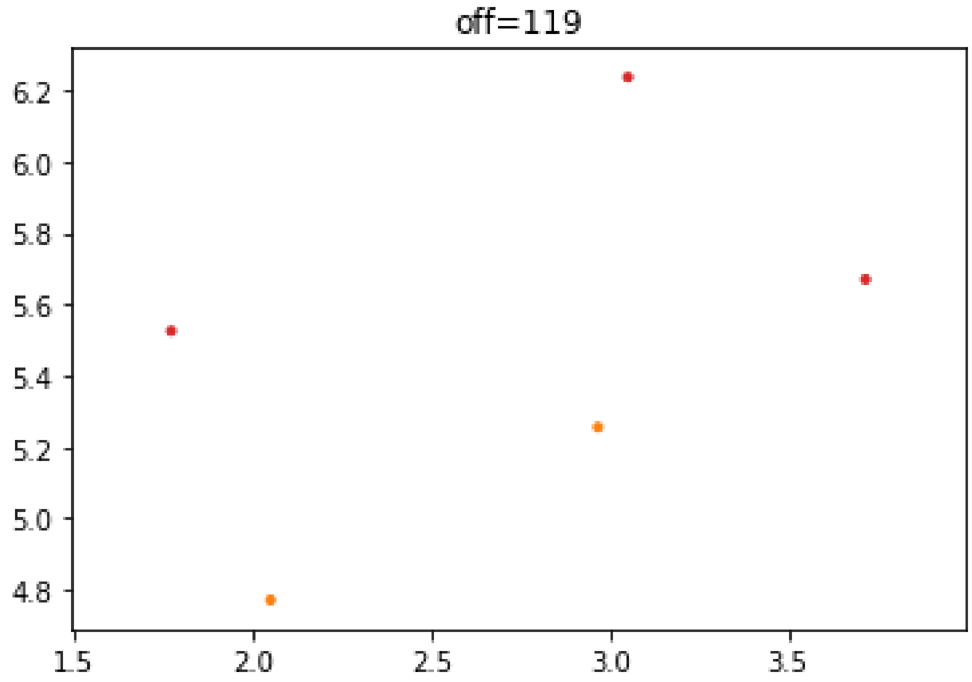
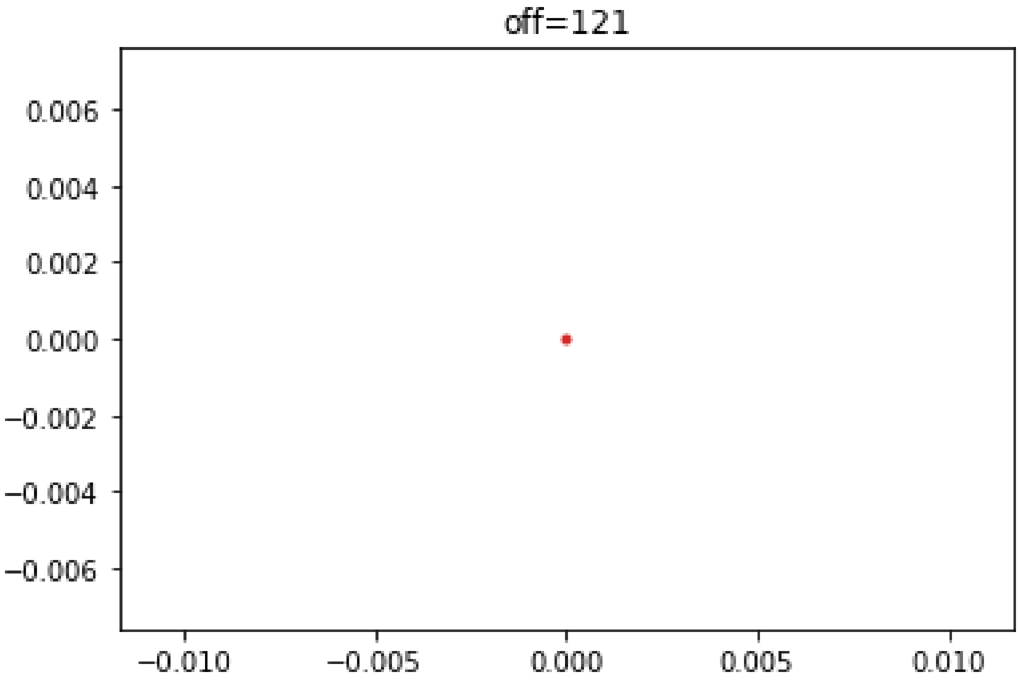
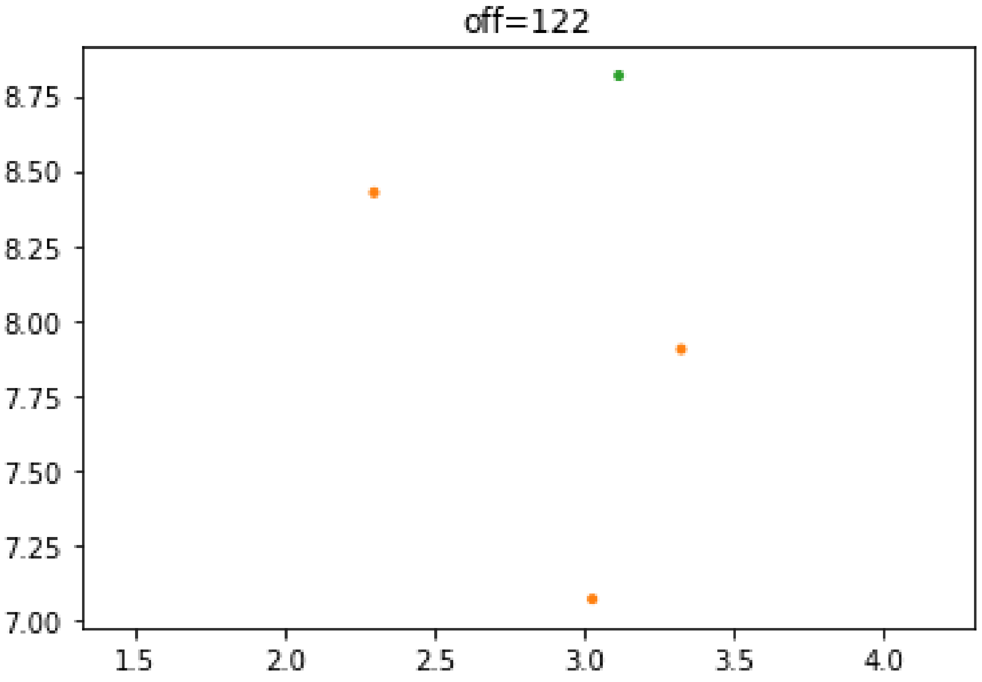


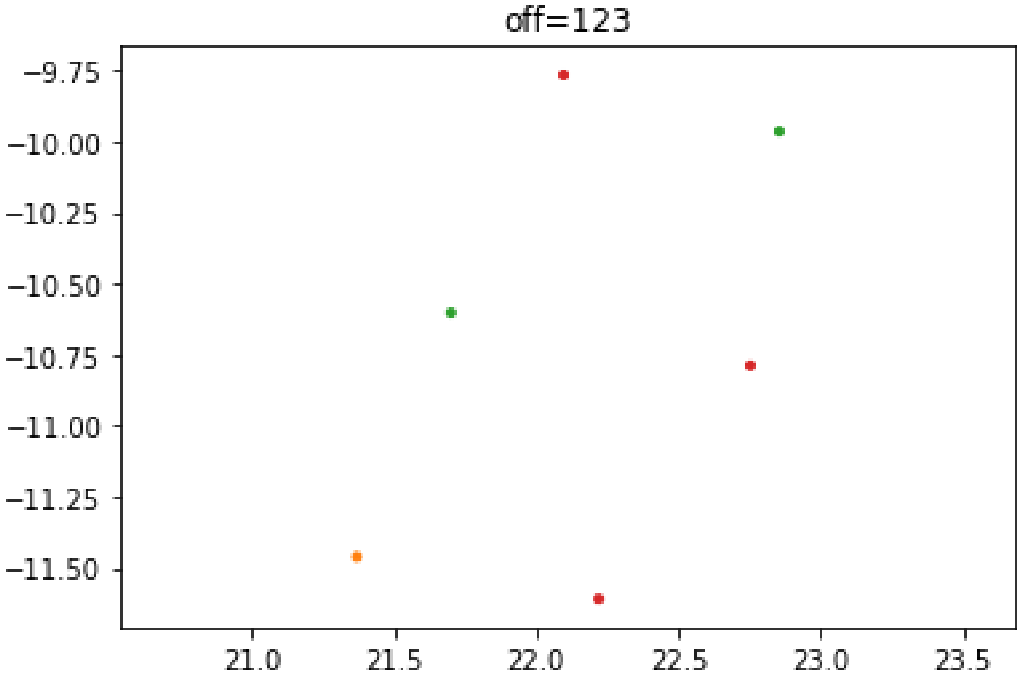
```
/home/ethan/.local/lib/python3.7/site-packages/umap/umap_.py:1383: UserWarning:

n_neighbors is larger than the dataset size; truncating to X.shape[0] - 1

/home/ethan/.local/lib/python3.7/site-packages/scipy/sparse/linalg/eigen/arpack/arpack.py:1592

k >= N for N * N square matrix. Attempting to use scipy.linalg.eigh instead.
```

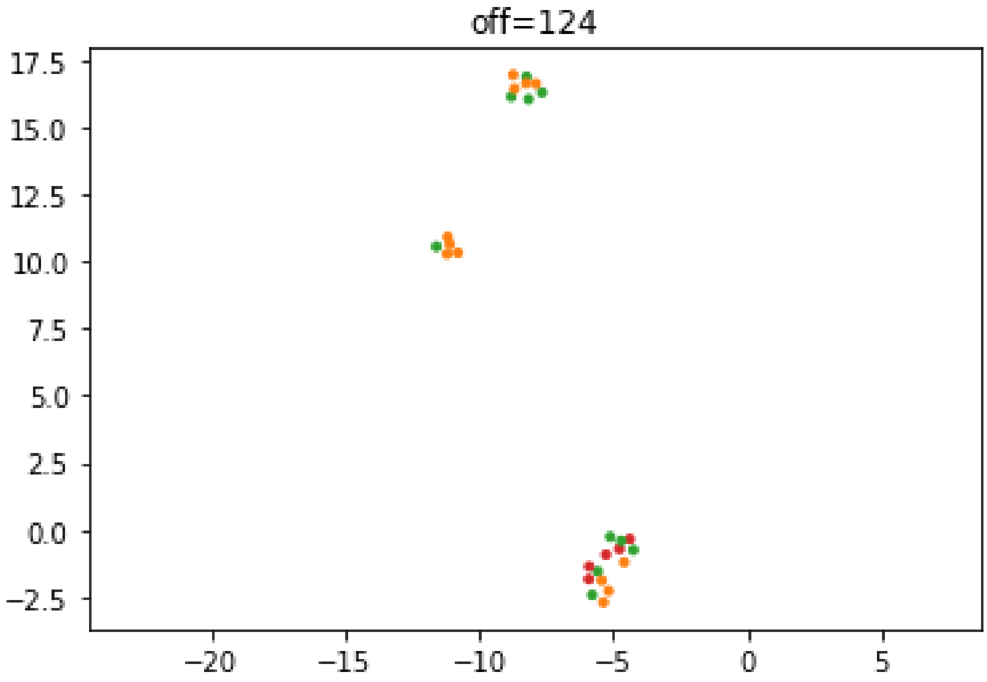


```
/home/ethan/.local/lib/python3.7/site-packages/umap/umap_.py:1383: UserWarning:
n_neighbors is larger than the dataset size; truncating to X.shape[0] - 1
```



```
/home/ethan/.local/lib/python3.7/site-packages/umap/umap_.py:1383: UserWarning:

n_neighbors is larger than the dataset size; truncating to X.shape[0] - 1
```





```
/home/ethan/.local/lib/python3.7/site-packages/umap/umap_.py:1383: UserWarning:
n_neighbors is larger than the dataset size; truncating to X.shape[0] - 1
/home/ethan/.local/lib/python3.7/site-packages/scipy/sparse/linalg/eigen/arpack/arpack.py:1592
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/home/ethan/.local/lib/python3.7/site-packages/umap/umap_.py:1383: UserWarning:
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n_neighbors is larger than the dataset size; truncating to X.shape[0] - 1
```
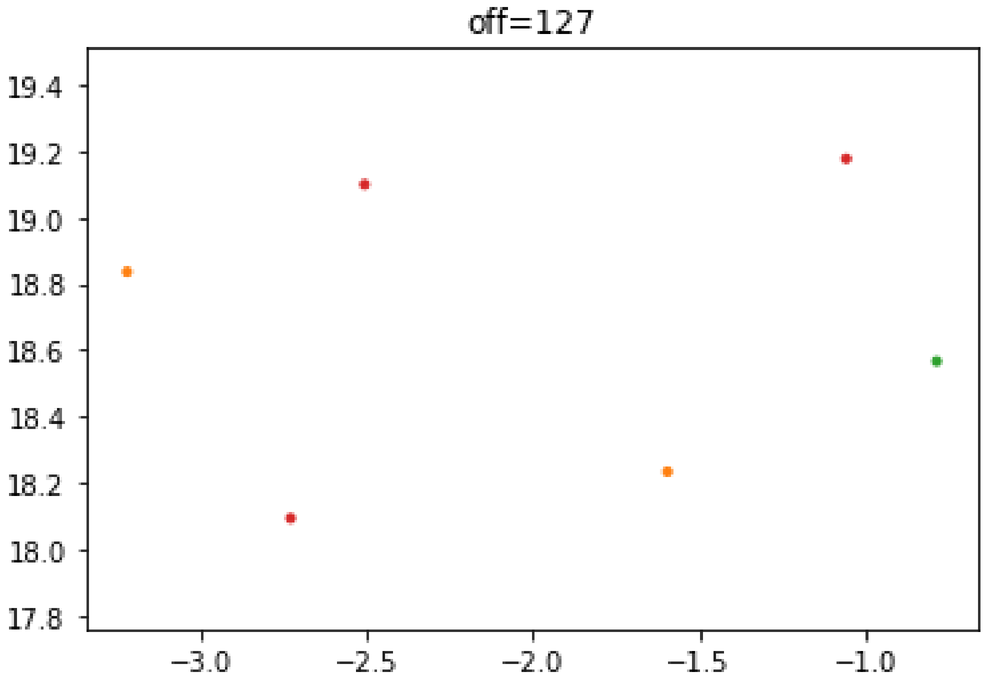
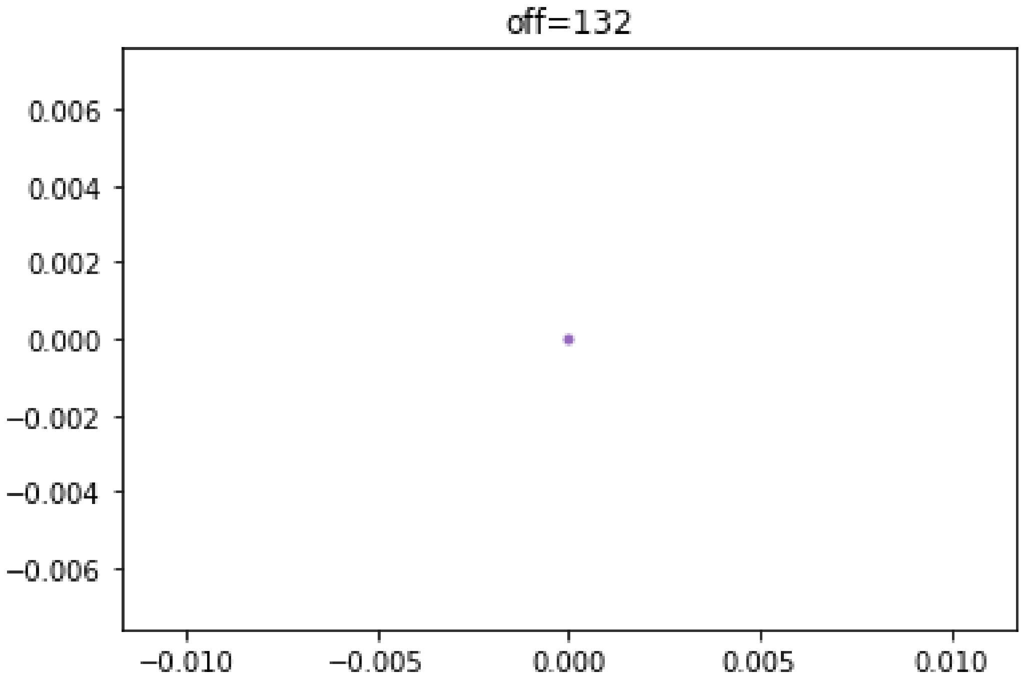
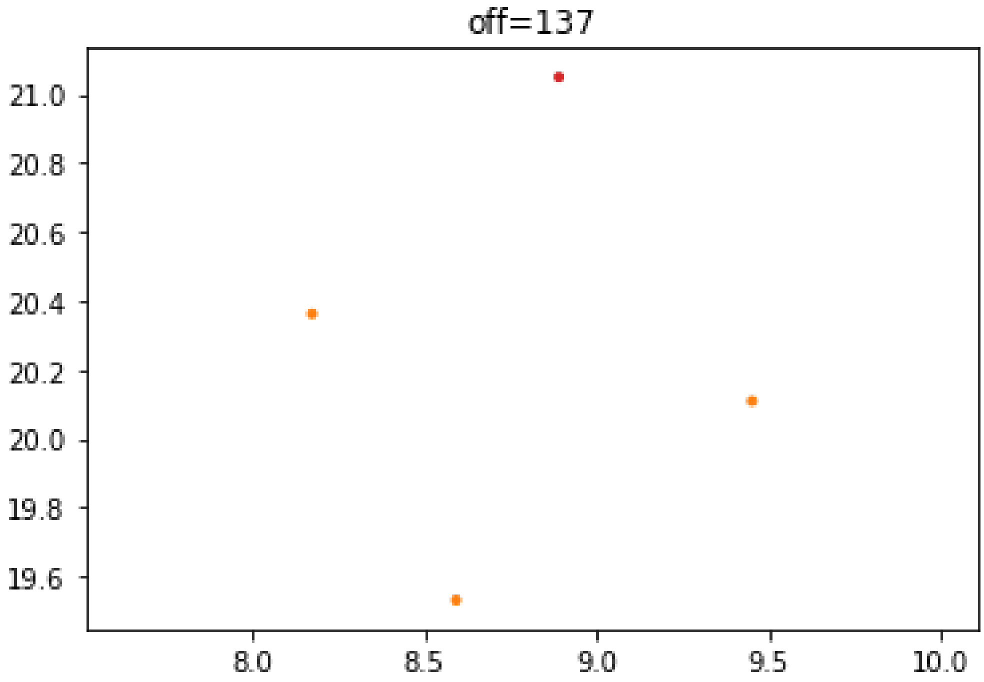
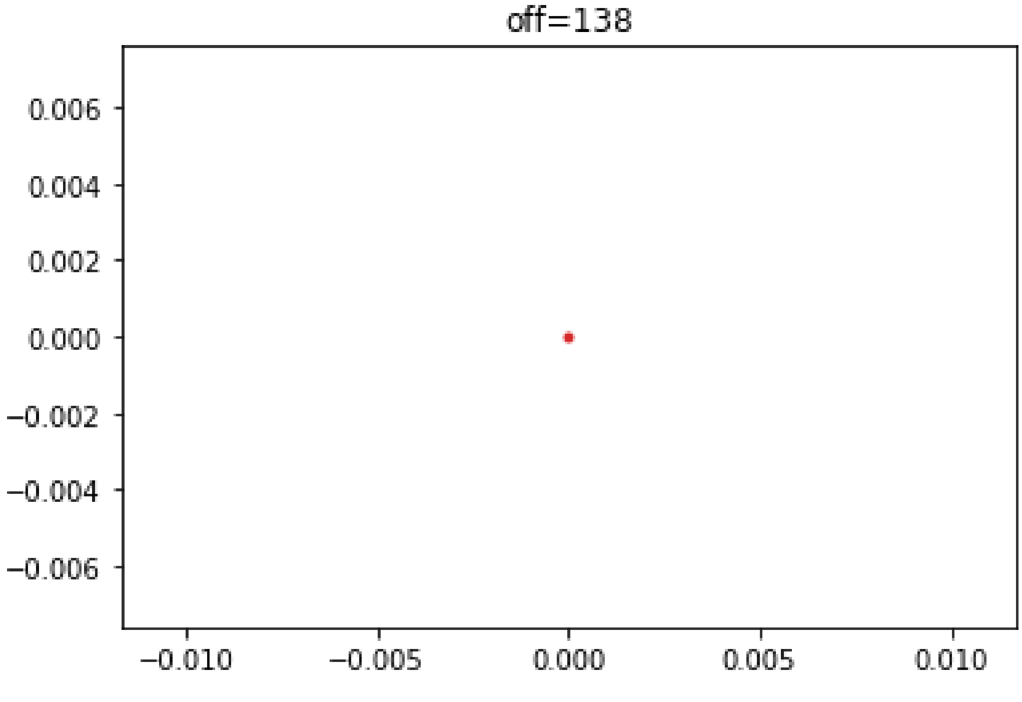



```
/home/ethan/.local/lib/python3.7/site-packages/umap/umap_.py:1383: UserWarning:
n_neighbors is larger than the dataset size; truncating to X.shape[0] - 1
/home/ethan/.local/lib/python3.7/site-packages/umap/umap_.py:1383: UserWarning:
n_neighbors is larger than the dataset size; truncating to X.shape[0] - 1
/home/ethan/.local/lib/python3.7/site-packages/scipy/sparse/linalg/eigen/arpack/arpack.py:1592
k >= N for N * N square matrix. Attempting to use scipy.linalg.eigh instead.
/home/ethan/.local/lib/python3.7/site-packages/umap/umap_.py:1383: UserWarning:
n_neighbors is larger than the dataset size; truncating to X.shape[0] - 1
/home/ethan/.local/lib/python3.7/site-packages/umap/umap_.py:1383: UserWarning:
n_neighbors is larger than the dataset size; truncating to X.shape[0] - 1
/home/ethan/.local/lib/python3.7/site-packages/scipy/sparse/linalg/eigen/arpack/arpack.py:1592
k >= N for N * N square matrix. Attempting to use scipy.linalg.eigh instead.
```



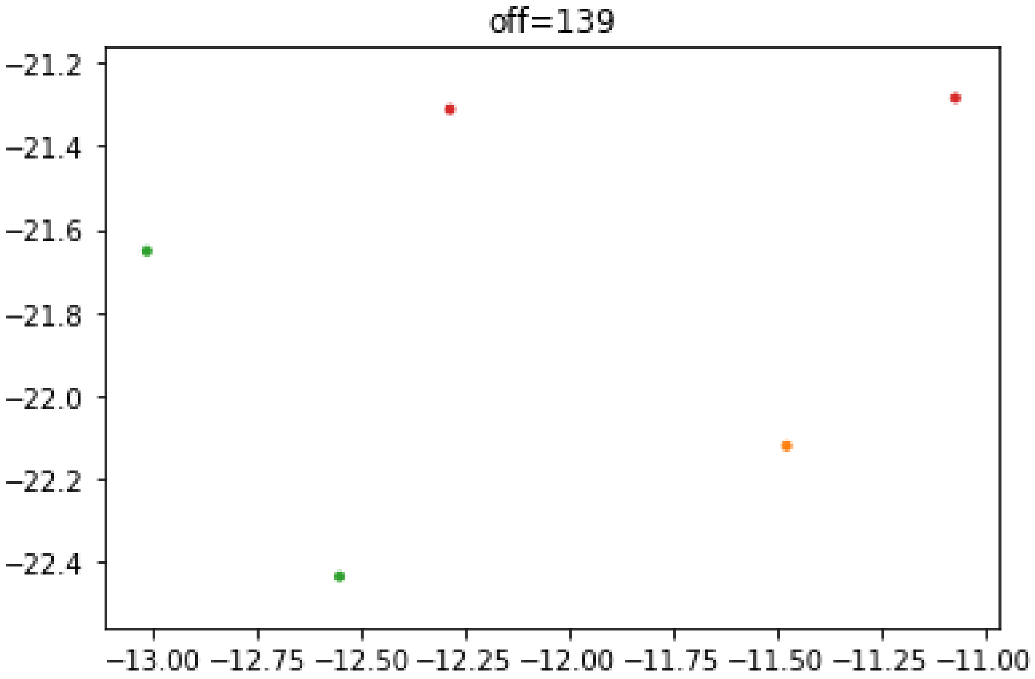
```
/home/ethan/.local/lib/python3.7/site-packages/umap/umap_.py:1383: UserWarning:

n_neighbors is larger than the dataset size; truncating to X.shape[0] - 1

/home/ethan/.local/lib/python3.7/site-packages/umap/umap_.py:1383: UserWarning:

n_neighbors is larger than the dataset size; truncating to X.shape[0] - 1

/home/ethan/.local/lib/python3.7/site-packages/umap/umap_.py:1383: UserWarning:

n_neighbors is larger than the dataset size; truncating to X.shape[0] - 1

/home/ethan/.local/lib/python3.7/site-packages/umap/umap_.py:1383: UserWarning:

n_neighbors is larger than the dataset size; truncating to X.shape[0] - 1

/home/ethan/.local/lib/python3.7/site-packages/scipy/sparse/linalg/eigen/arpack/arpack.py:1592

k >= N for N * N square matrix. Attempting to use scipy.linalg.eigh instead.

/home/ethan/.local/lib/python3.7/site-packages/umap/umap_.py:1383: UserWarning:

n_neighbors is larger than the dataset size; truncating to X.shape[0] - 1
```





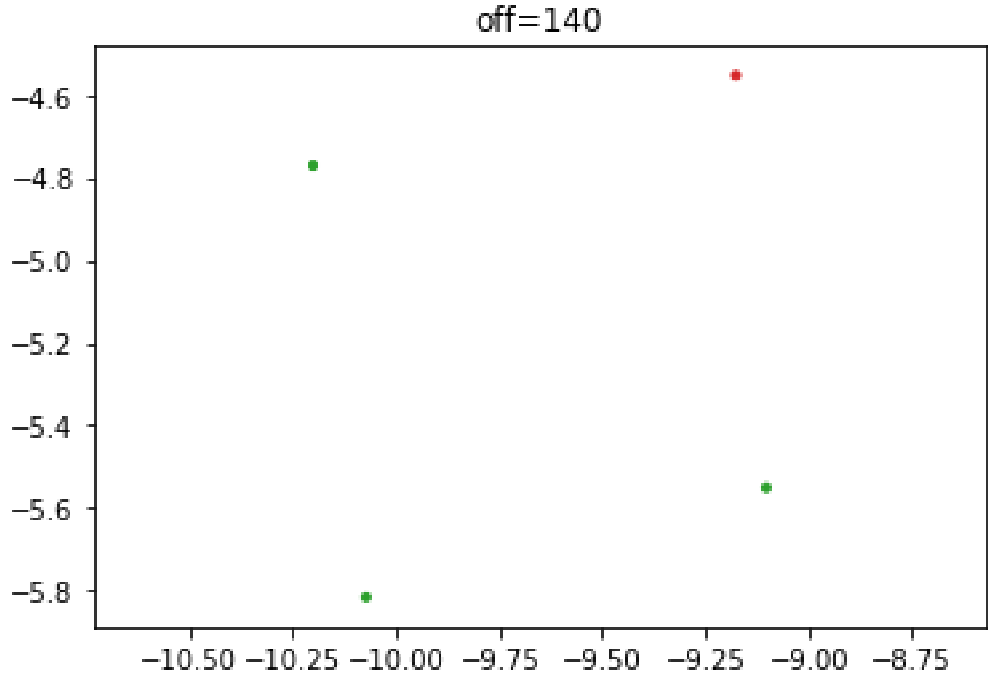
```
/home/ethan/.local/lib/python3.7/site-packages/umap/umap_.py:1383: UserWarning:
```

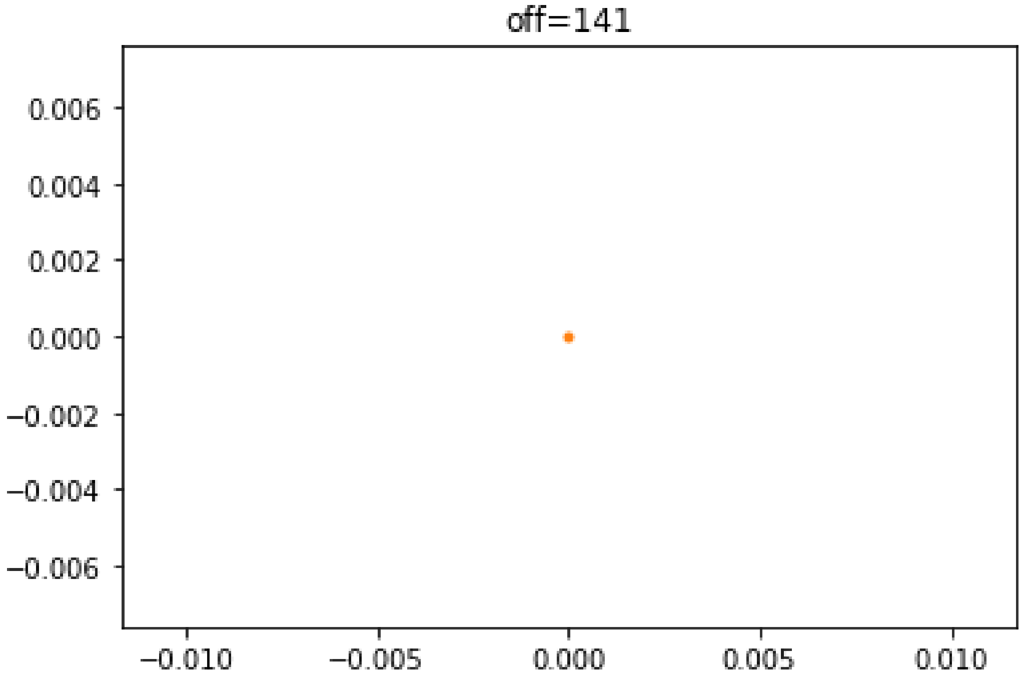
```
n_neighbors is larger than the dataset size; truncating to X.shape[0] - 1
```



off=139

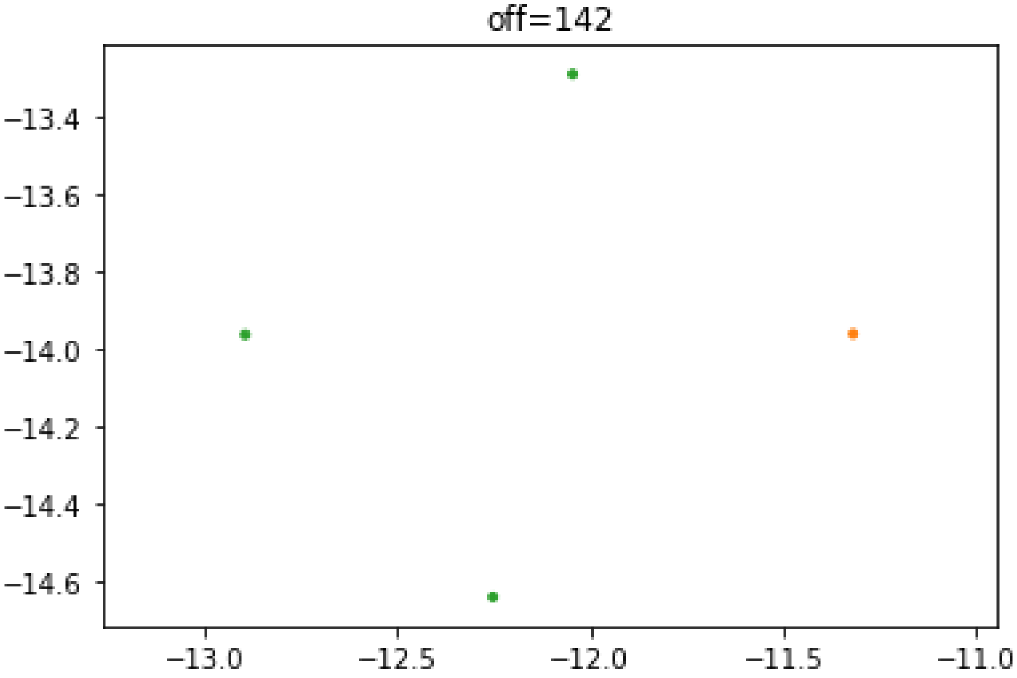
```
/home/ethan/.local/lib/python3.7/site-packages/umap/umap_.py:1383: UserWarning:
n_neighbors is larger than the dataset size; truncating to X.shape[0] - 1
```



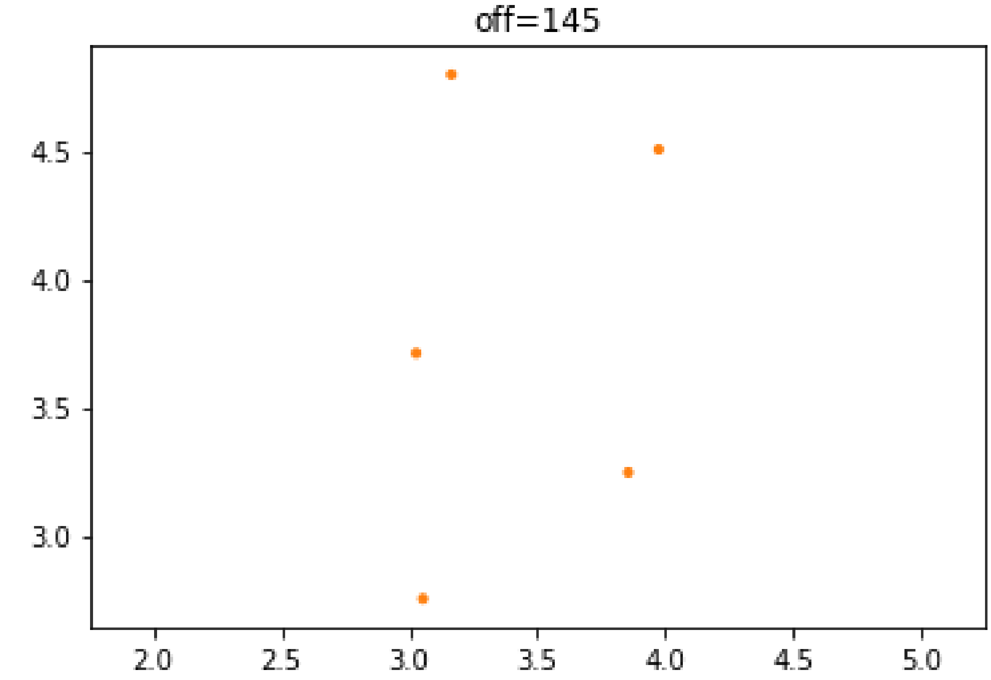


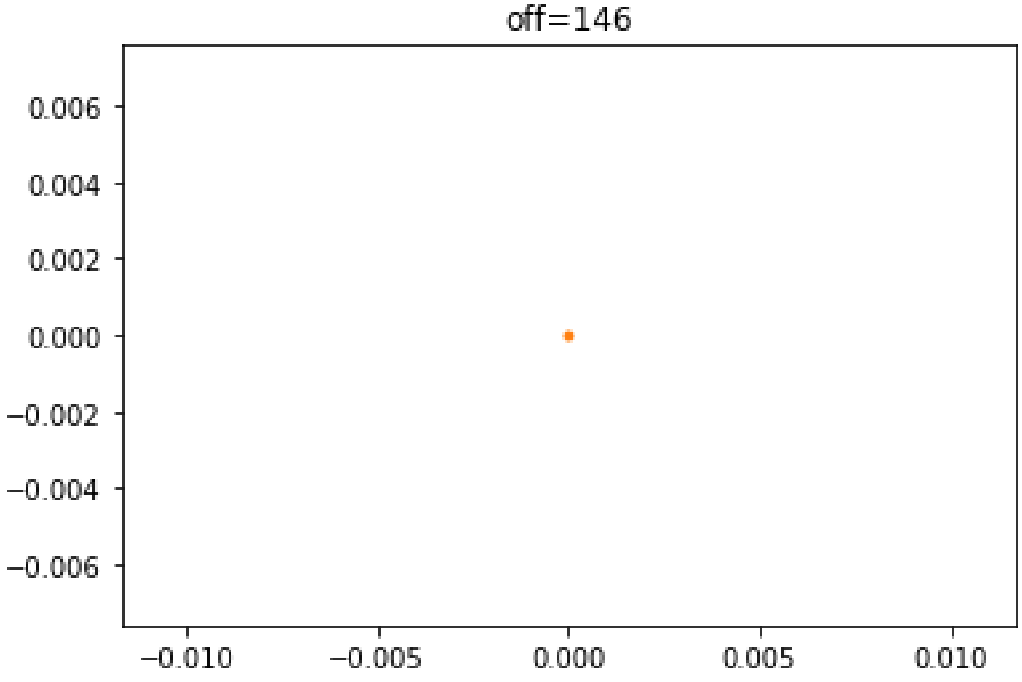
```
/home/ethan/.local/lib/python3.7/site-packages/umap/umap_.py:1383: UserWarning:
```

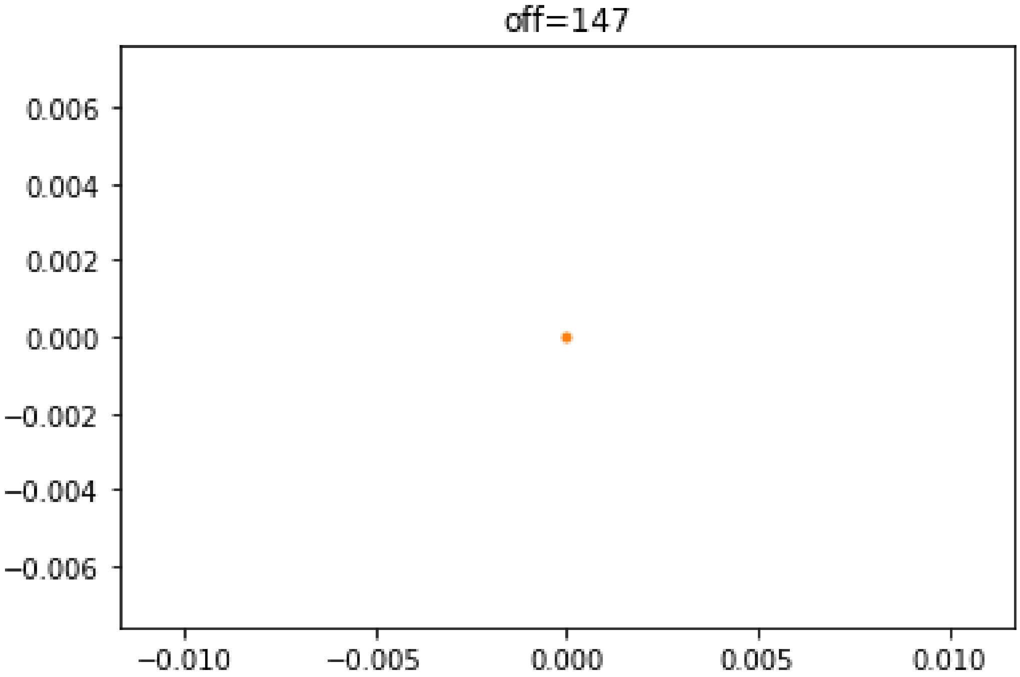
```
n_neighbors is larger than the dataset size; truncating to X.shape[0] - 1
```

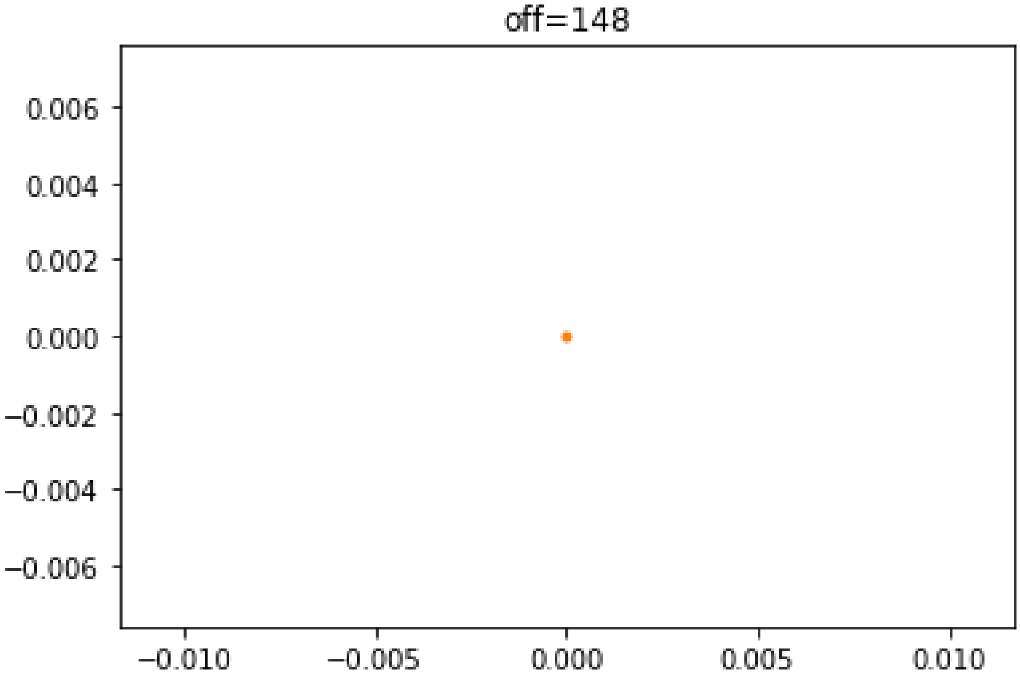


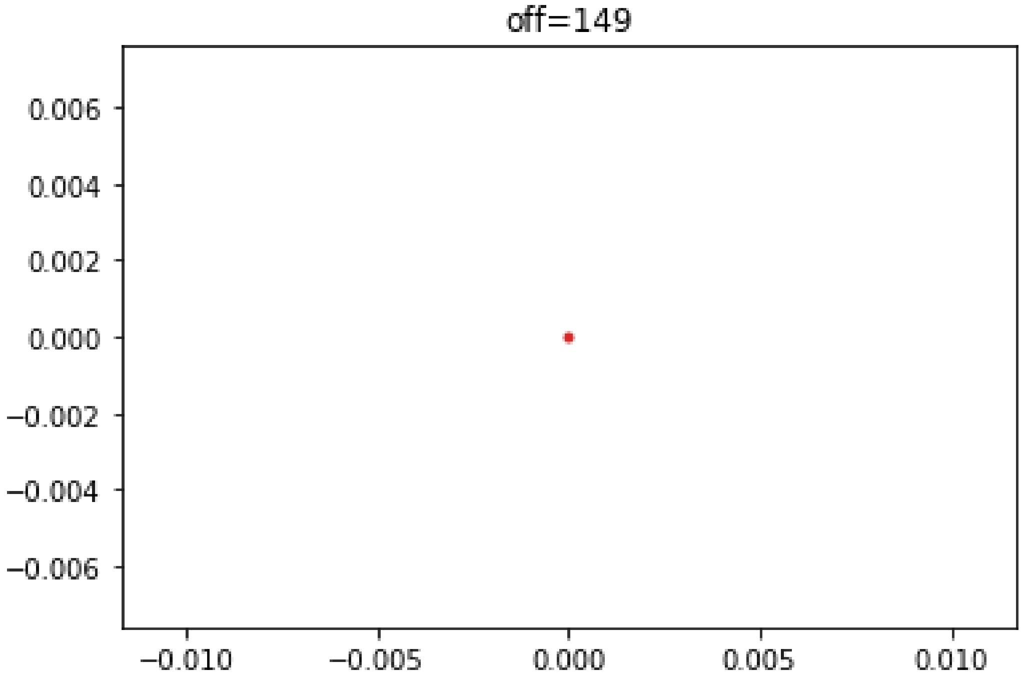
```
/home/ethan/.local/lib/python3.7/site-packages/umap/umap_.py:1383: UserWarning:
n_neighbors is larger than the dataset size; truncating to X.shape[0] - 1
/home/ethan/.local/lib/python3.7/site-packages/scipy/sparse/linalg/eigen/arpack/arpack.py:1592
k >= N for N * N square matrix. Attempting to use scipy.linalg.eigh instead.
/home/ethan/.local/lib/python3.7/site-packages/umap/umap_.py:1383: UserWarning:
n_neighbors is larger than the dataset size; truncating to X.shape[0] - 1
/home/ethan/.local/lib/python3.7/site-packages/scipy/sparse/linalg/eigen/arpack/arpack.py:1592
k >= N for N * N square matrix. Attempting to use scipy.linalg.eigh instead.
/home/ethan/.local/lib/python3.7/site-packages/umap/umap_.py:1383: UserWarning:
n_neighbors is larger than the dataset size; truncating to X.shape[0] - 1
```

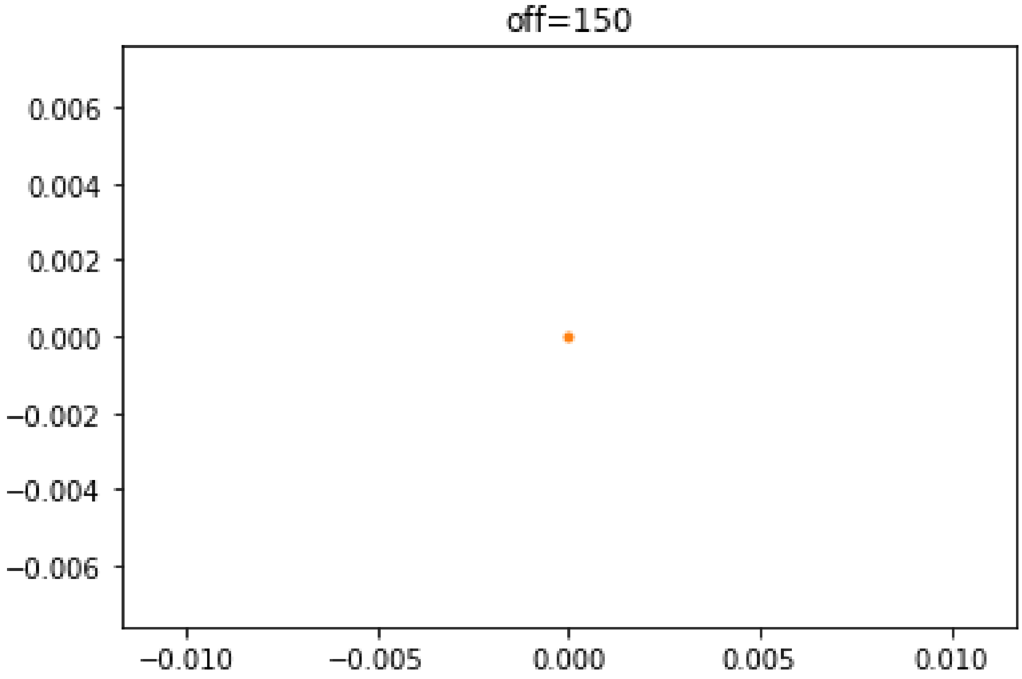

off=145
4.5
4.0
3.5
3.0
2.0
2.5
3.0
3.5
4.0
4.5
5.0


off=146
0.006
0.004
0.002
0.000
−0.002
−0.004
−0.006
−0.010
−0.005
0.000
0.005
0.010


off=147
0.006
0.004
0.002
0.000
−0.002
−0.004
−0.006
−0.010
−0.005
0.000
0.005
0.010

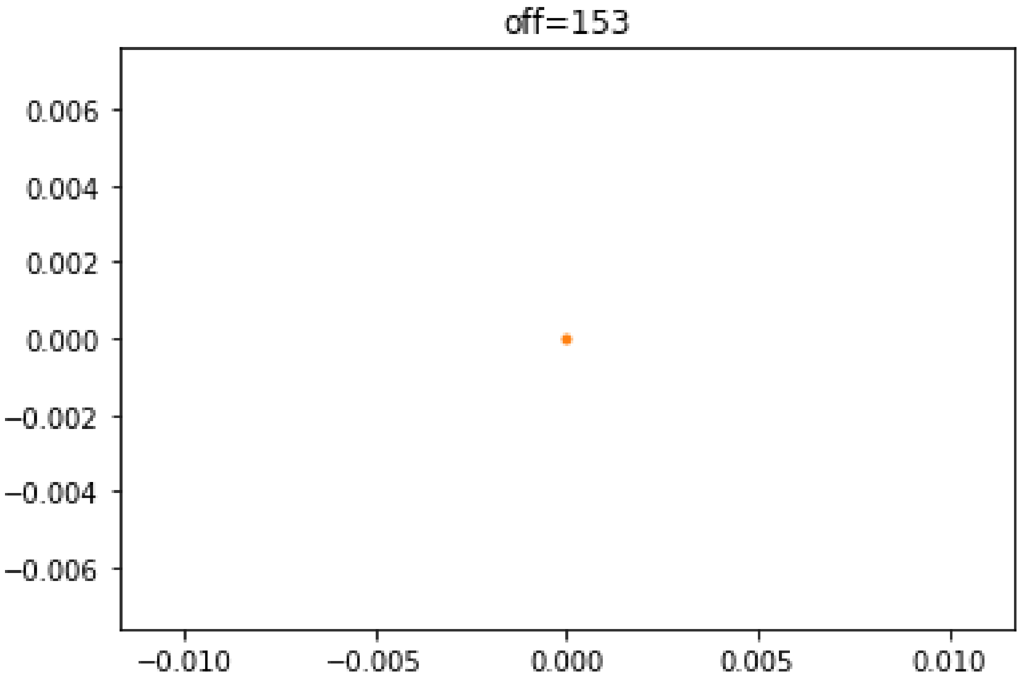

off=148
0.006
0.004
0.002
0.000
−0.002
−0.004
−0.006
−0.010
−0.005
0.000
0.005
0.010

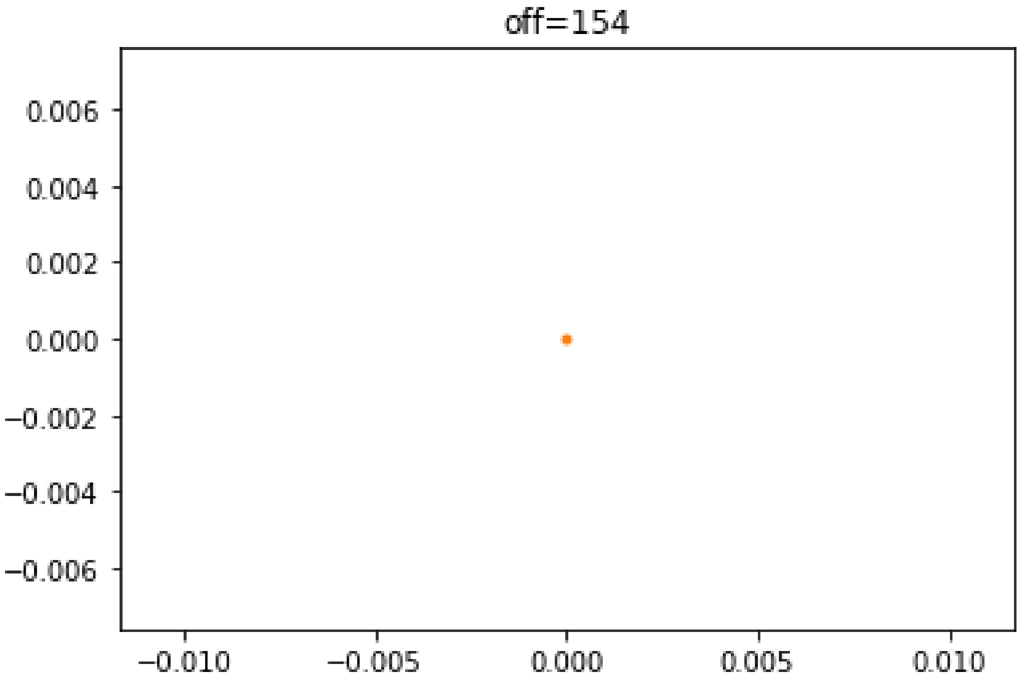




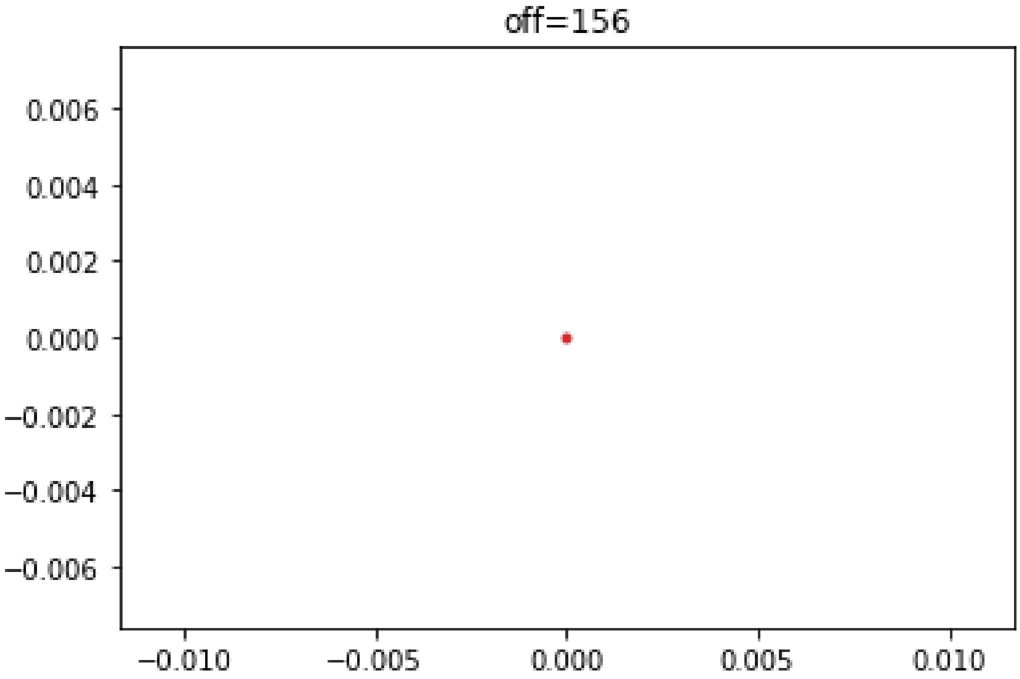
```
/home/ethan/.local/lib/python3.7/site-packages/umap/umap_.py:1383: UserWarning:
```

```
n_neighbors is larger than the dataset size; truncating to X.shape[0] - 1

/home/ethan/.local/lib/python3.7/site-packages/scipy/sparse/linalg/eigen/arpack/arpack.py:1592

k >= N for N * N square matrix. Attempting to use scipy.linalg.eigh instead.

/home/ethan/.local/lib/python3.7/site-packages/umap/umap_.py:1383: UserWarning:

n_neighbors is larger than the dataset size; truncating to X.shape[0] - 1
```

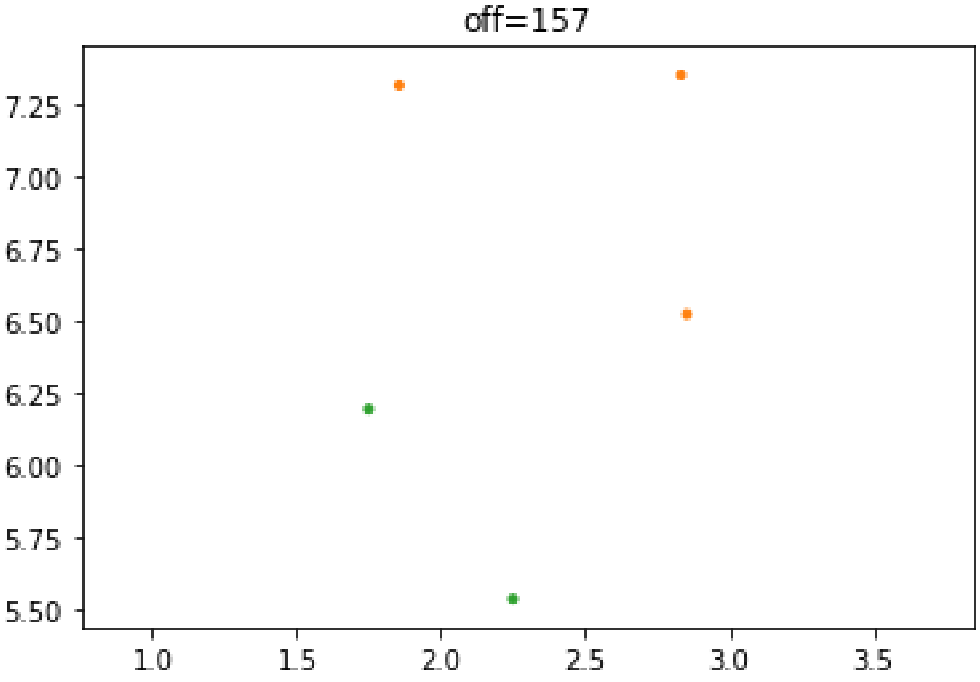




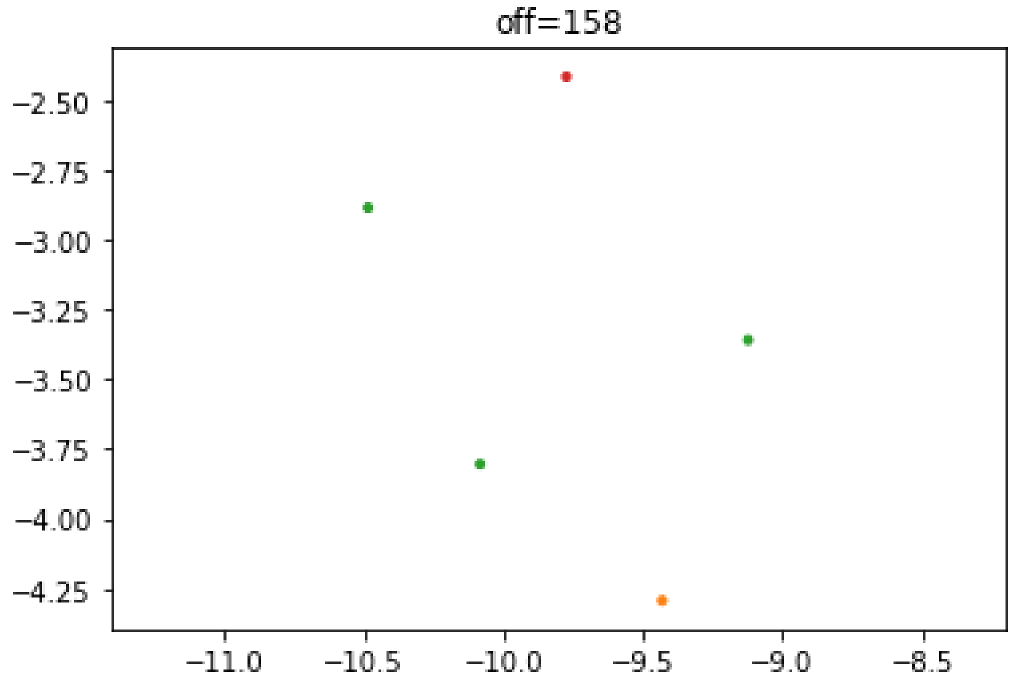
```
/home/ethan/.local/lib/python3.7/site-packages/umap/umap_.py:1383: UserWarning:
n_neighbors is larger than the dataset size; truncating to X.shape[0] - 1
```



```
/home/ethan/.local/lib/python3.7/site-packages/umap/umap_.py:1383: UserWarning:
n_neighbors is larger than the dataset size; truncating to X.shape[0] - 1
```



```
/home/ethan/.local/lib/python3.7/site-packages/umap/umap_.py:1383: UserWarning:
n_neighbors is larger than the dataset size; truncating to X.shape[0] - 1
```


off=158
−2.50
−2.75
−3.00
−3.25
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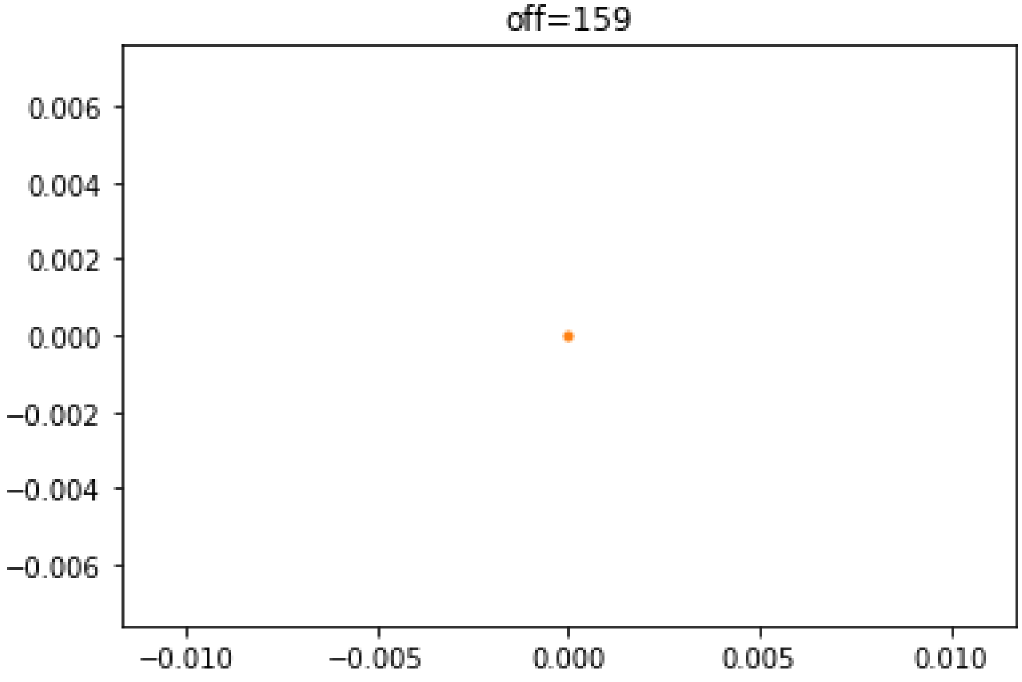
−3.75
−4.00
−4.25
−11.0
−10.5
−10.0
−9.5
−9.0
−8.5


off=159
0.006
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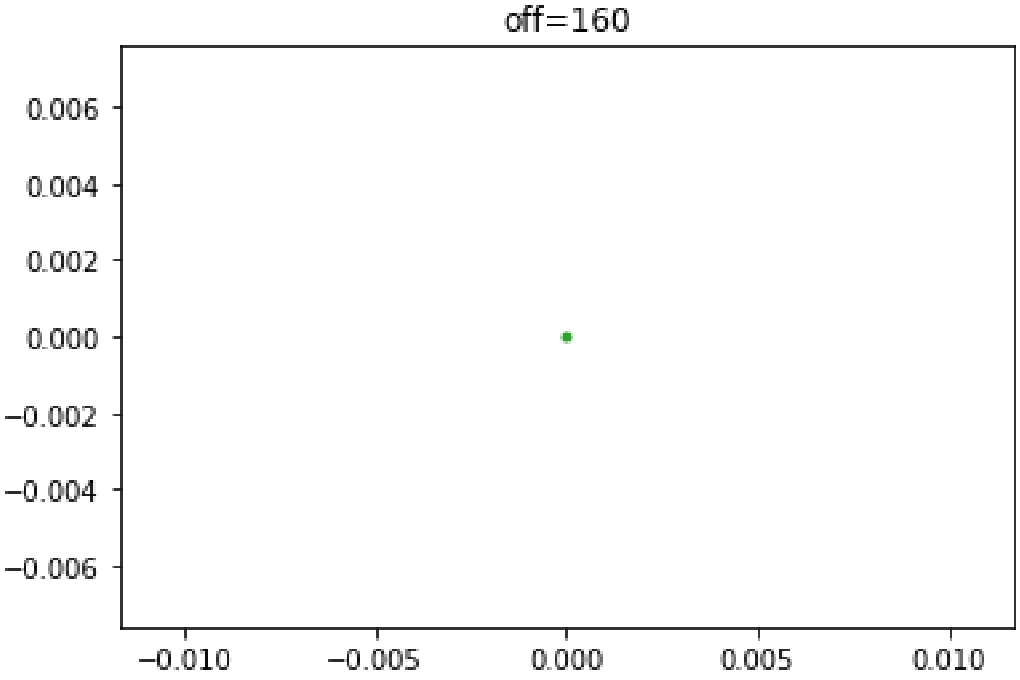
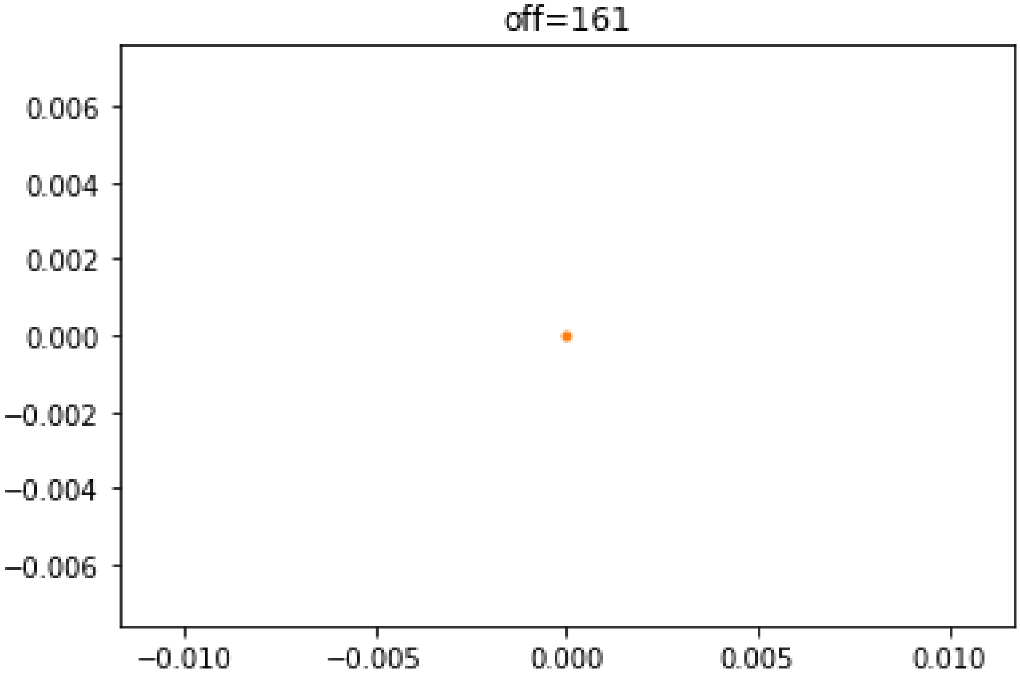
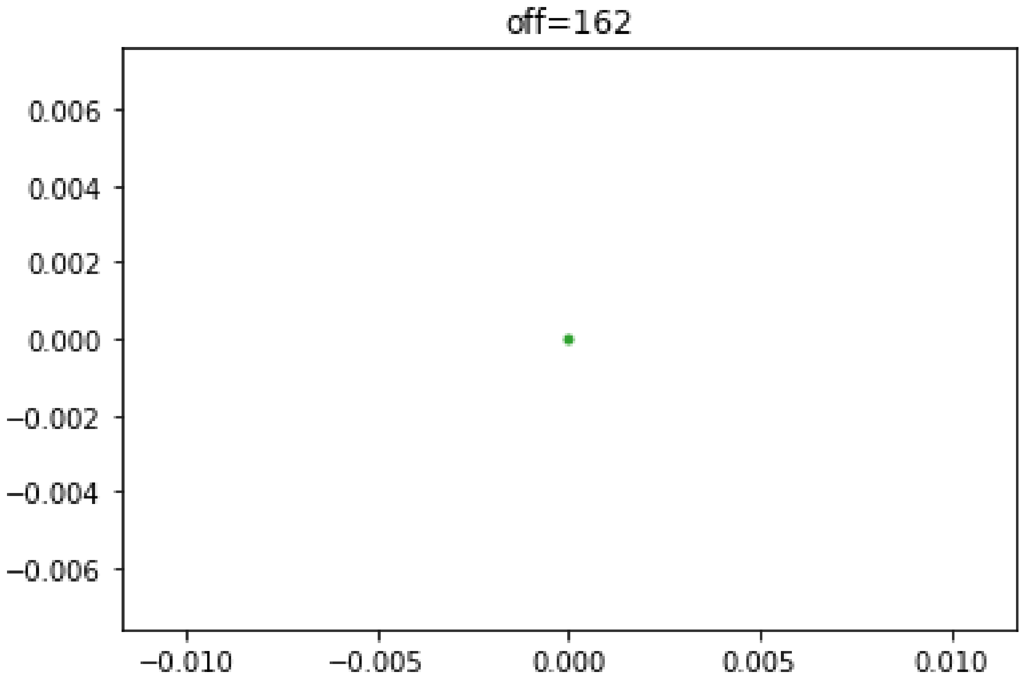
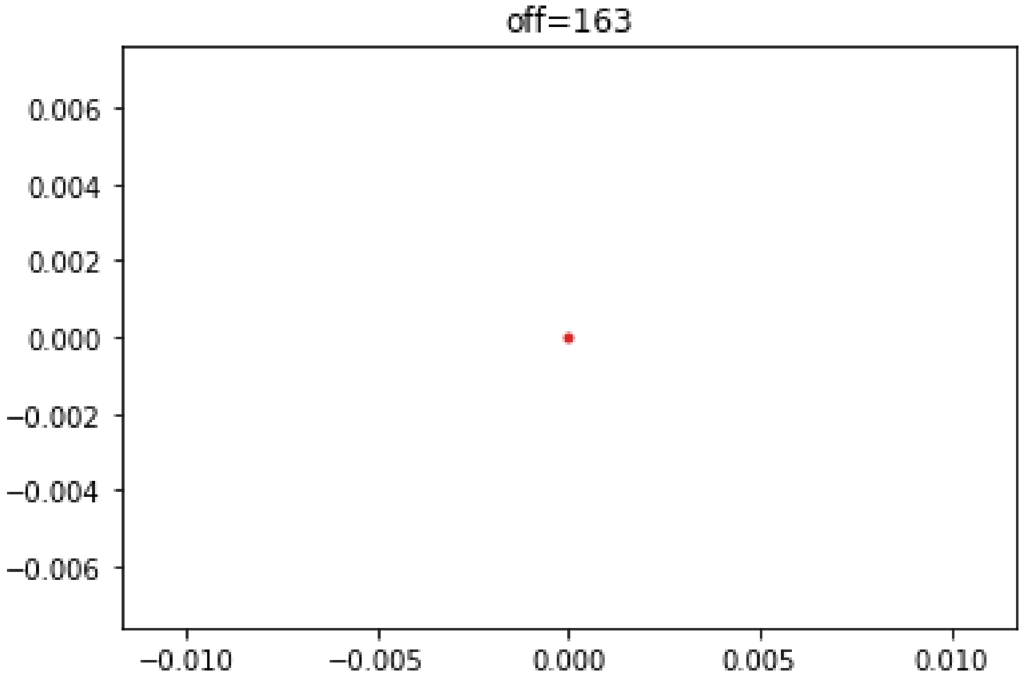
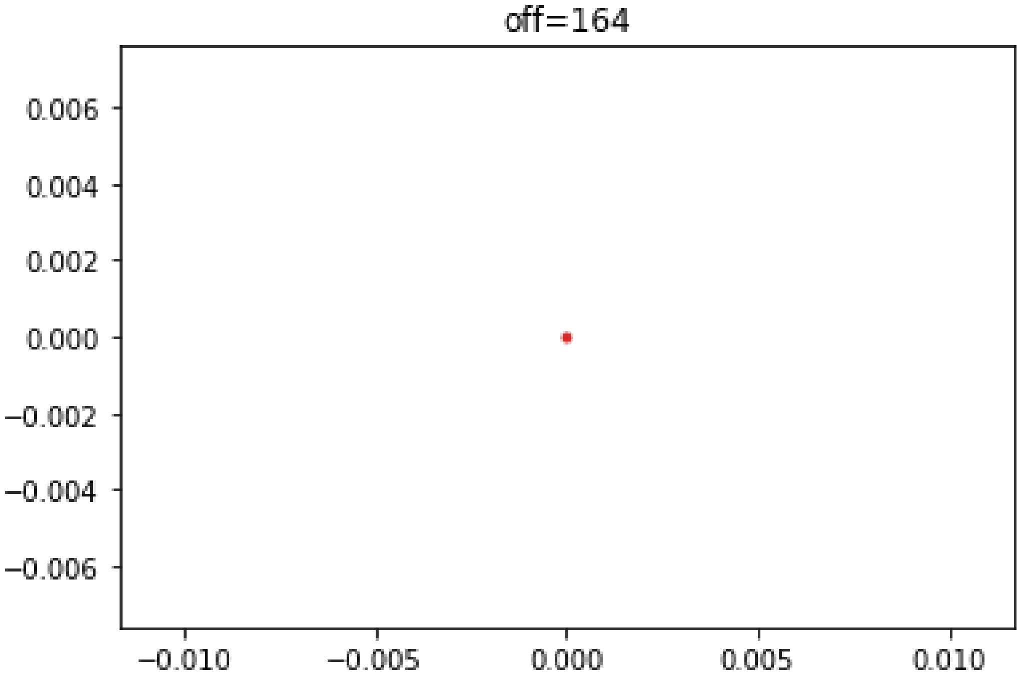
0.002
0.000
−0.002
−0.004
−0.006
−0.010
−0.005
0.000
0.005
0.010

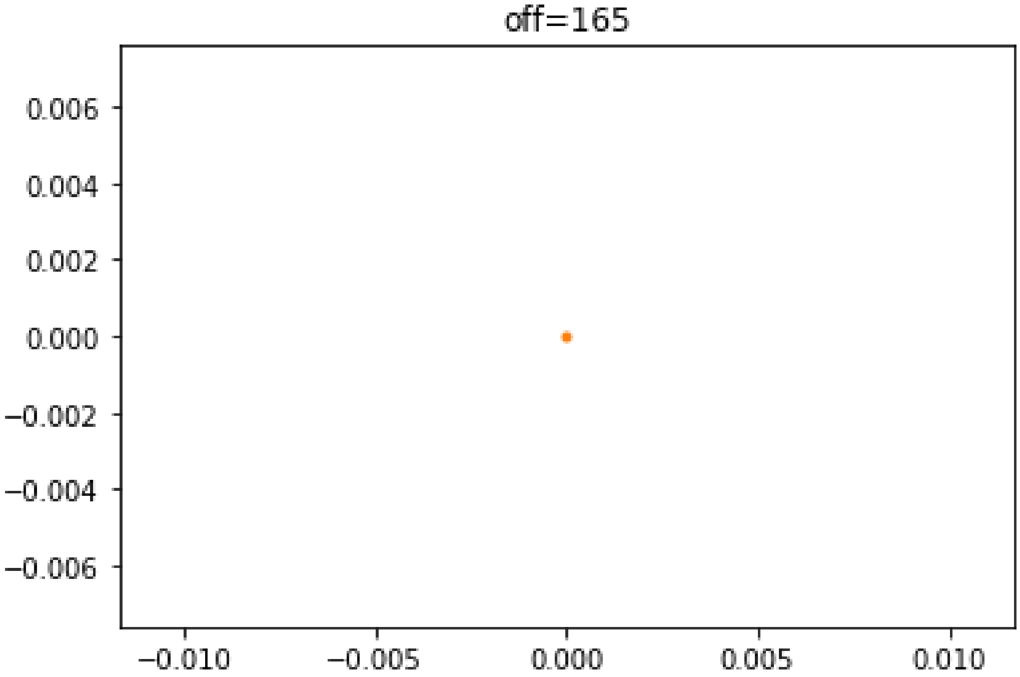

off=160
0.006
0.004
0.002
0.000
−0.002
−0.004
−0.006
−0.010
−0.005
0.000
0.005
0.010

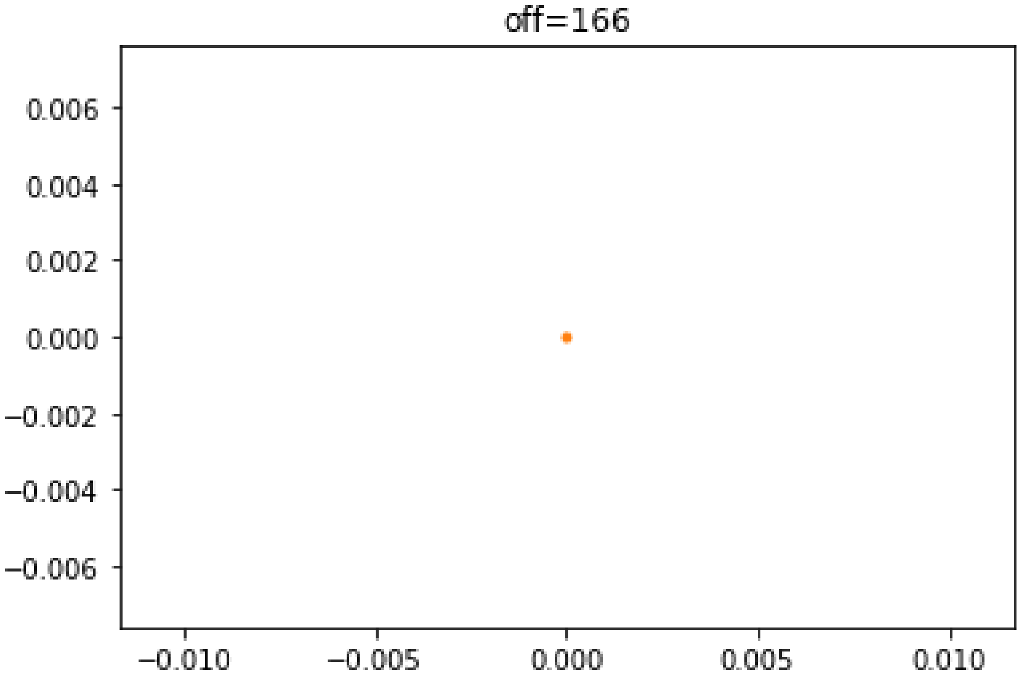

off=161
0.006
0.004
0.002
0.000
−0.002
−0.004
−0.006
−0.010
−0.005
0.000
0.005
0.010


off=162


off=163


off=164
0.006
0.004
0.002
0.000
−0.002
−0.004
−0.006
−0.010
−0.005
0.000
0.005
0.010


off=165
0.006
0.004
0.002
0.000
−0.002
−0.004
−0.006
−0.010
−0.005
0.000
0.005
0.010


off=166
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−0.004
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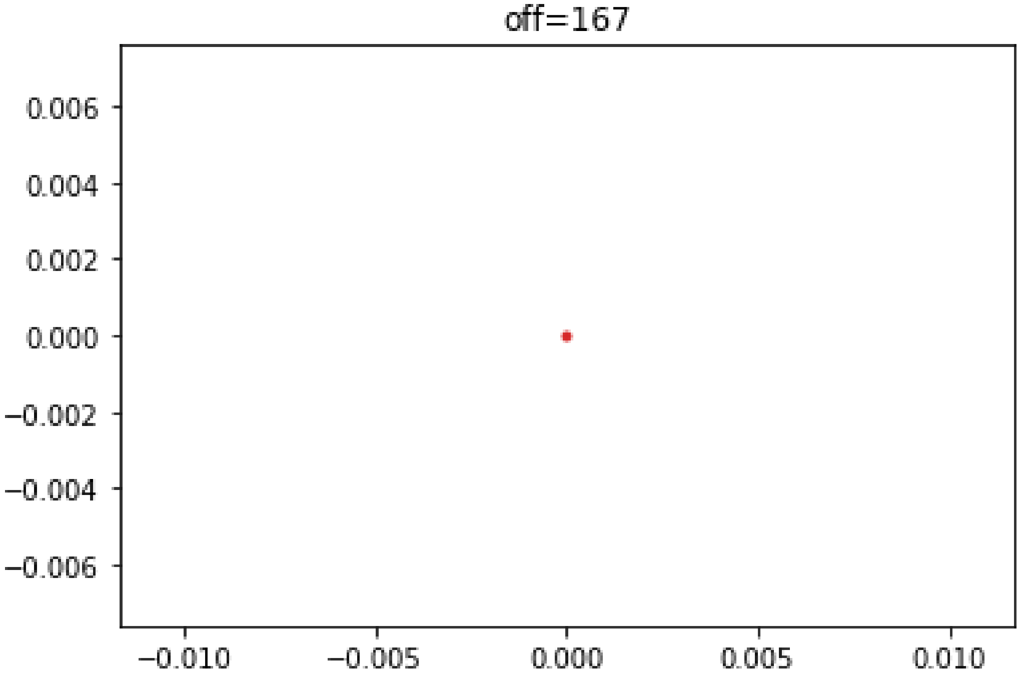
−0.010
−0.005
0.000
0.005
0.010


off=167
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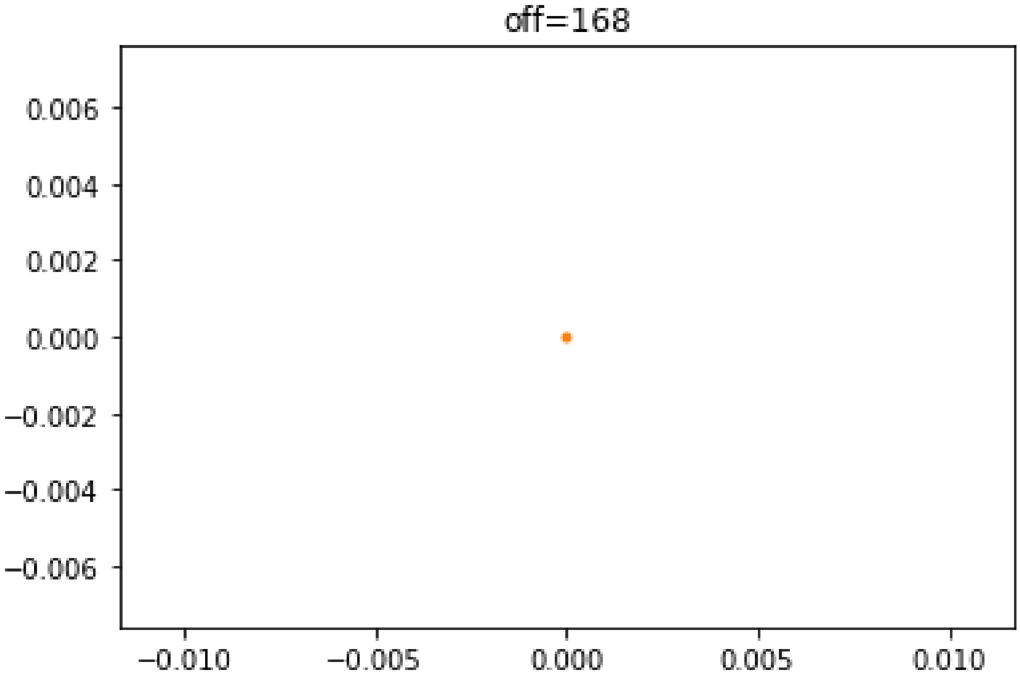
−0.005
0.000
0.005
0.010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0.002
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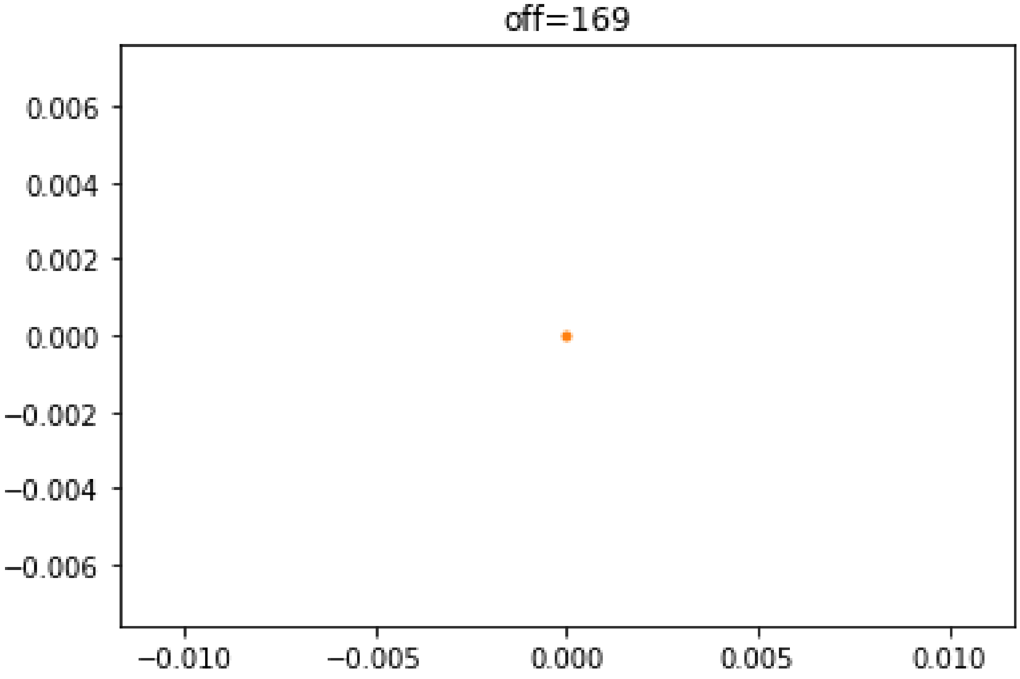
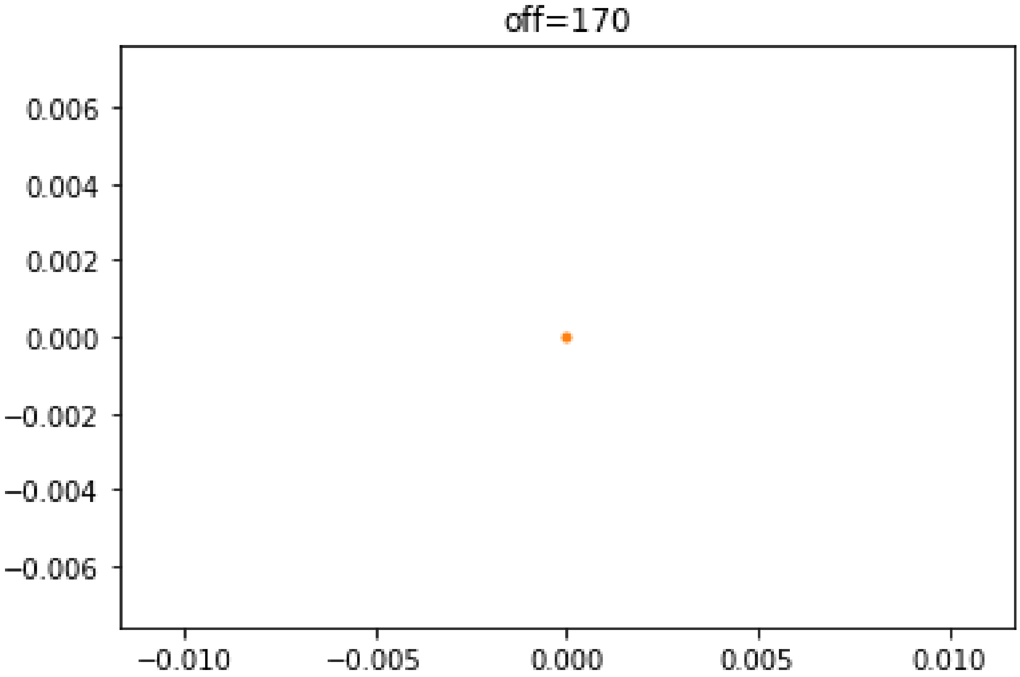
0.005
0.010


off=169
0.006
0.004
0.002
0.000
−0.002
−0.004
−0.006
−0.010
−0.005
0.000
0.005
0.010


off=170
0.006
0.004
0.002
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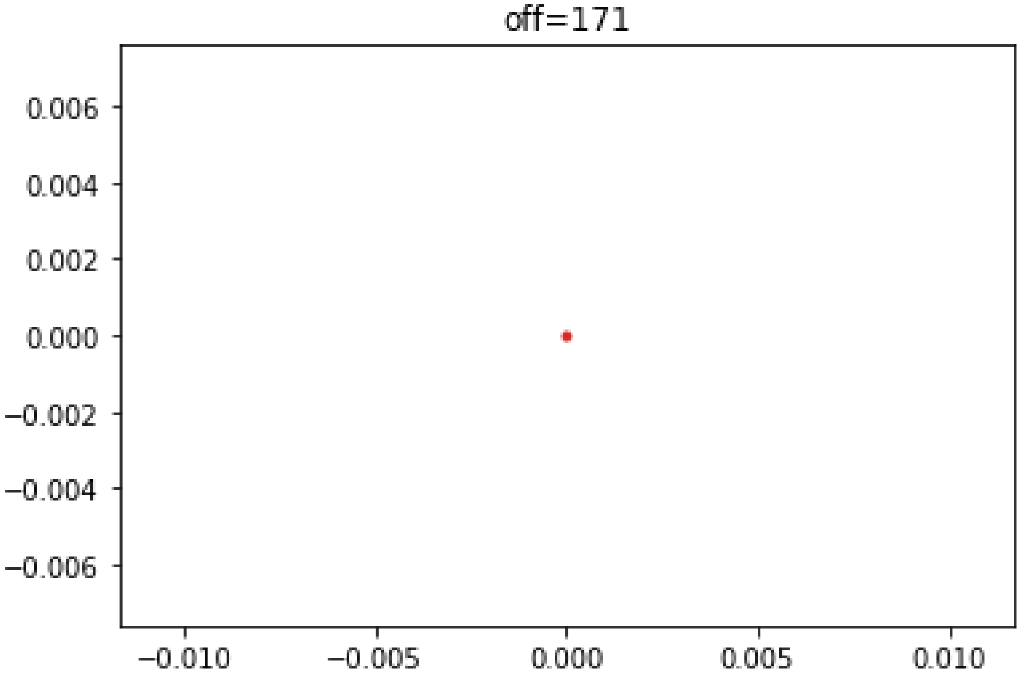
−0.004
−0.006
−0.010
−0.005
0.000
0.005
0.010


off=171
0.006
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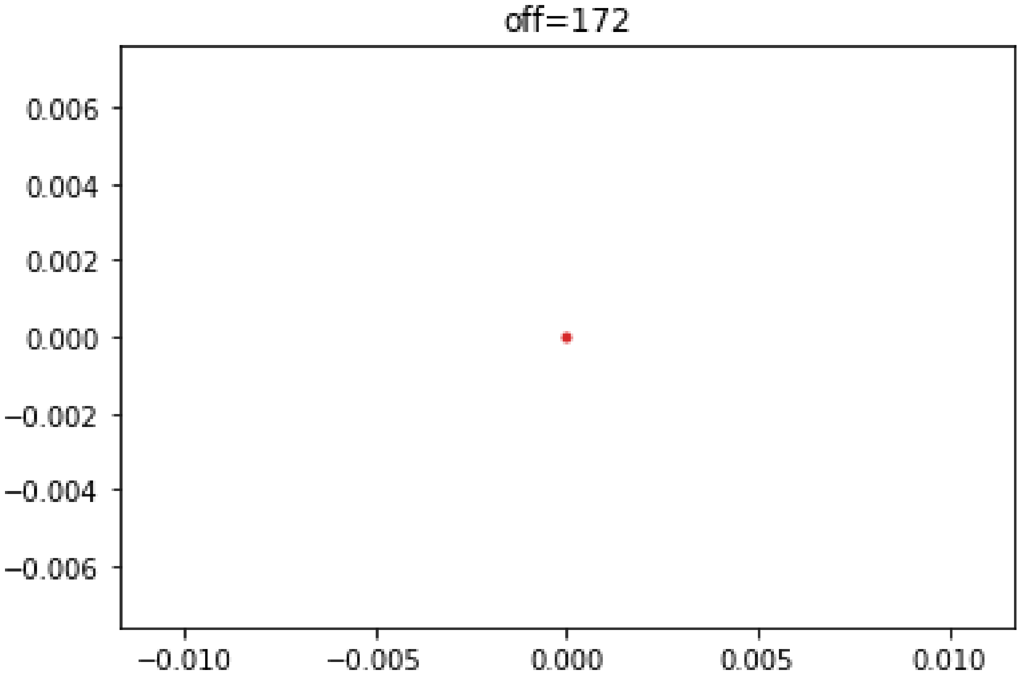
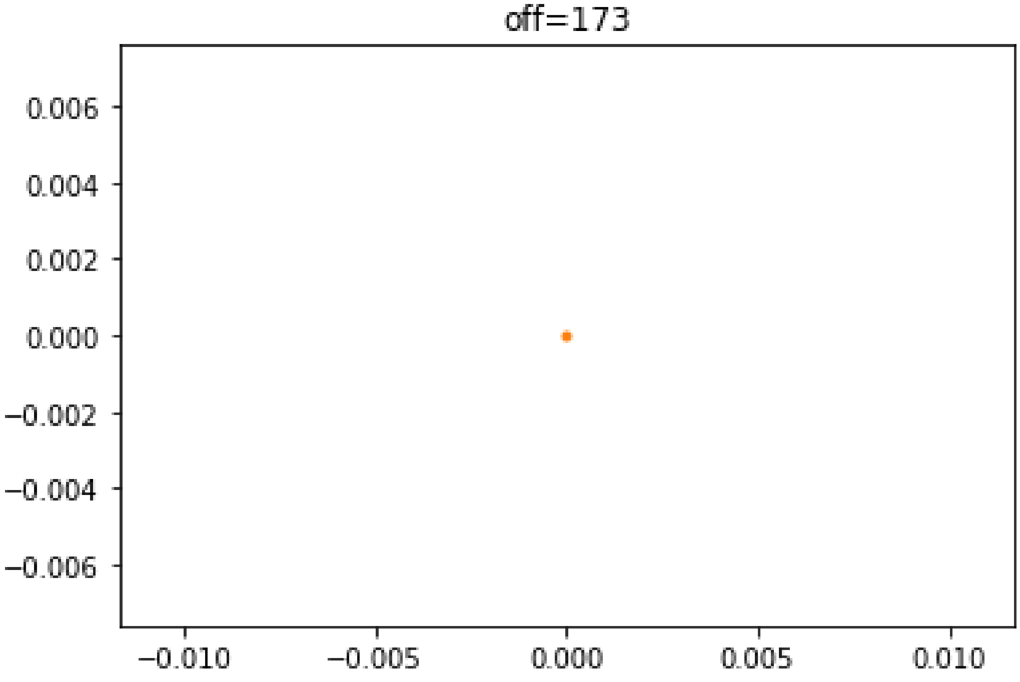
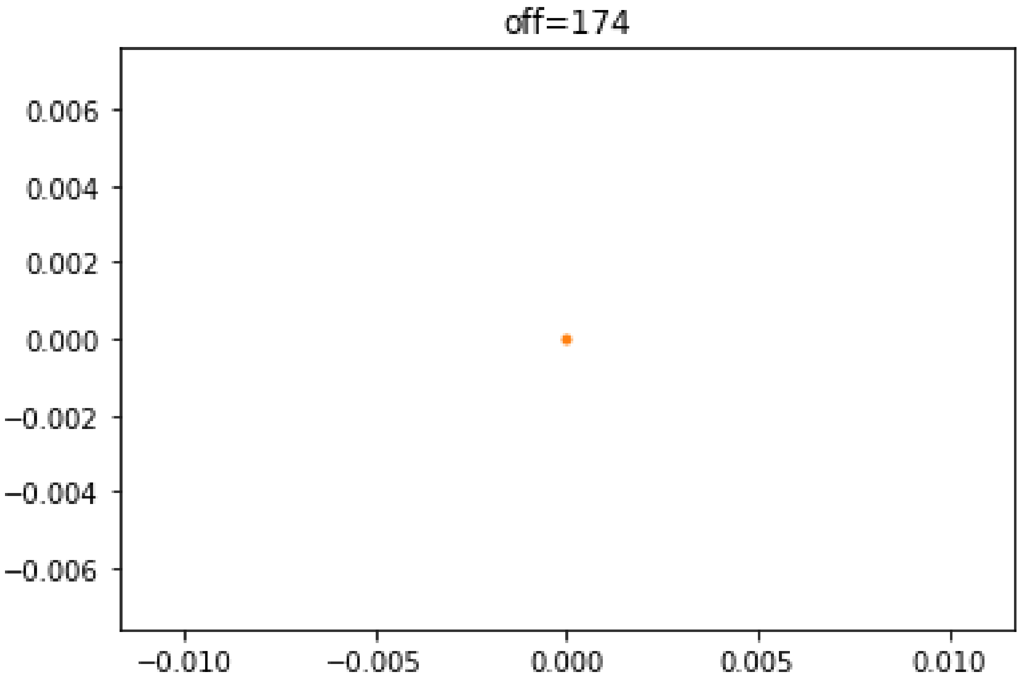
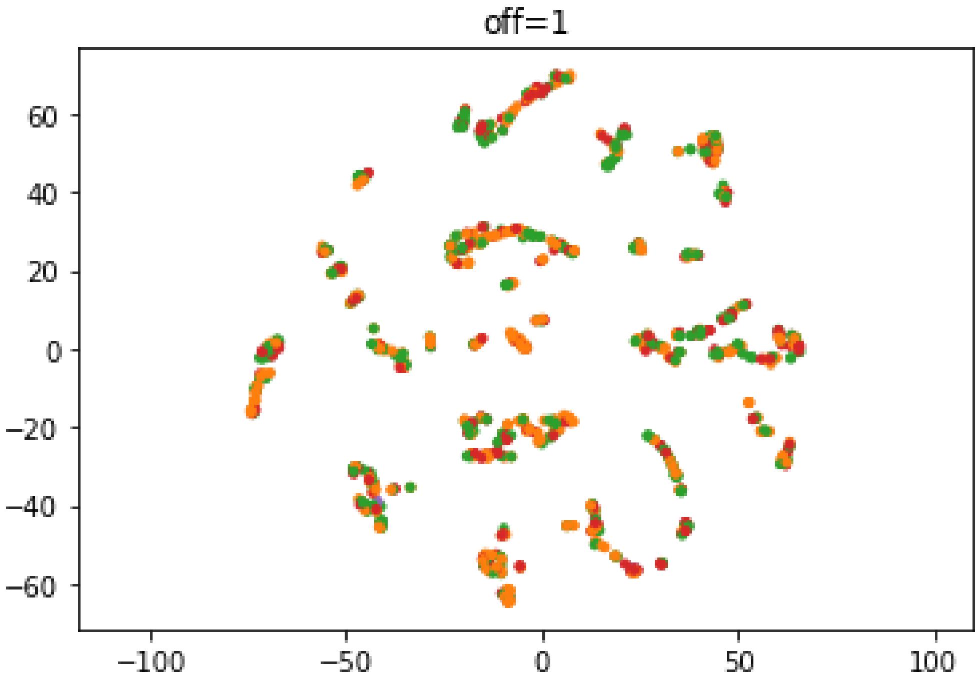
0.002
0.000
−0.002
−0.004
−0.006
−0.010
−0.005
0.000
0.005
0.010

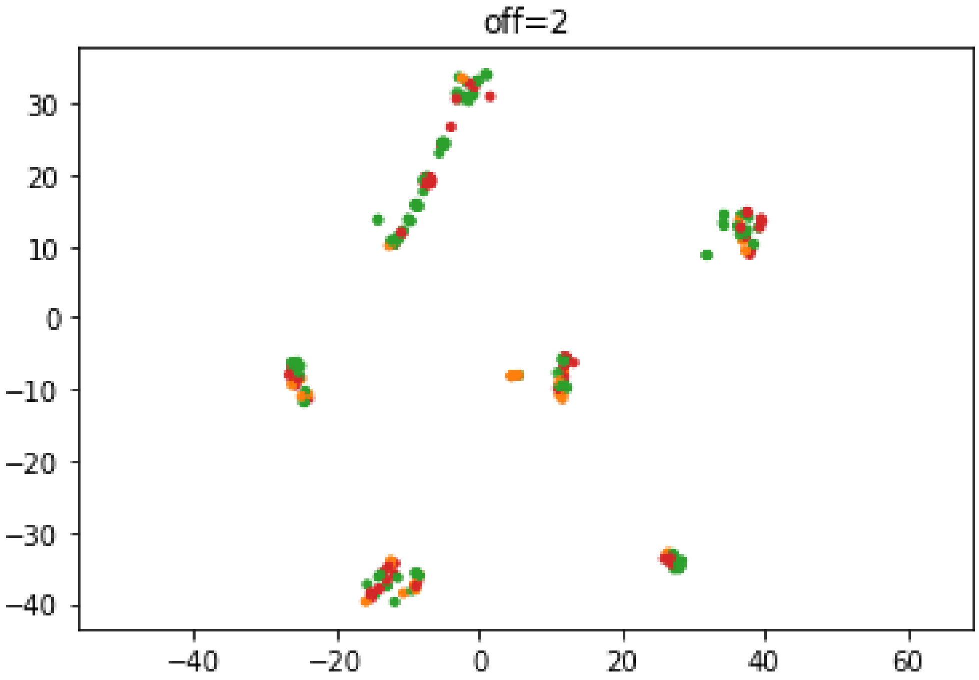

off=172
0.006
0.004
0.002
0.000
−0.002
−0.004
−0.006
−0.010
−0.005
0.000
0.005
0.010

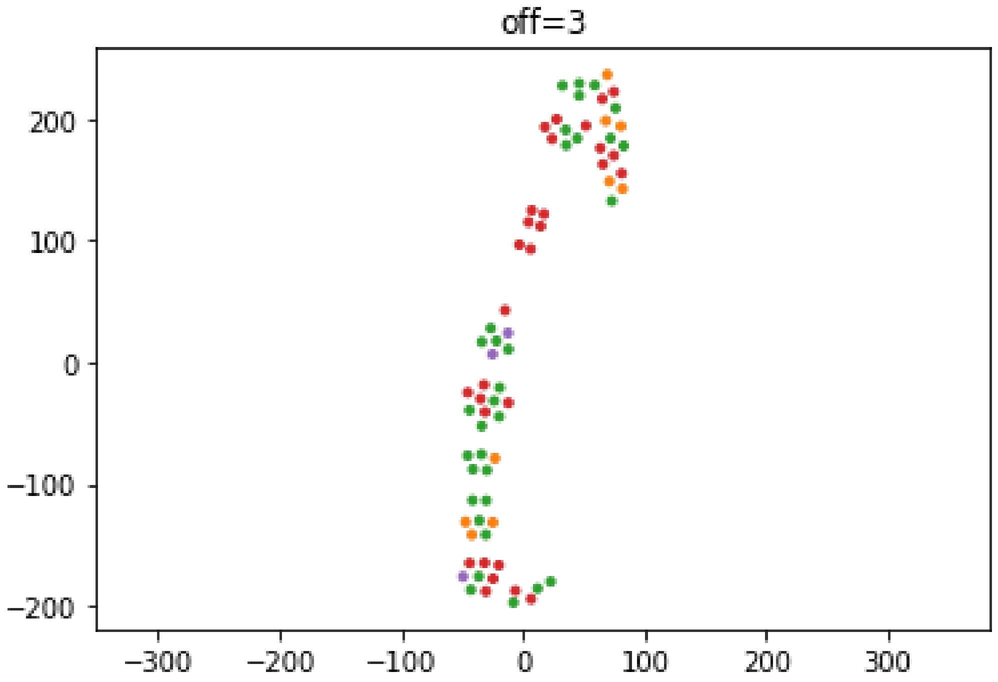

off=173
0.006
0.004
0.002
0.000
−0.002
−0.004
−0.006
−0.010
−0.005
0.000
0.005
0.010

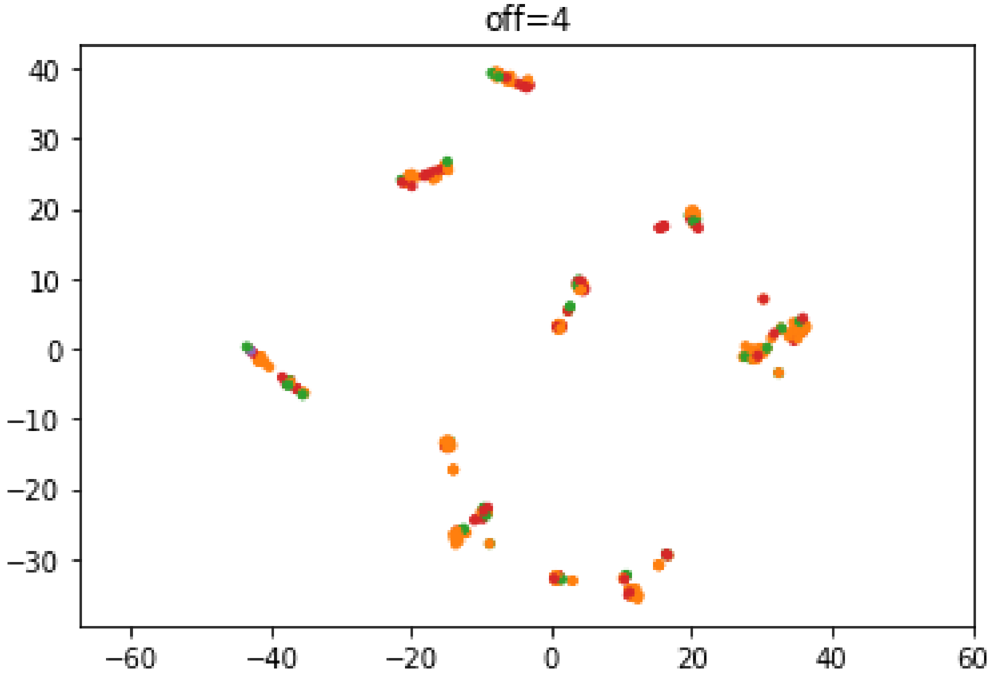


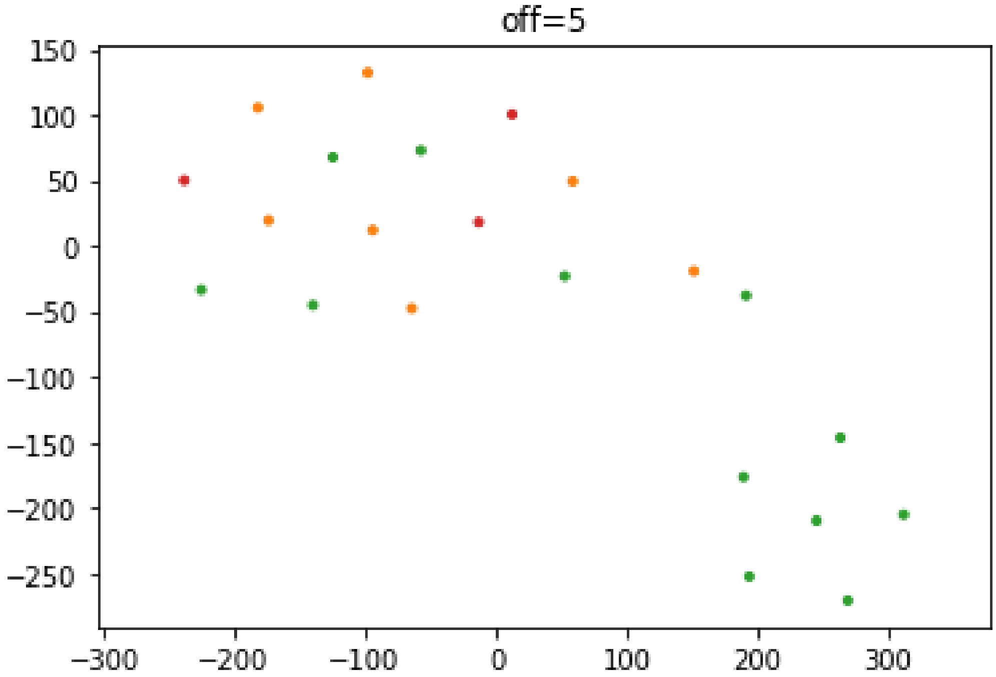
```
In [73]: for off in set(samp.OFFENSE):

             mask = samp_X.OFFENSE == off

             data = samp_X[mask]

             try:
                 trans = TSNE(perplexity=12).fit_transform(data)

                 plt.scatter(trans[:, 0], trans[:, 1], c=[sns.color_palette()[x] for x in samp_
                 plt.gca().set_aspect('equal', 'datalim')
                 plt.title(f'off={off}')
                 plt.show()
             except:

                 continue
```

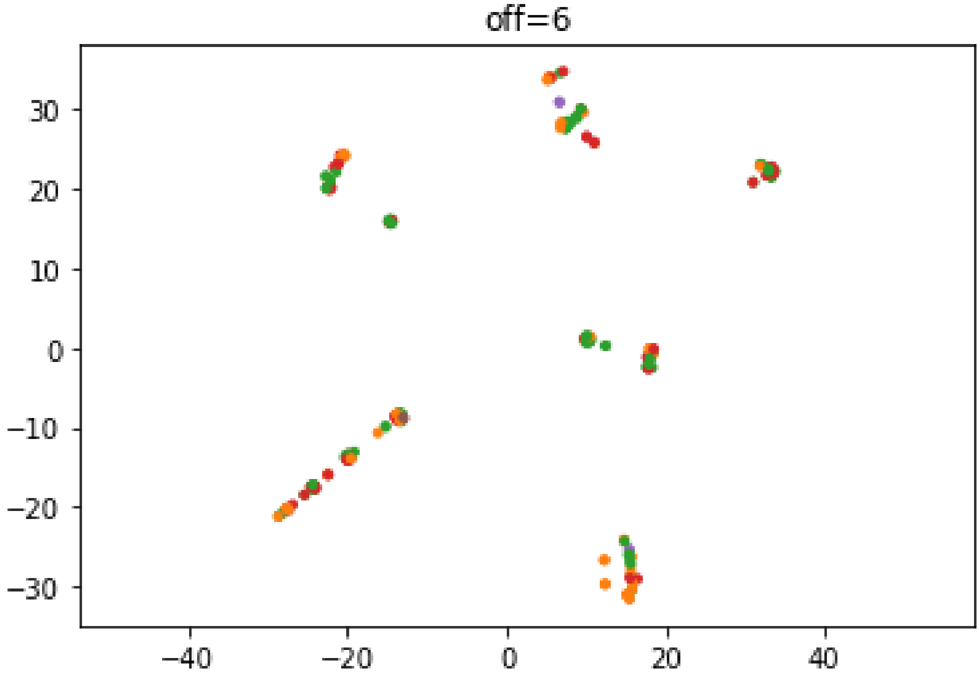

off=1
60
40
20
0
−20
−40
−60
−100
−50
0
50
100

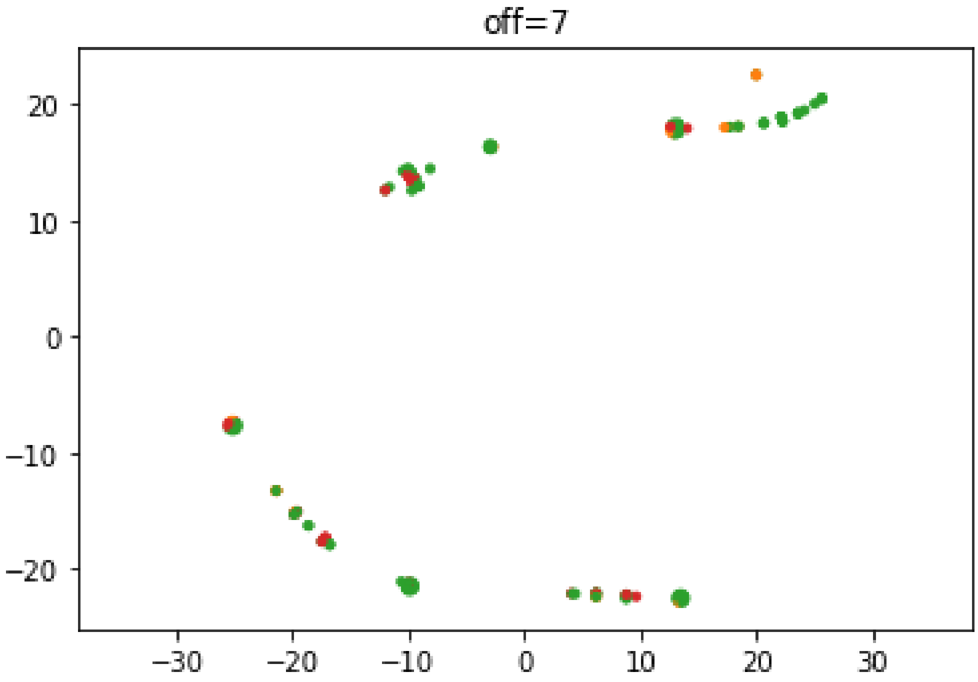

off=2
30
20
10
0
−10
−20
−30
−40
−40
−20
0
20
40
60

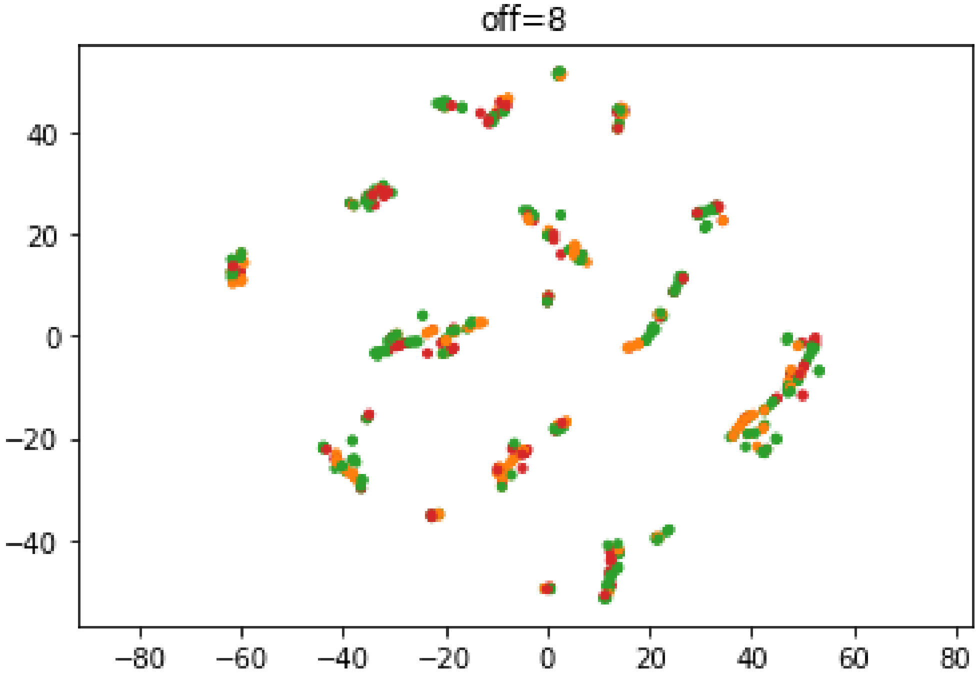

off=3
200
100
0
−100
−200
−300
−200
−100
0
100
200
300


off=4
40
30
20
10
0
−10
−20
−30
−60
−40
−20
0
20
40
60


off=5
150
100
50
0
−50
−100
−150
−200
−250
−300
−200
−100
0
100
200
300


off=6
30
20
10
0
−10
−20
−30
−40
−20
0
20
40


off=7
20
10
0
−10
−20
−30
−20
−10
0
10
20
30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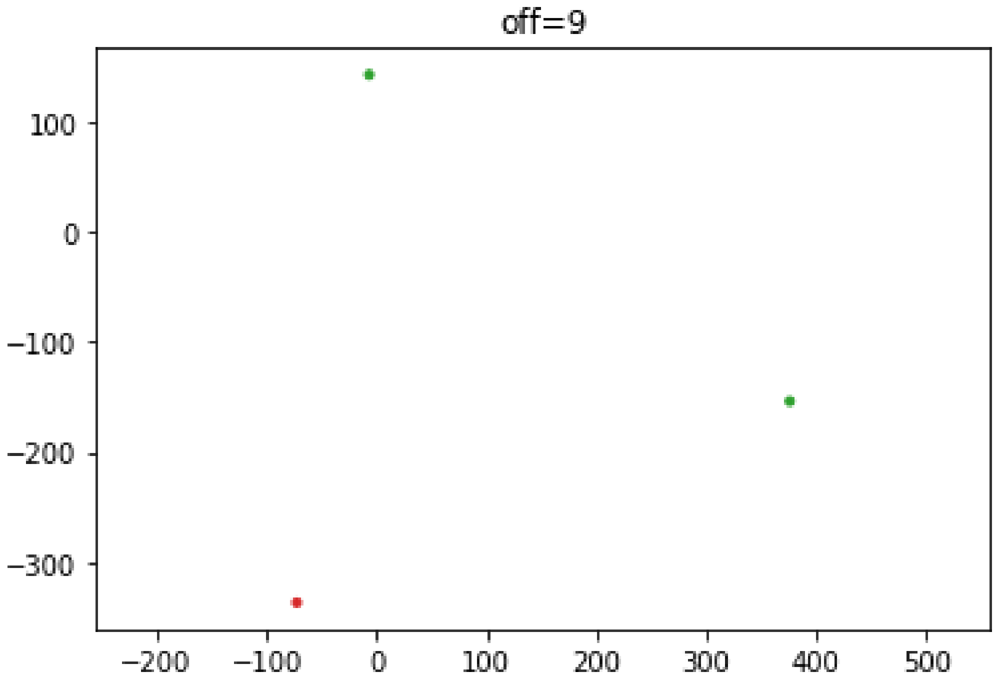
40
20
0
−20
−40
−80
−60
−40
−20
0
20
40
60
80


off=9
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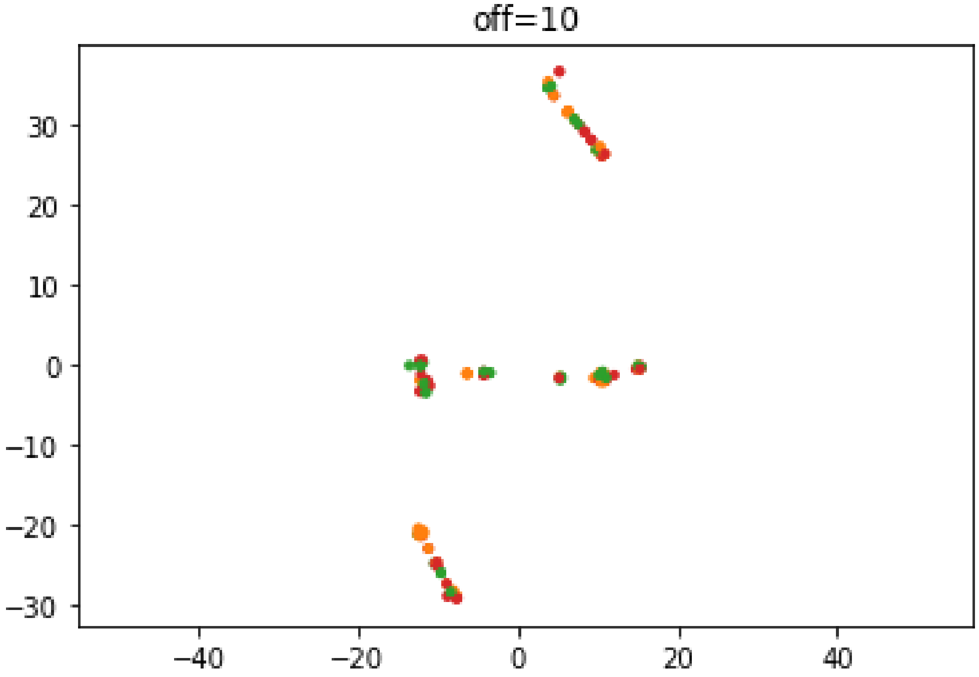
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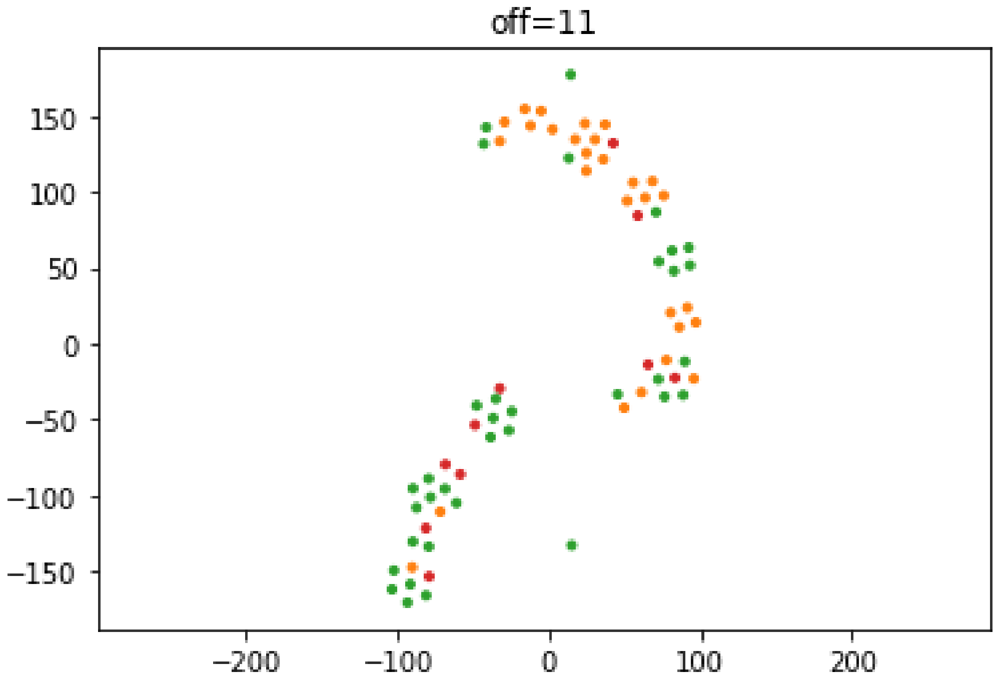
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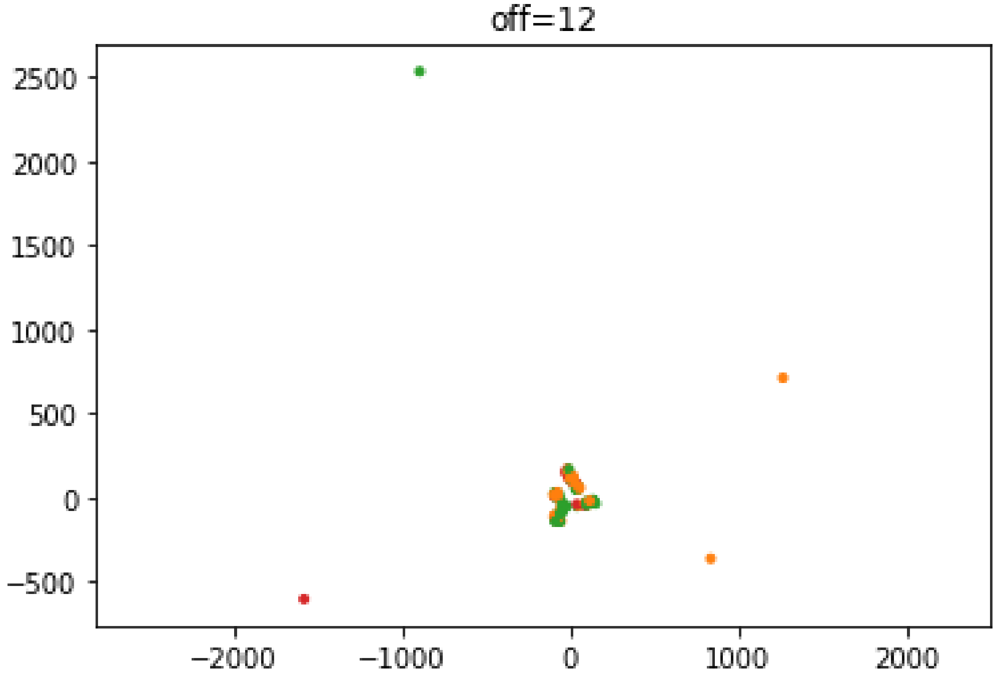
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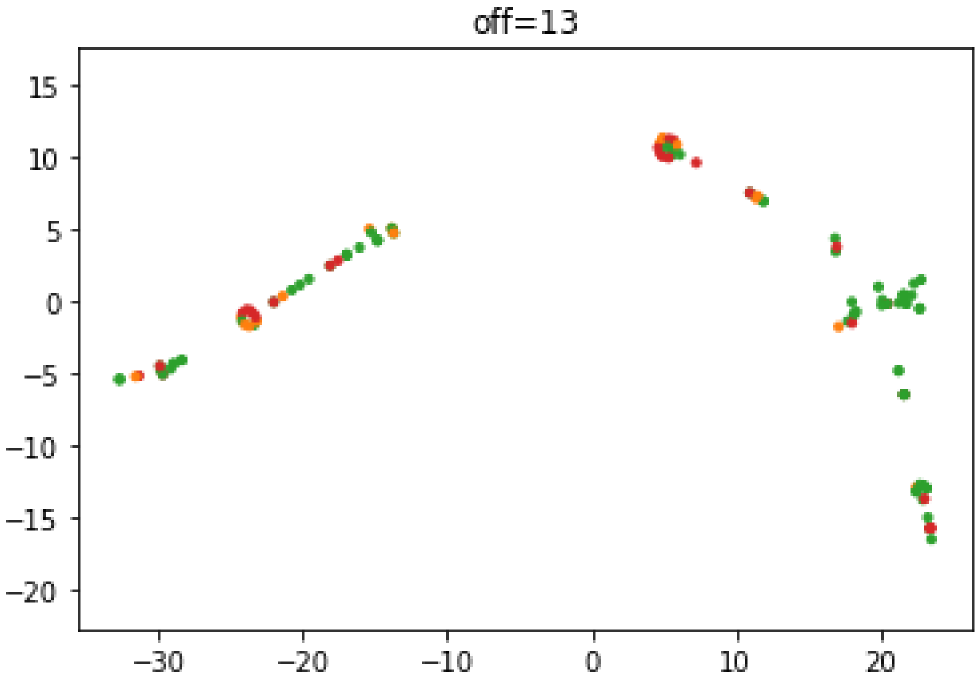
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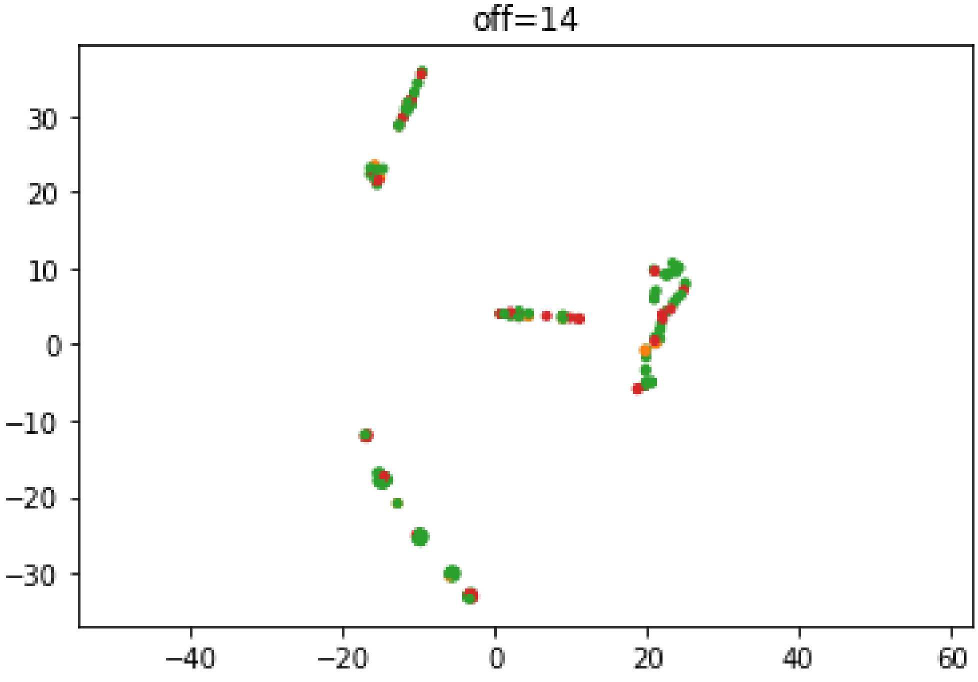
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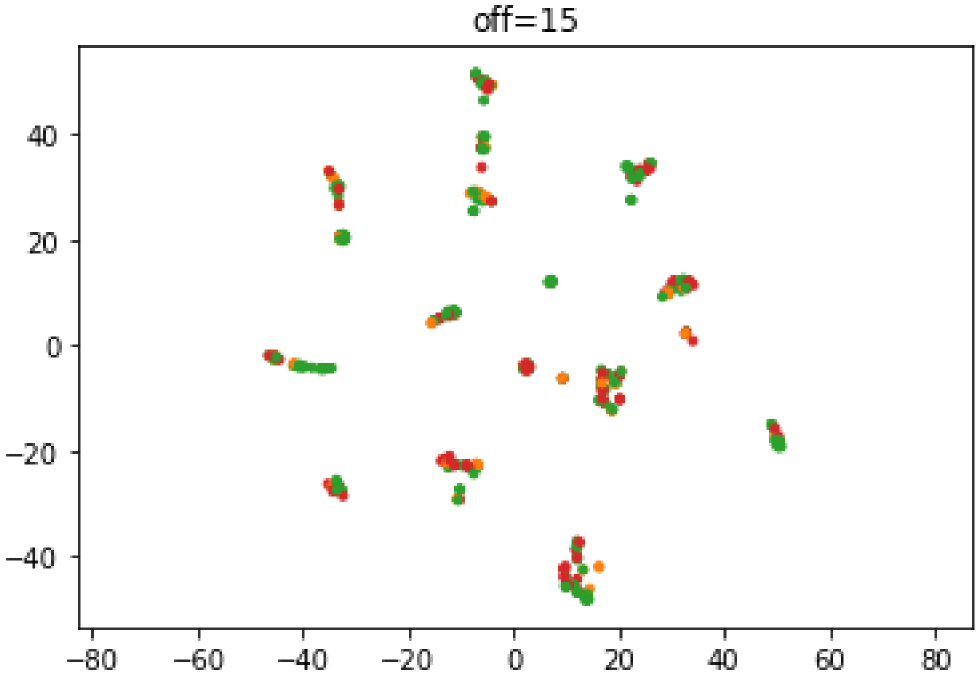
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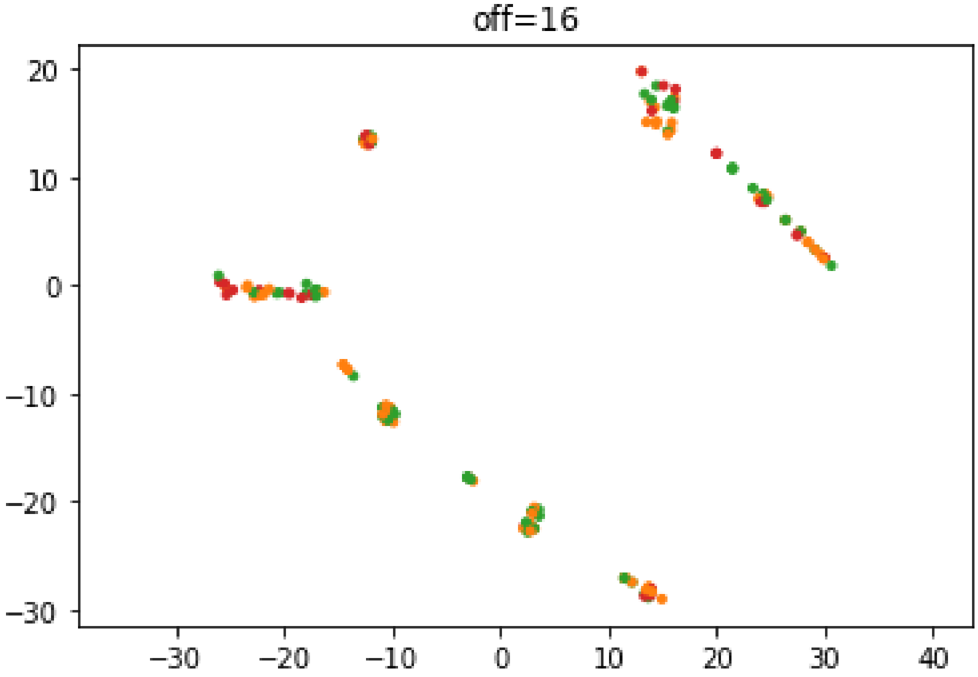
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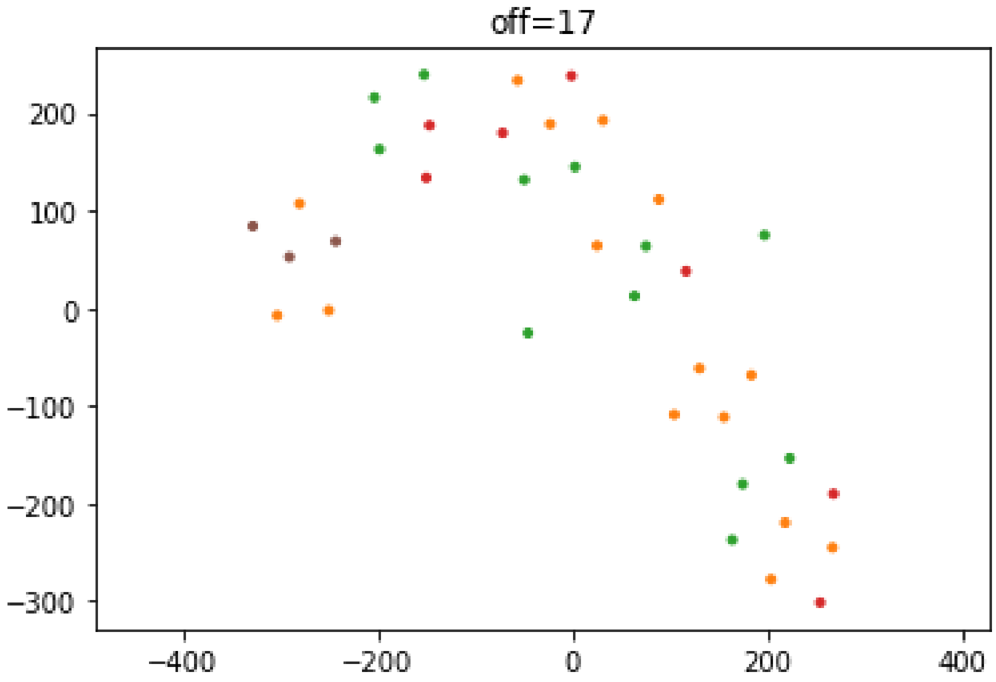
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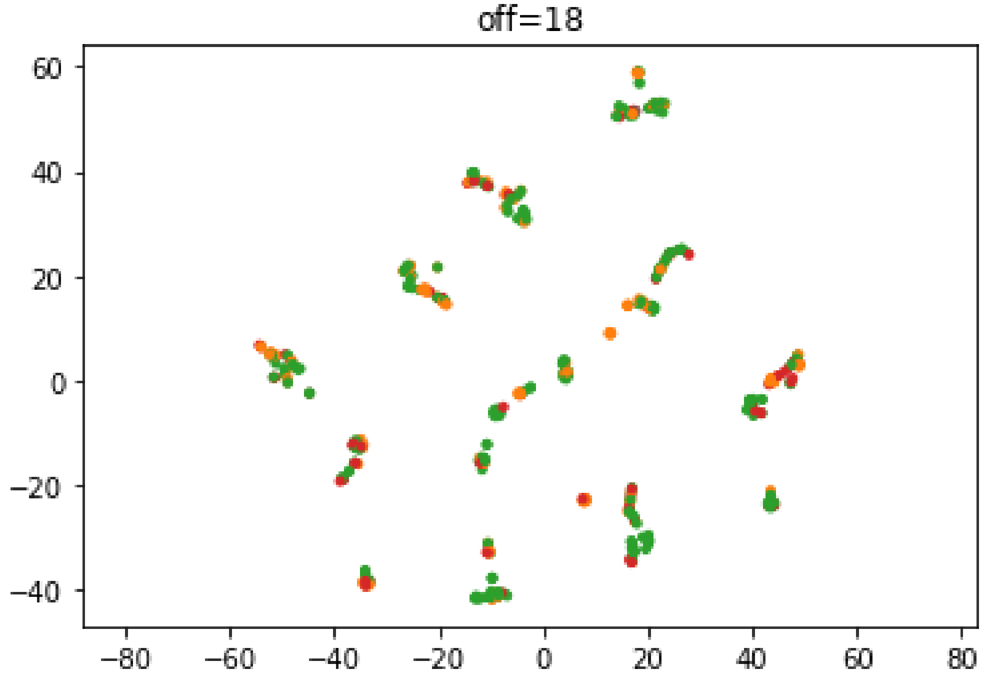
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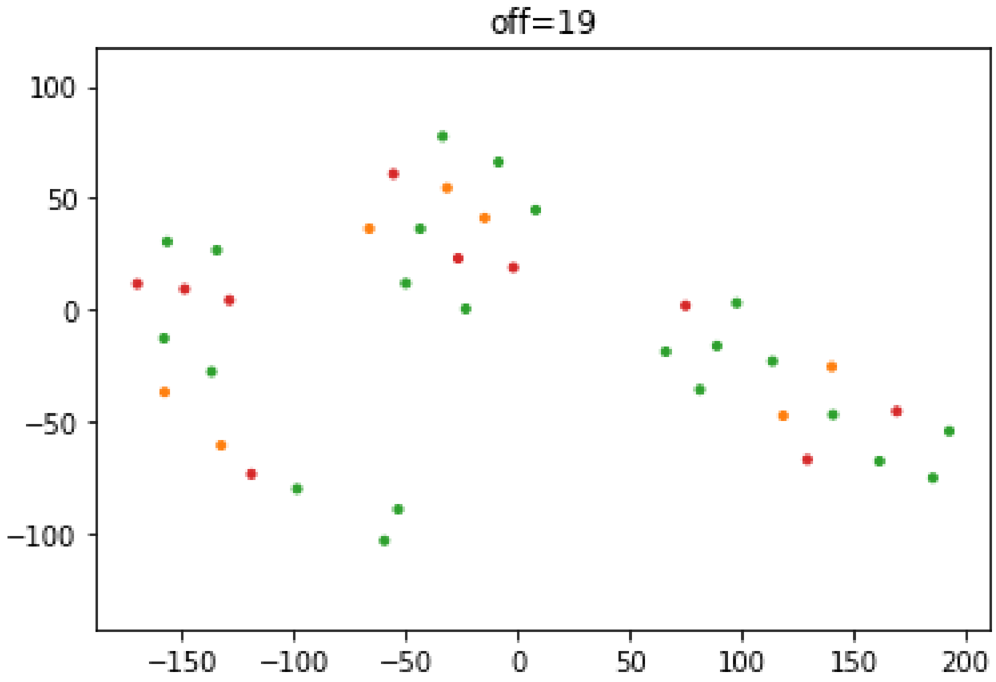
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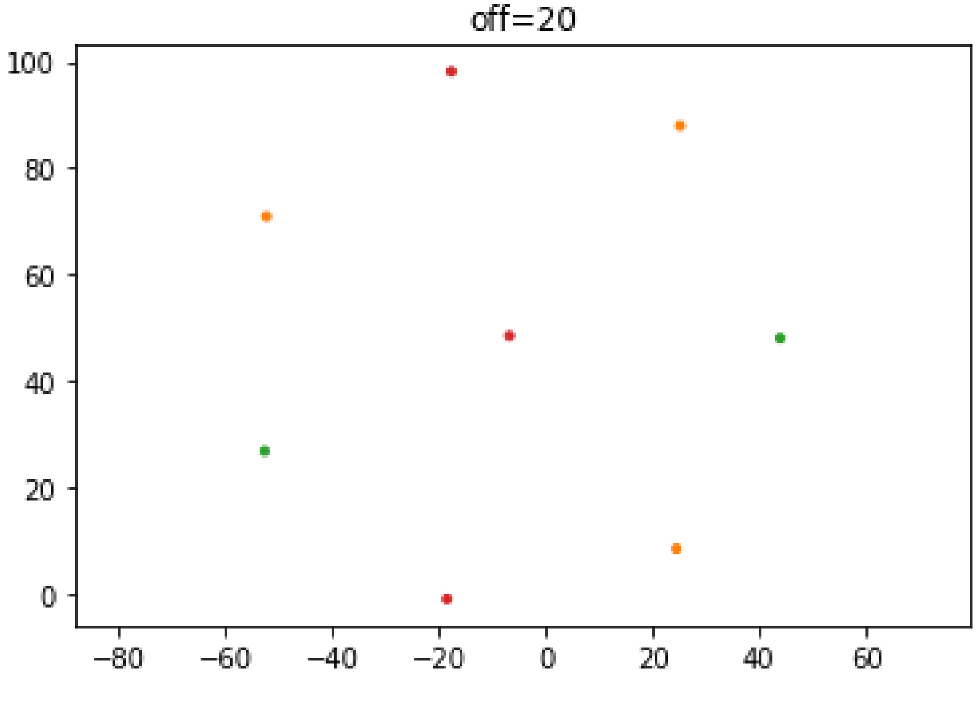
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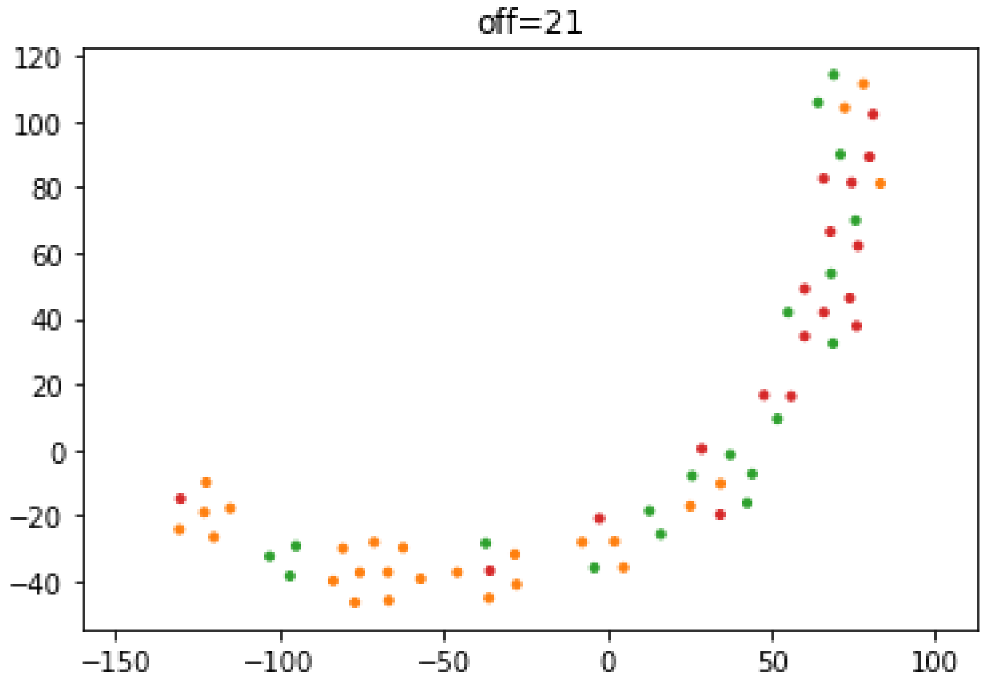
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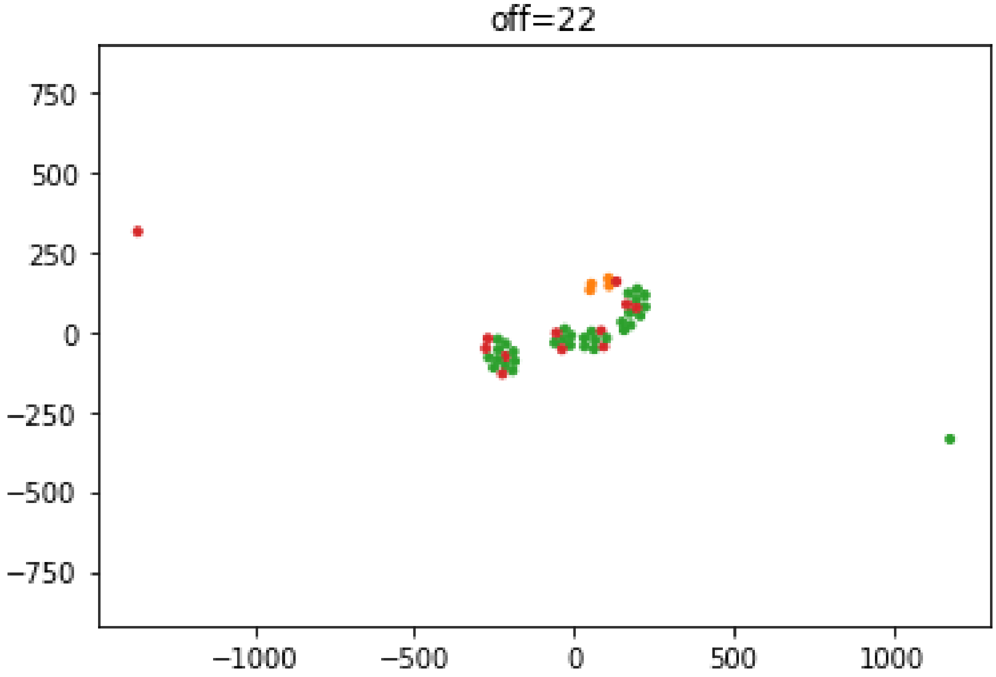
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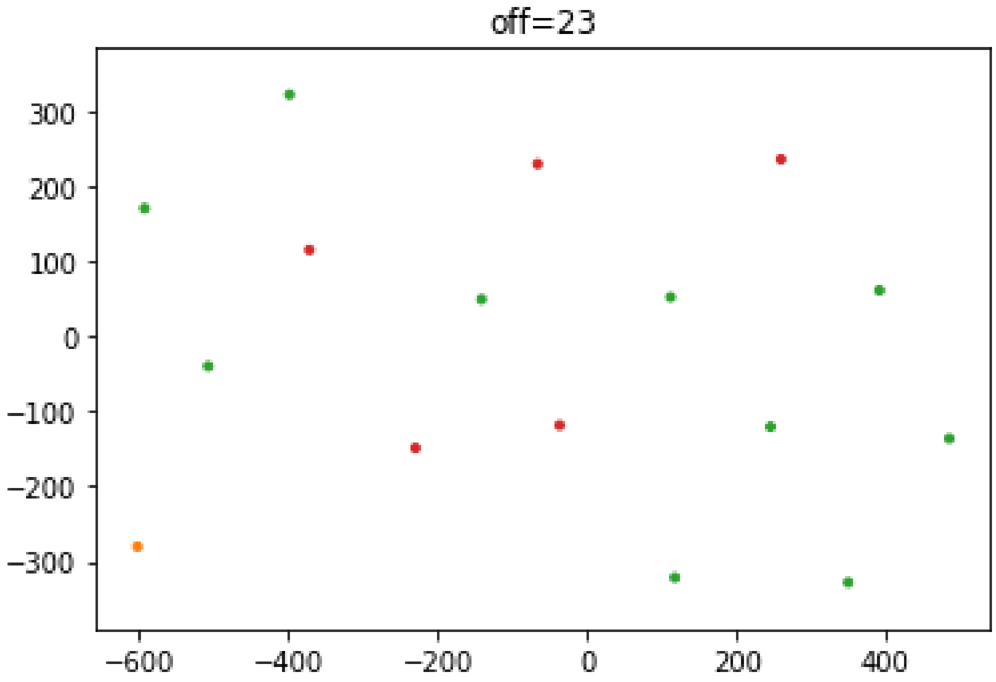
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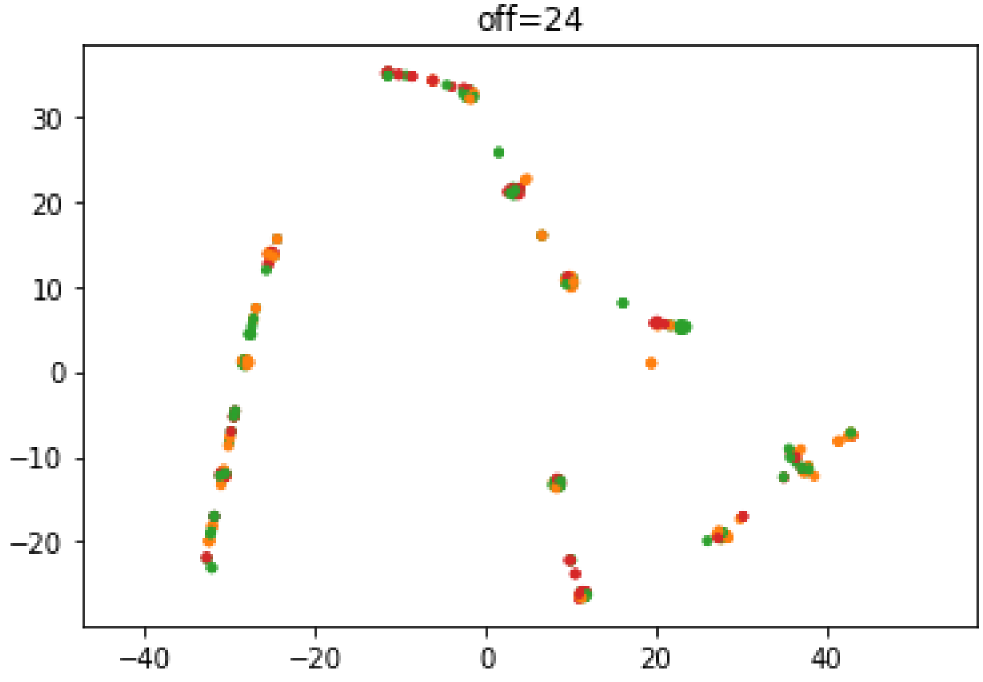
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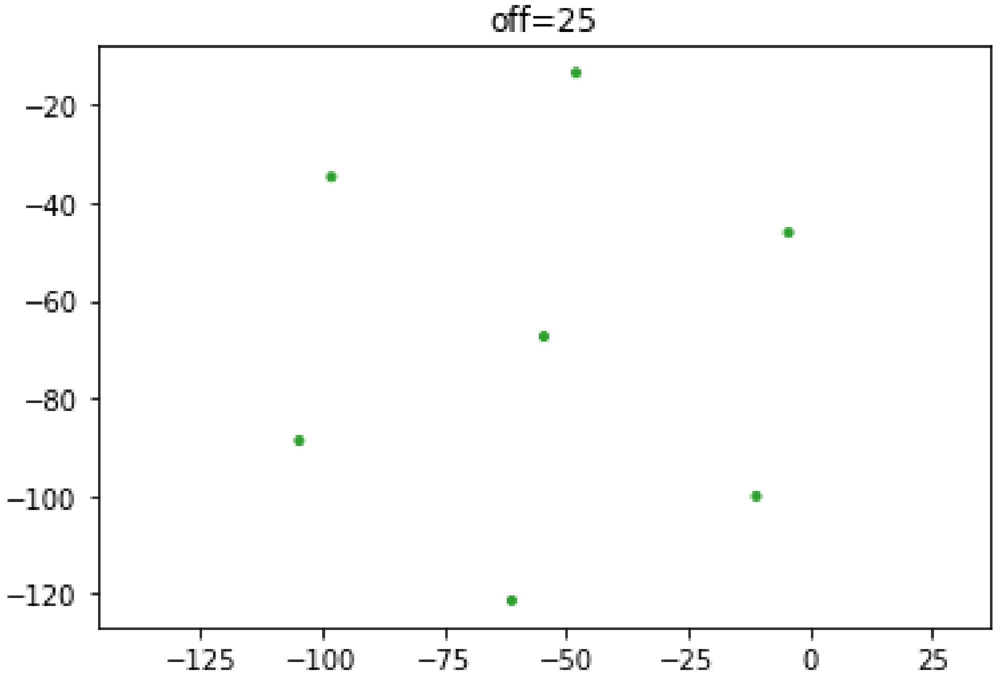
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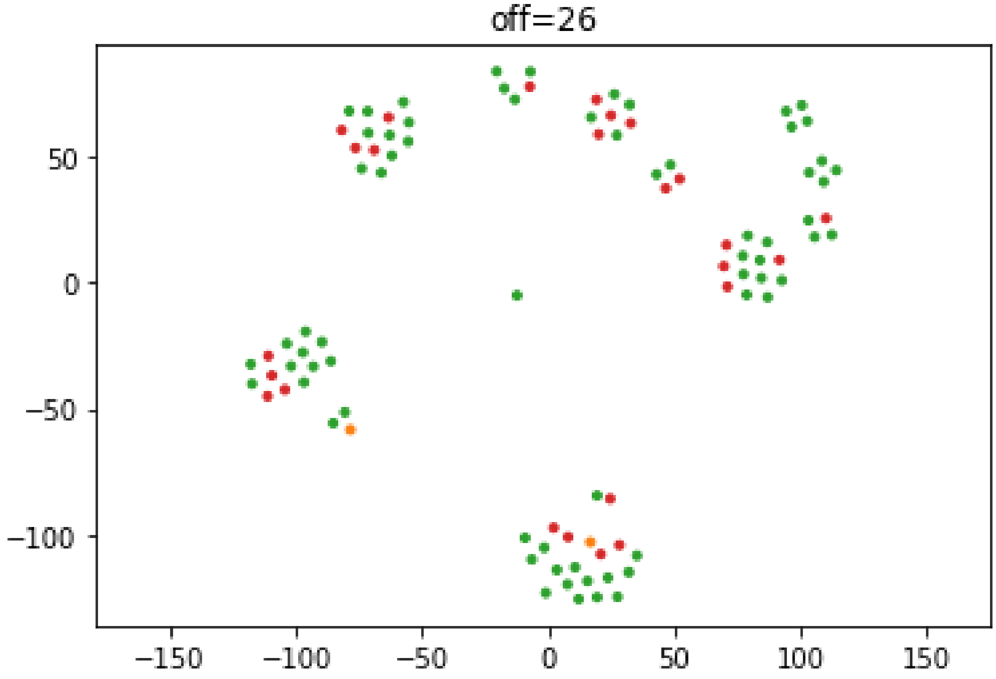
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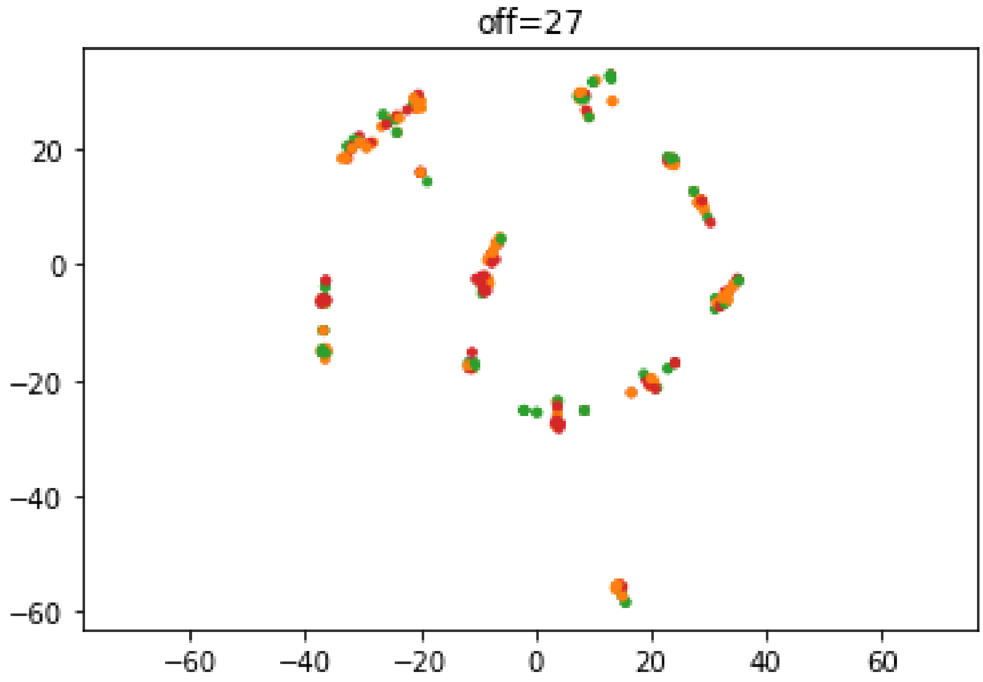
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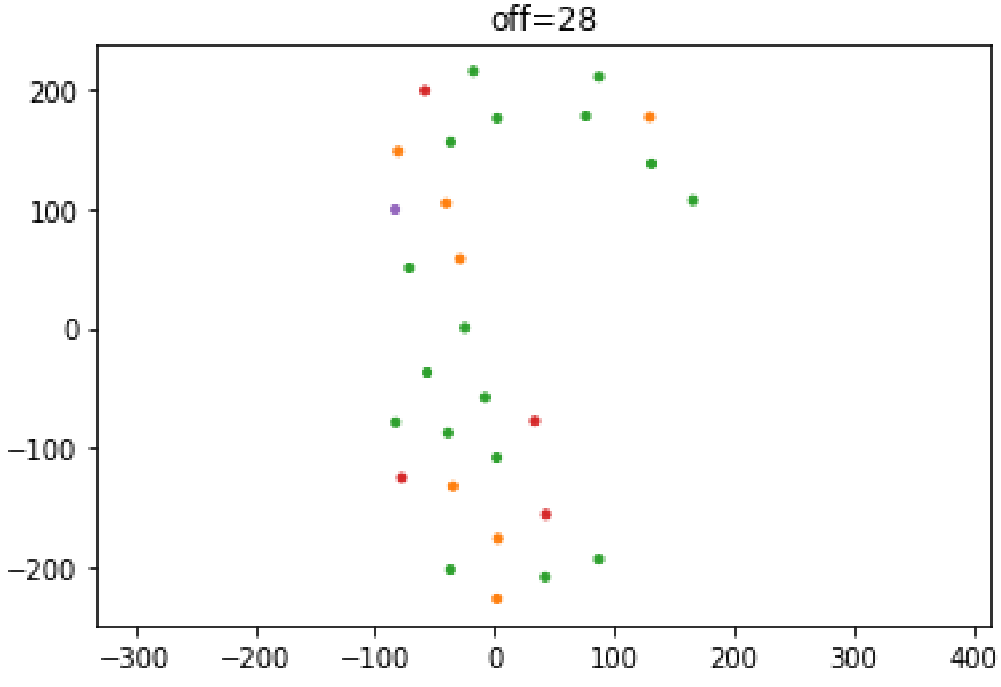
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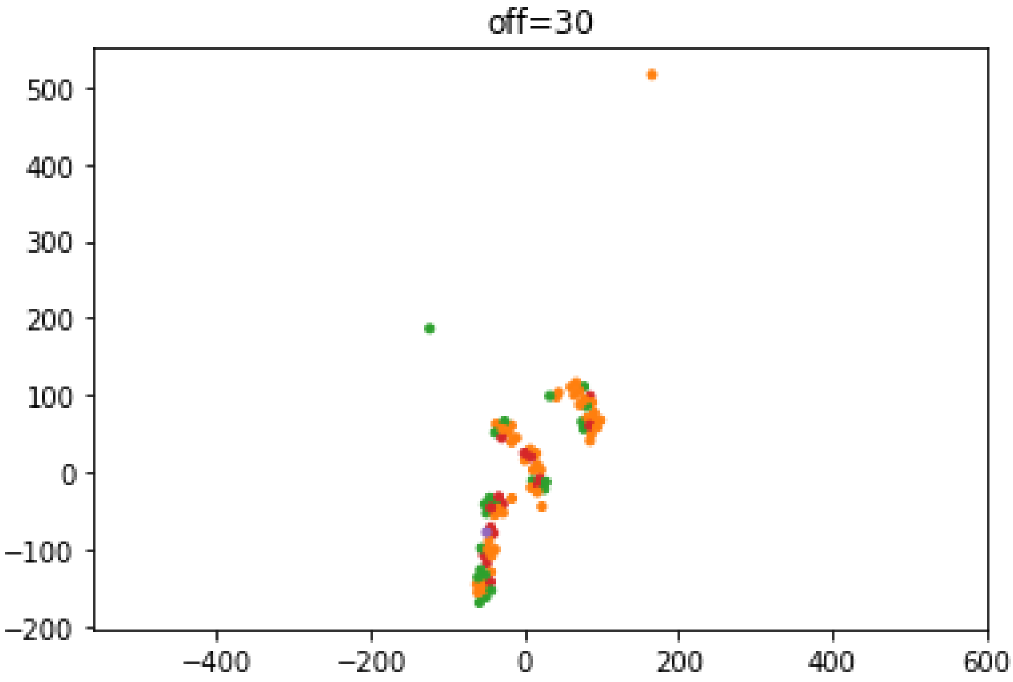
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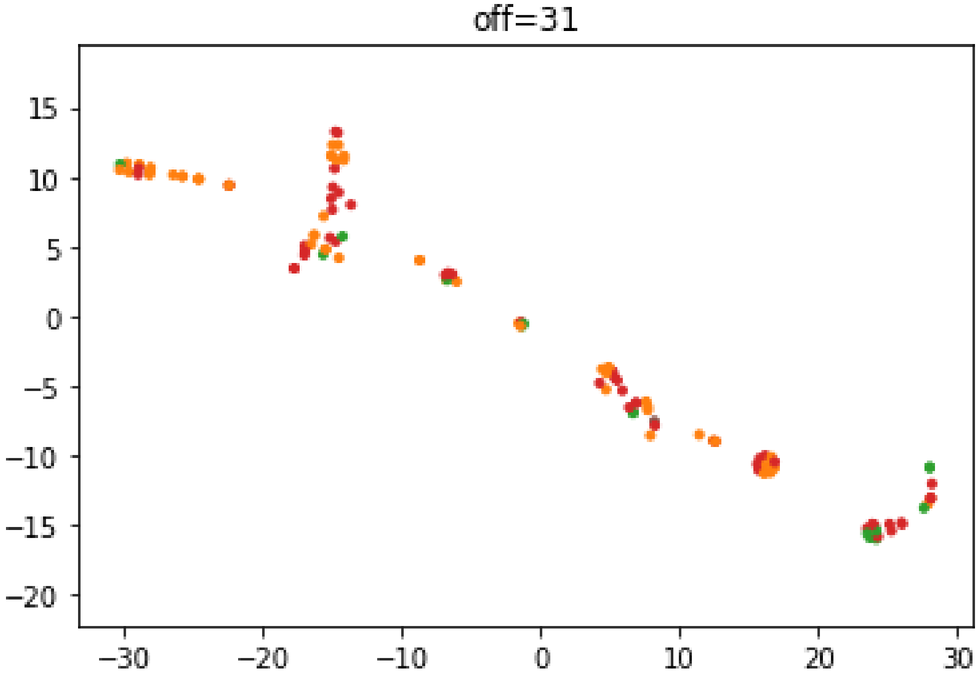
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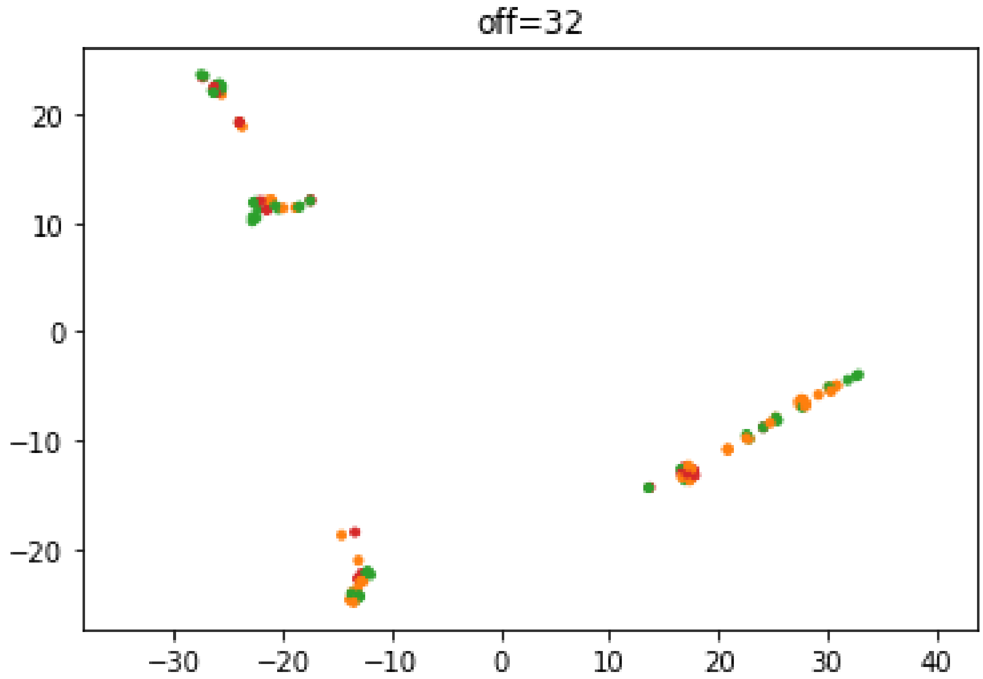
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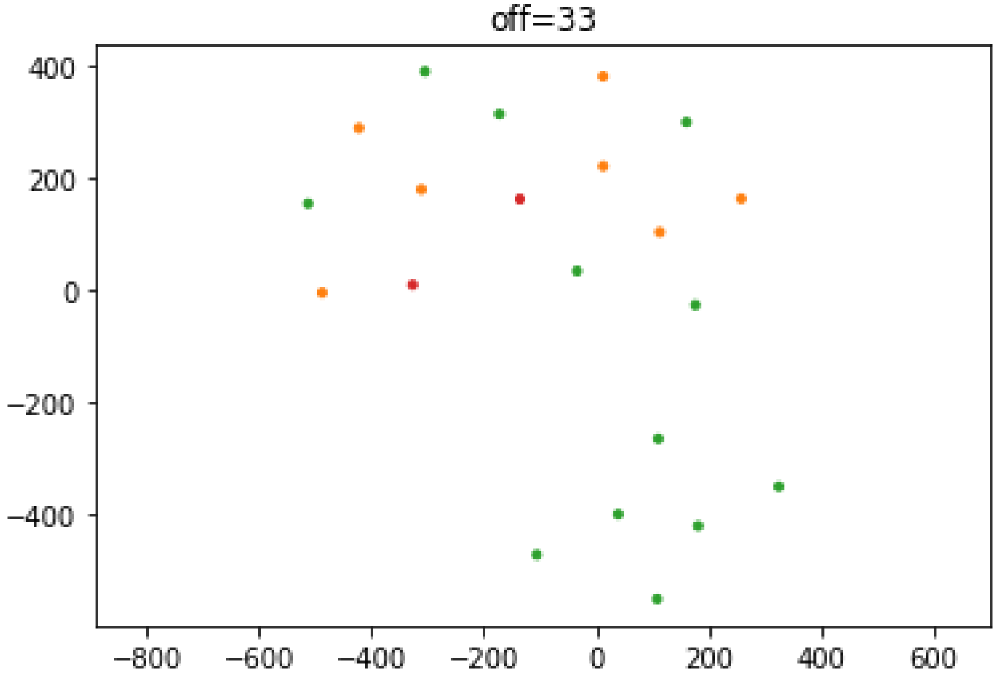
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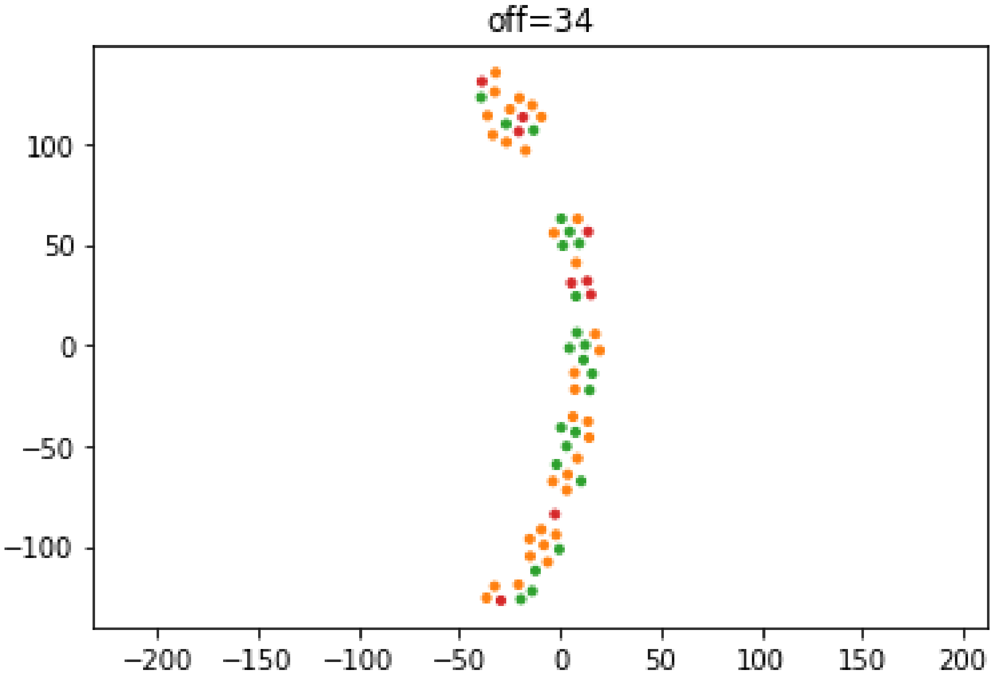
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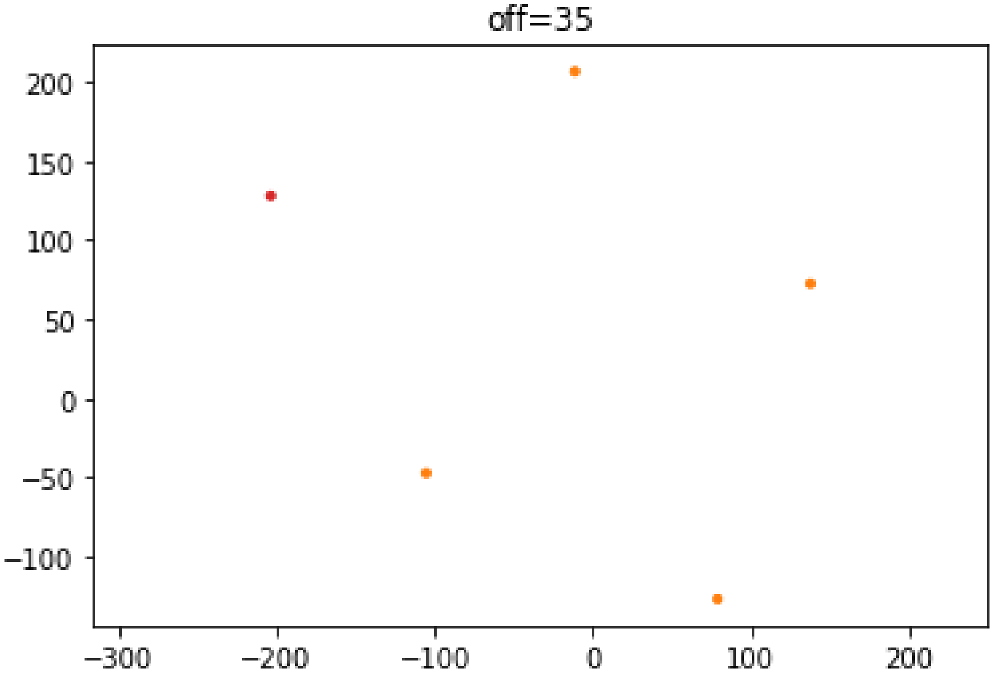
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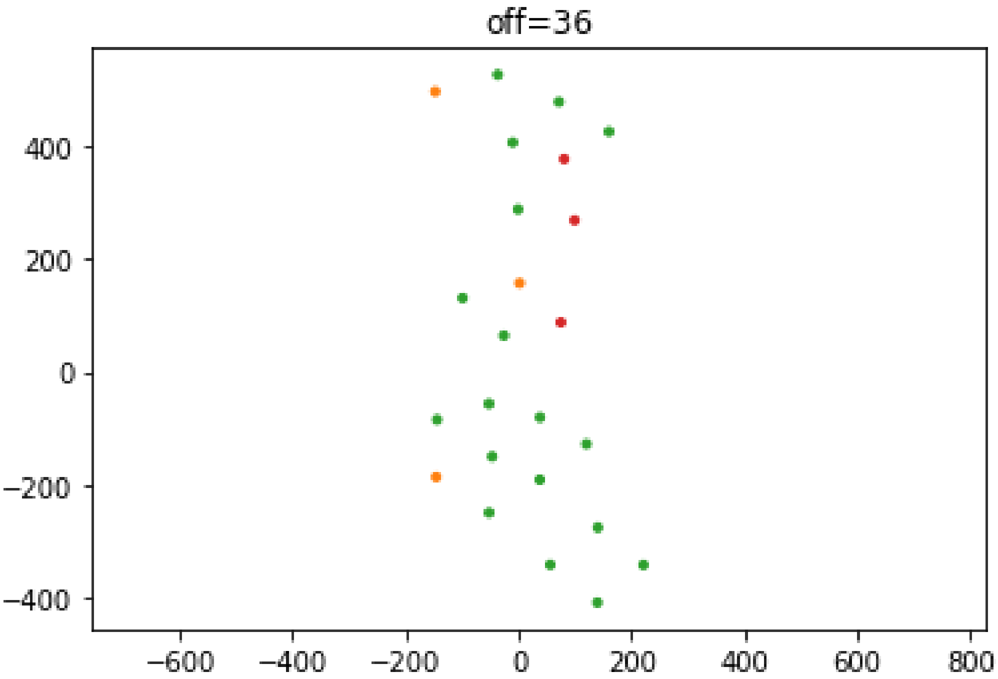
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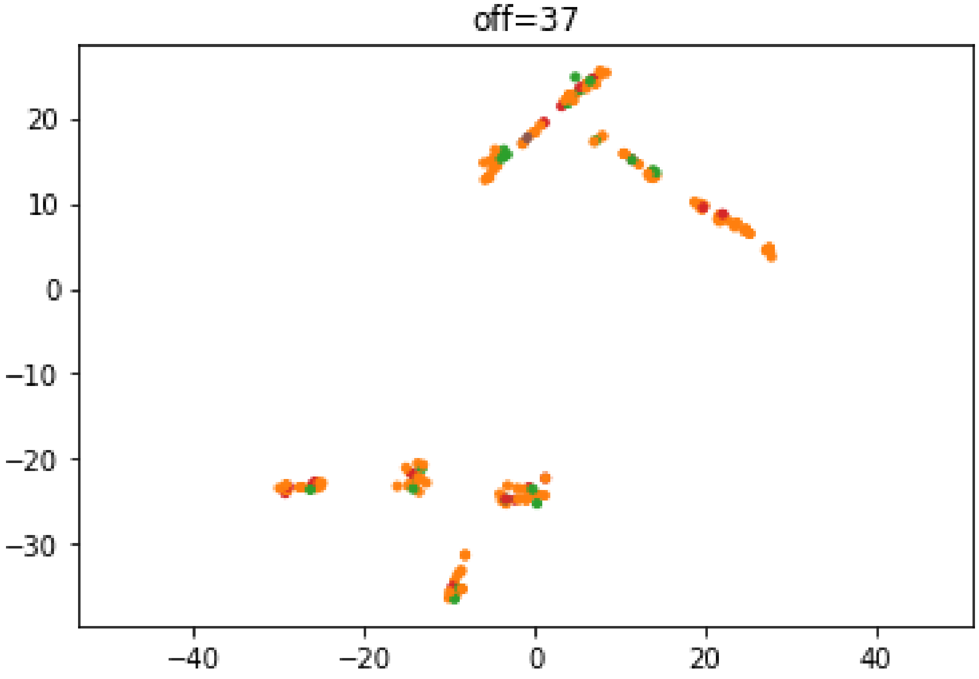
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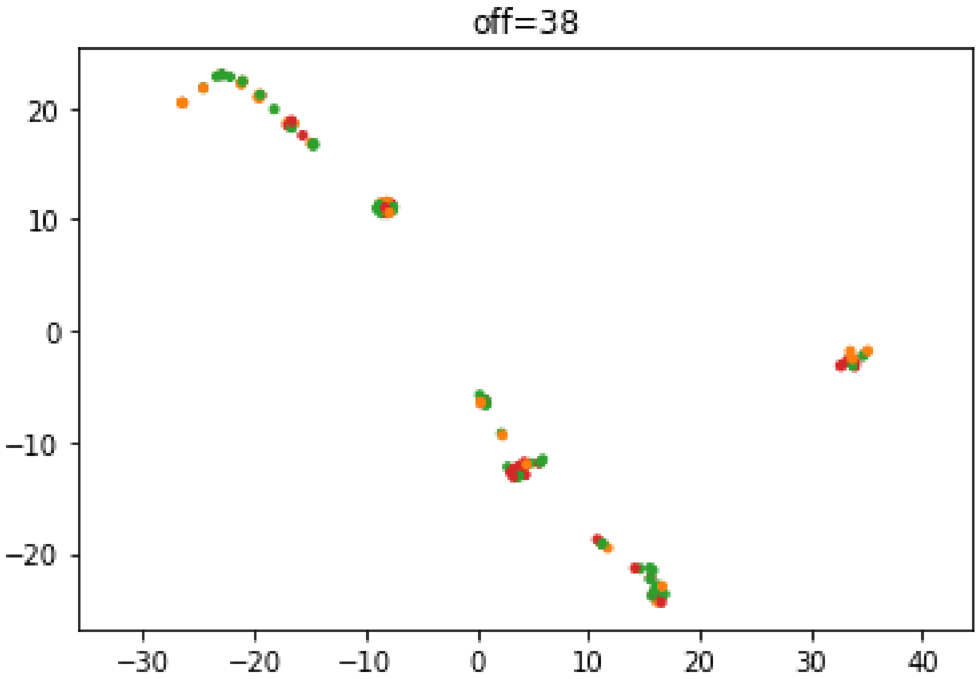
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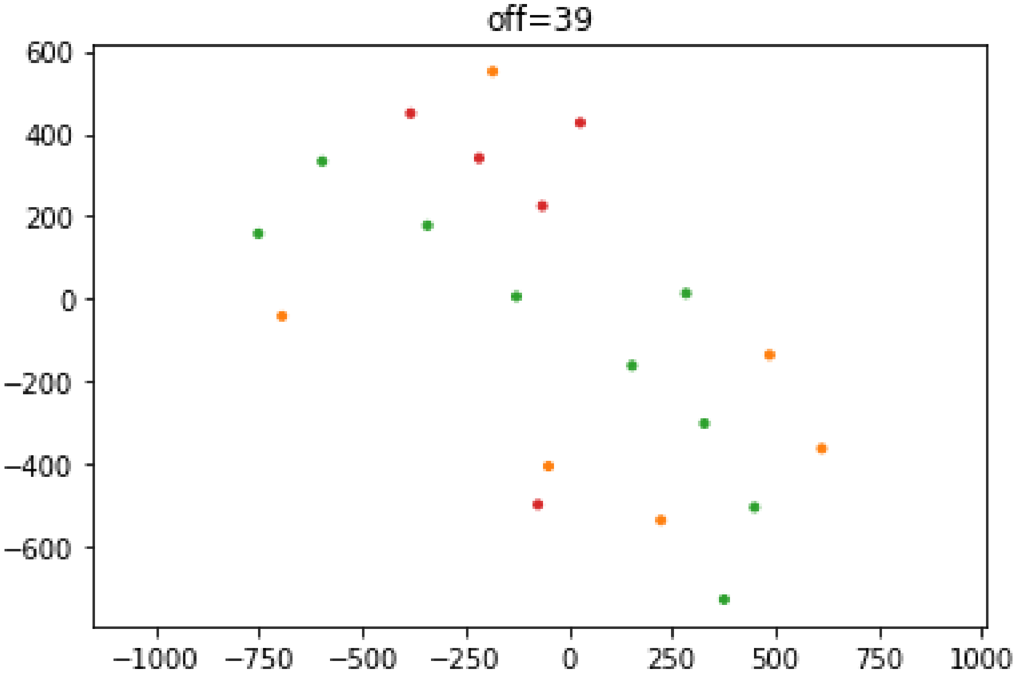
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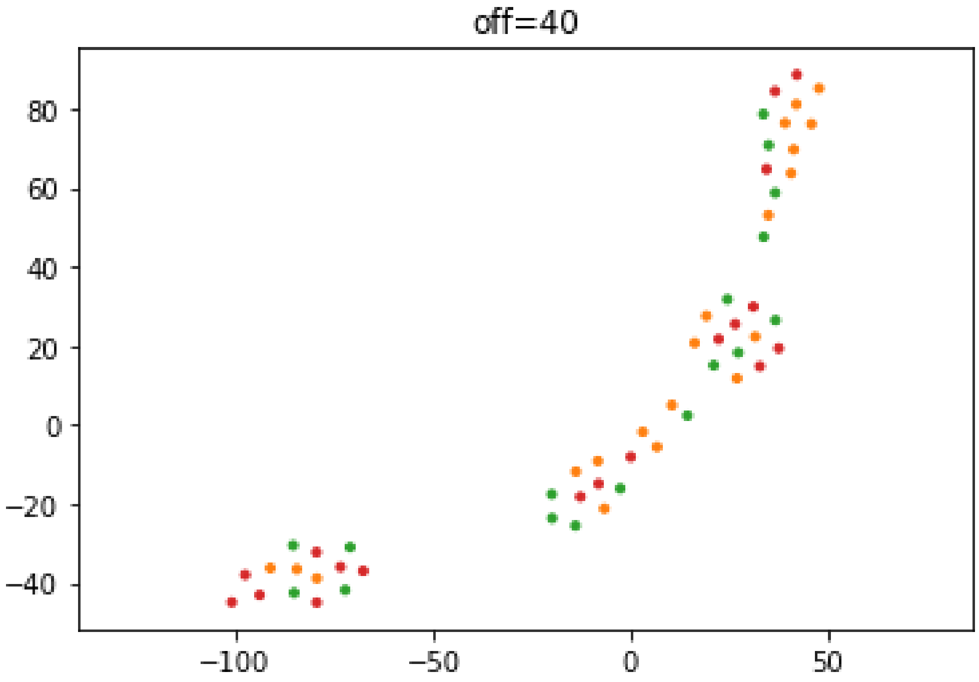
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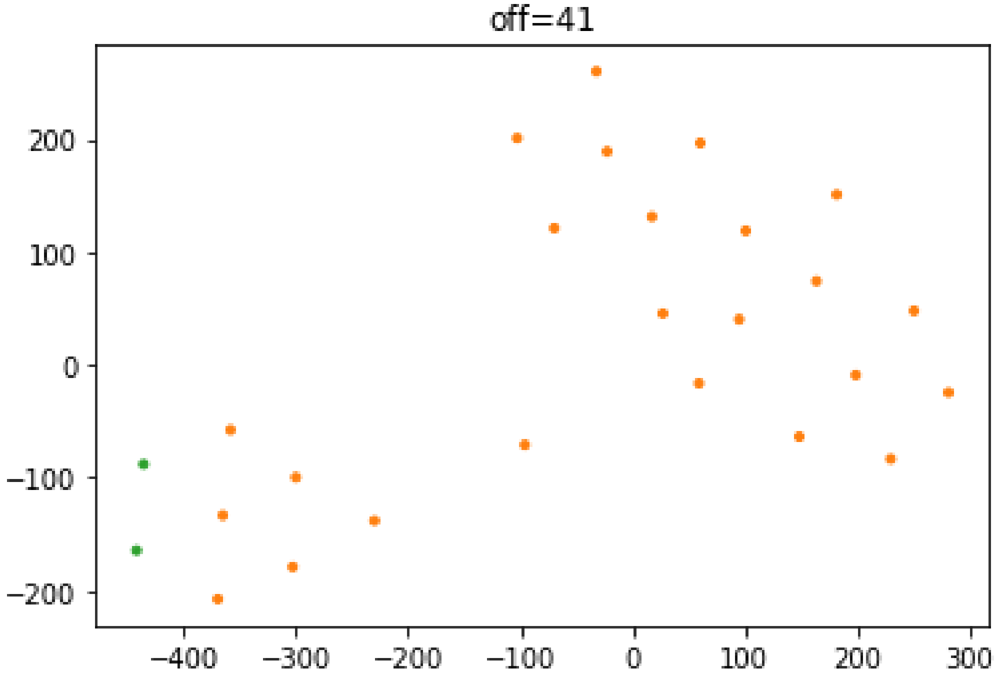
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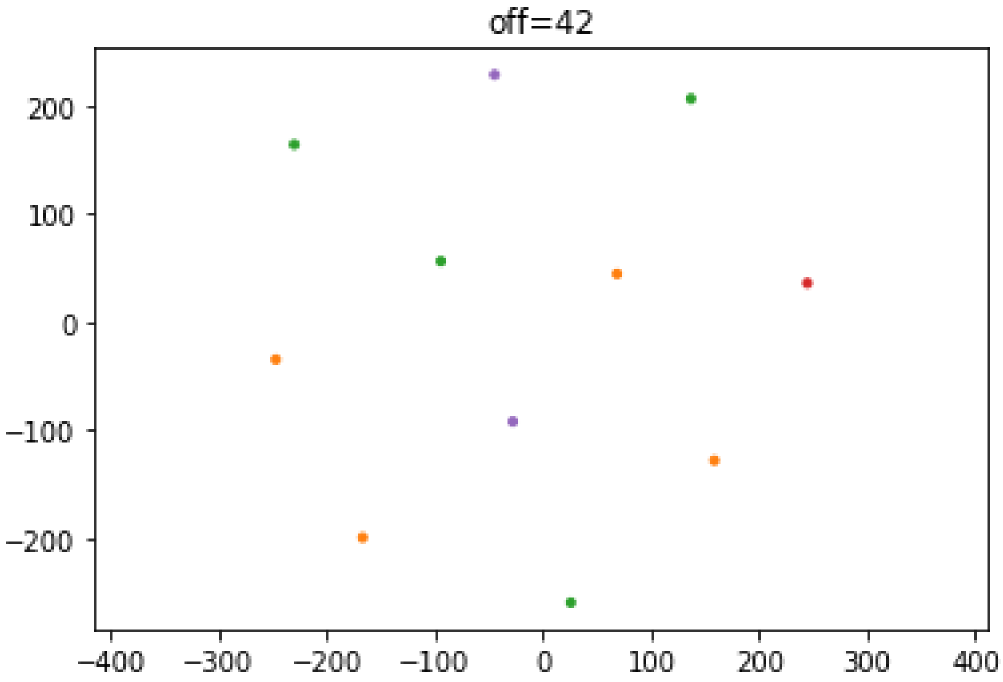
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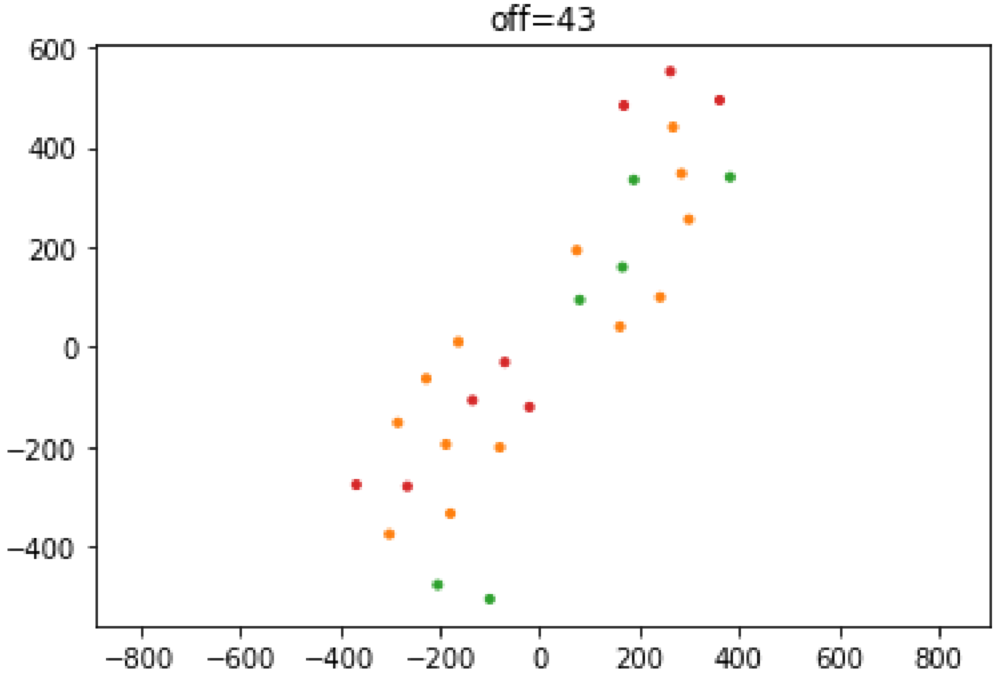
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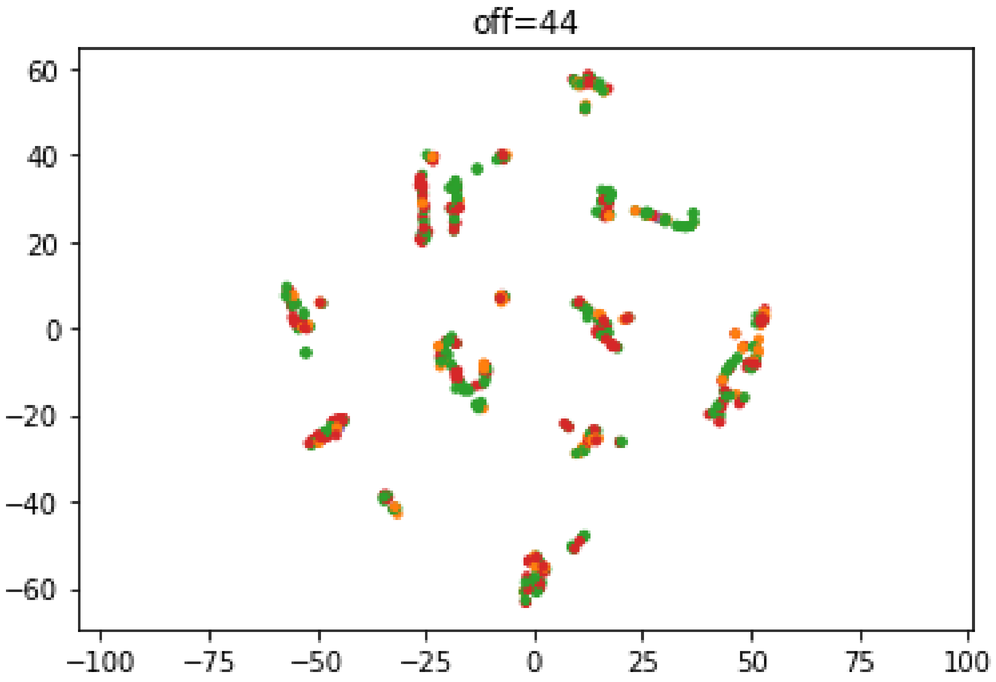
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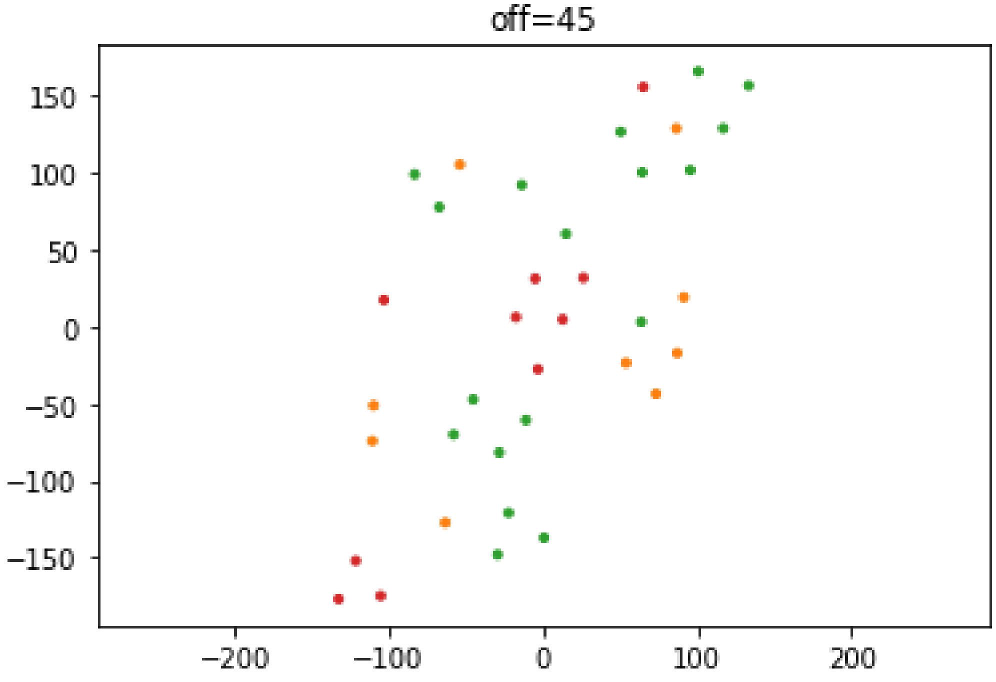
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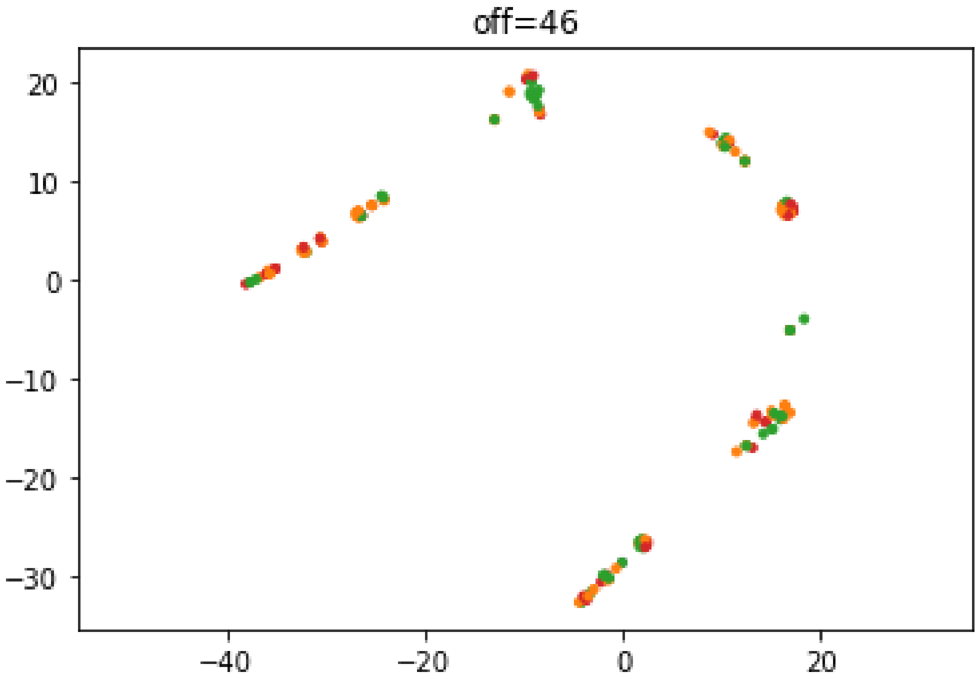
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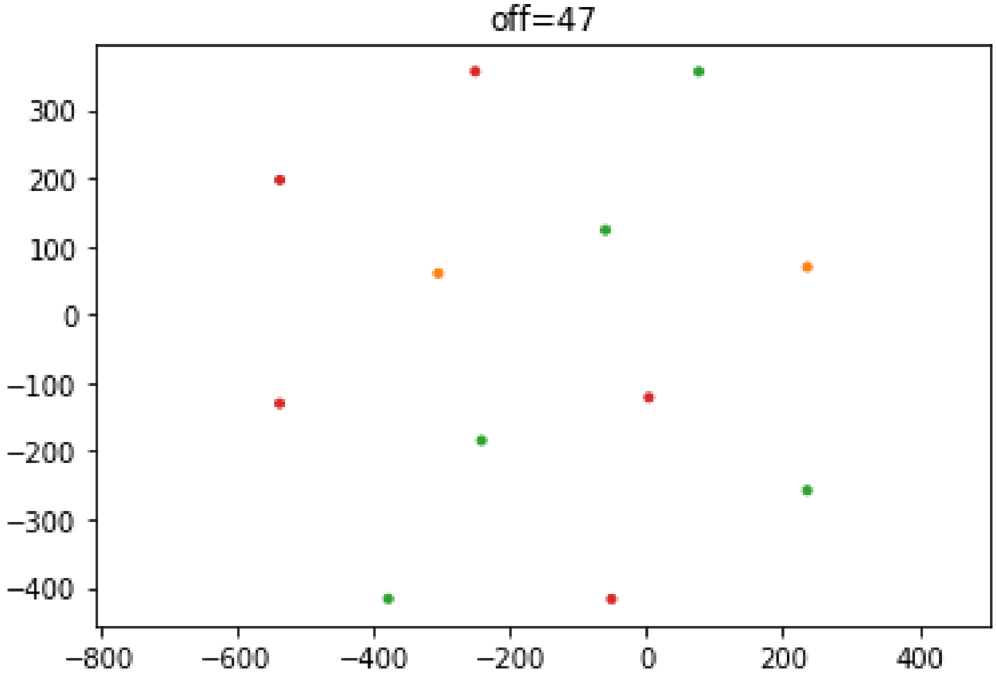
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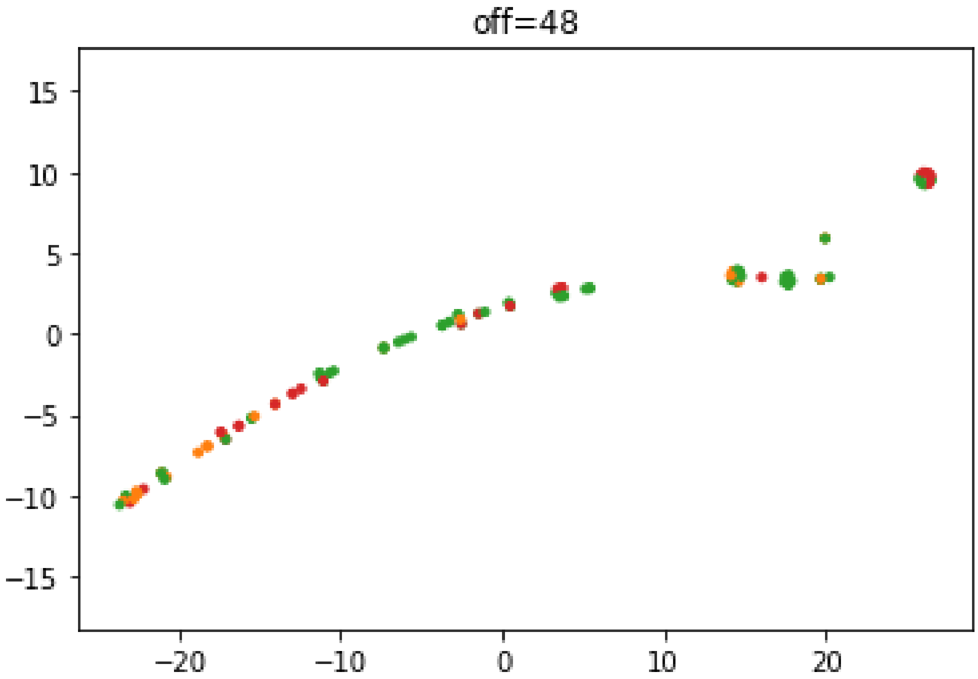
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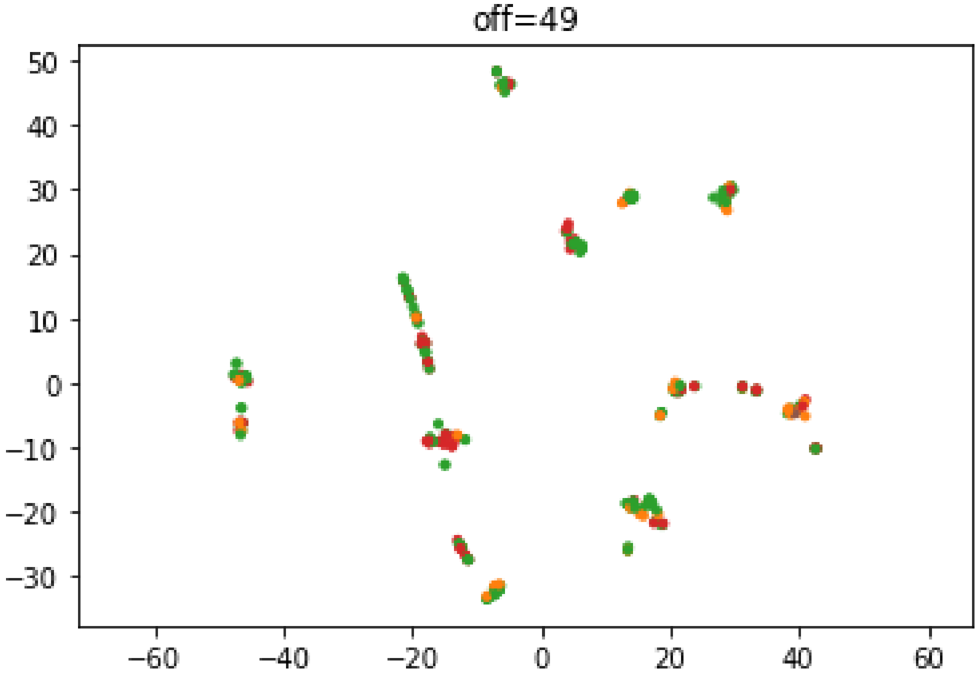
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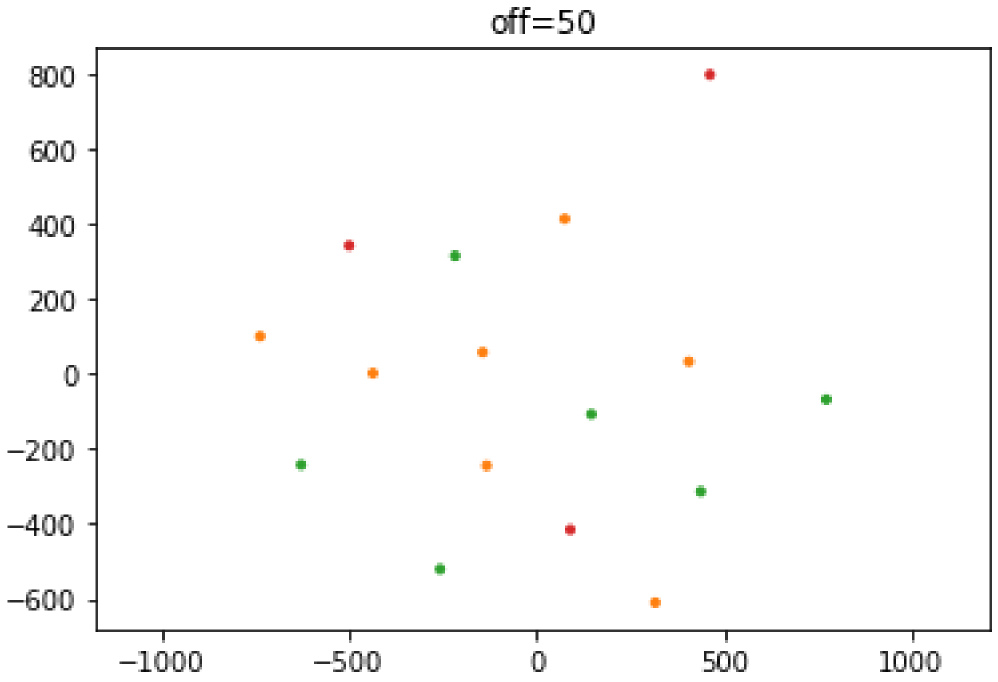
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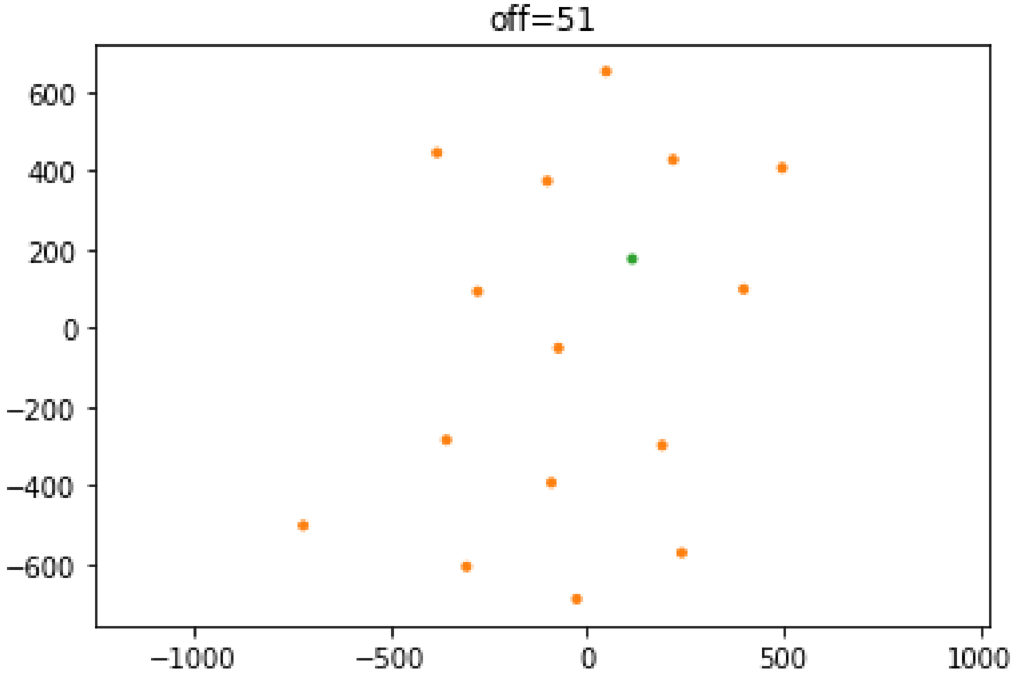
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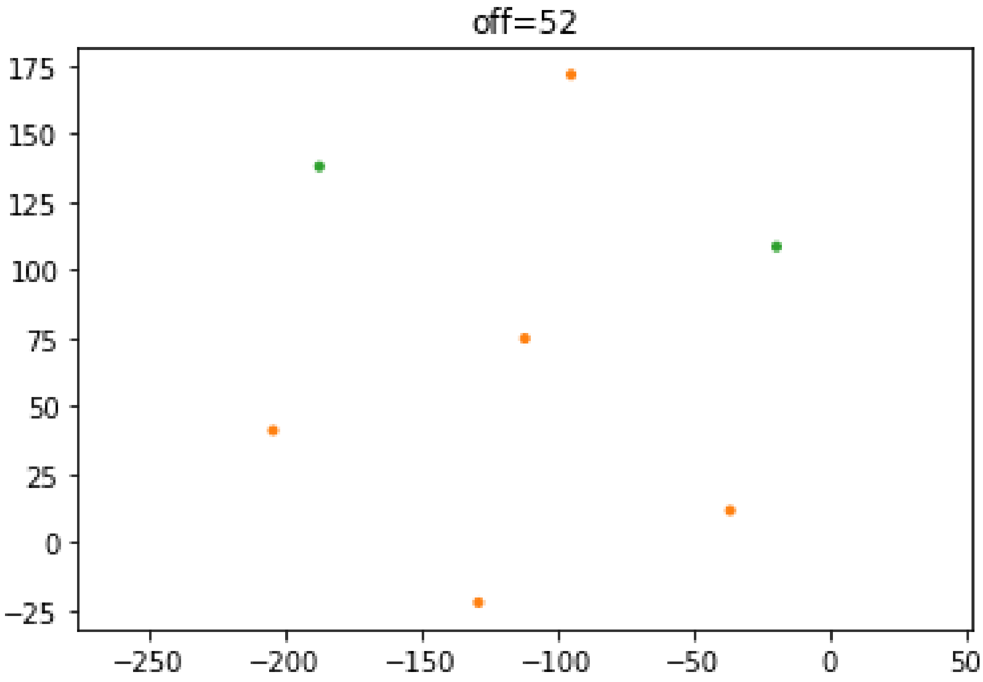
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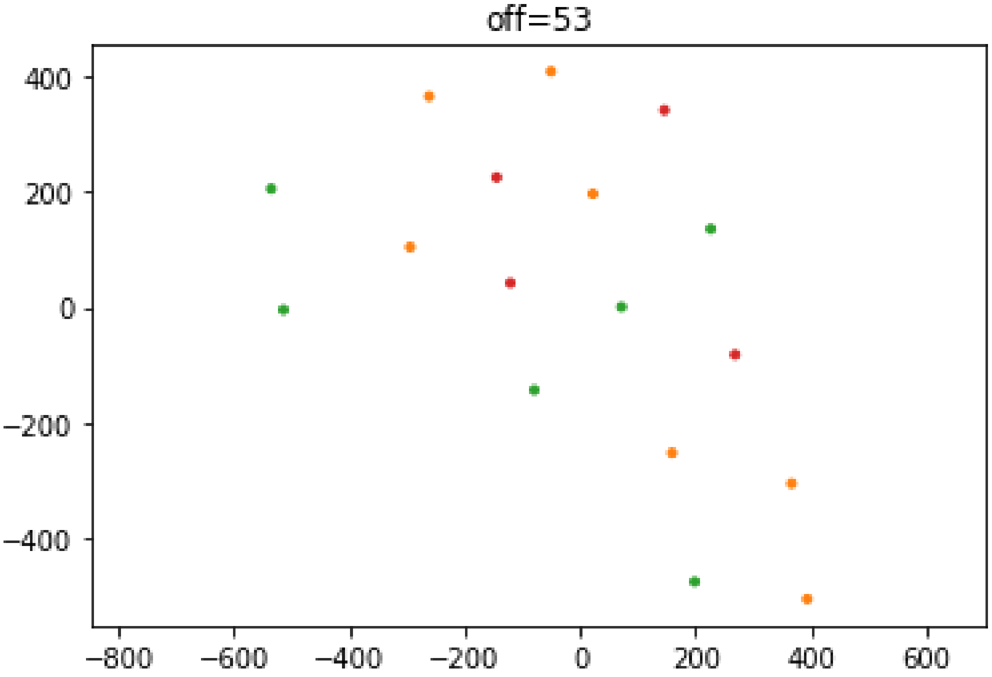
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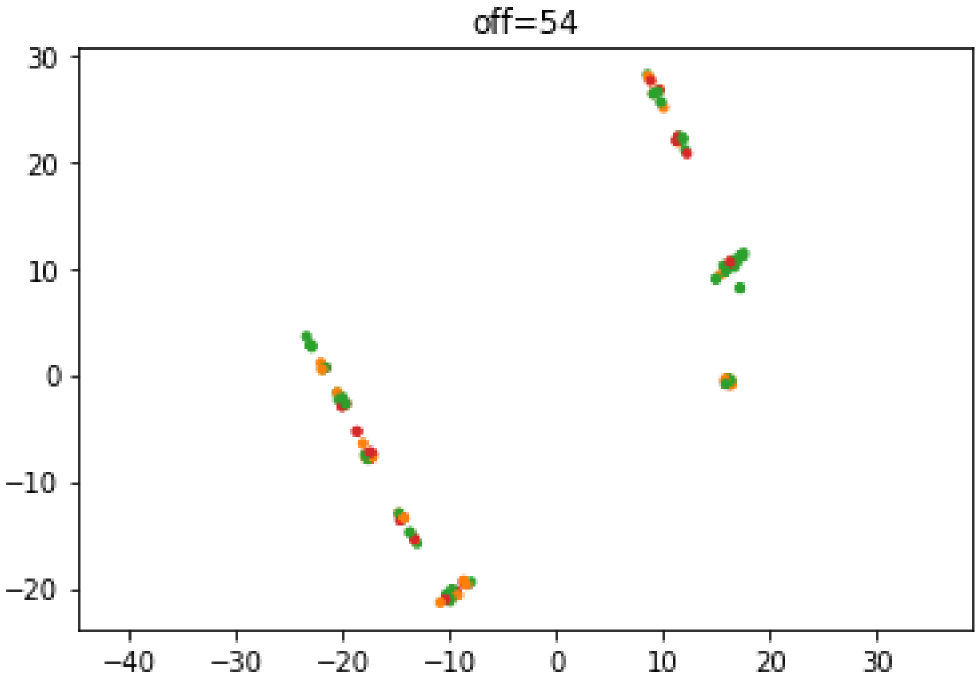
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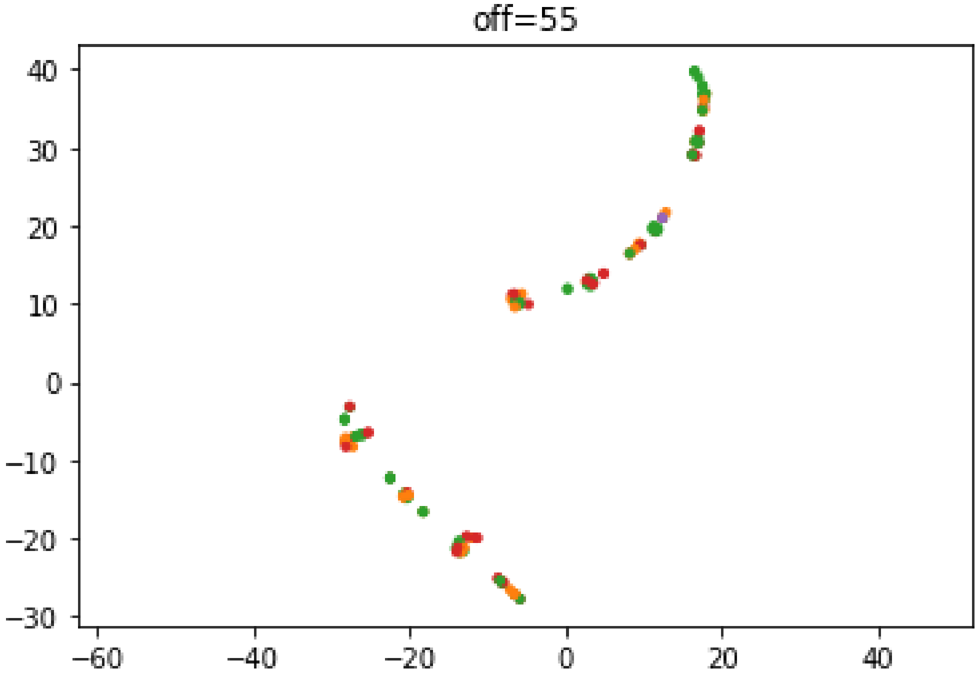
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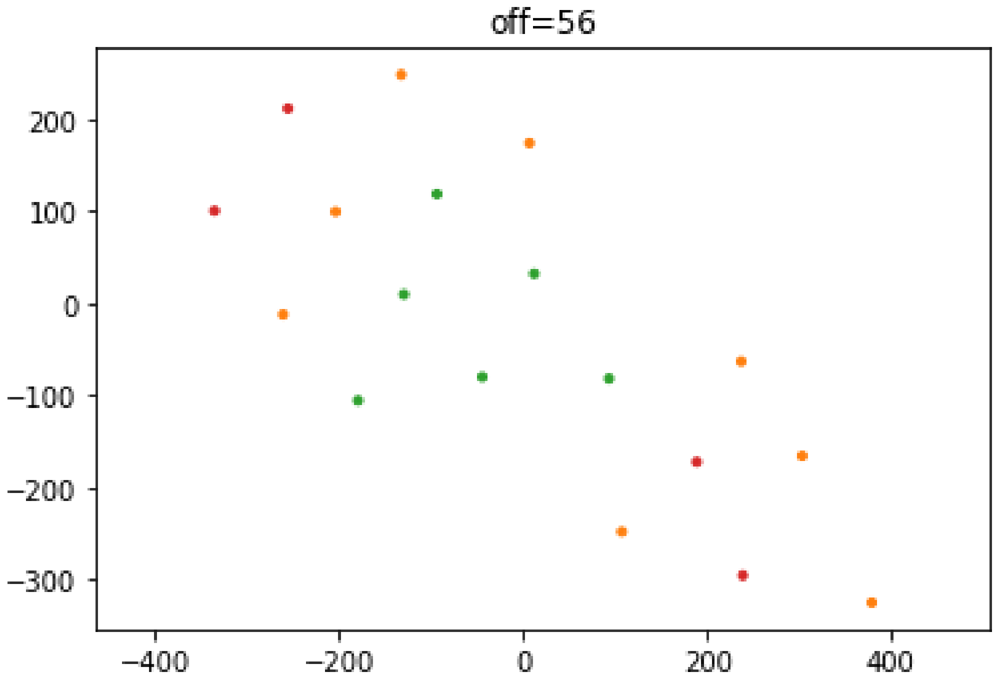
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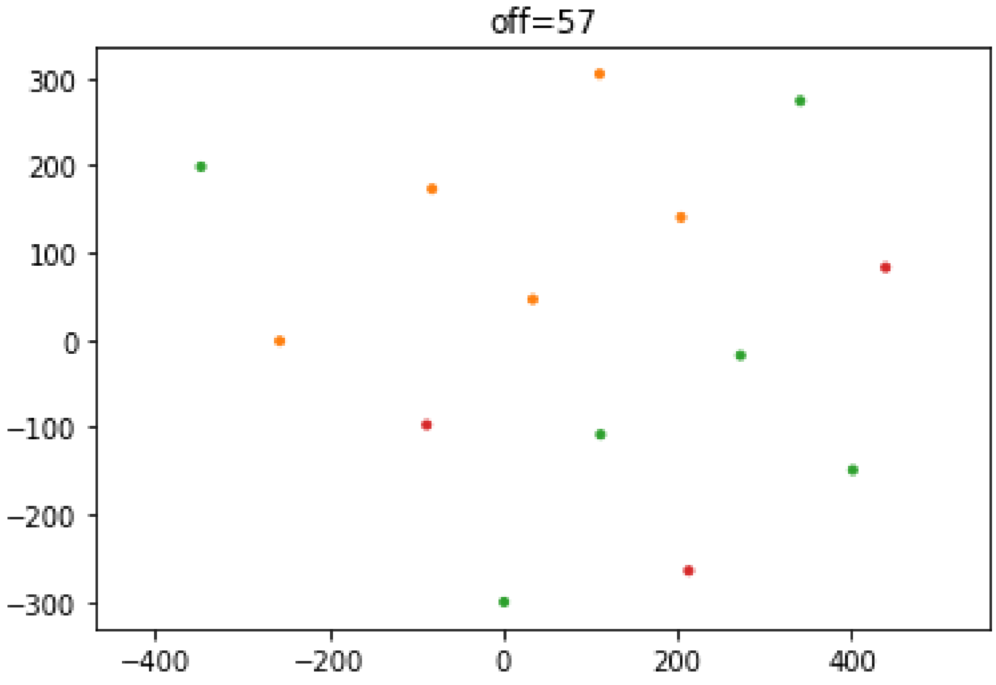
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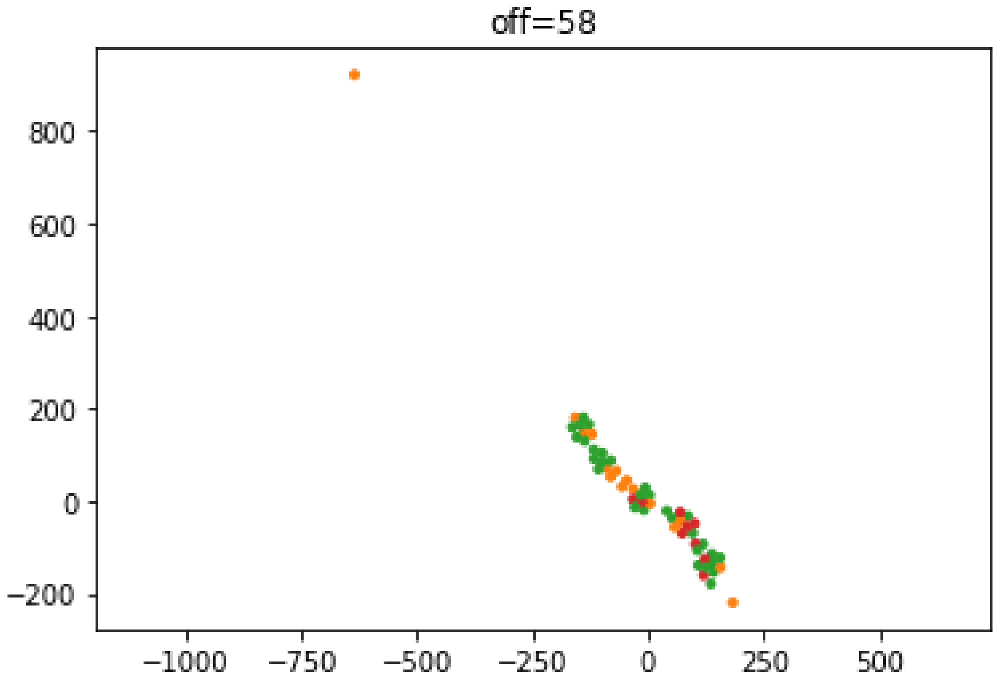
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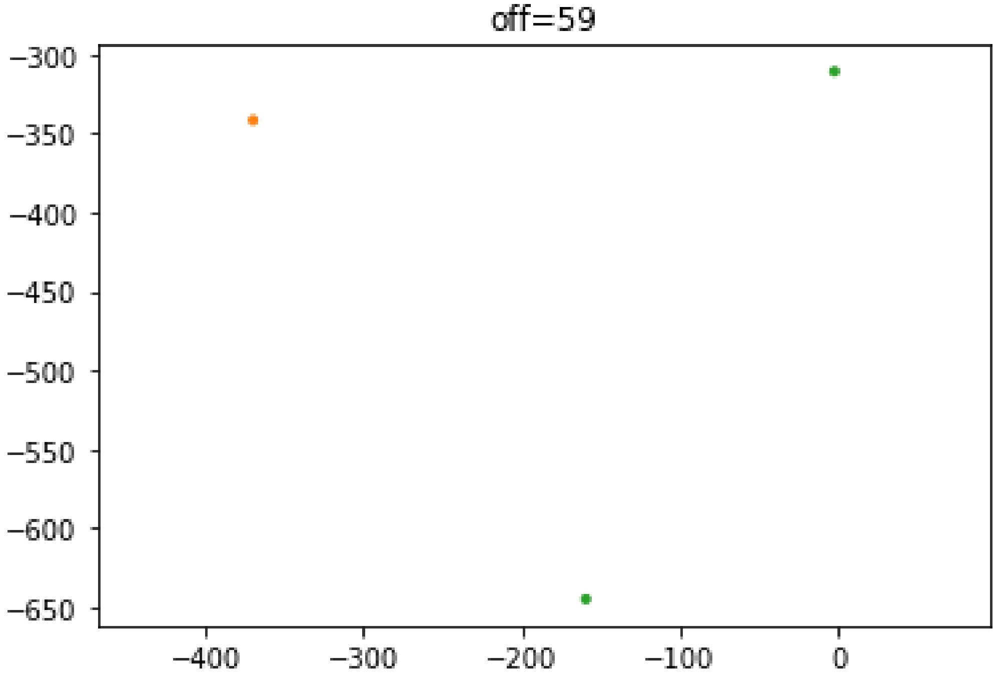
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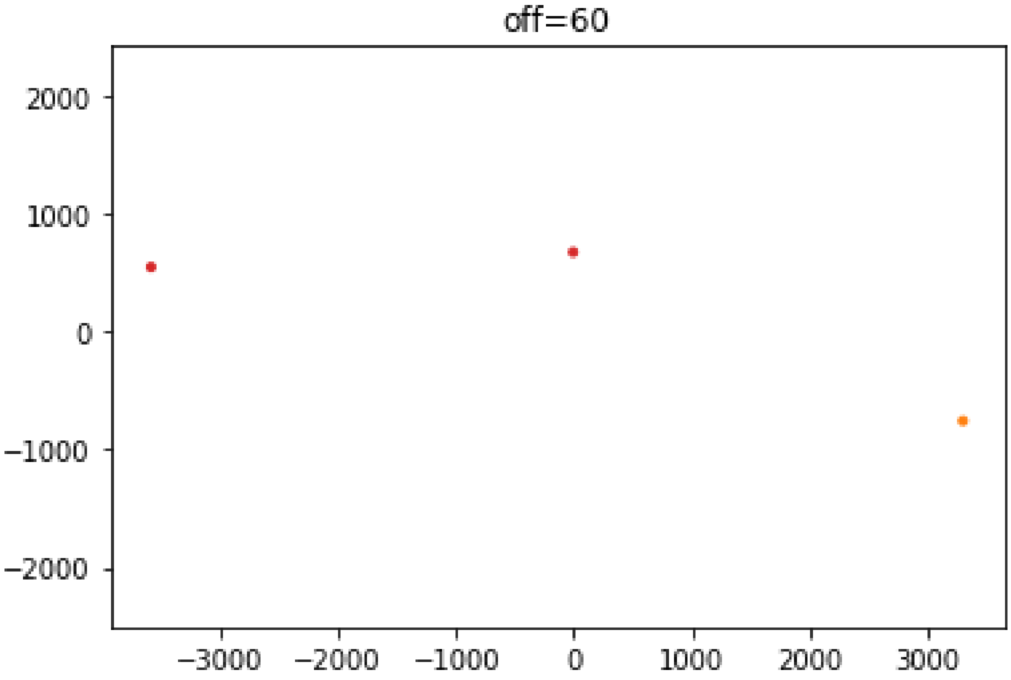
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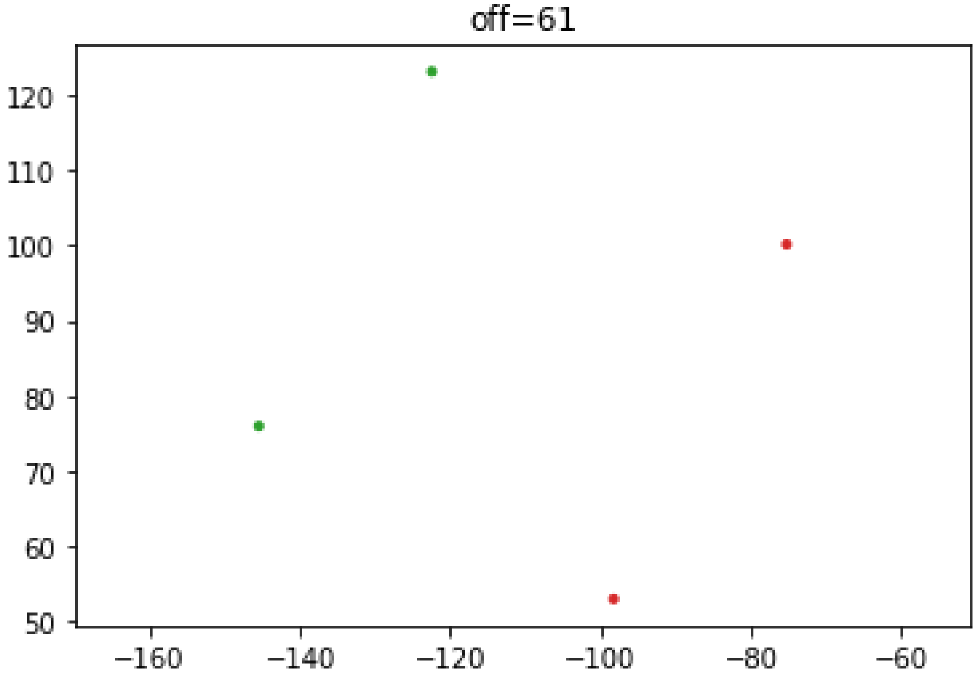
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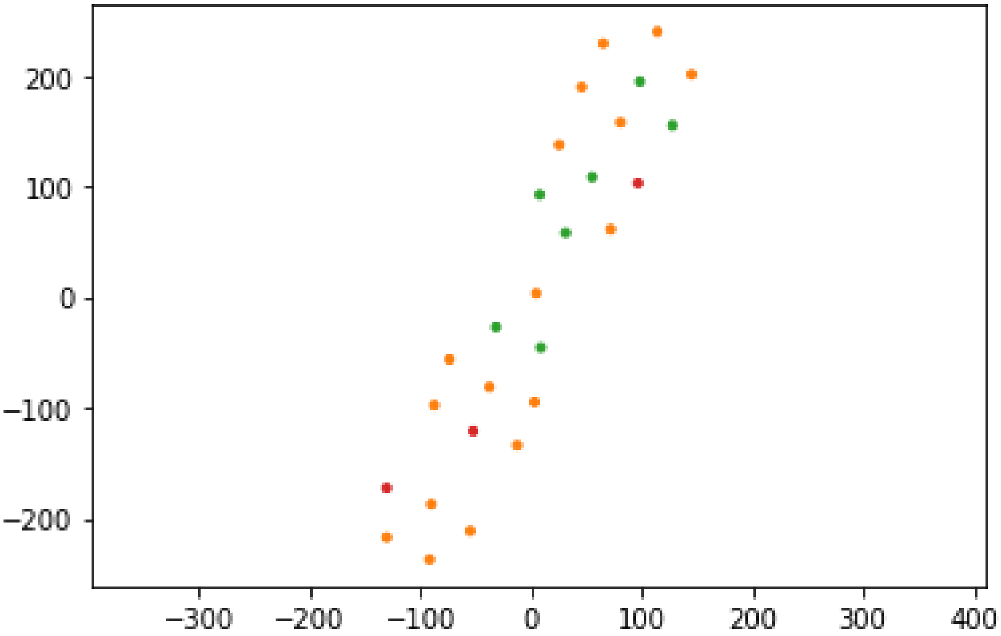
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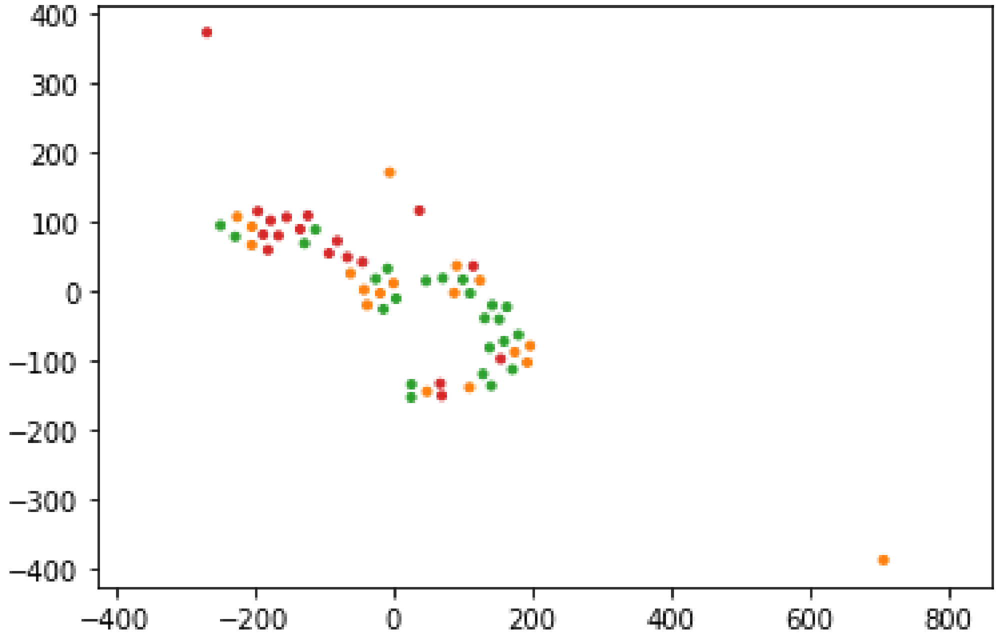
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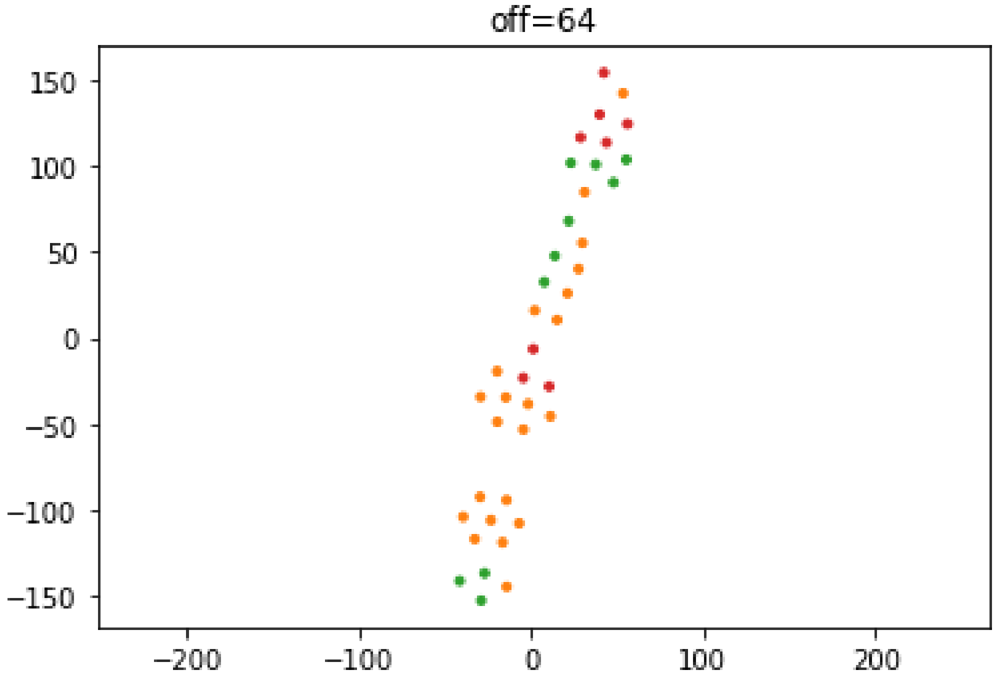
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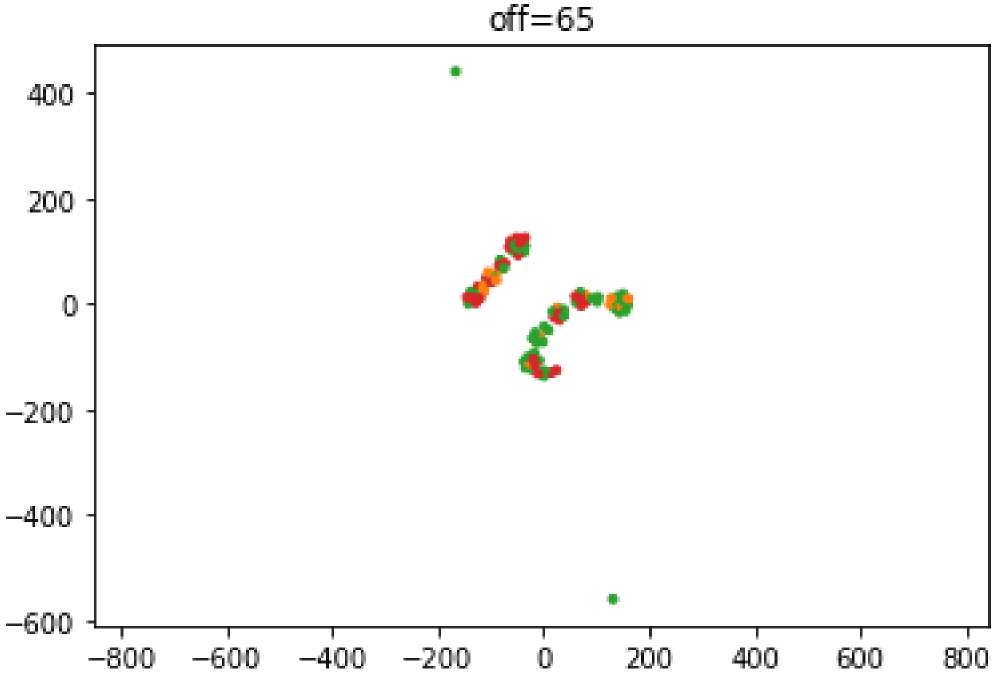
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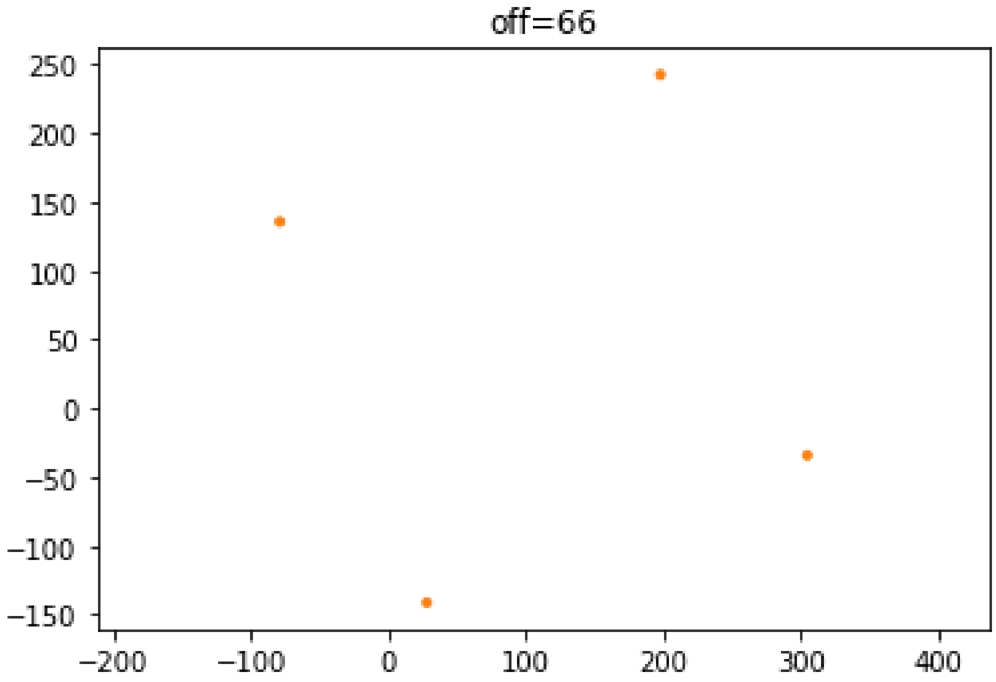
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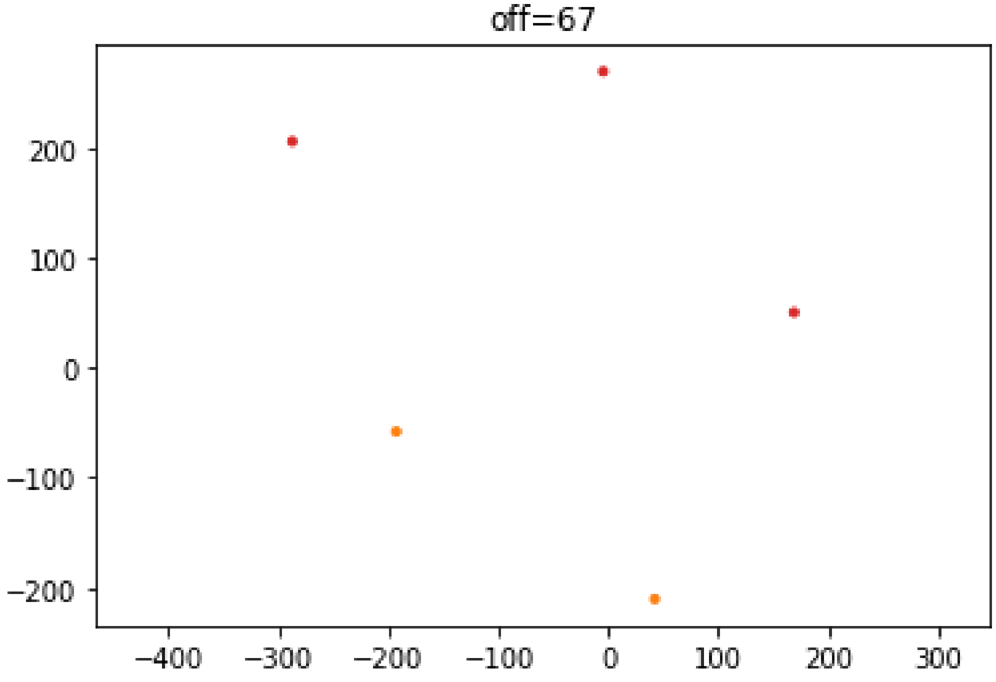
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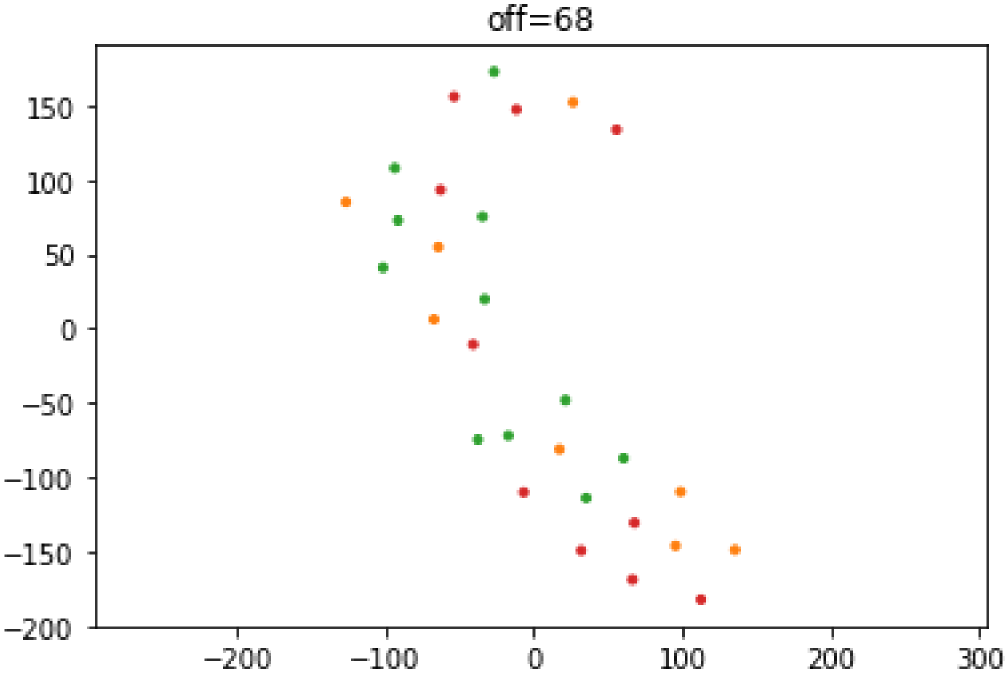
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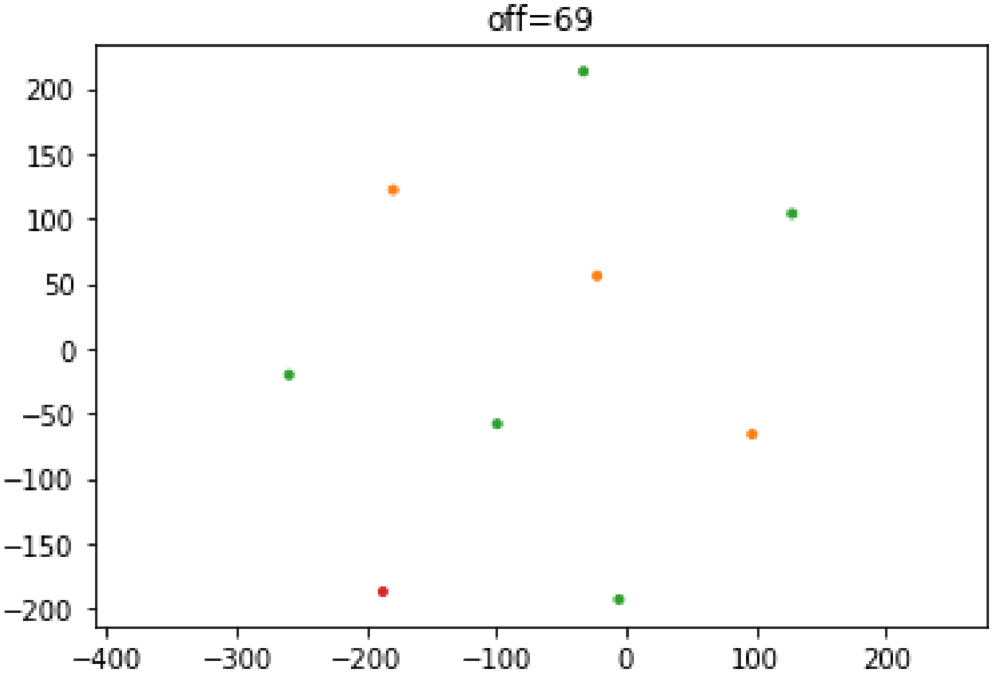
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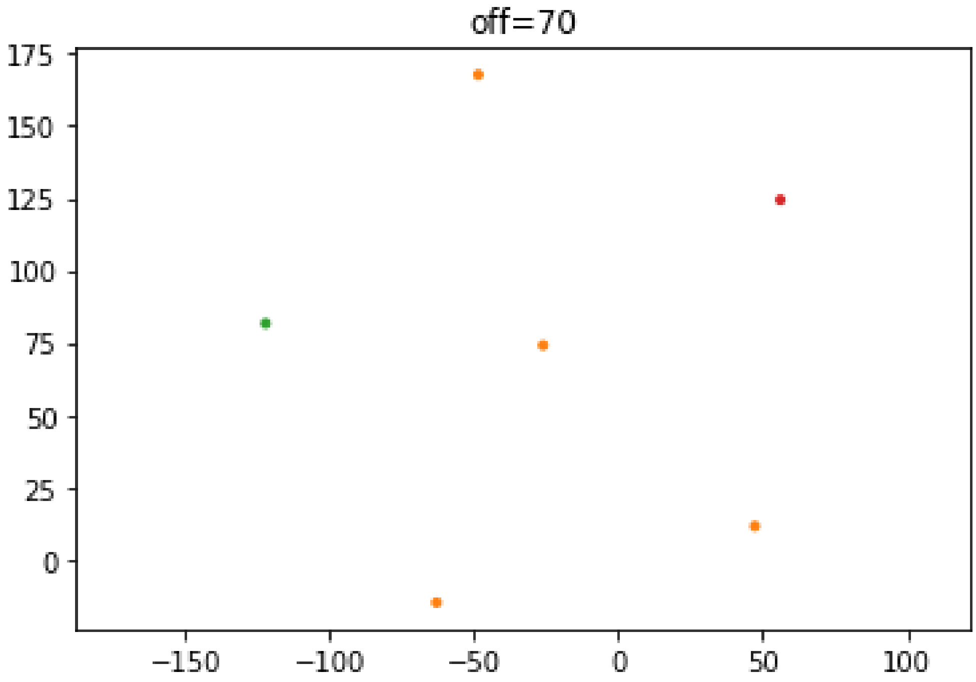
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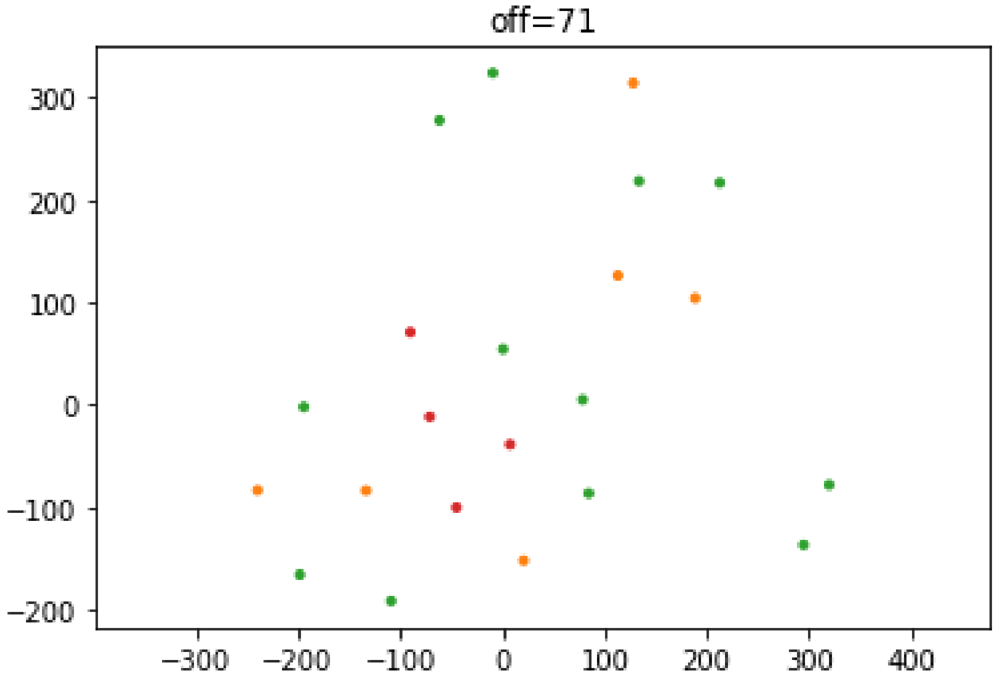
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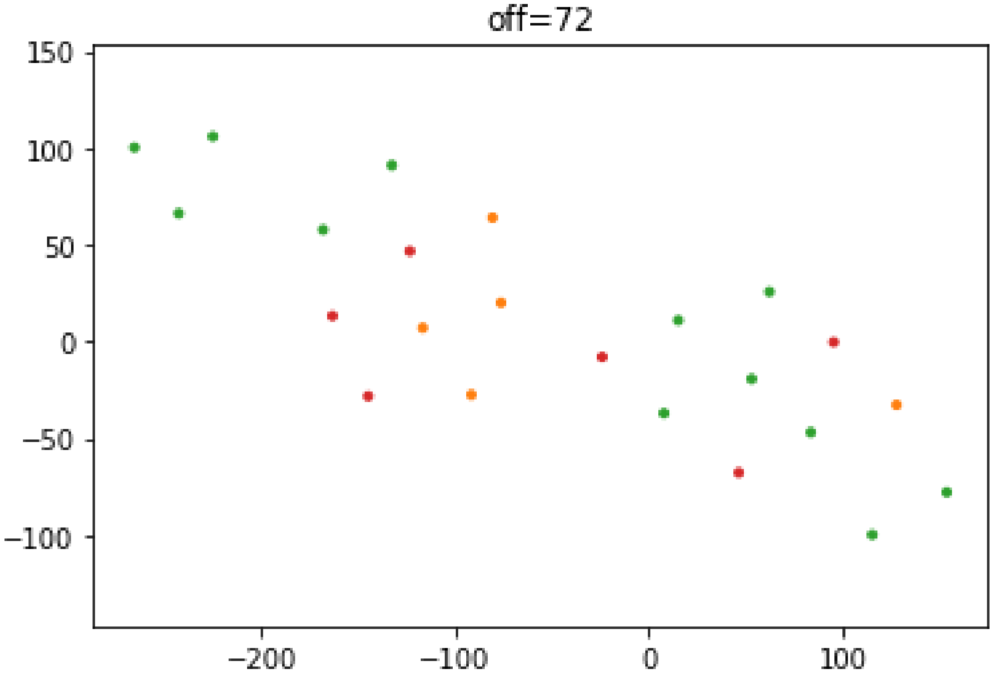
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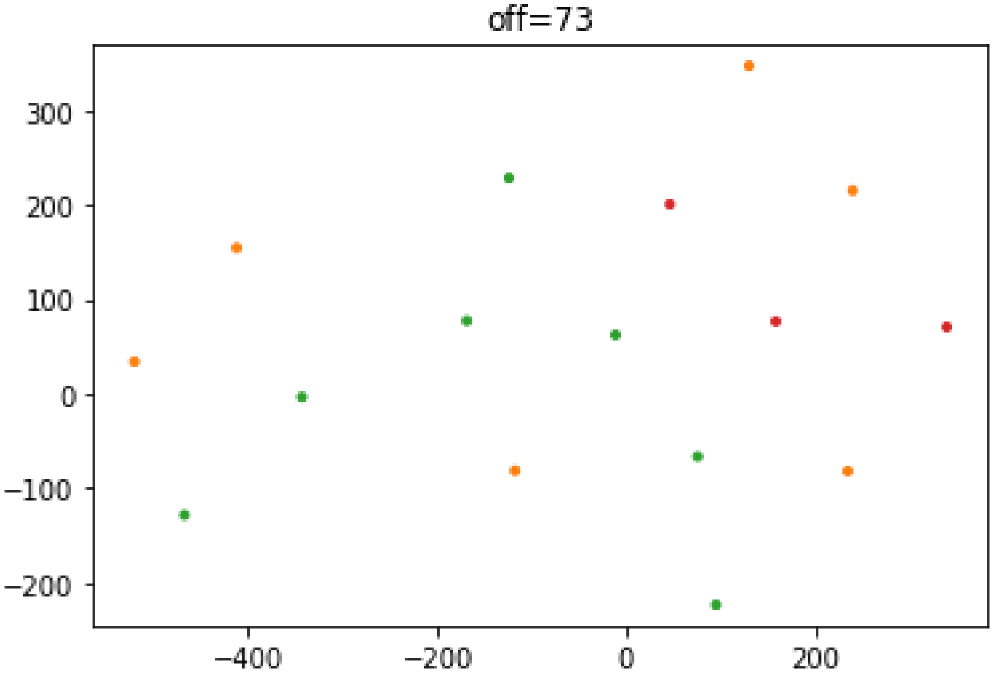
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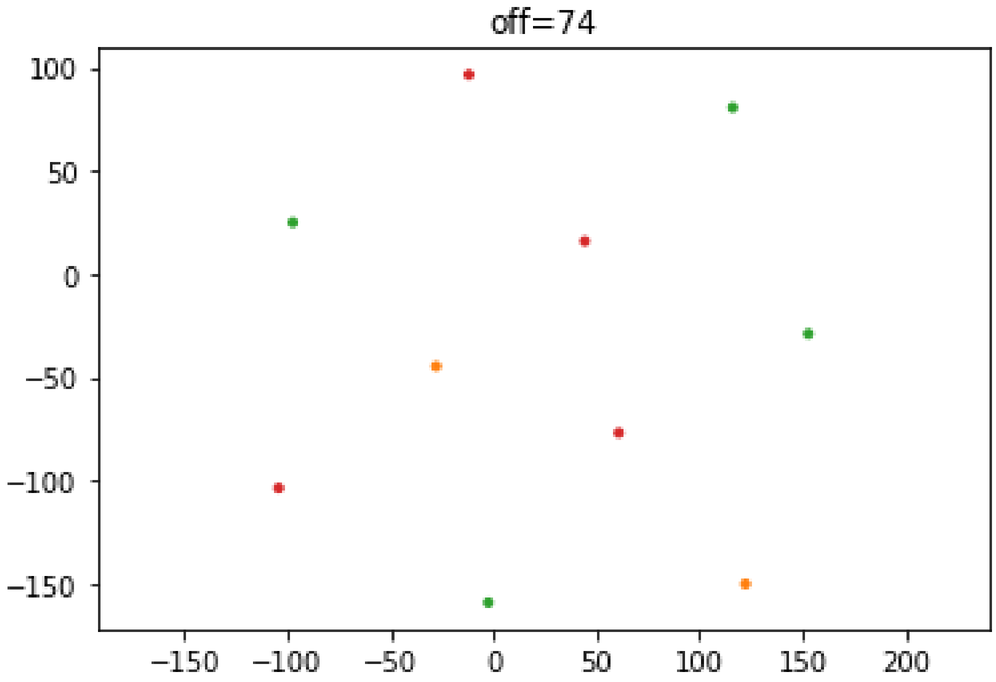
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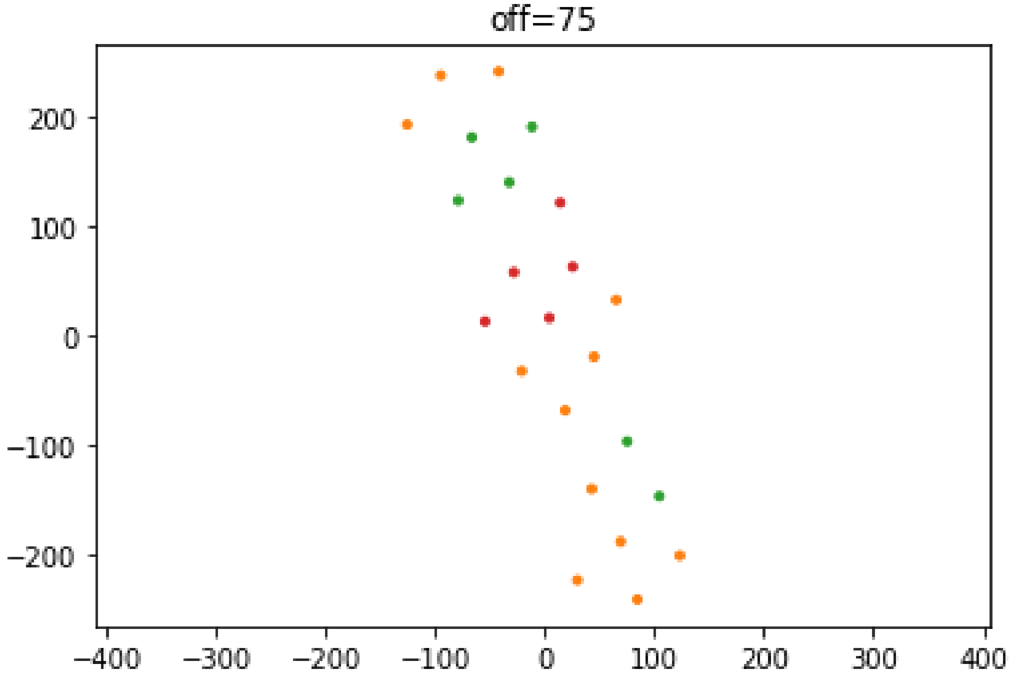
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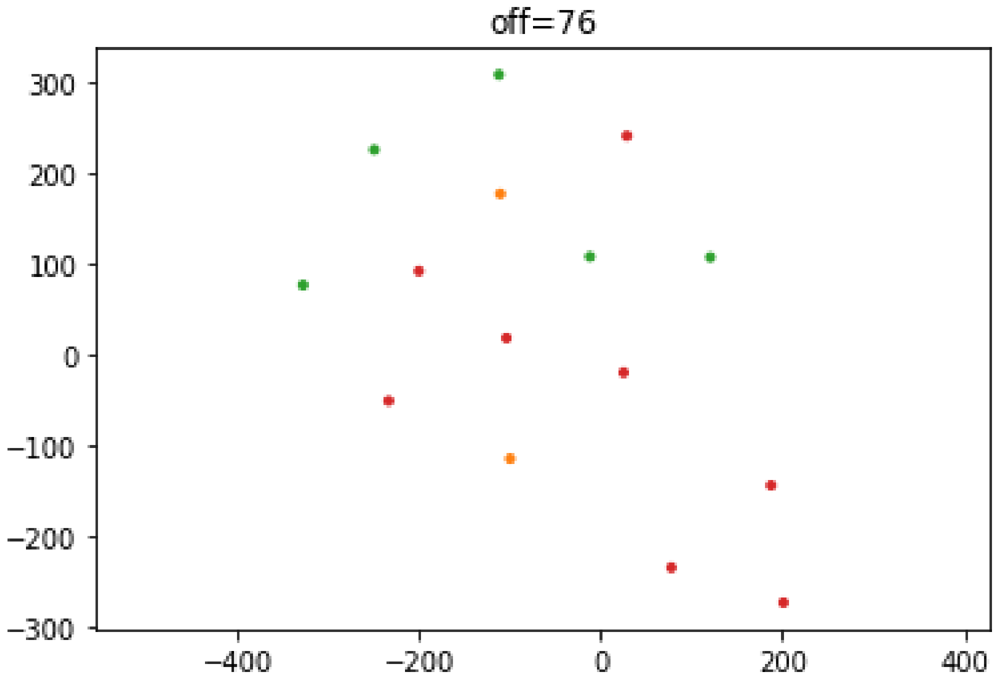
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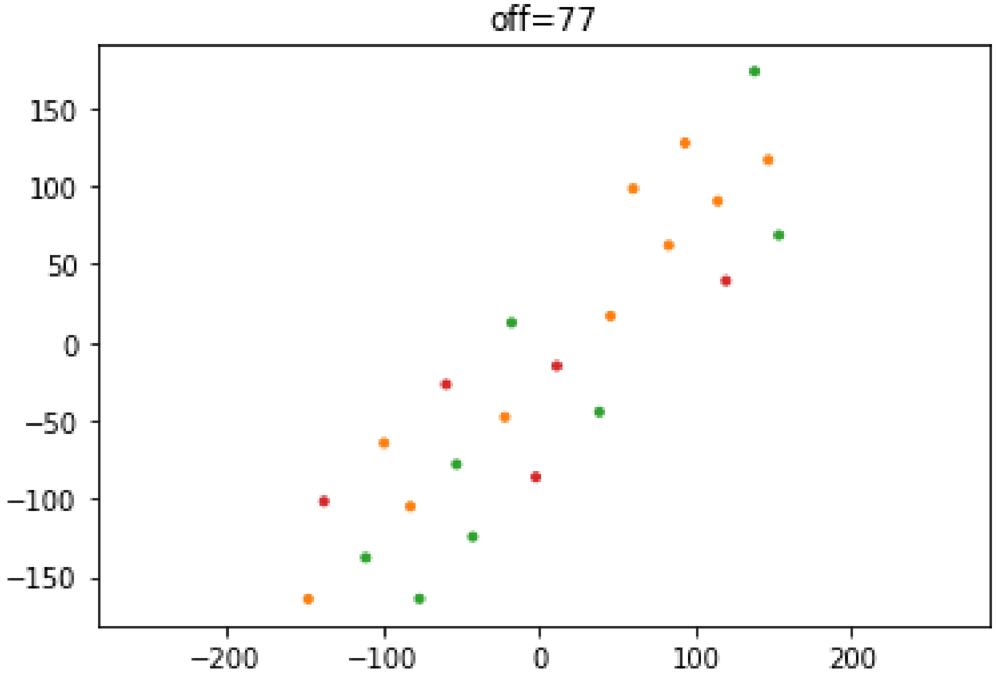
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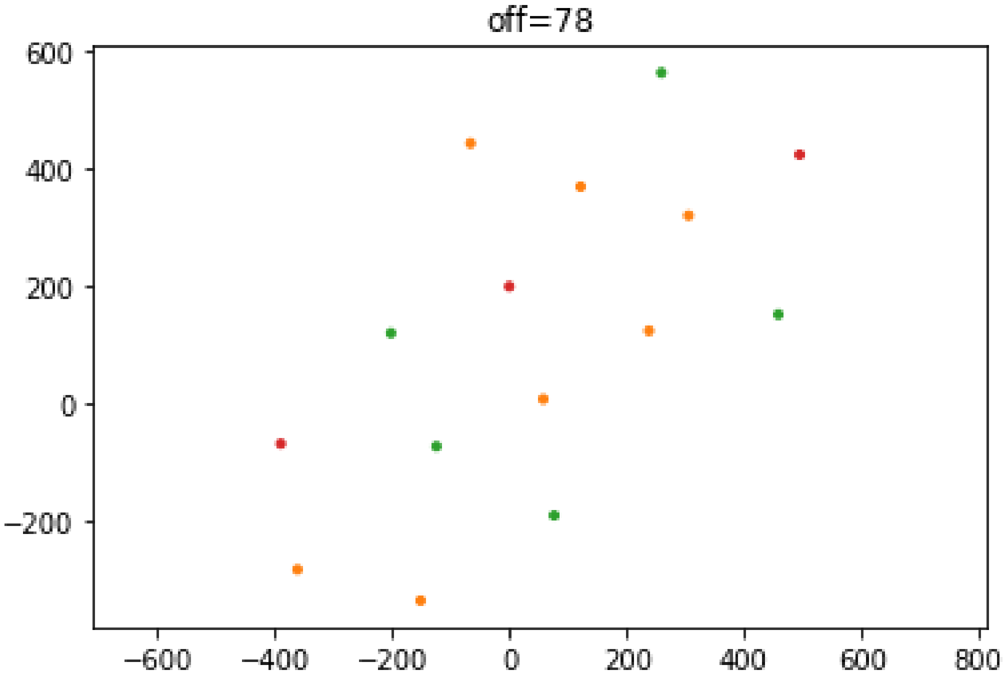
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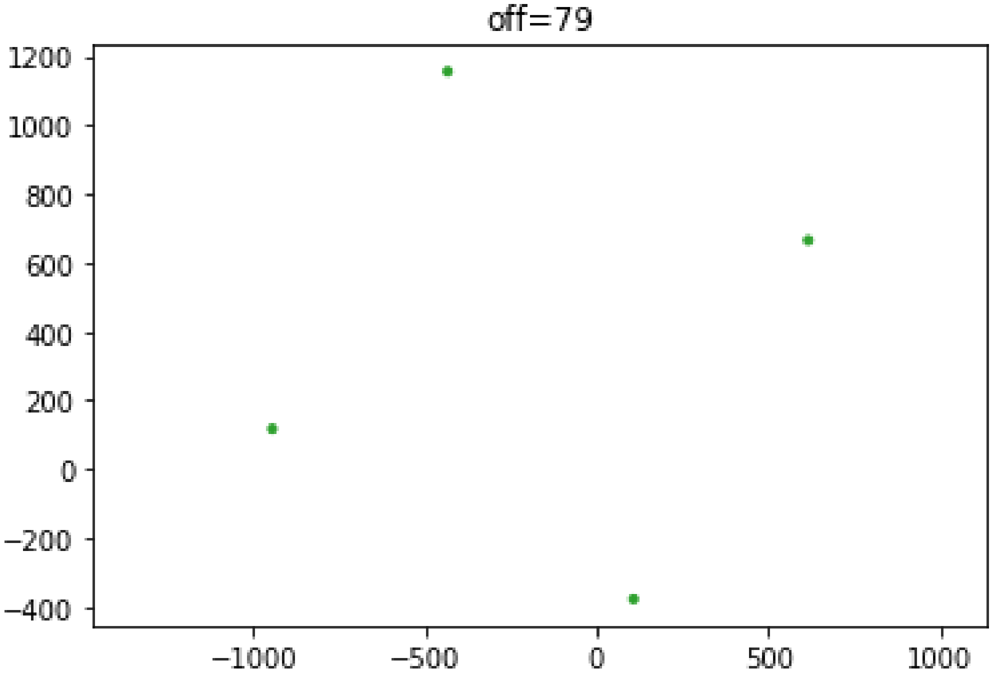
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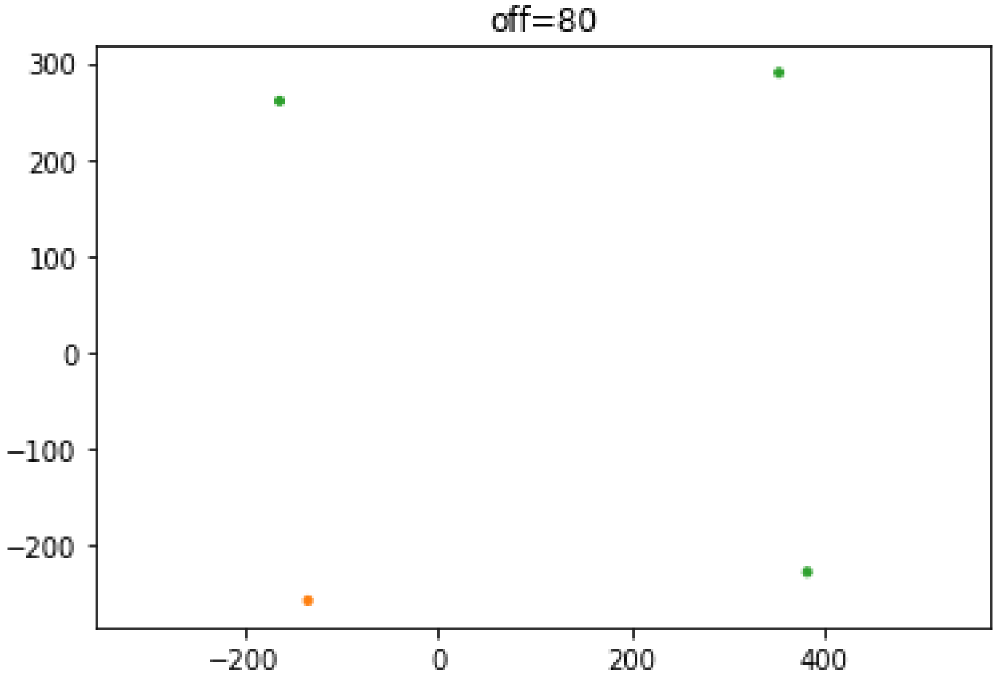
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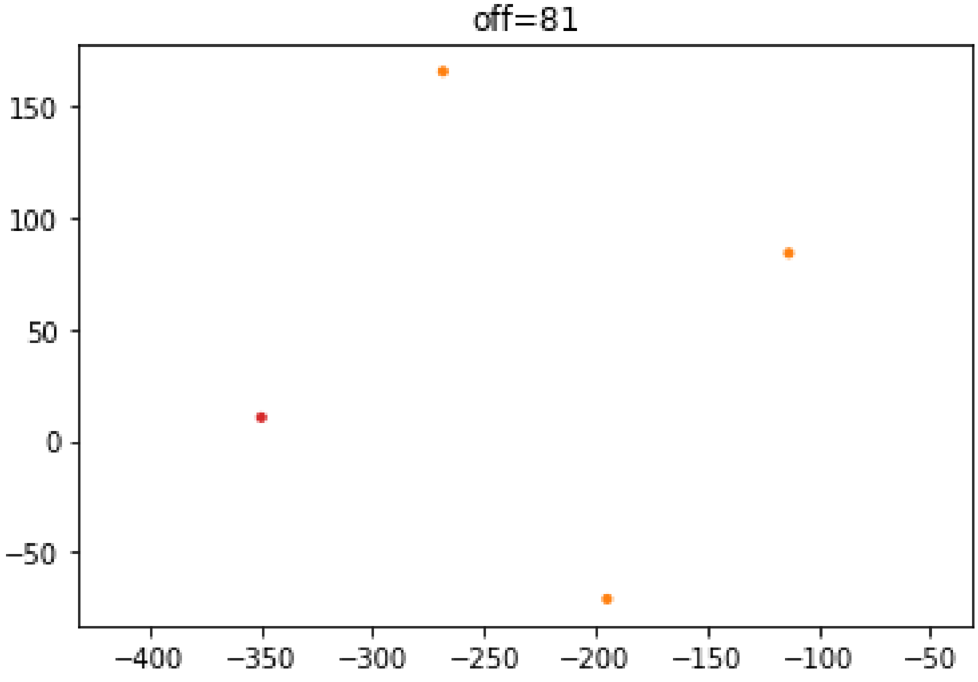
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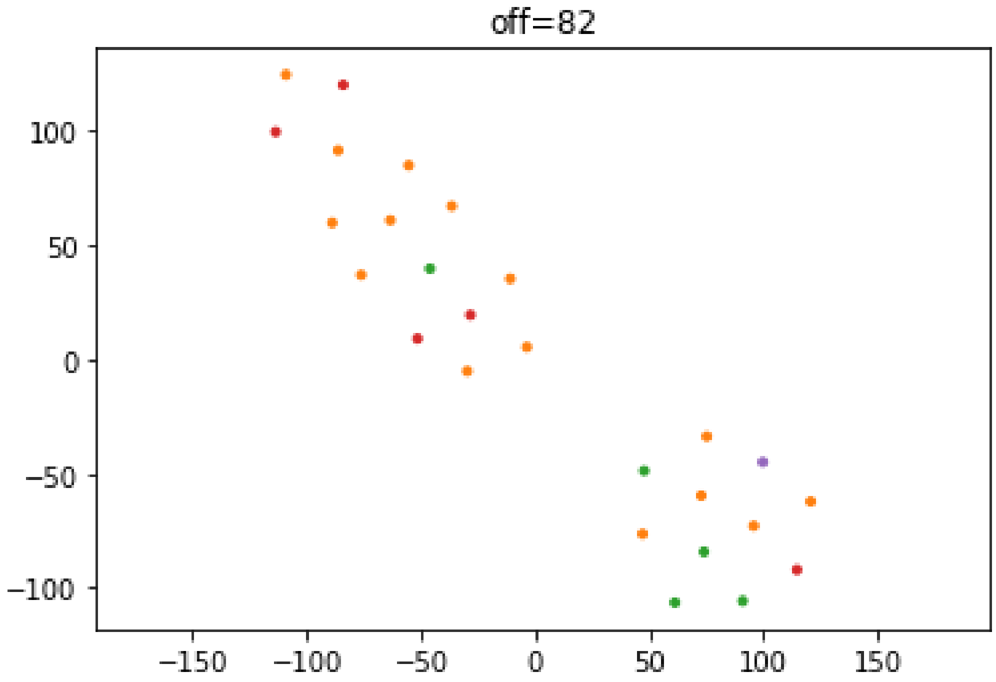
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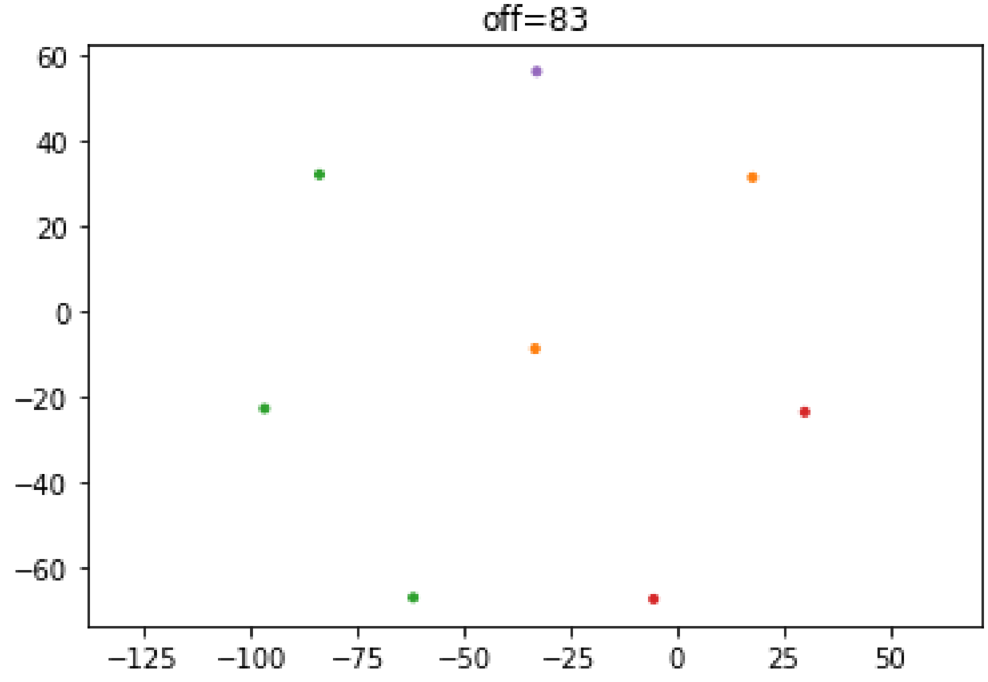
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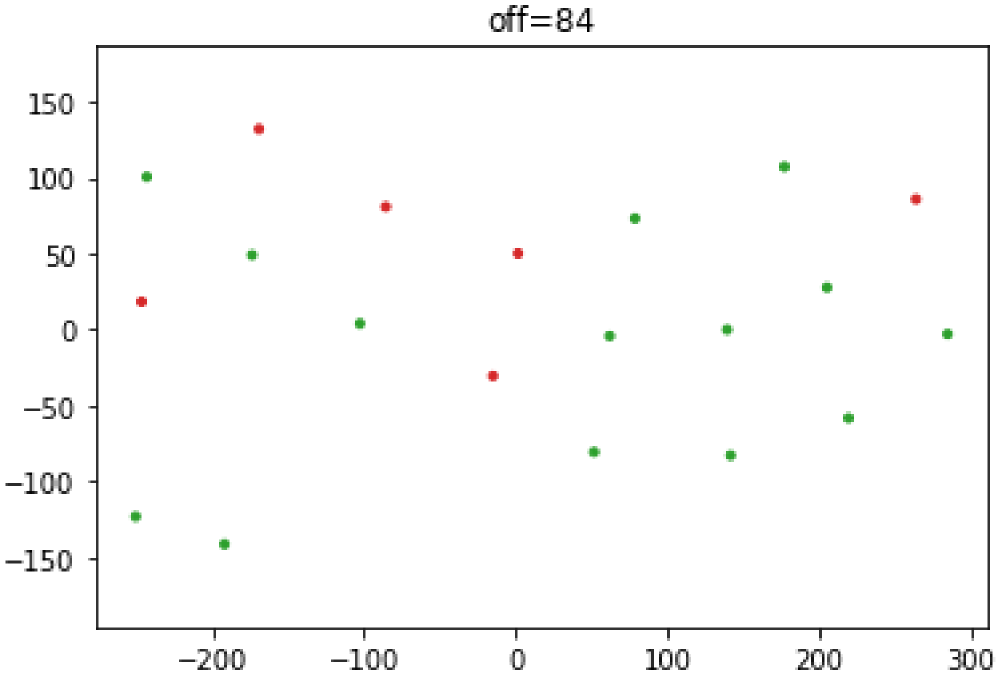
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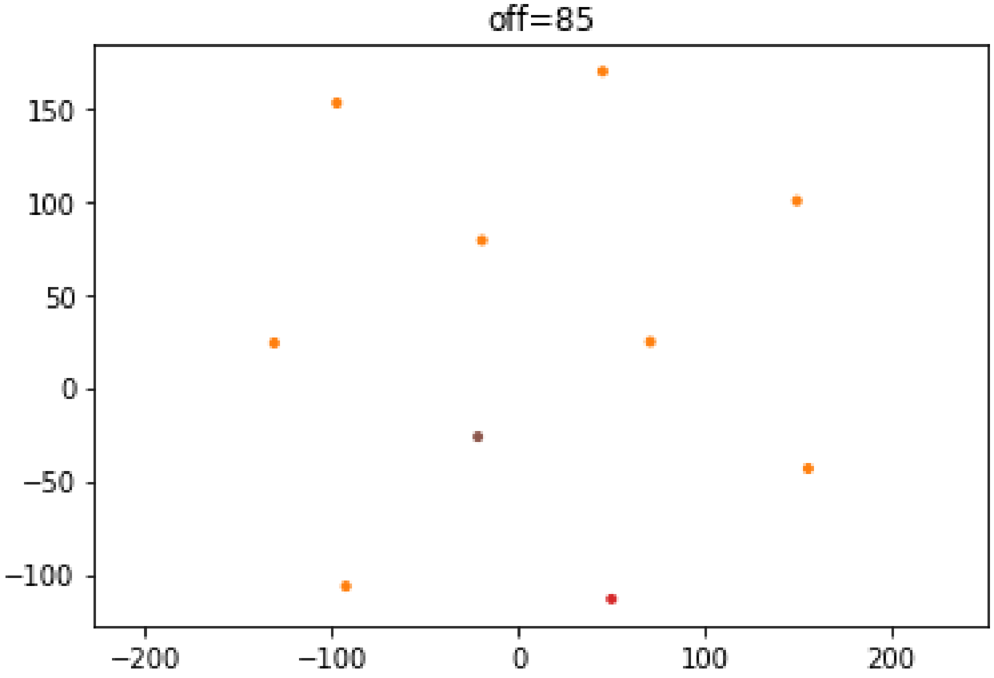
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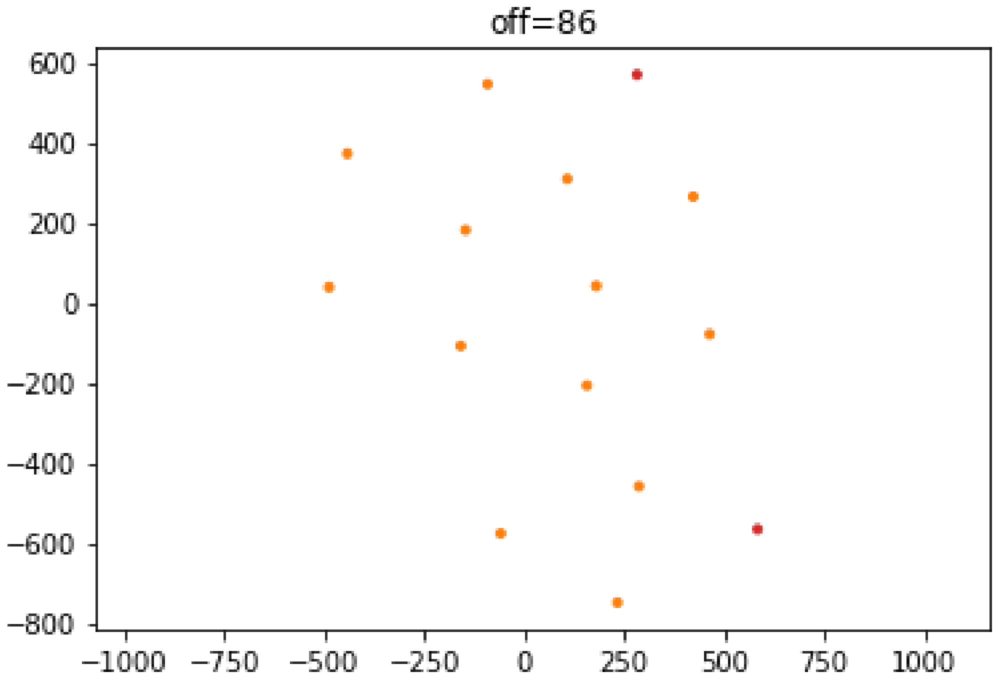
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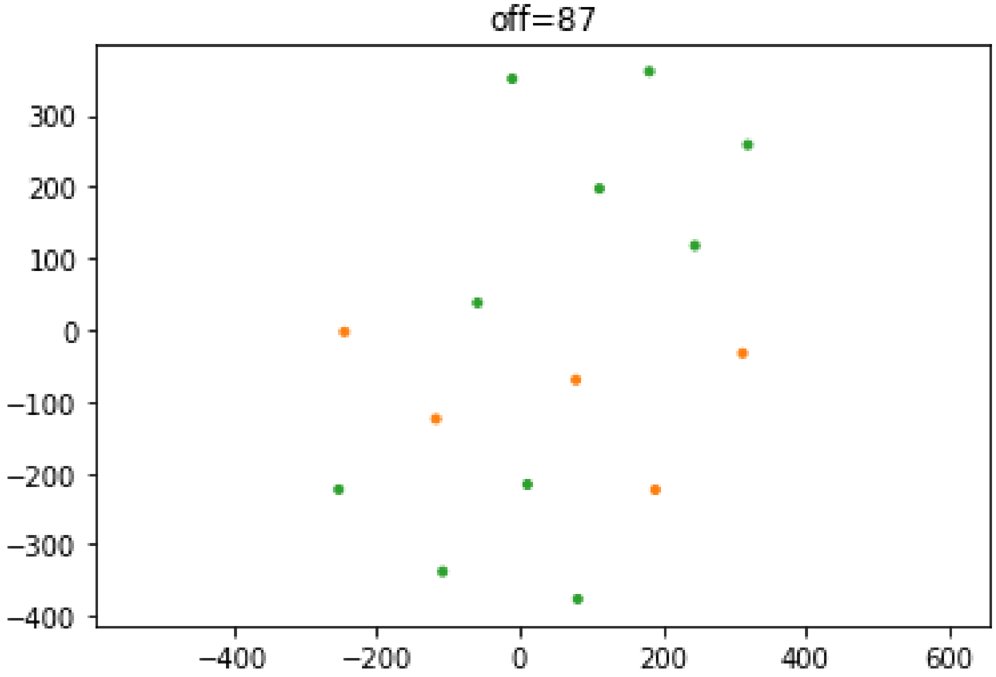
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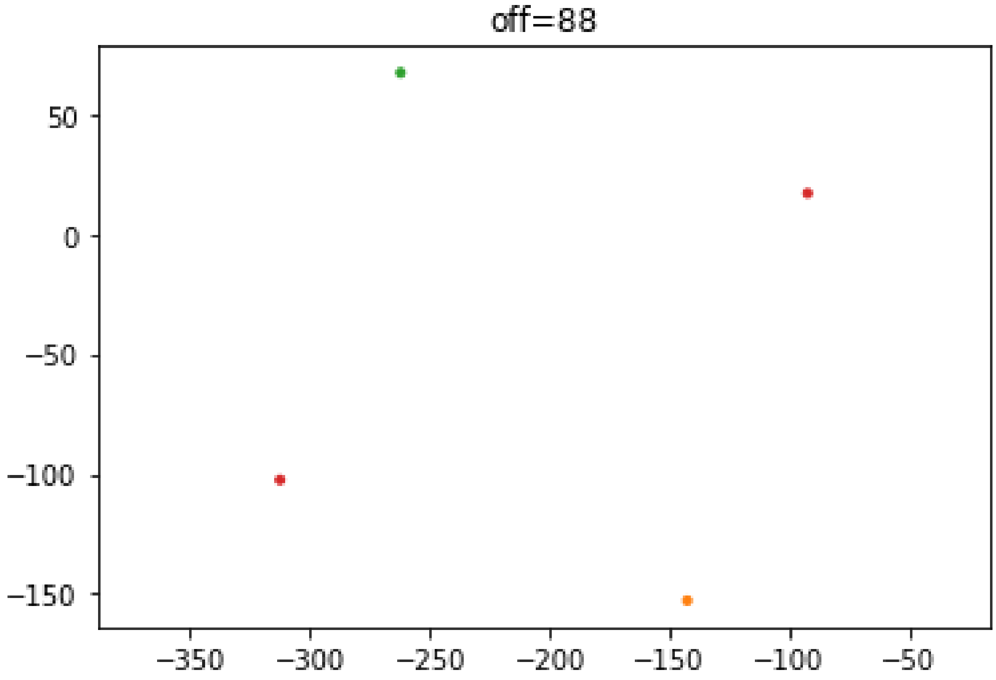
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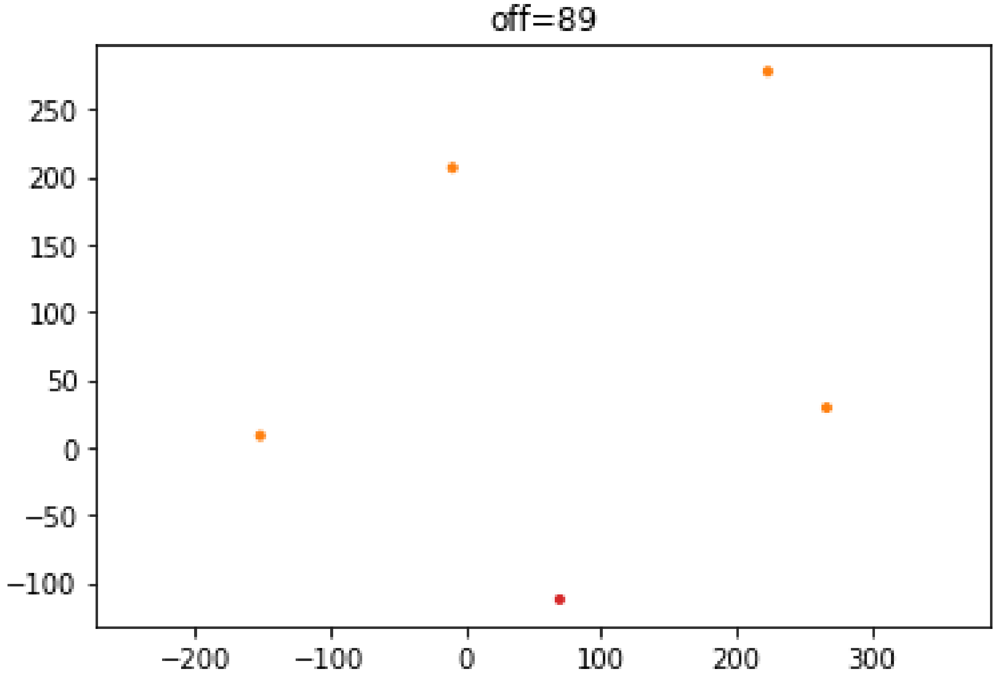
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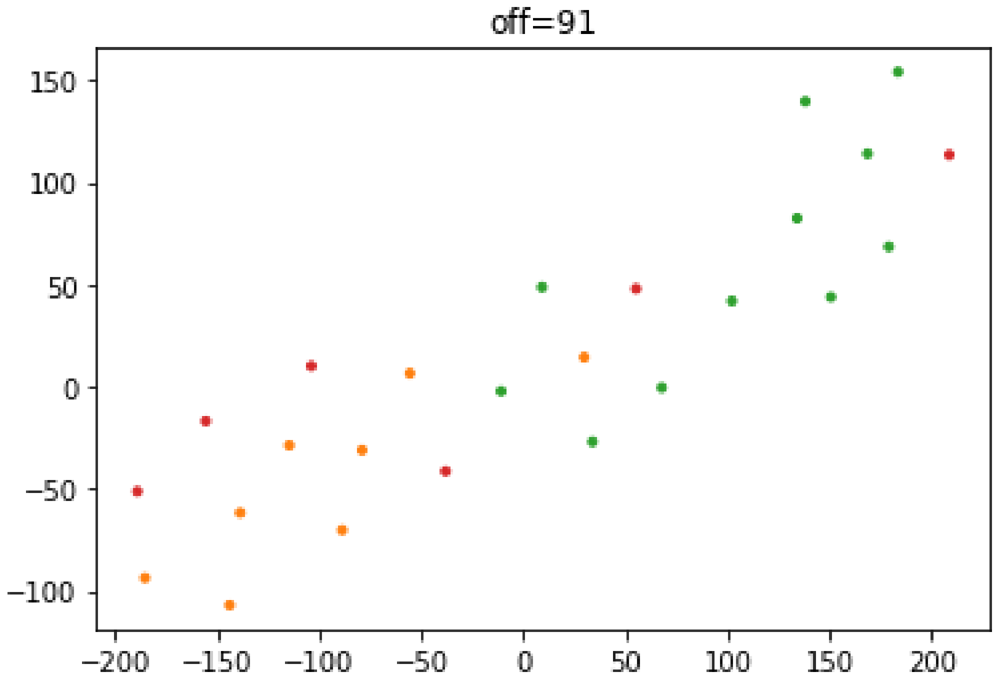
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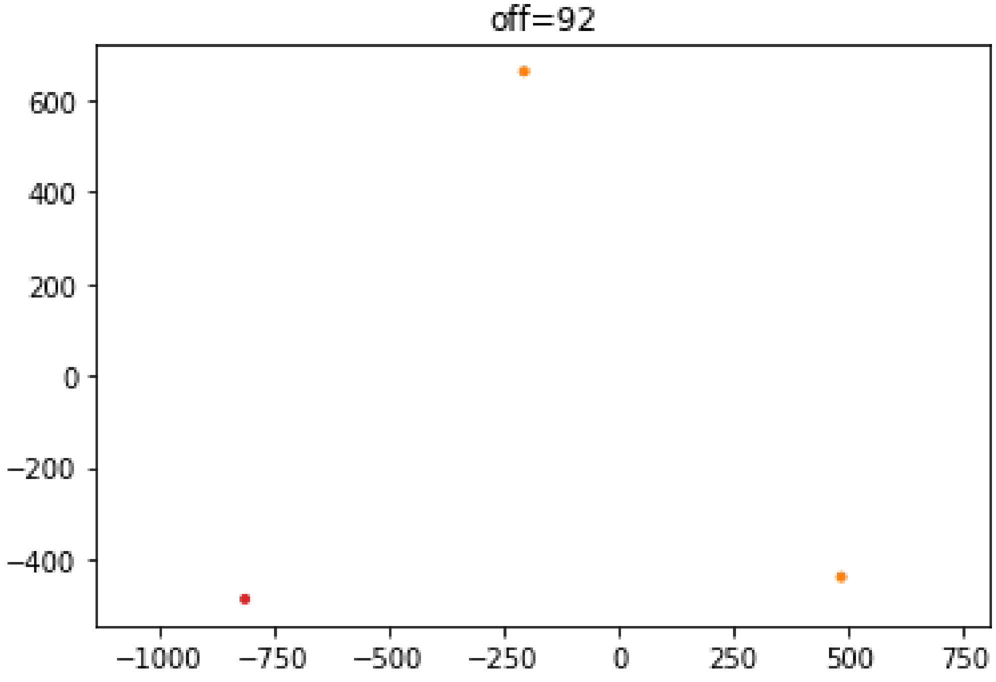
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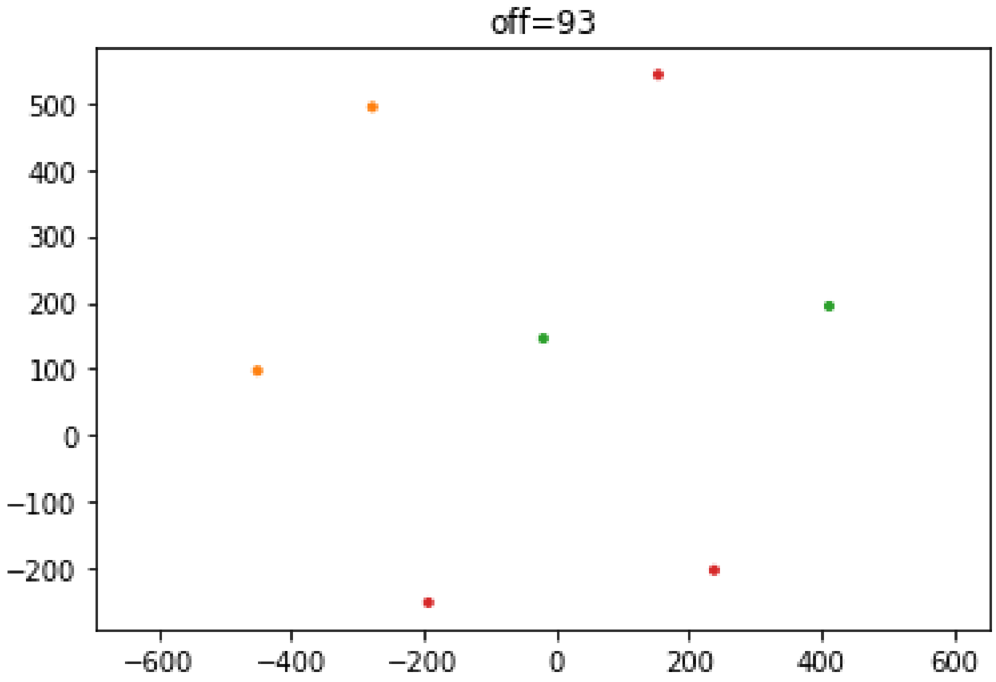
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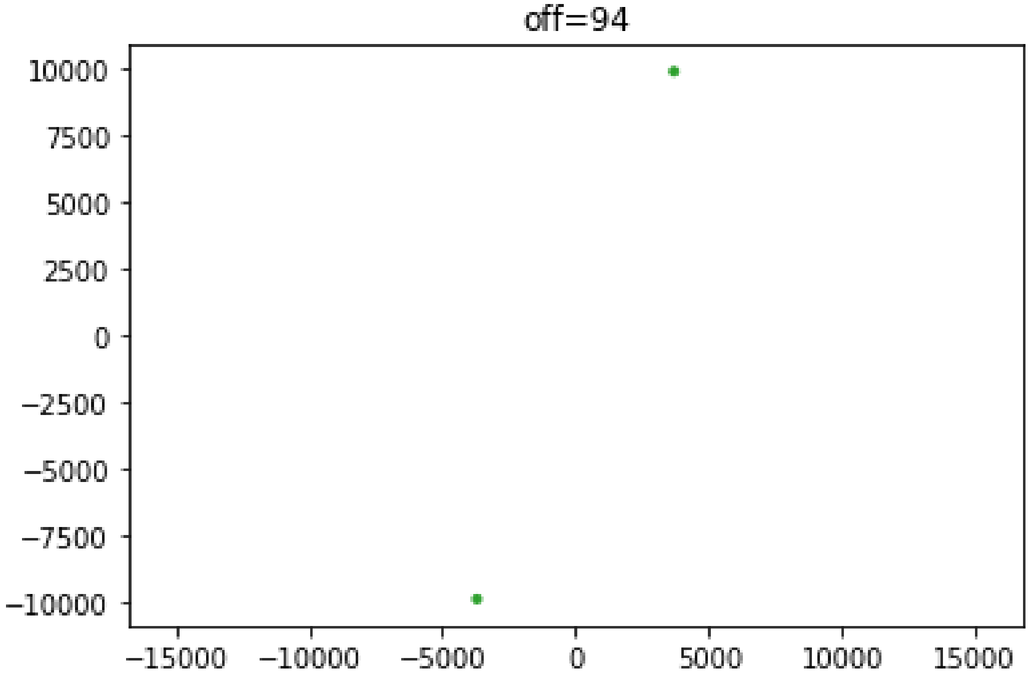
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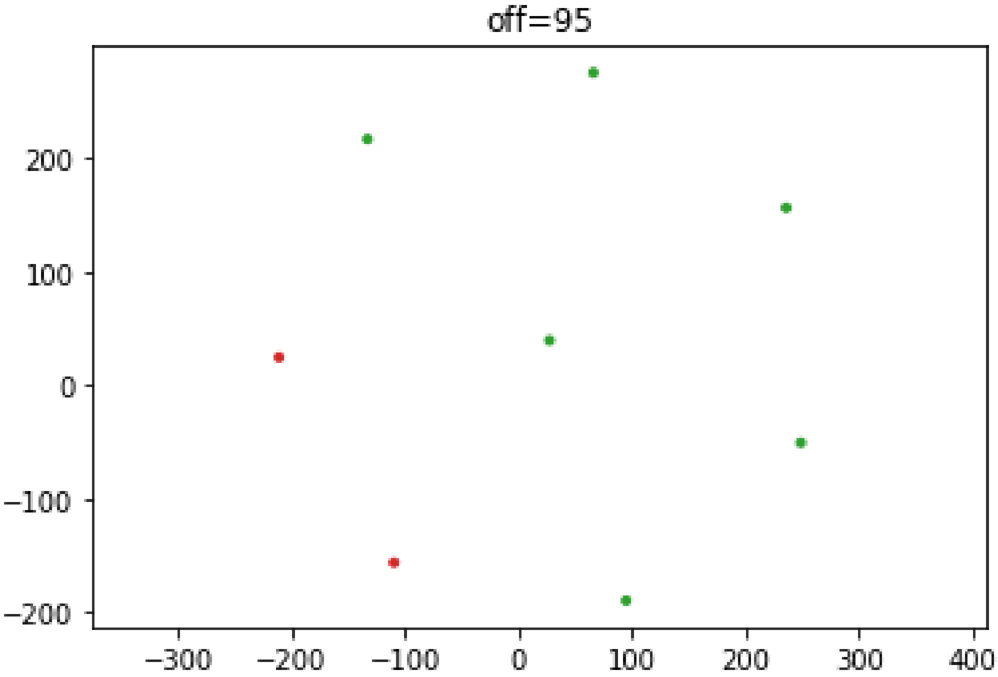
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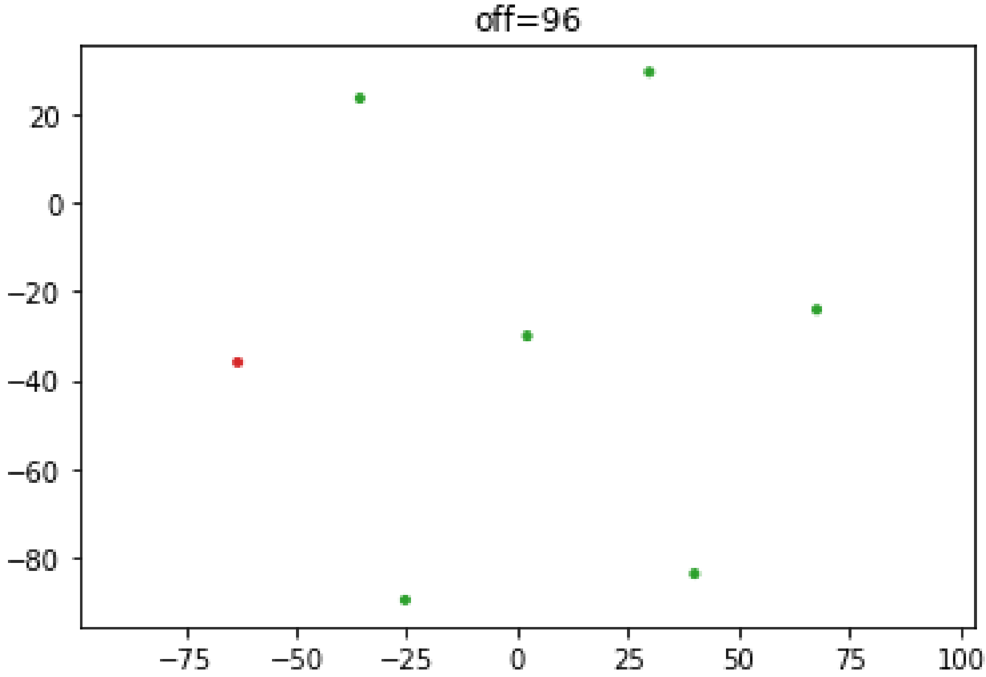
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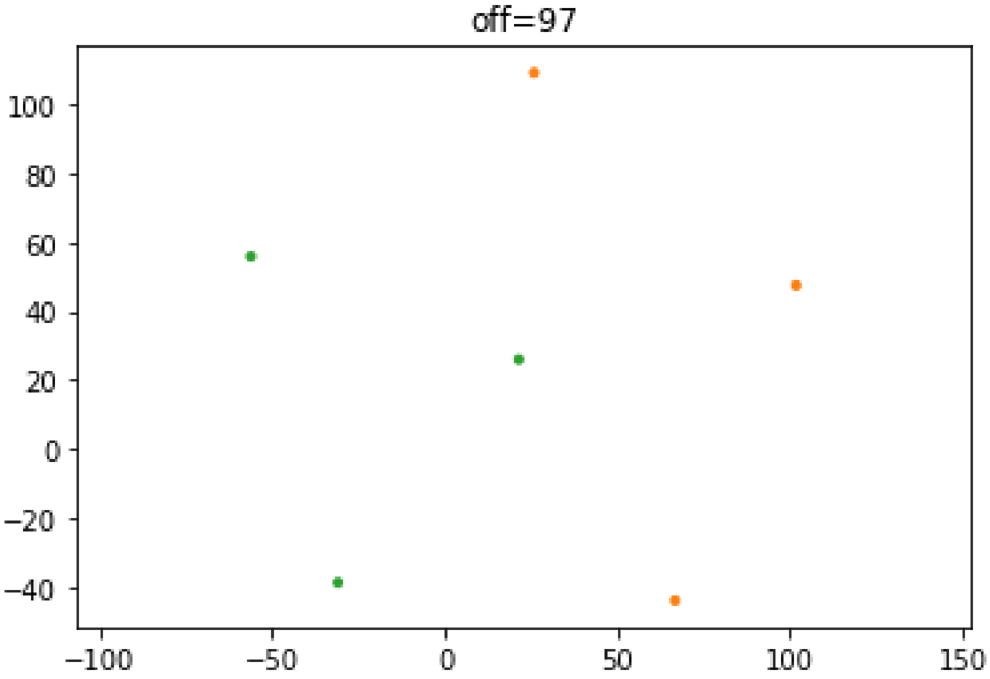
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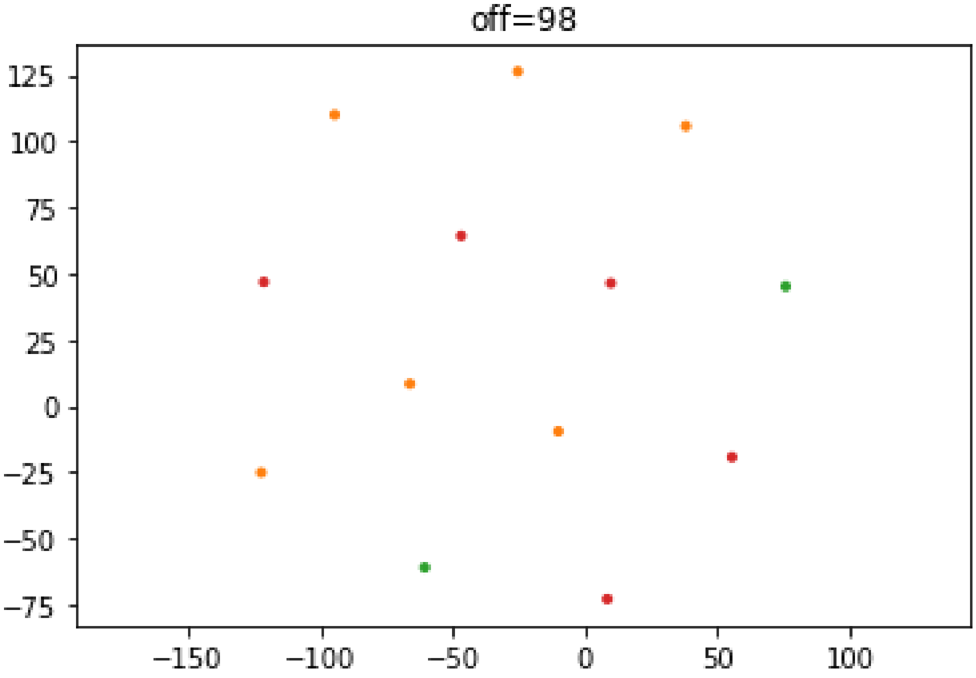
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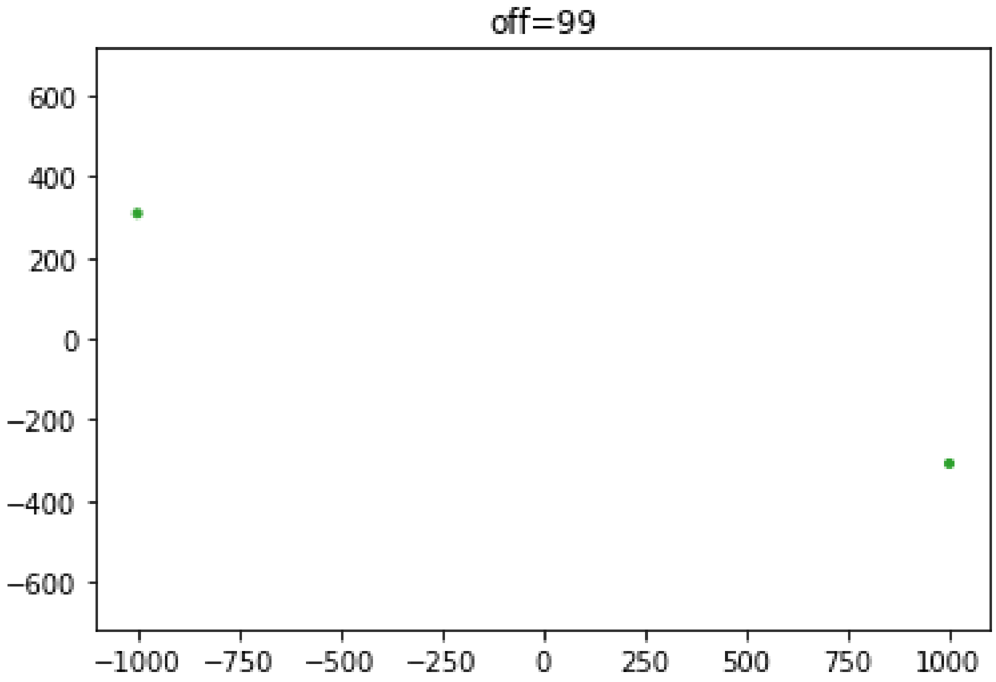
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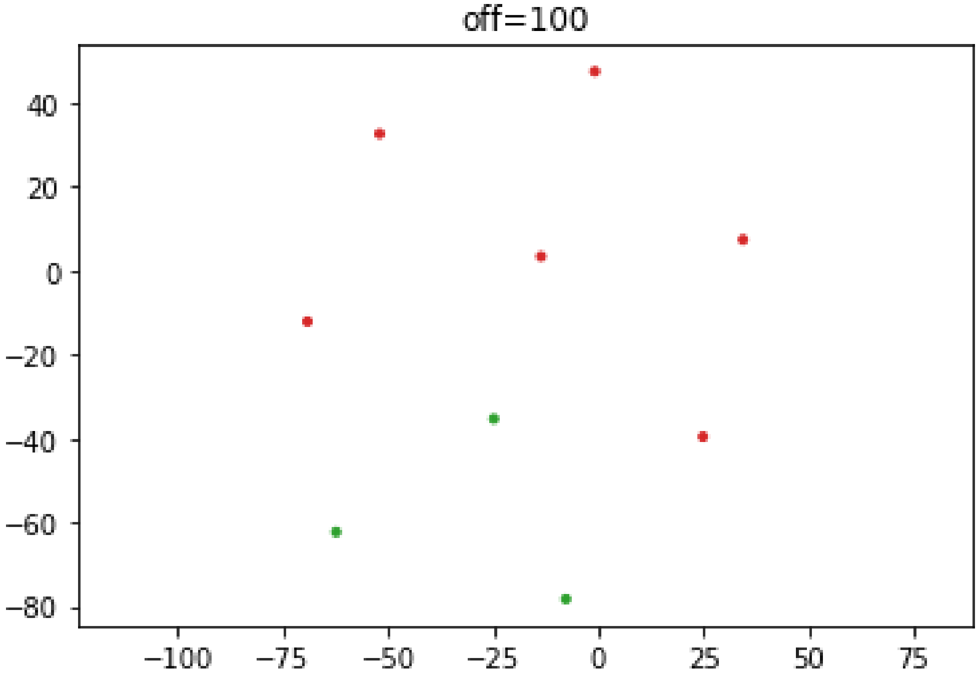
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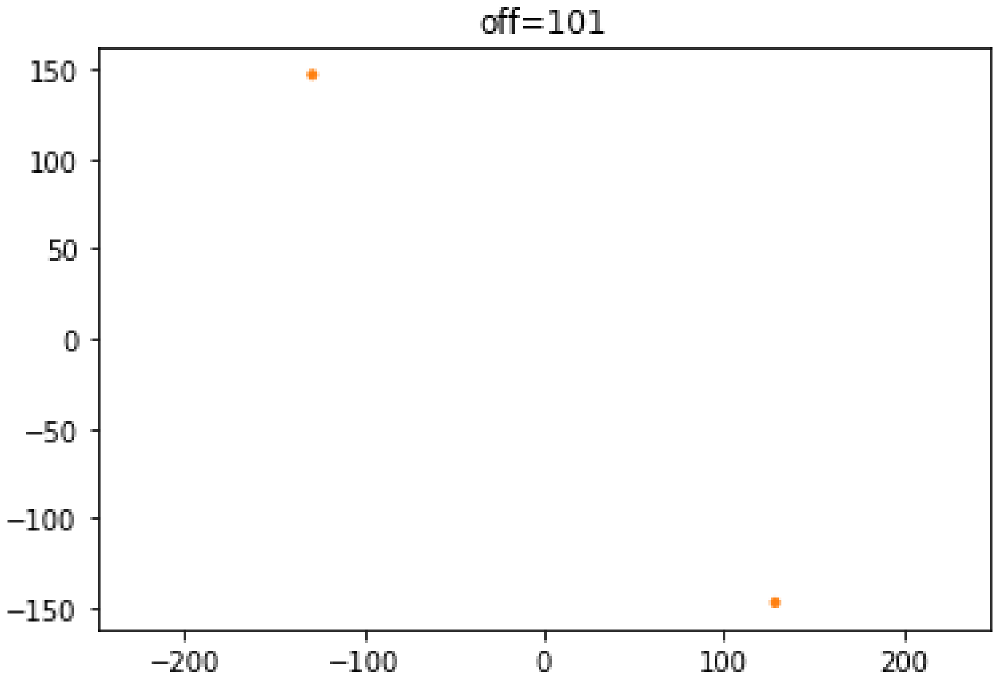
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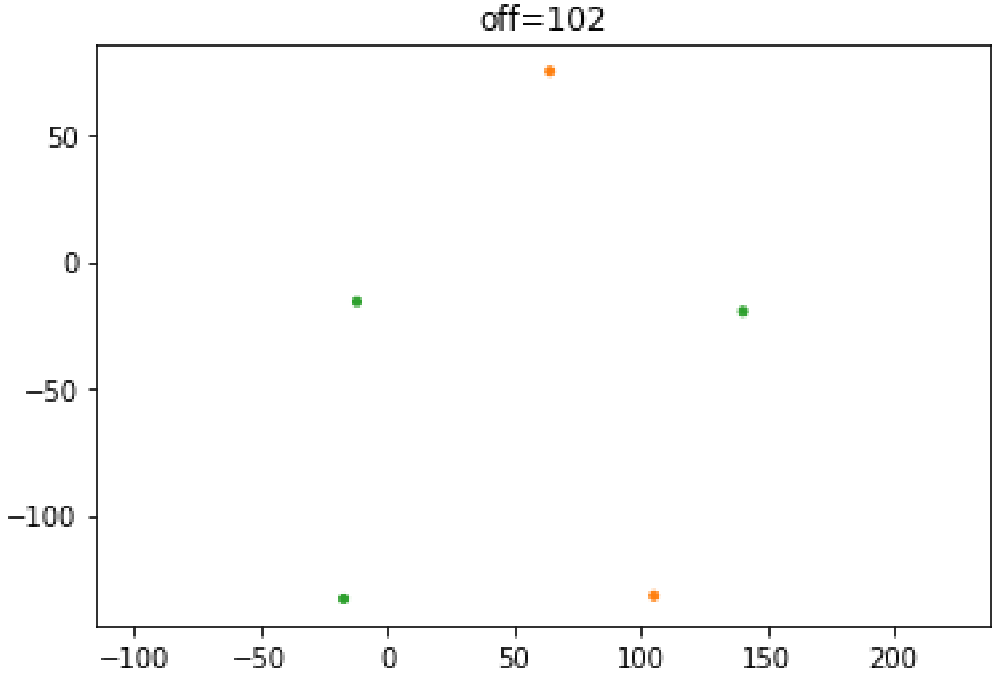
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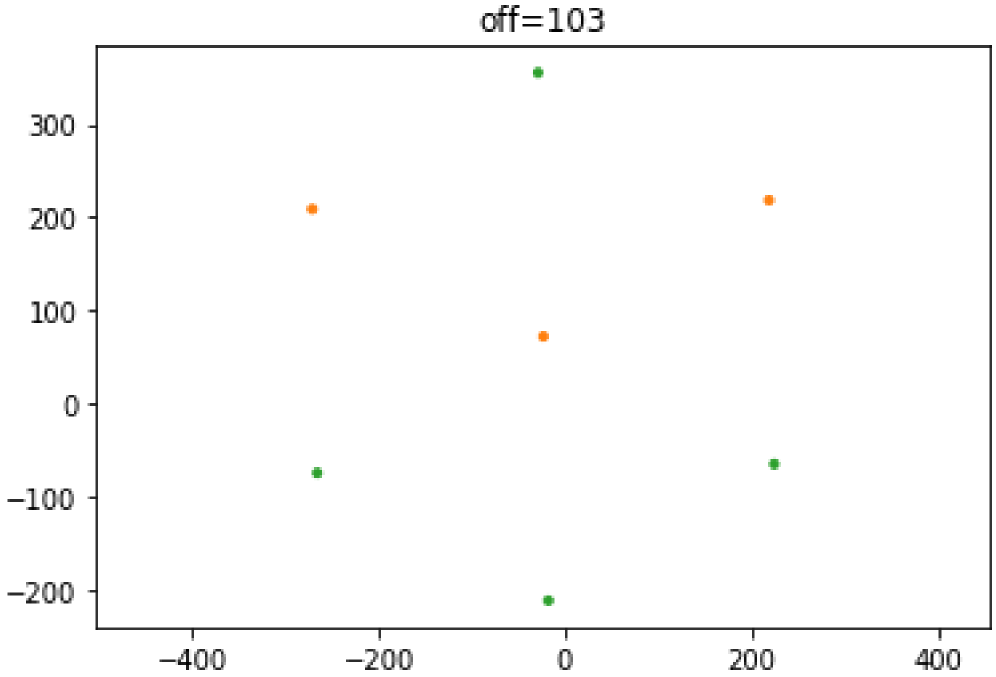
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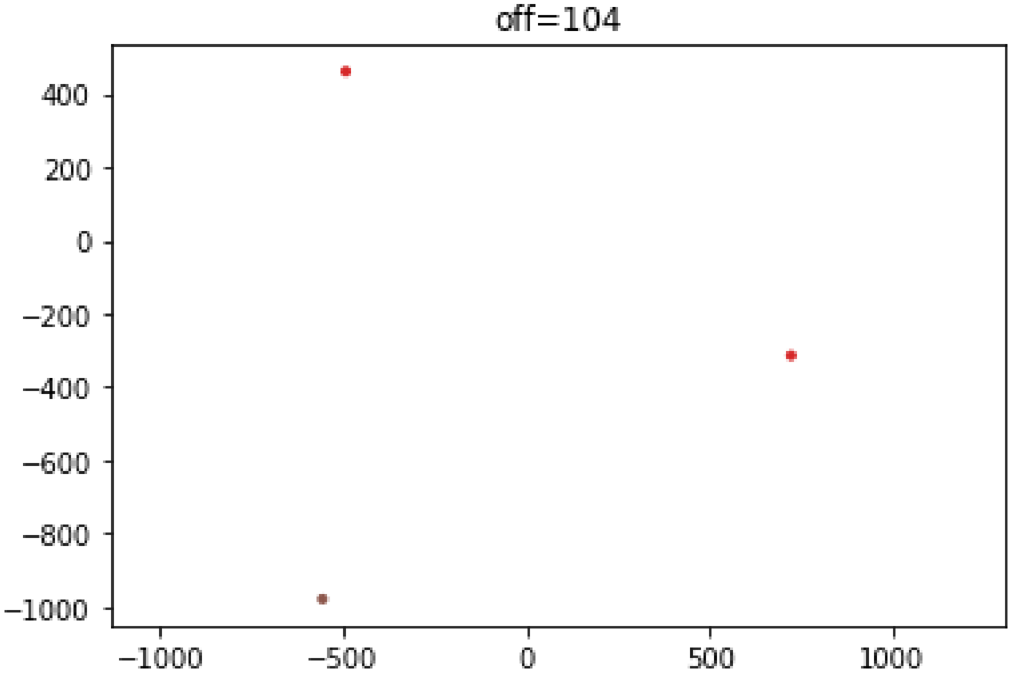
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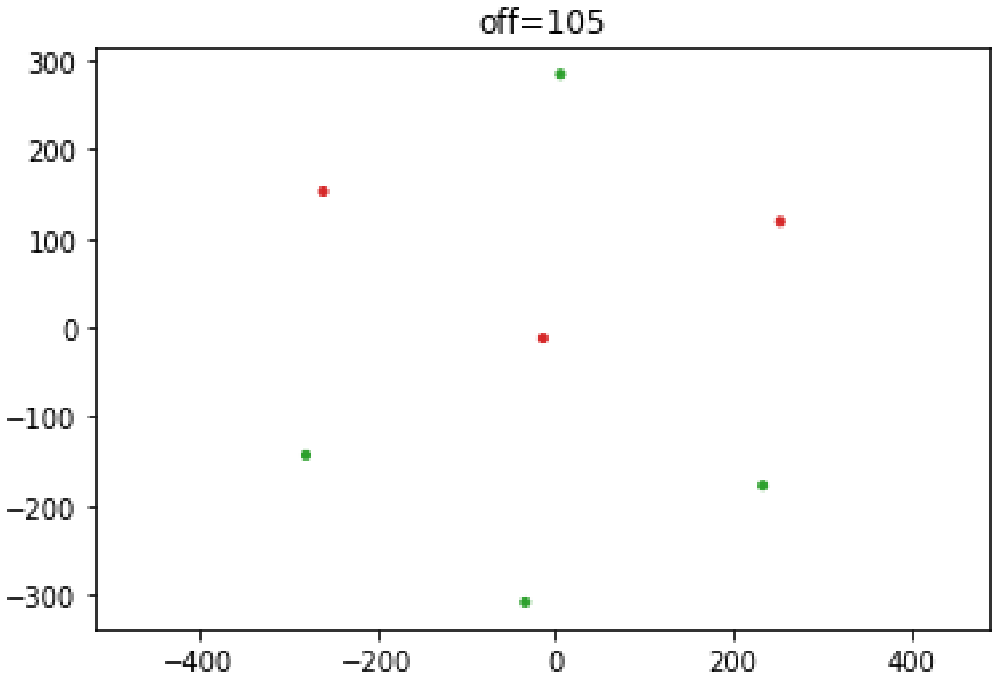
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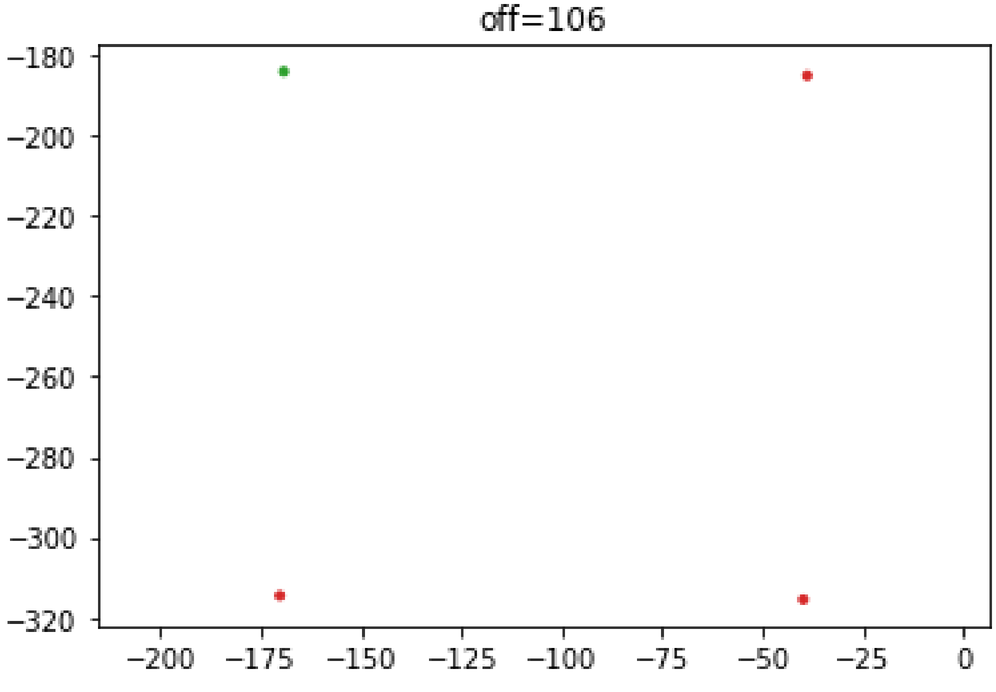
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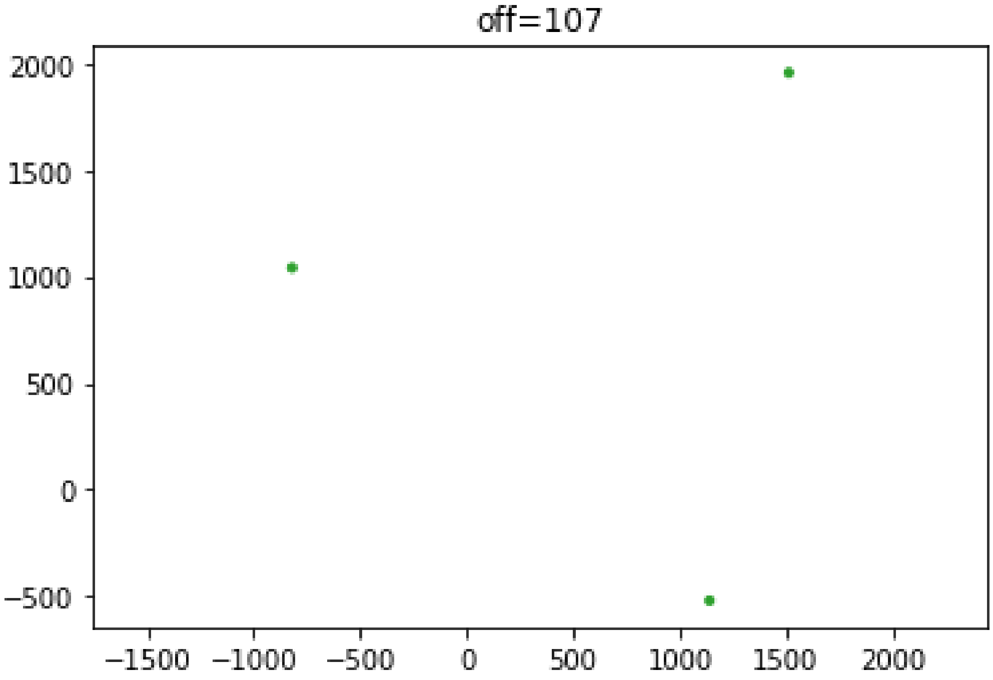
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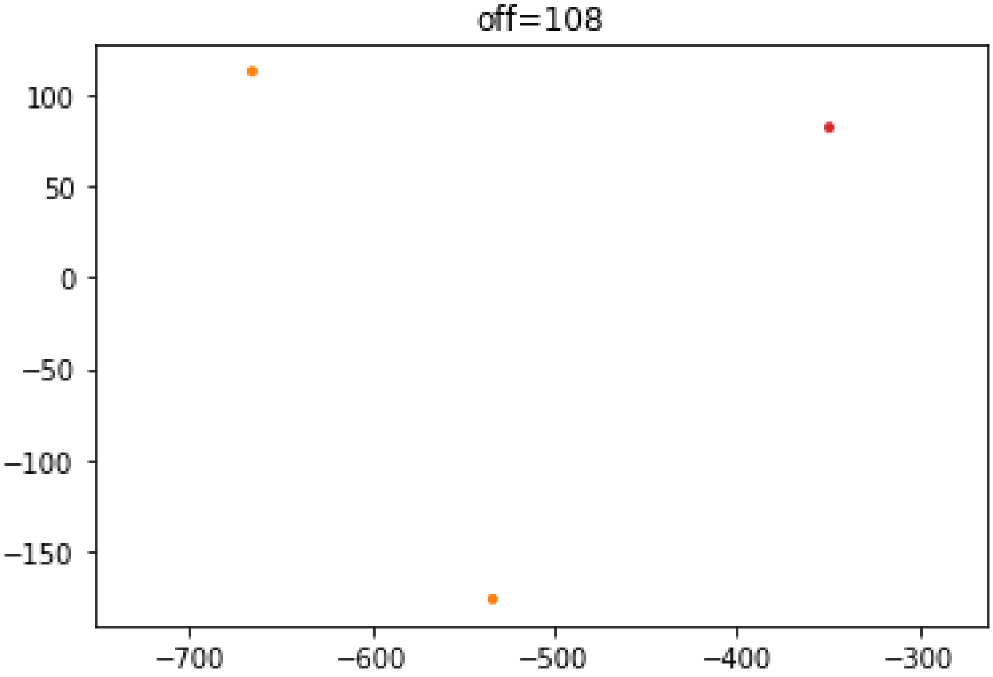
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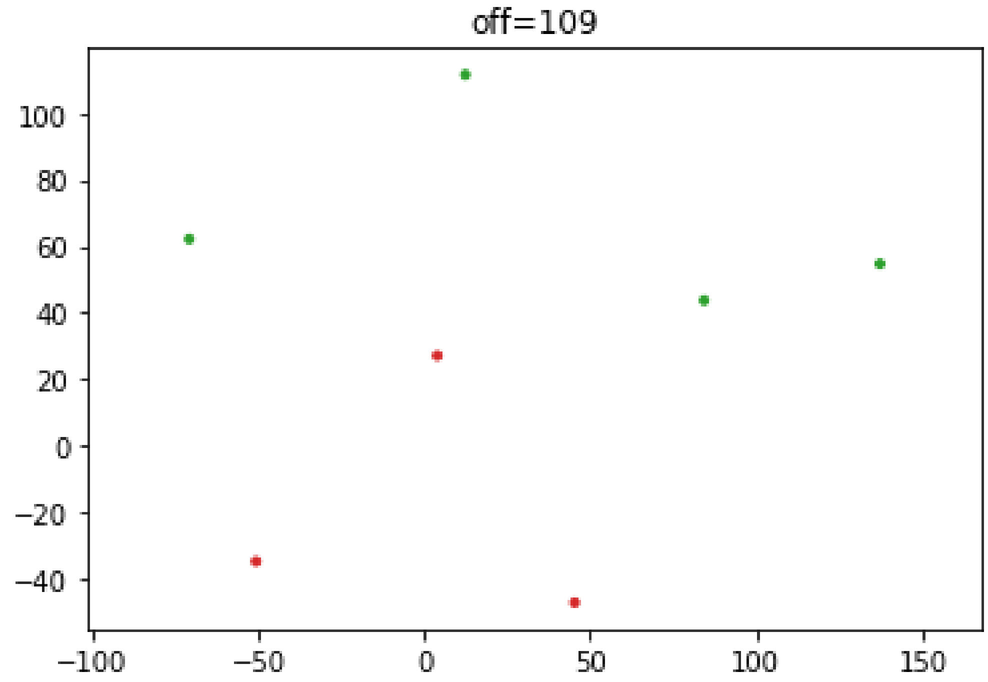
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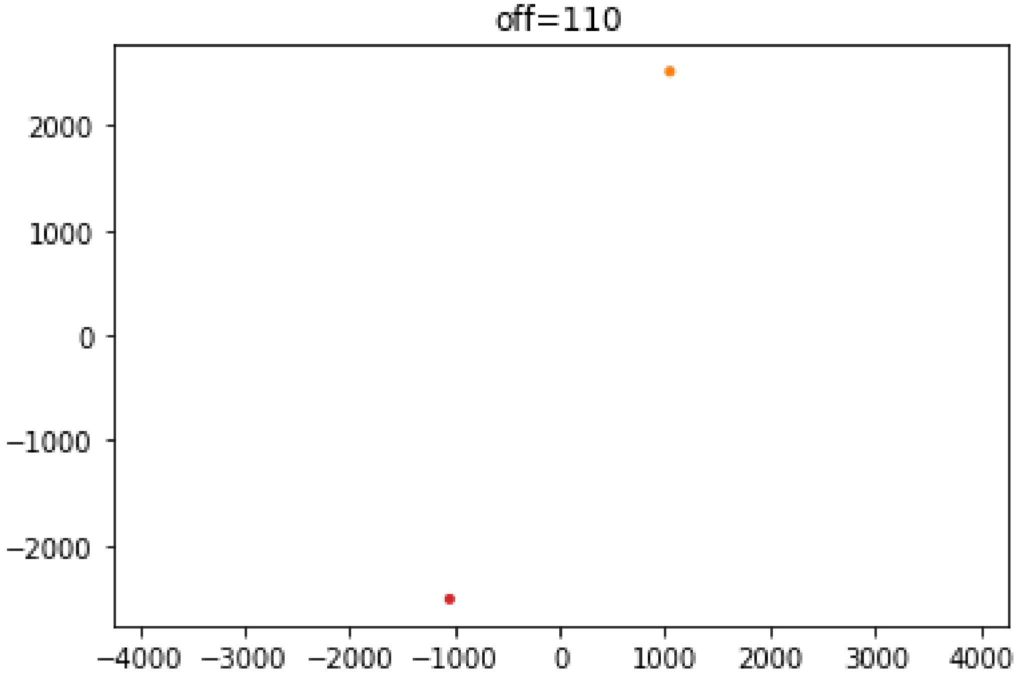
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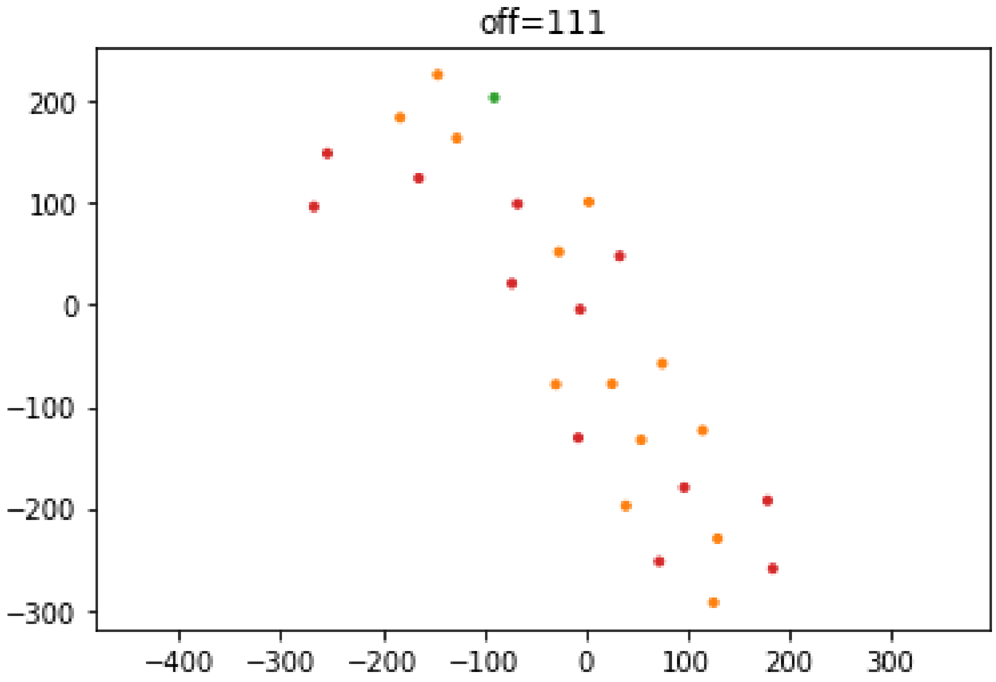
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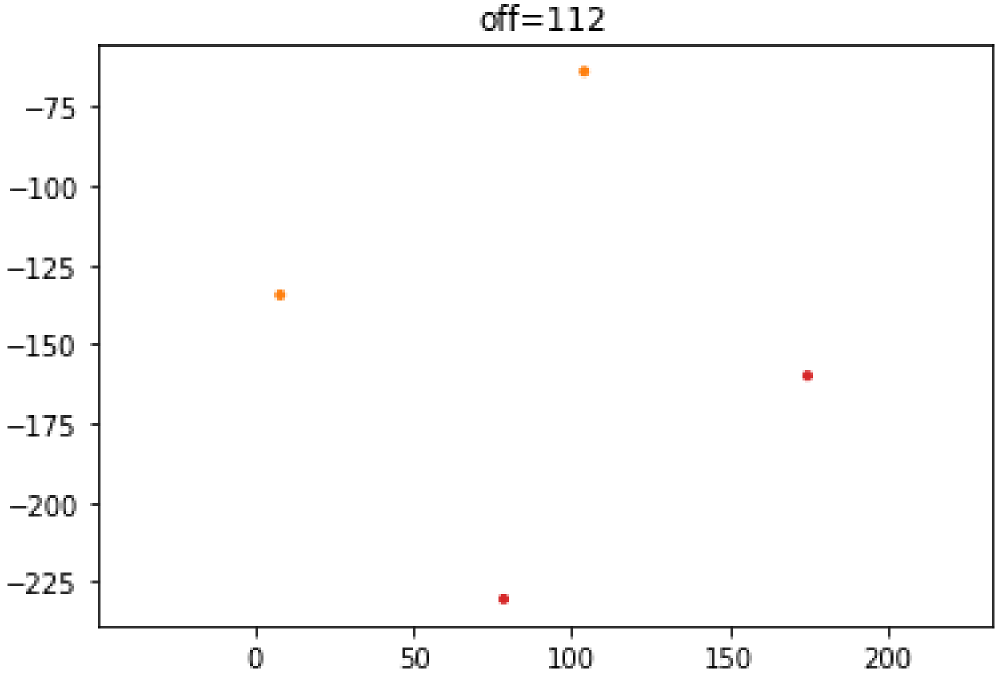
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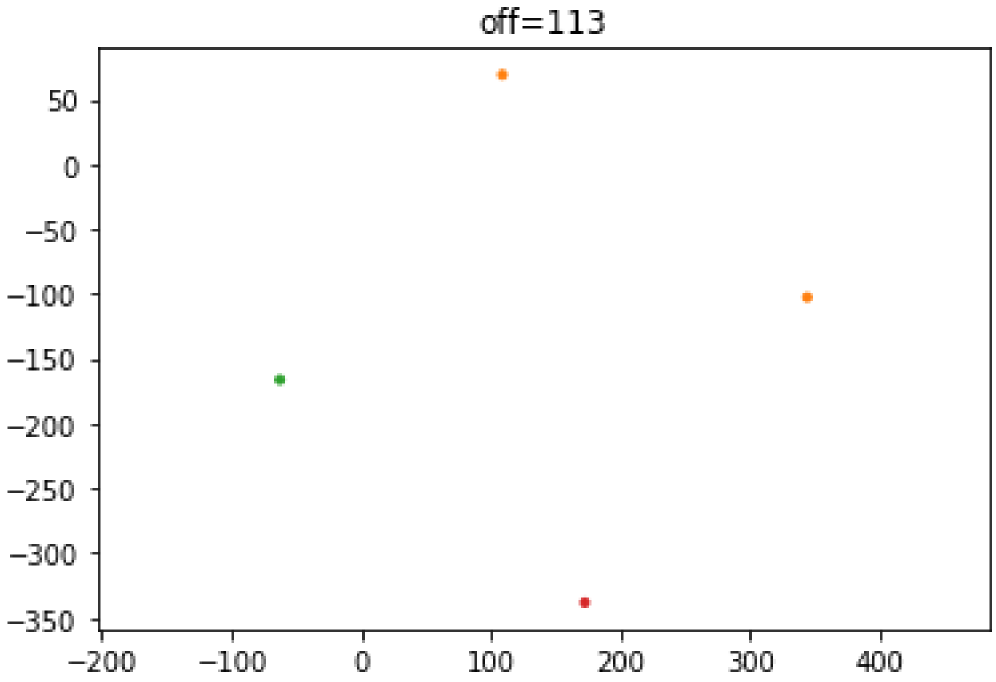
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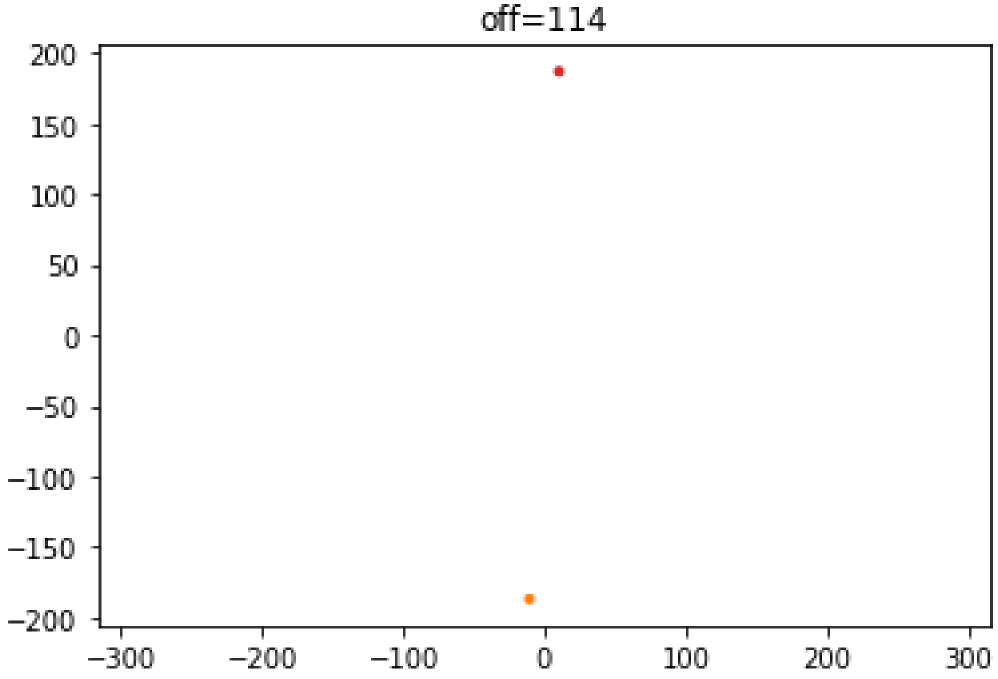
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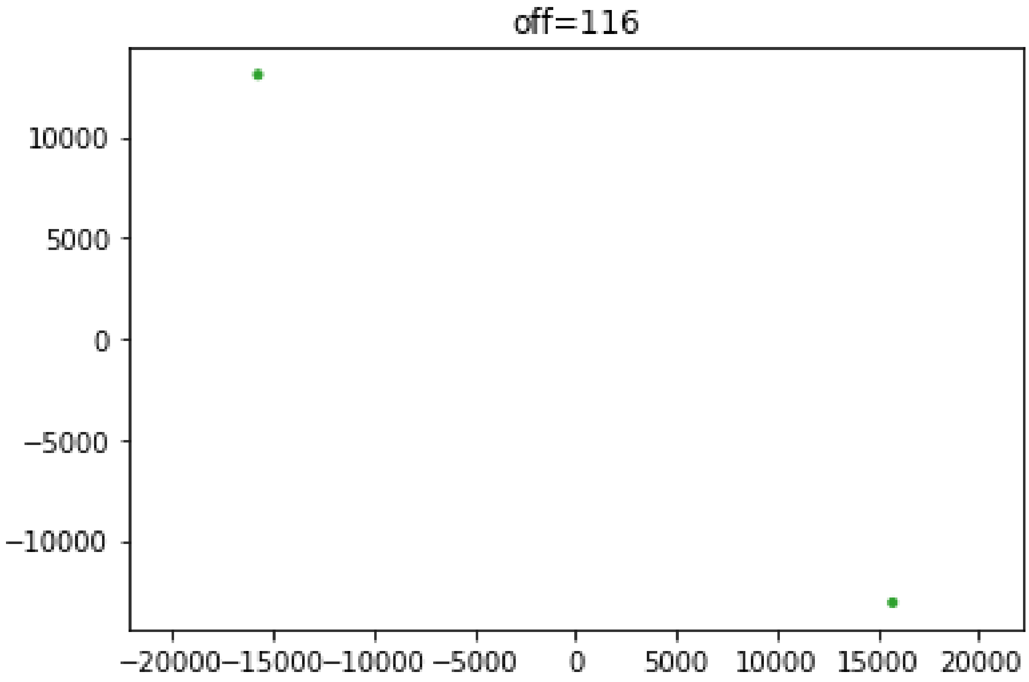
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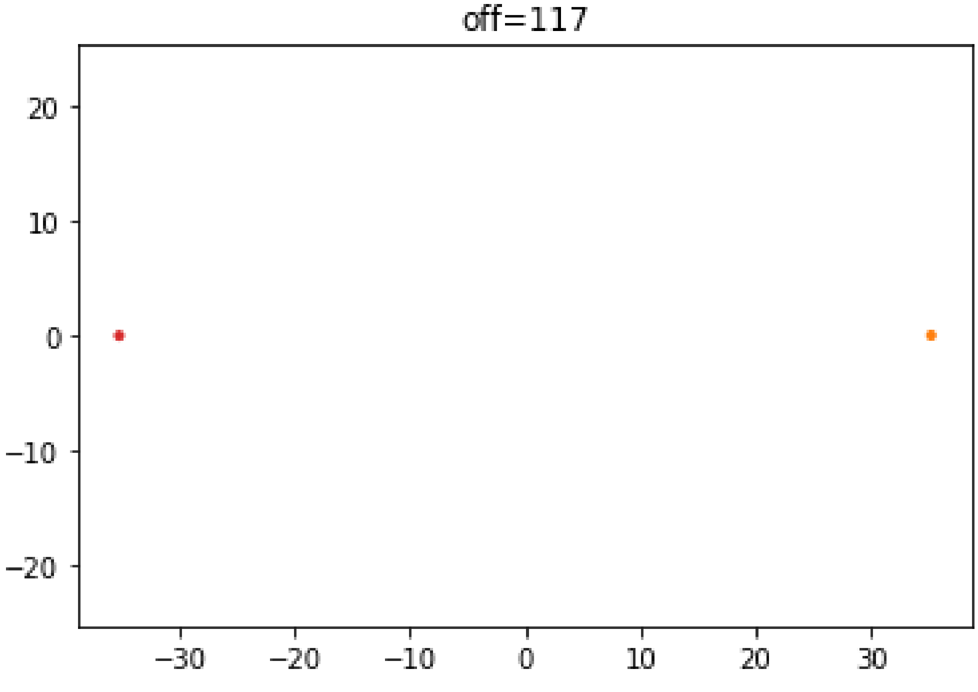
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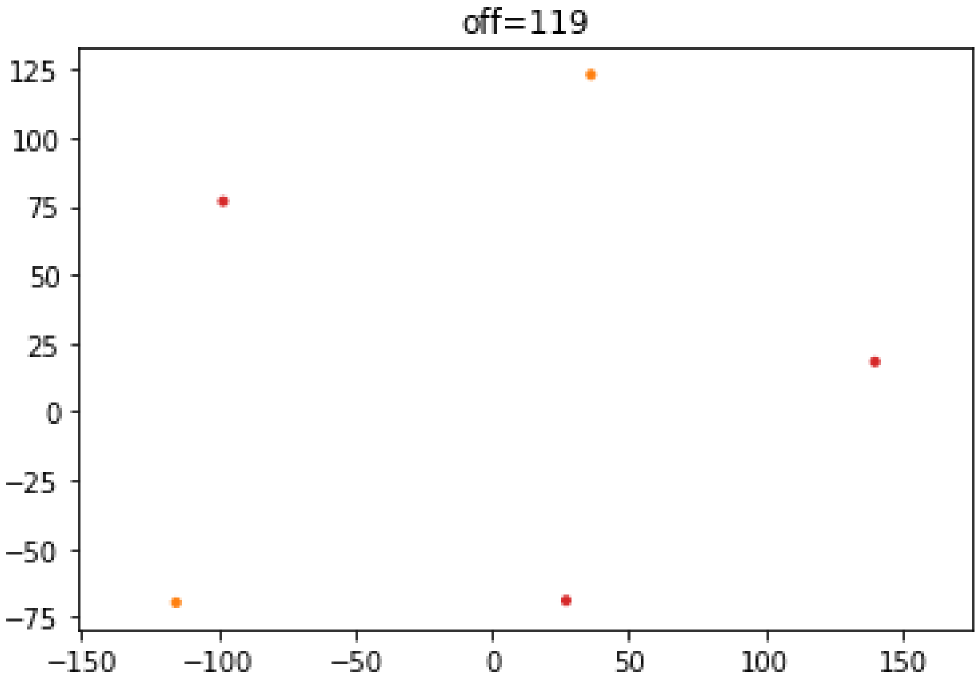
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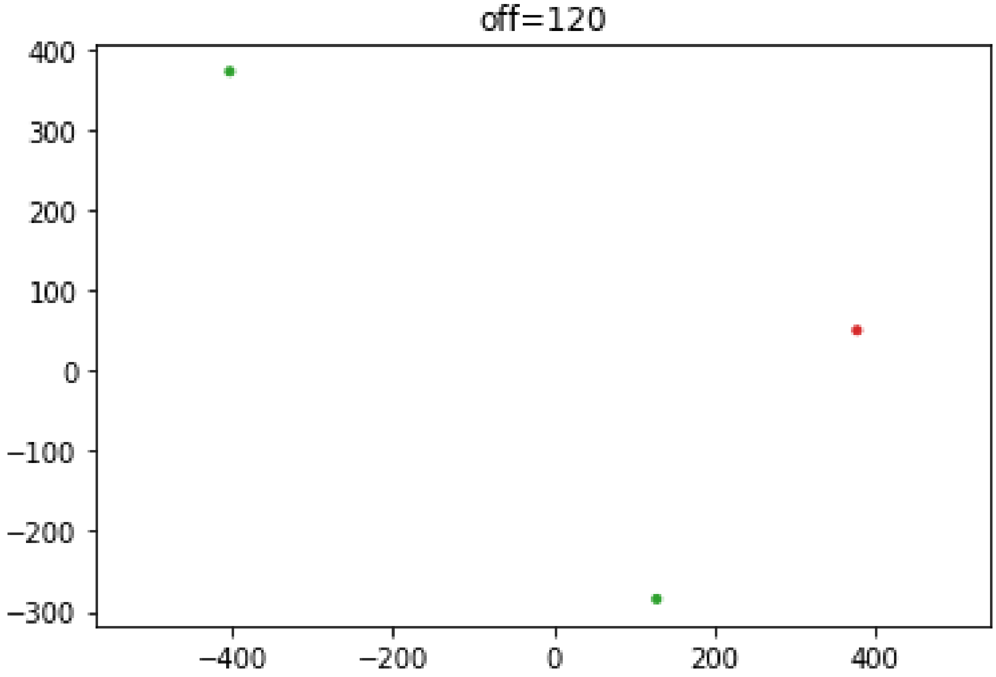
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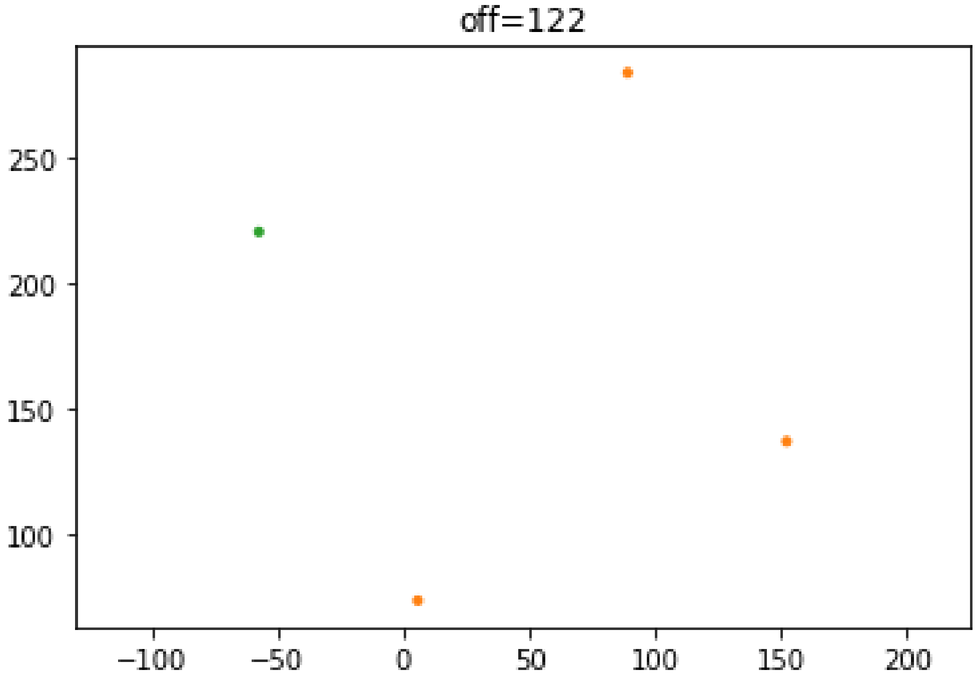
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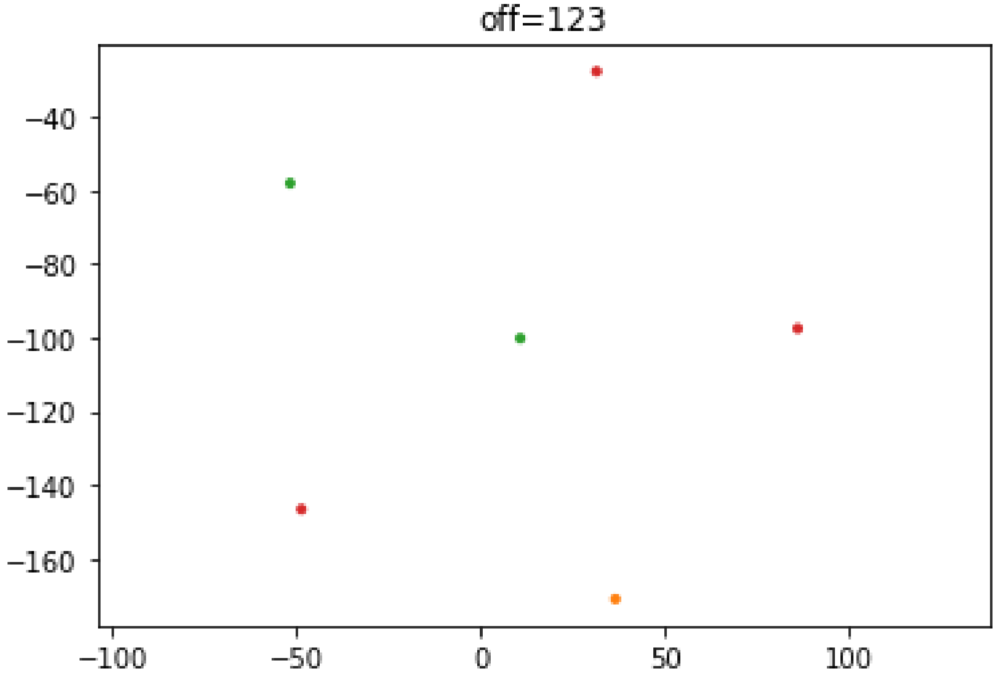
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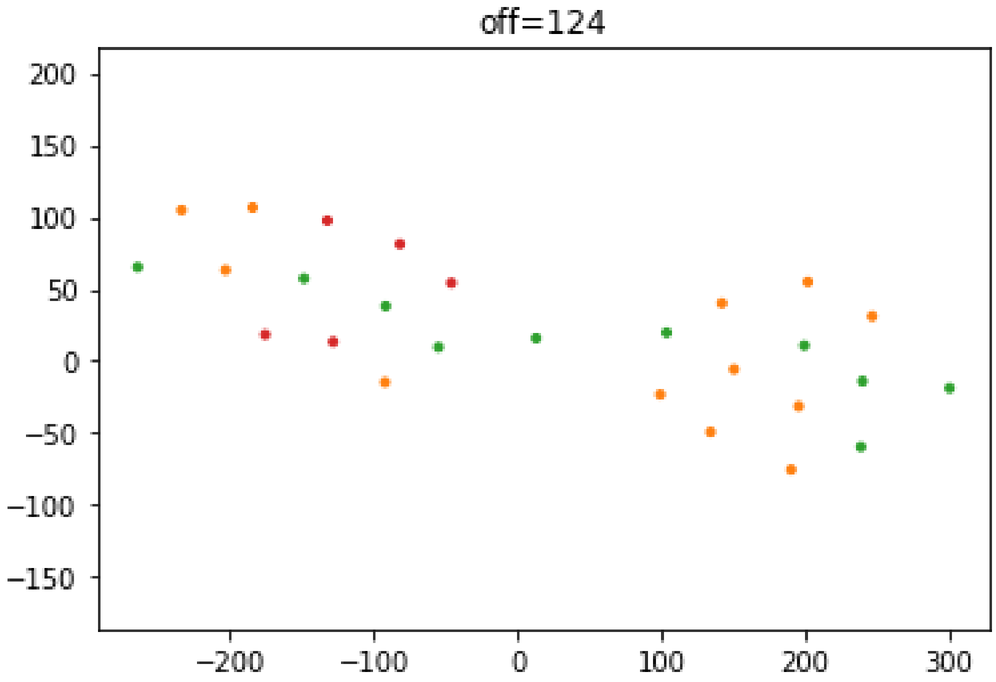
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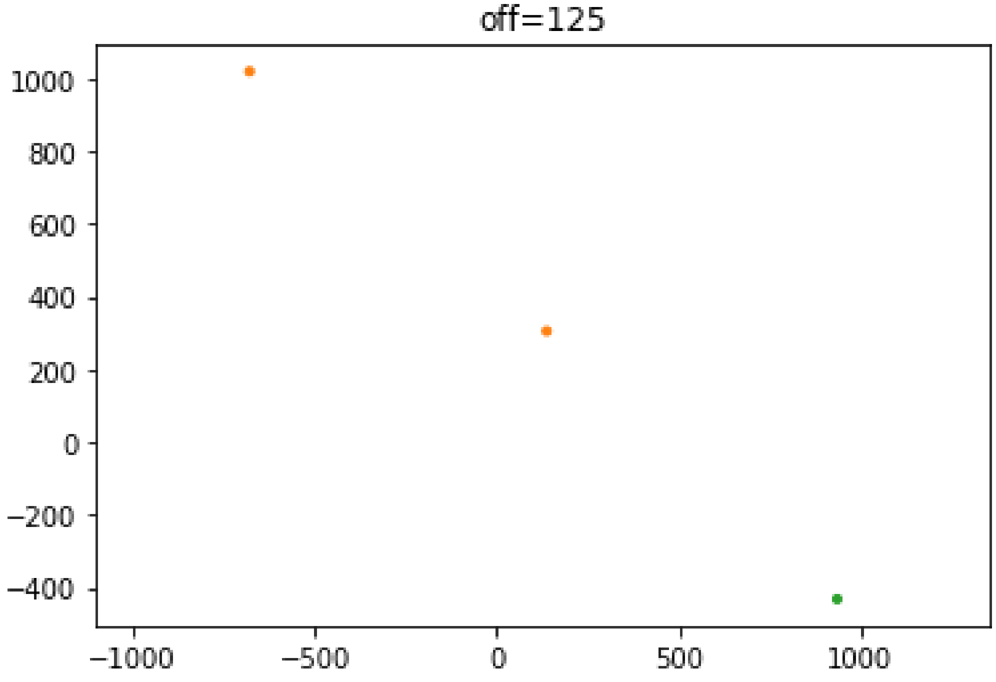
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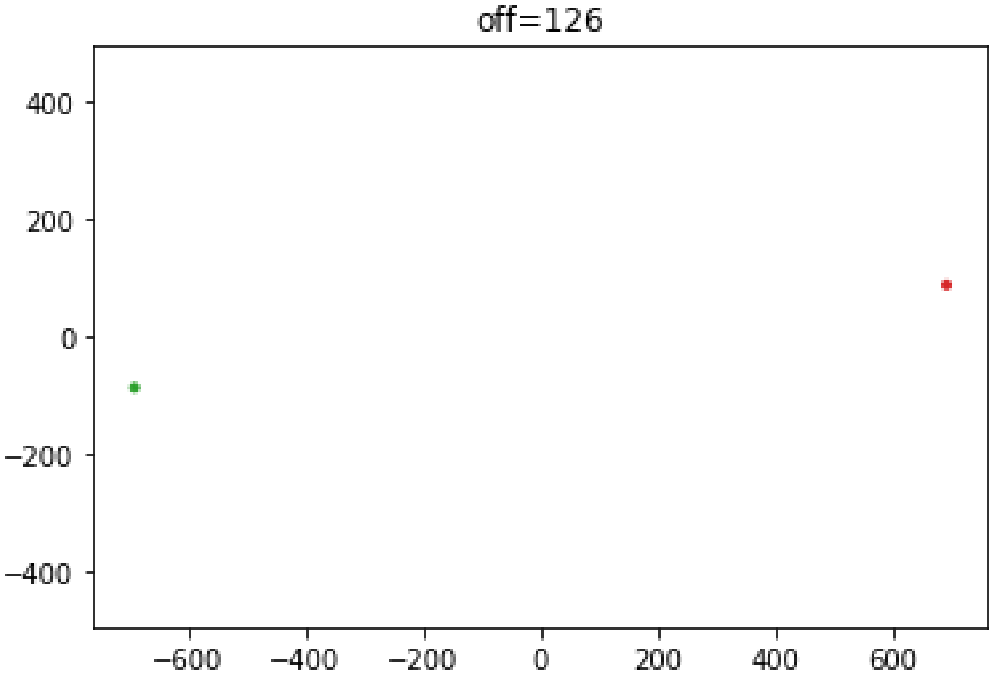
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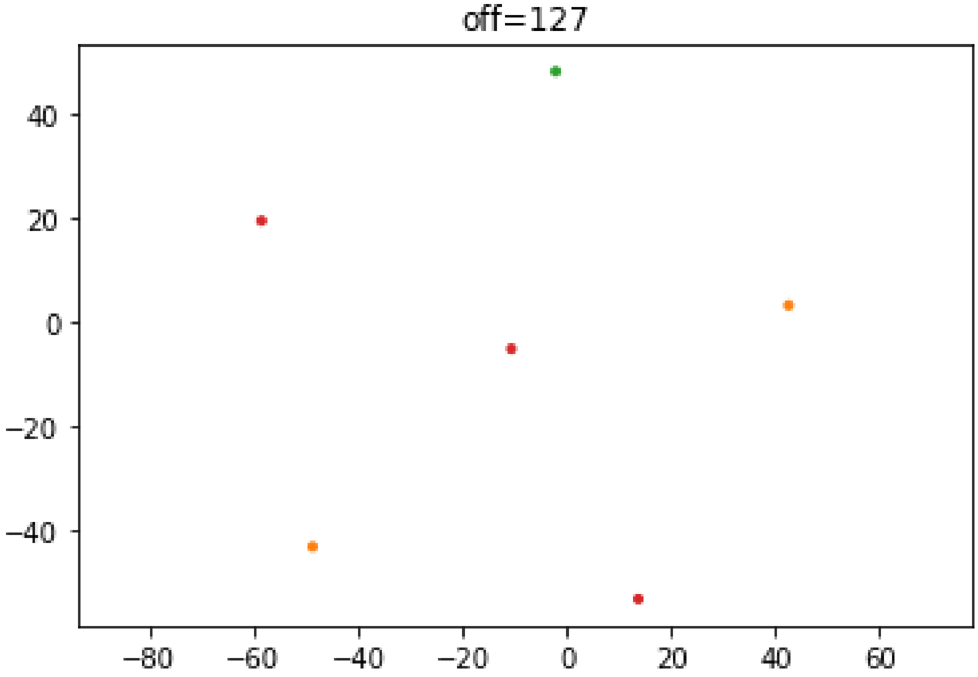
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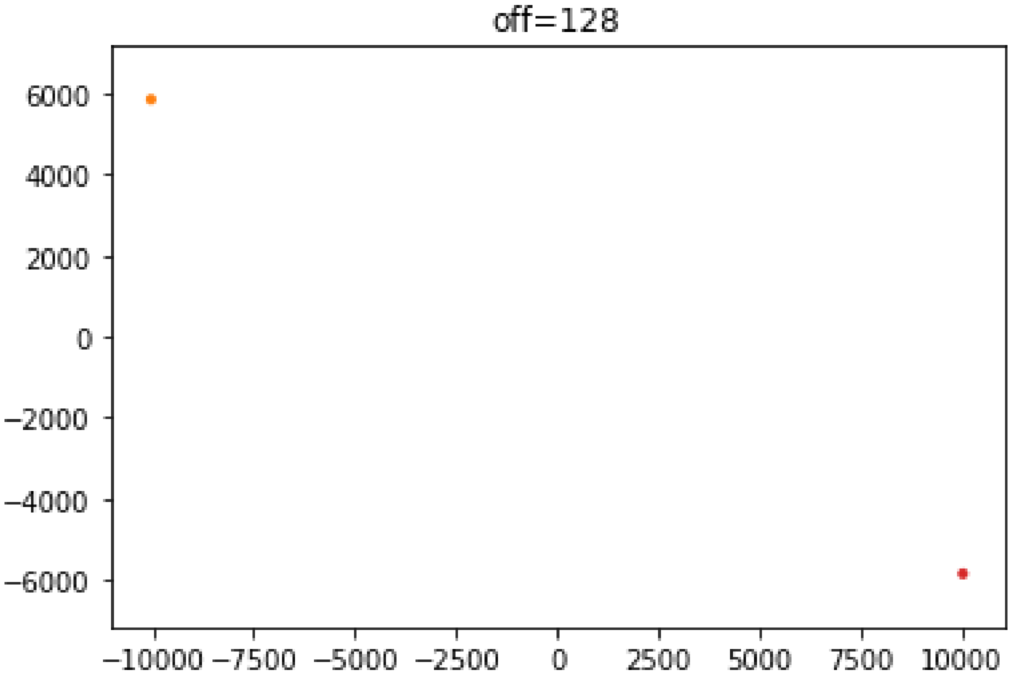
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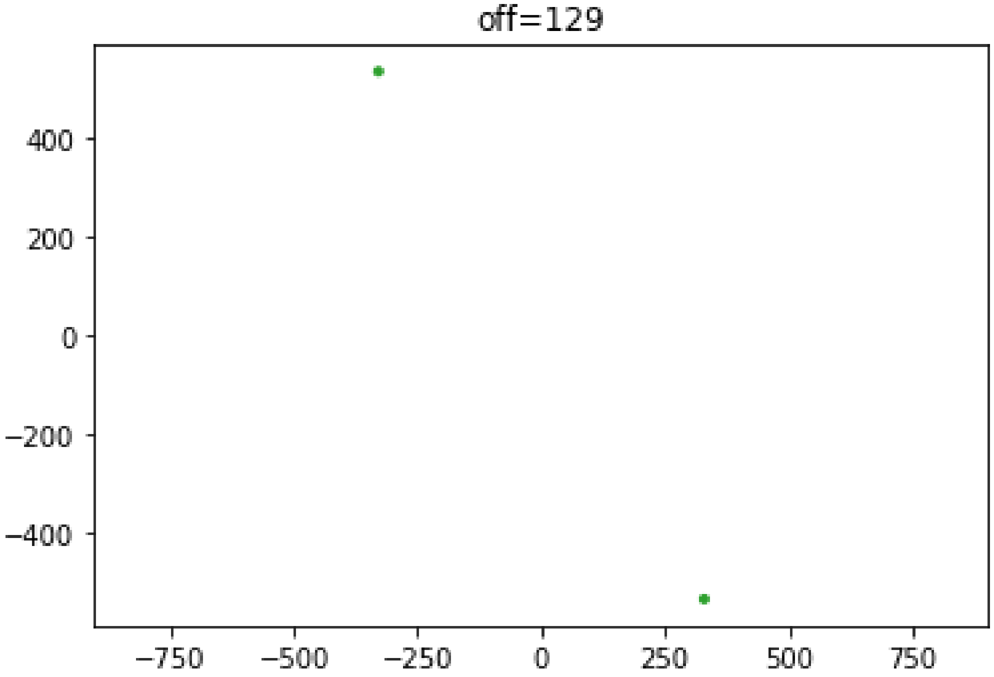
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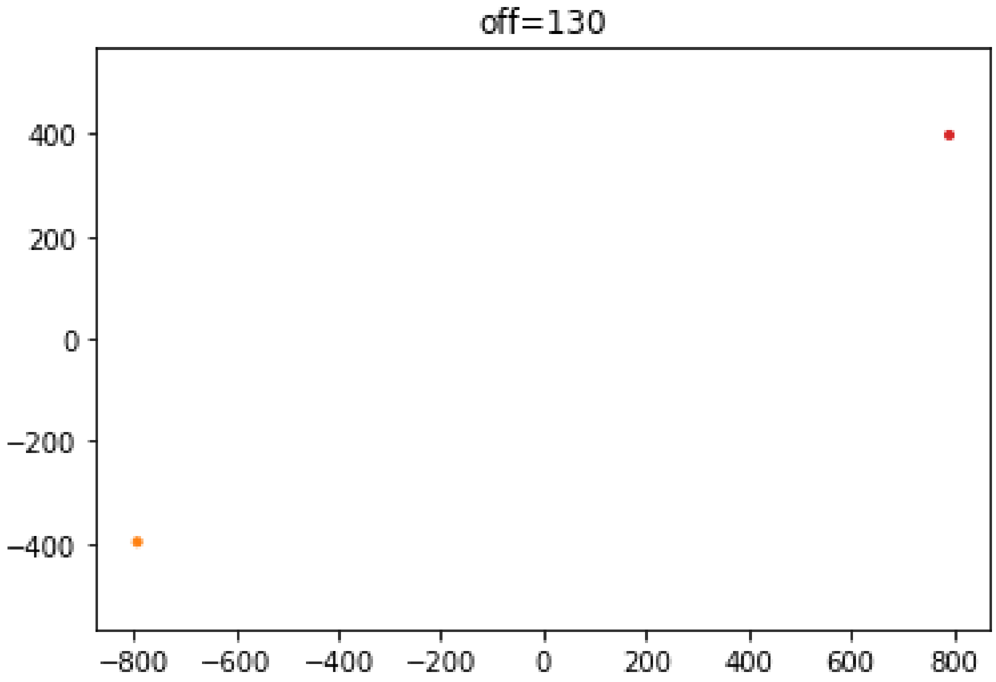
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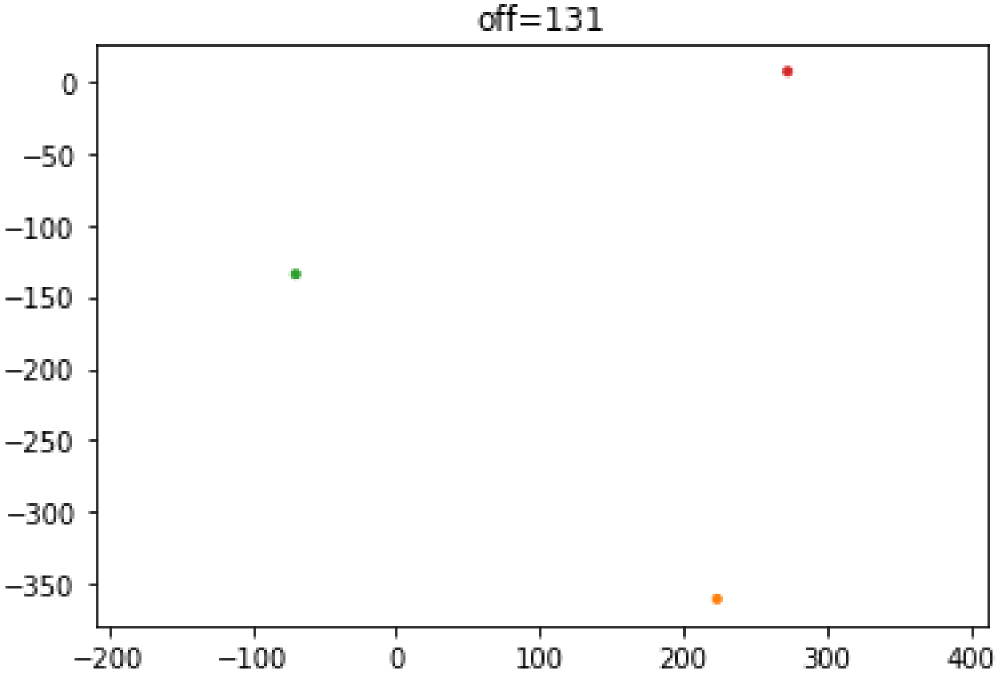
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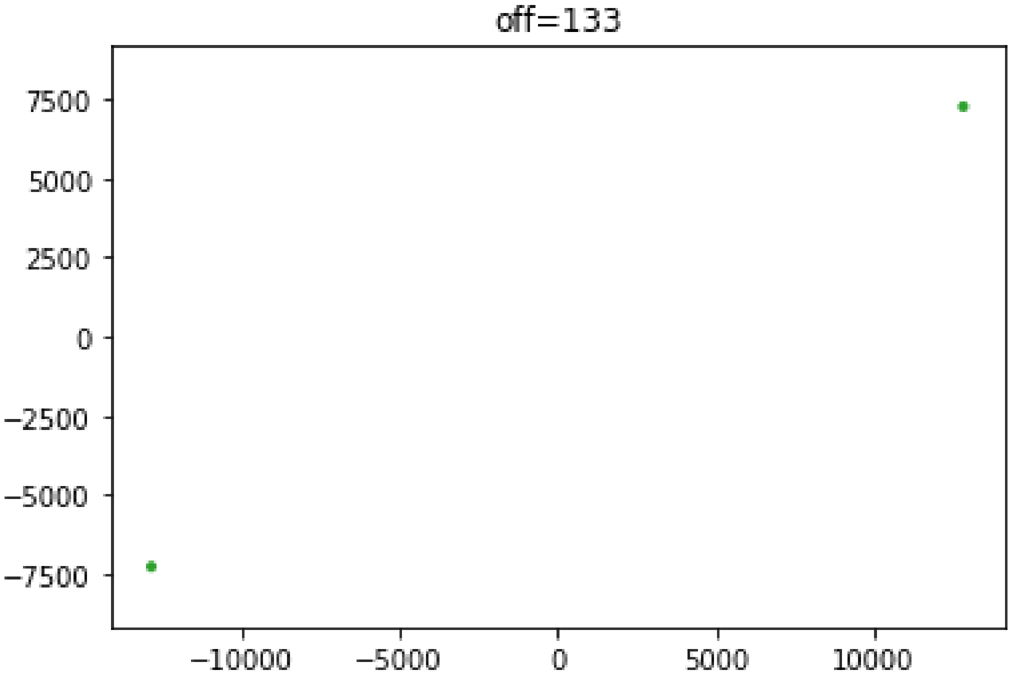
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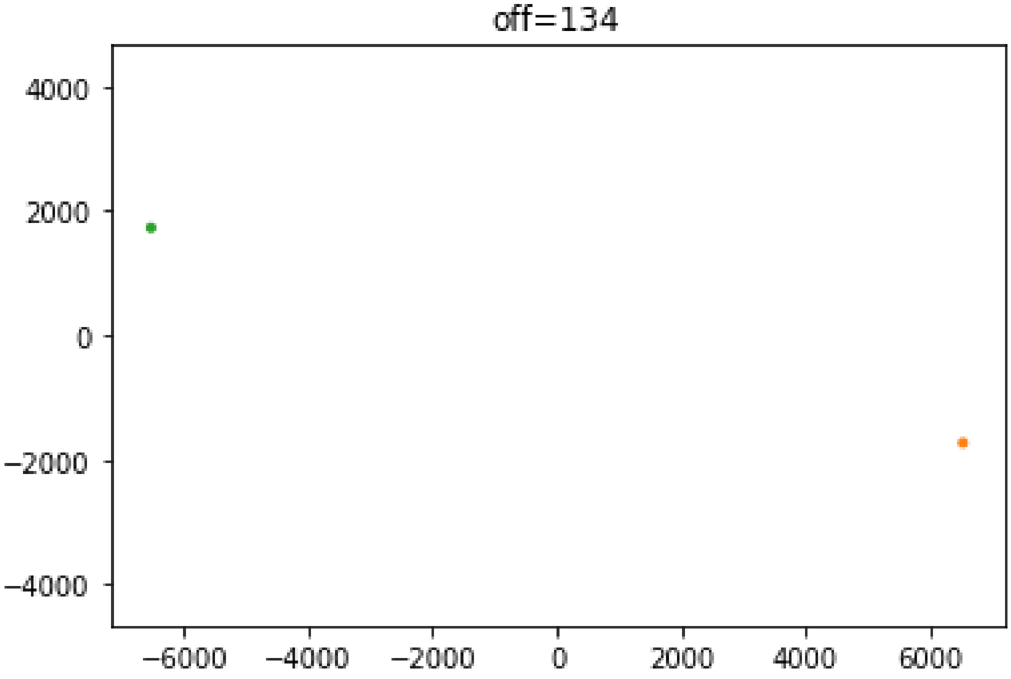
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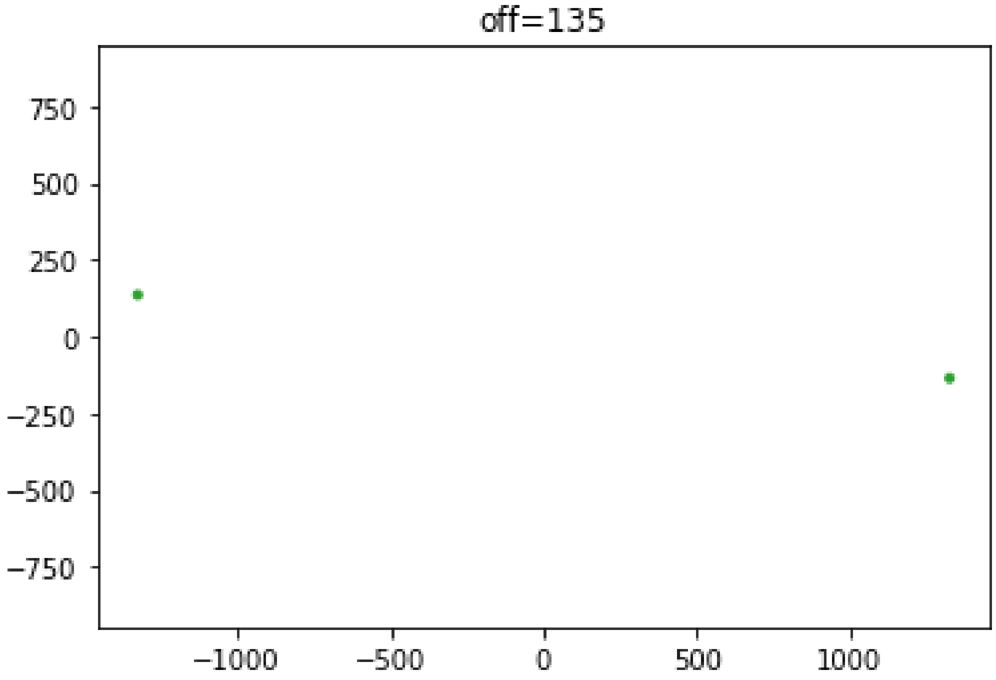
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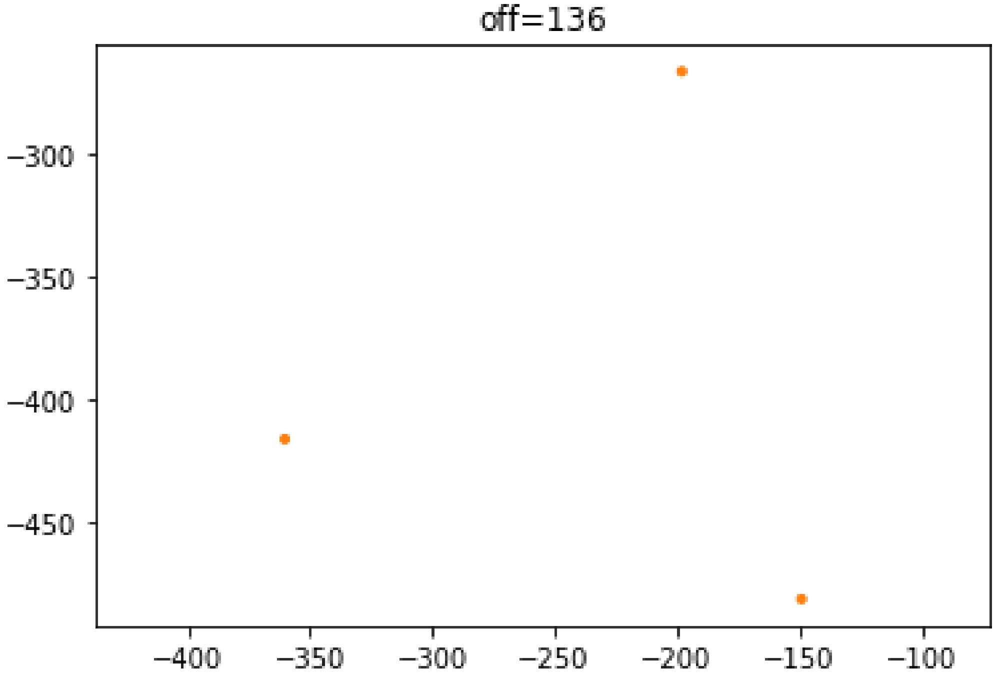
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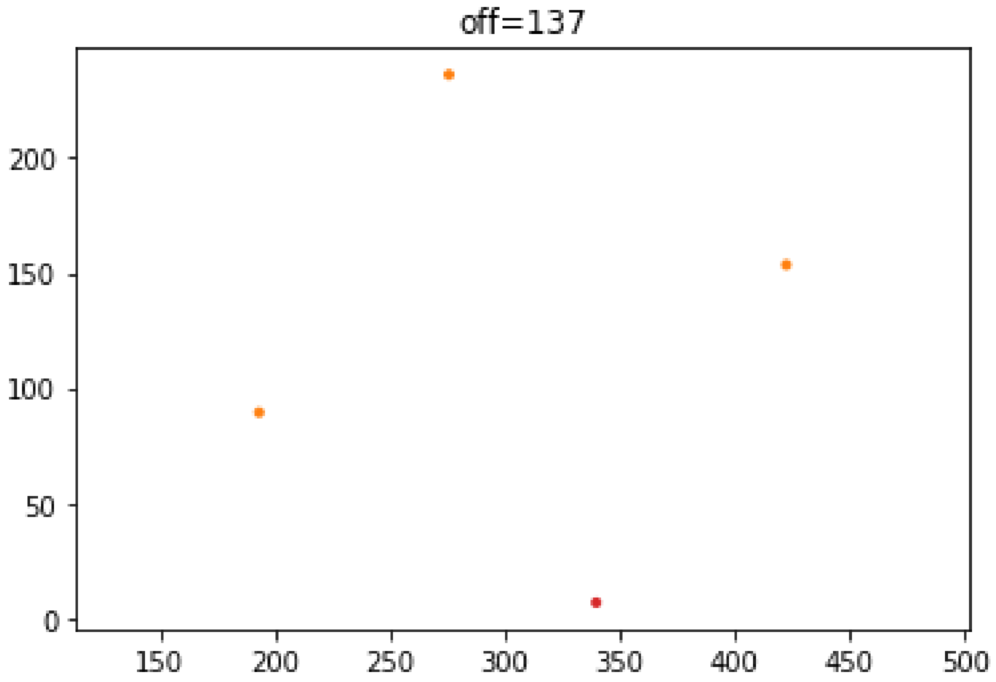
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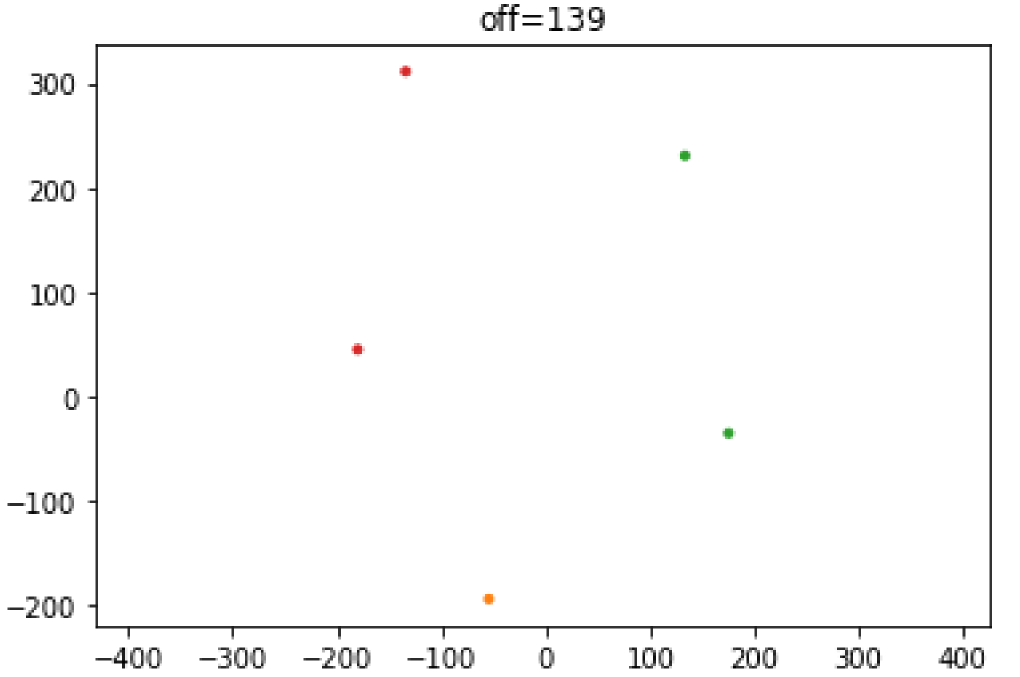
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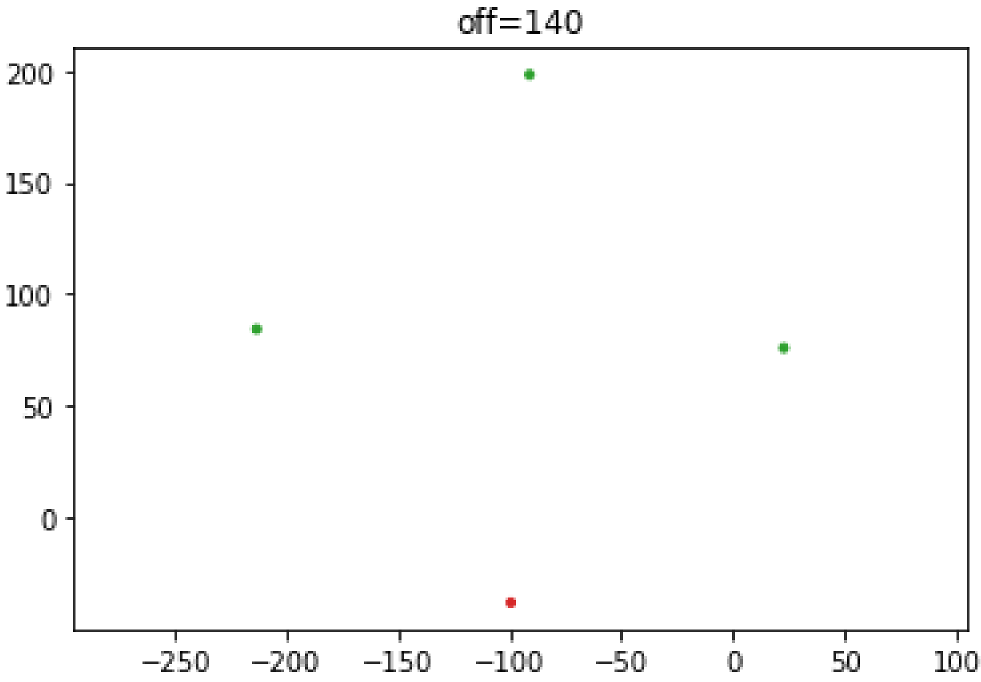
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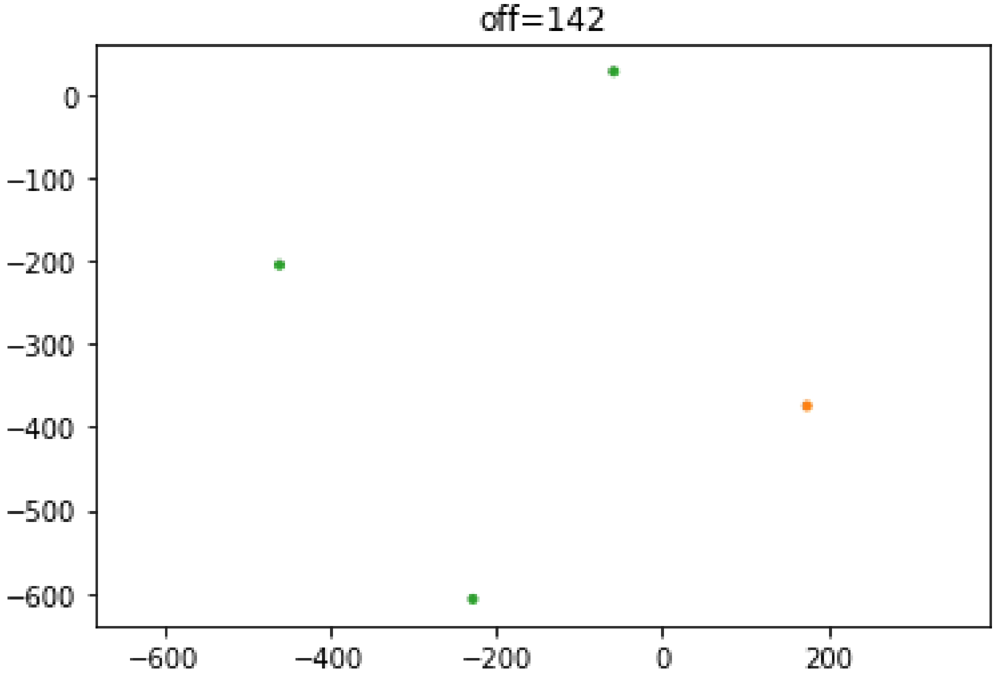
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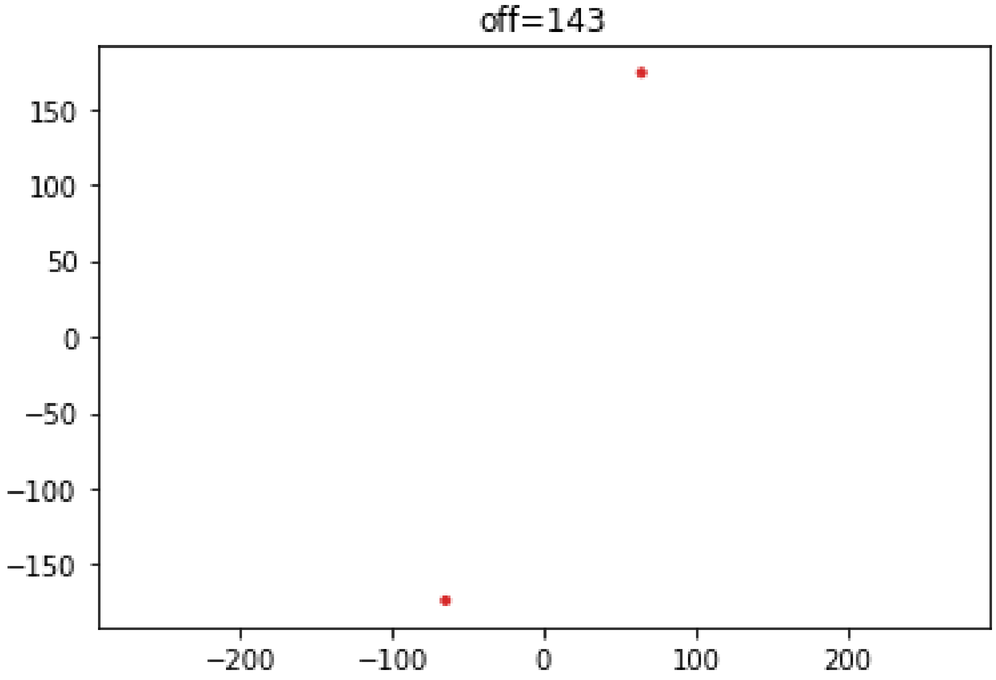
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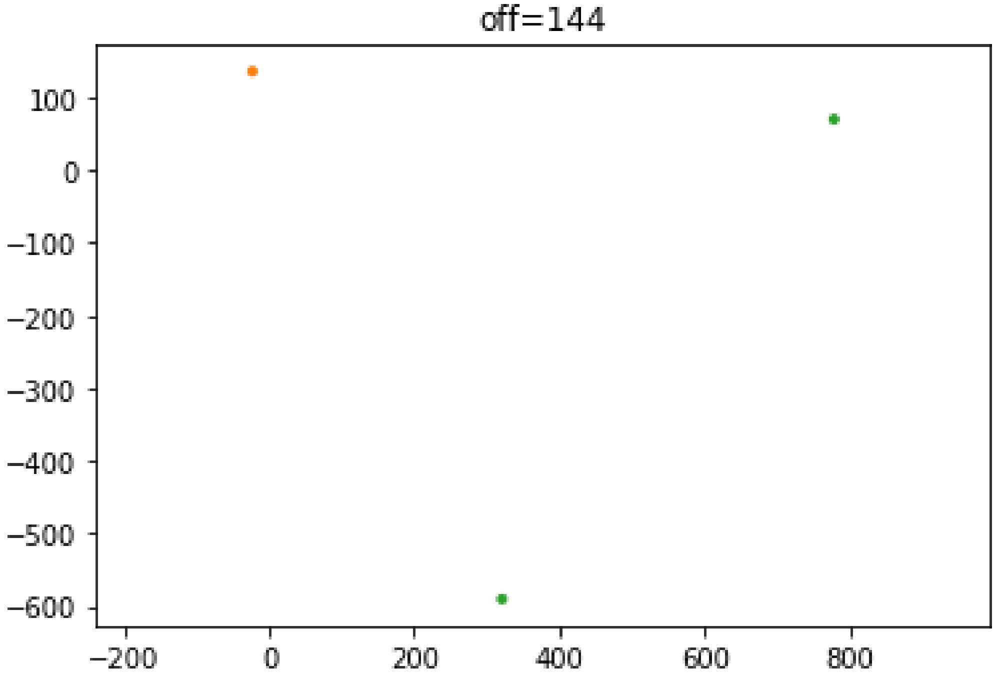
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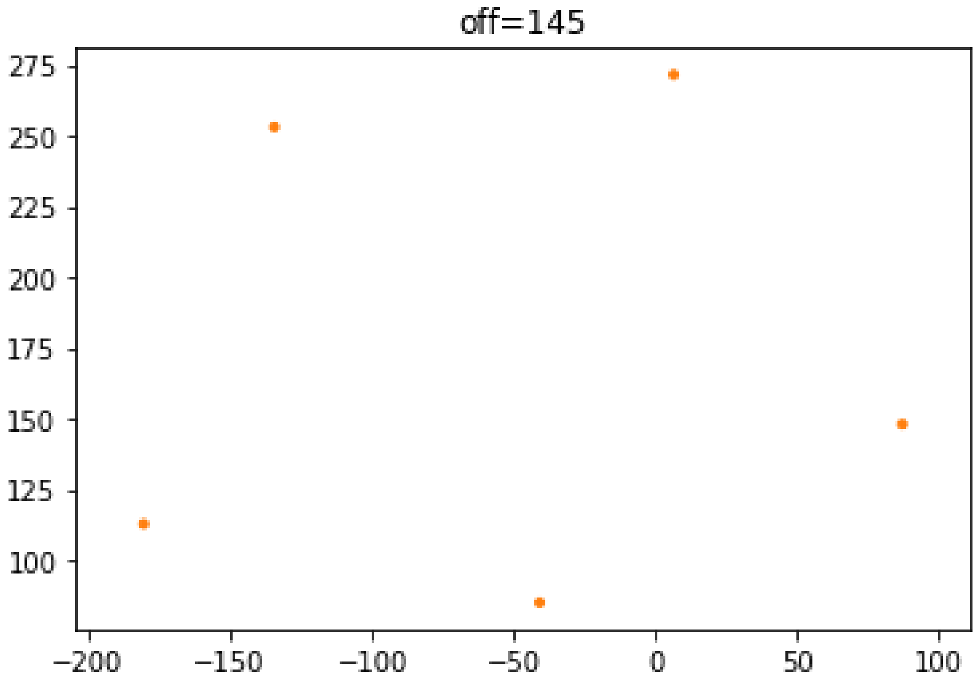
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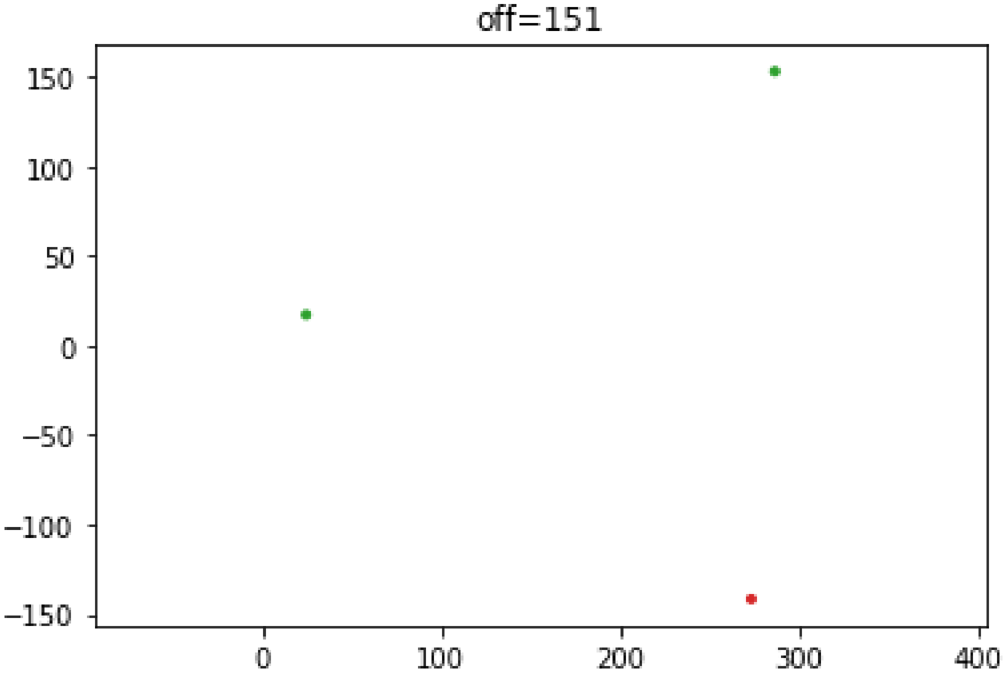
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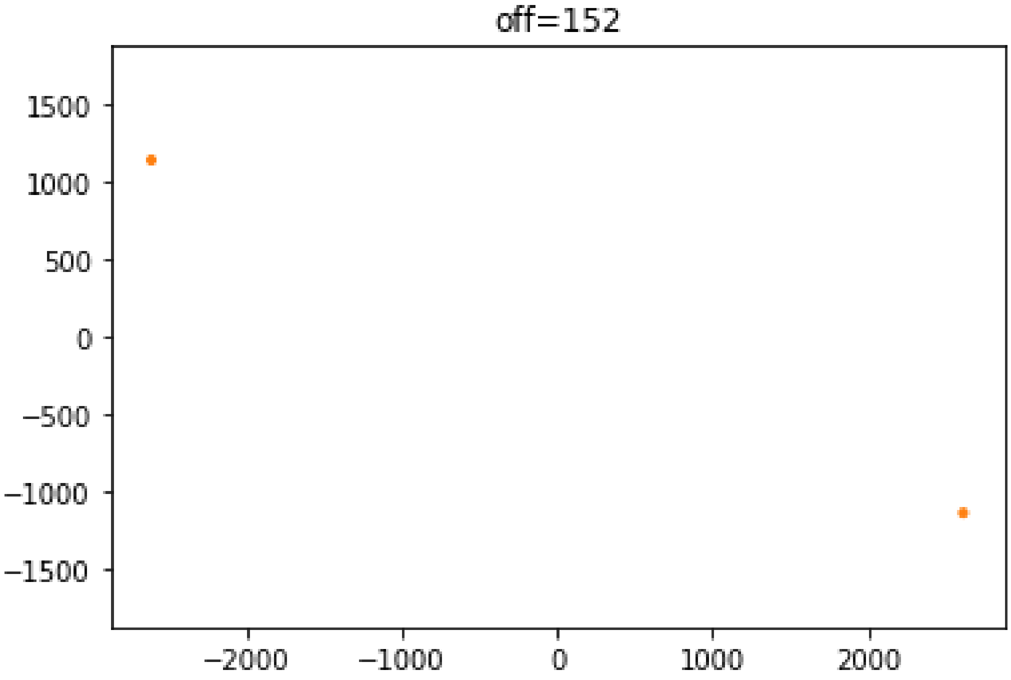
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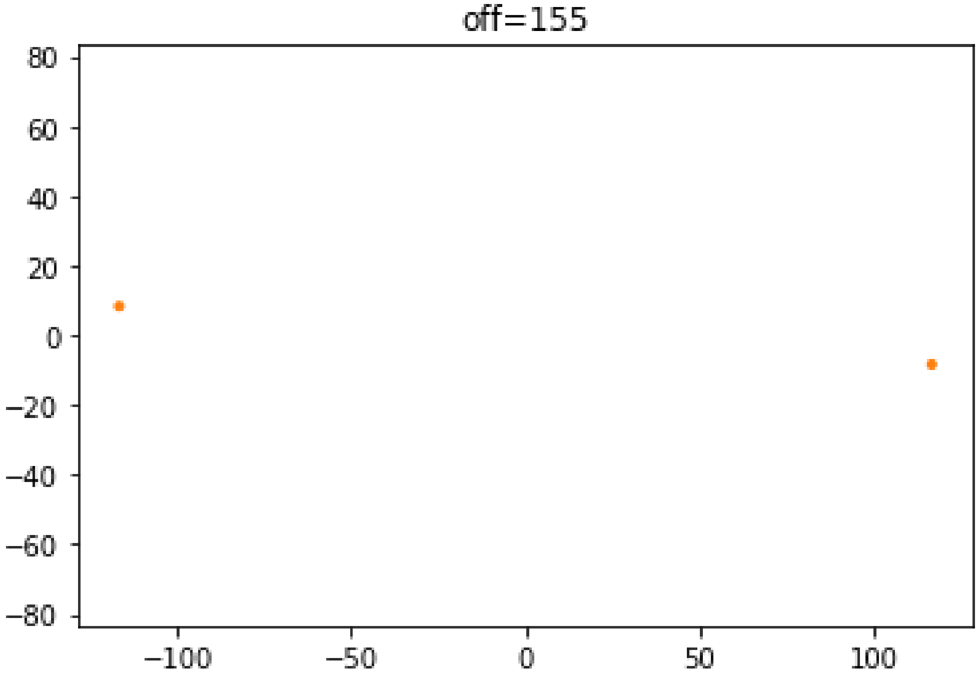
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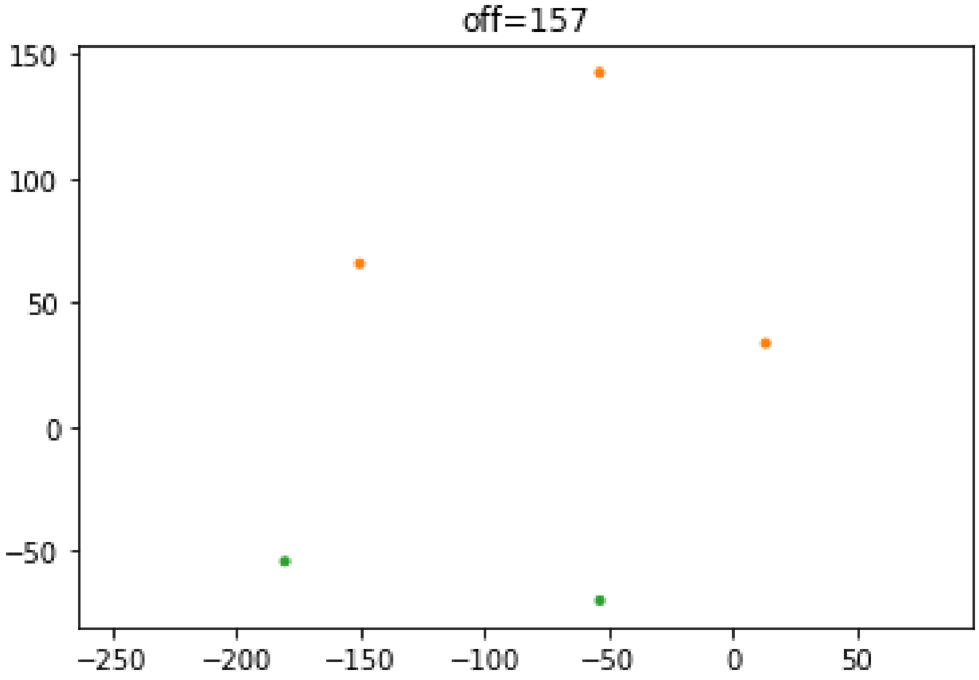

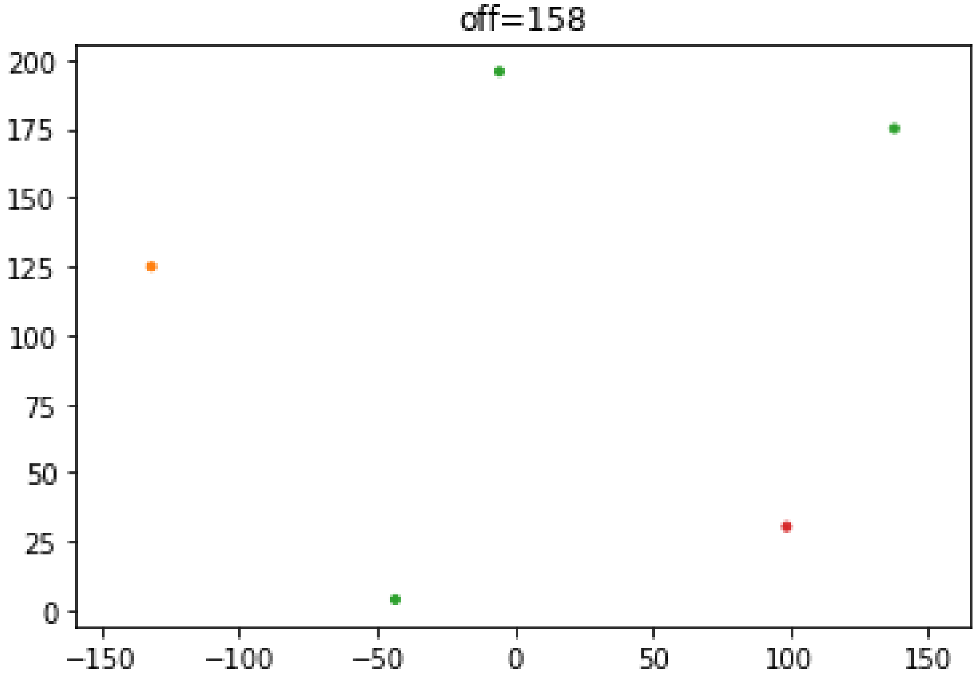

TSNE is having mized results while UMAP doesn't seem to capture any good groupings. Maybe I should go straight to kmeans or kdtrees\ I should block by crime and examine a few "big" crimes the try several different perplexities.

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In [ ]:
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