Pattern Recognition – S p r i n g 2 0 2 3

Network Anomaly Detection

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Imports

In [ ]:
```
!pip install kneed
```

```
Looking in indexes: https://pypi.org/simple, https://us-python.pkg.dev/colab-wheels/public/simple/
Collecting kneed
  Downloading kneed-0.8.2-py3-none-any.whl (10 kB)
Requirement already satisfied: scipy>=1.0.0 in /usr/local/lib/python3.9/dist-packages (from kneed) (1.10.1)
Requirement already satisfied: numpy>=1.14.2 in /usr/local/lib/python3.9/dist-packages (from kneed) (1.22.4)
Installing collected packages: kneed
Successfully installed kneed-0.8.2
```

In [ ]:
```
import numpy as np
import jax.numpy as jnp
from jax import jit
import matplotlib.pyplot as plt
import pandas as pd
import math
import os
import re
from sklearn.neighbors import NearestNeighbors
from sklearn.model_selection import train_test_split
from sklearn.preprocessing import LabelEncoder
from sklearn.metrics import accuracy_score
from kneed import KneeLocator
import plotly.express as px
from scipy.optimize import linear_sum_assignment
from sklearn.metrics.pairwise import (
    additive_chi2_kernel,
    chi2_kernel,
    cosine_similarity,
    laplacian_kernel,
    linear_kernel,
    polynomial_kernel,
    rbf_kernel,
    sigmoid_kernel,
)

SEED = 42
np.random.seed(SEED)
```

In [ ]:
```
from google.colab import drive

drive.mount("/content/drive")
path = "/content/drive/My Drive/pattern/2/"
try:
    os.mkdir(path)
except OSError as error:
    print(error)
```

```
Mounted at /content/drive
[Errno 17] File exists: '/content/drive/My Drive/pattern/2/'
```

Loading the data

In [ ]:
```
train_10_percent = pd.read_csv(
    "https://archive.ics.uci.edu/ml/machine-learning-databases/kddcup99-mld/kddcup.data_10_percent.gz",
    compression="gzip",
    header=None,
)
```

In [ ]:
```
test = pd.read_csv(
    "https://archive.ics.uci.edu/ml/machine-learning-databases/kddcup99-mld/corrected.gz",
    compression="gzip",
    header=None,
)
```

In [ ]:
```
cols = [
    "duration",
    "protocol_type",
    "service",
    "flag",
    "src_bytes",
    "dst_bytes",
    "land",
    "wrong_fragment",
    "urgent",
    "hot",
    "num_failed_logins",
```

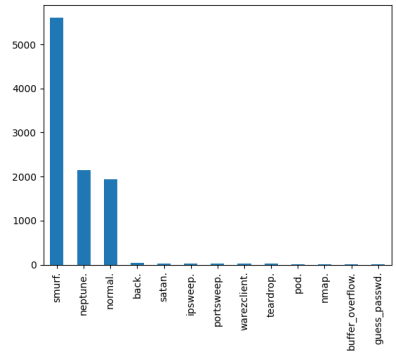
```
    "logged_in",
    "num_compromised",
    "root_shell",
    "su_attempted",
    "num_root",
    "num_file_creations",
    "num_shells",
    "num_access_files",
    "num_outbound_cmds",
    "is_host_login",
    "is_guest_login",
    "count",
    "srv_count",
    "serror_rate",
    "srv_serror_rate",
    "rerror_rate",
    "srv_rerror_rate",
    "same_srv_rate",
    "diff_srv_rate",
    "srv_diff_host_rate",
    "dst_host_count",
    "dst_host_srv_count",
    "dst_host_same_srv_rate",
    "dst_host_diff_srv_rate",
    "dst_host_same_src_port_rate",
    "dst_host_srv_diff_host_rate",
    "dst_host_serror_rate",
    "dst_host_srv_serror_rate",
    "dst_host_rerror_rate",
    "dst_host_srv_rerror_rate",
    "outcome",
]
test.columns = cols
train_10_percent.columns = cols
```

Splitting the data

Splitting by 0.02

In [ ]:
```
X_train02, X_test02, y_train02, y_test02 = train_test_split(
    train_10_percent.iloc[:, :-1],
    train_10_percent.iloc[:, -1],
    train_size=0.02,
    random_state=SEED,
    stratify=train_10_percent.iloc[:, -1],
)
```

In [ ]:
```
y_train02.value_counts().plot(kind="bar")
plt.show()
```



In [ ]:
```
X_train02.head()
```

Out[ ]:

	duration	protocol_type	service	flag	src_bytes	dst_bytes	land	wrong_fragment	urgent	hot	...	dst_host_count	dst_host_srv_count	dst_host_
215576	0	icmp	ecr_i	SF	1032	0	0	0	0	0	...	255	255	
260869	0	icmp	ecr_i	SF	1032	0	0	0	0	0	...	255	255	
197950	0	icmp	ecr_i	SF	1032	0	0	0	0	0	...	255	255	
166006	0	icmp	ecr_i	SF	1032	0	0	0	0	0	...	255	255	
110009	0	tcp	private	S0	0	0	0	0	0	0	...	255	5	

5 rows × 41 columns

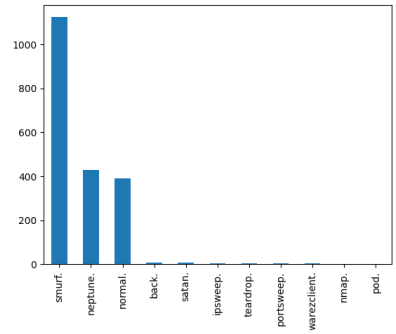
In [ ]:
```
X_train02.to_numpy()
```

Out[ ]:
```
array([[0, 'icmp', 'ecr_i', ..., 0.0, 0.0, 0.0],
       [0, 'icmp', 'ecr_i', ..., 0.0, 0.0, 0.0],
       [0, 'icmp', 'ecr_i', ..., 0.0, 0.0, 0.0],
       ...,
       [0, 'tcp', 'private', ..., 0.0, 1.0, 1.0],
       [0, 'icmp', 'ecr_i', ..., 0.0, 0.0, 0.0],
       [0, 'icmp', 'ecr_i', ..., 0.0, 0.0, 0.0]], dtype=object)
```

Splitting by 0.025

In [ ]:
```
X_train025, X_test025, y_train025, y_test025 = train_test_split(
    train_10_percent.iloc[:, :-1],
    train_10_percent.iloc[:, -1],
    train_size=0.025,
    random_state=SEED,
    stratify=train_10_percent.iloc[:, -1],
)
```

In [ ]:
```
y_train025.value_counts().plot(kind="bar")
plt.show()
```



In [ ]:
```
X_train004.head()
```

Out[ ]:

	duration	protocol_type	service	flag	src_bytes	dst_bytes	land	wrong_fragment	urgent	hot	...	dst_host_count	dst_host_srv_count	dst_host_
259019	0	icmp	ecr_i	SF	1032	0	0	0	0	0	...	255	255	
324041	0	icmp	ecr_i	SF	1032	0	0	0	0	0	...	255	255	
249235	0	icmp	ecr_i	SF	1032	0	0	0	0	0	...	255	255	
41387	0	tcp	http	REJ	0	0	0	0	0	0	...	2	255	
405574	0	icmp	ecr_i	SF	520	0	0	0	0	0	...	255	255	

5 rows × 41 columns

In [ ]:
```
X_train004.to_numpy()
```

Out[ ]:
```
array([[0, 'icmp', 'ecr_i', ..., 0.0, 0.0, 0.0],
       [0, 'icmp', 'ecr_i', ..., 0.0, 0.0, 0.0],
       [0, 'icmp', 'ecr_i', ..., 0.0, 0.0, 0.0],
       ...,
       [0, 'icmp', 'ecr_i', ..., 0.0, 0.0, 0.0],
       [0, 'tcp', 'private', ..., 1.0, 0.0, 0.0],
       [0, 'tcp', 'http', ..., 0.0, 0.0, 0.0]], dtype=object)
```

Investigating the dataset

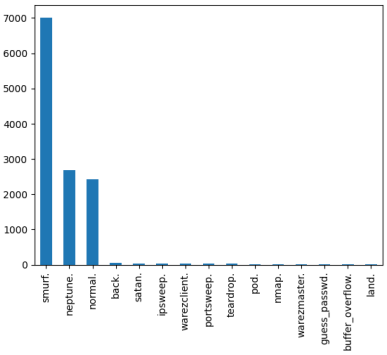
In [ ]:
```
train_10_percent.head()
```

Out[ ]:

	duration	protocol_type	service	flag	src_bytes	dst_bytes	land	wrong_fragment	urgent	hot	...	dst_host_srv_count	dst_host_same_srv_rate	dst_hos
0	0	tcp	http	SF	181	5450	0	0	0	0	...	9	1.0	
1	0	tcp	http	SF	239	486	0	0	0	0	...	19	1.0	
2	0	tcp	http	SF	235	1337	0	0	0	0	...	29	1.0	
3	0	tcp	http	SF	219	1337	0	0	0	0	...	39	1.0	
4	0	tcp	http	SF	217	2032	0	0	0	0	...	49	1.0	

5 rows × 42 columns

In [ ]:
```
test.head()
```



In [ ]:
```
X_train025.head()
```

Out[ ]:

	duration	protocol_type	service	flag	src_bytes	dst_bytes	land	wrong_fragment	urgent	hot	...	dst_host_count	dst_host_srv_count	dst_host_
154374	0	icmp	ecr_i	SF	1032	0	0	0	0	0	...	255	255	
78554	0	tcp	http	SF	248	293	0	0	0	0	...	19	236	
35963	0	tcp	http	SF	374	10063	0	0	0	0	...	66	255	
19926	0	tcp	http	SF	207	377	0	0	0	0	...	10	255	
300920	0	icmp	ecr_i	SF	1032	0	0	0	0	0	...	255	255	

5 rows × 41 columns

In [ ]:
```
X_train025.to_numpy()
```

Out[ ]:
```
array([[0, 'icmp', 'ecr_i', ..., 0.0, 0.0, 0.0],
       [0, 'tcp', 'http', ..., 0.0, 0.0, 0.0],
       [0, 'tcp', 'http', ..., 0.0, 0.0, 0.0],
       ...,
       [0, 'icmp', 'ecr_i', ..., 0.0, 0.0, 0.0],
       [0, 'icmp', 'ecr_i', ..., 0.0, 0.0, 0.0],
       [0, 'icmp', 'ecr_i', ..., 0.0, 0.0, 0.0]], dtype=object)
```

splitting by 0.004

In [ ]:
```
X_train004, X_test004, y_train004, y_test004 = train_test_split(
    train_10_percent.iloc[:, :-1],
    train_10_percent.iloc[:, -1],
    train_size=0.004,
    random_state=SEED,
    stratify=train_10_percent.iloc[:, -1],
)
```

In [ ]:
```
y_train004.value_counts().plot(kind="bar")
plt.show()
```

Out[ ]:

	duration	protocol_type	service	flag	src_bytes	dst_bytes	land	wrong_fragment	urgent	hot	...	dst_host_srv_count	dst_host_same_srv_rate	dst_hos
0	0	udp	private	SF	105	146	0	0	0	0	...	254	1.0	
1	0	udp	private	SF	105	146	0	0	0	0	...	254	1.0	
2	0	udp	private	SF	105	146	0	0	0	0	...	254	1.0	
3	0	udp	private	SF	105	146	0	0	0	0	...	254	1.0	
4	0	udp	private	SF	105	146	0	0	0	0	...	254	1.0	

5 rows × 42 columns

In [ ]:
```
train_10_percent.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 494021 entries, 0 to 494020
Data columns (total 42 columns):
 #   Column                       Non-Null Count   Dtype
---  ------                       --------------   -----
 0   duration                     494021 non-null  int64
 1   protocol_type                494021 non-null  object
 2   service                      494021 non-null  object
 3   flag                         494021 non-null  object
 4   src_bytes                    494021 non-null  int64
 5   dst_bytes                    494021 non-null  int64
 6   land                         494021 non-null  int64
 7   wrong_fragment               494021 non-null  int64
 8   urgent                       494021 non-null  int64
 9   hot                          494021 non-null  int64
 10  num_failed_logins            494021 non-null  int64
 11  logged_in                    494021 non-null  int64
 12  num_compromised              494021 non-null  int64
 13  root_shell                   494021 non-null  int64
 14  su_attempted                 494021 non-null  int64
 15  num_root                     494021 non-null  int64
 16  num_file_creations           494021 non-null  int64
 17  num_shells                   494021 non-null  int64
 18  num_access_files             494021 non-null  int64
 19  num_outbound_cmds            494021 non-null  int64
 20  is_host_login                494021 non-null  int64
 21  is_guest_login               494021 non-null  int64
 22  count                        494021 non-null  int64
 23  srv_count                    494021 non-null  int64
 24  serror_rate                  494021 non-null  float64
 25  srv_serror_rate              494021 non-null  float64
 26  rerror_rate                  494021 non-null  float64
 27  srv_rerror_rate              494021 non-null  float64
 28  same_srv_rate                494021 non-null  float64
 29  diff_srv_rate                494021 non-null  float64
 30  srv_diff_host_rate           494021 non-null  float64
 31  dst_host_count               494021 non-null  int64
 32  dst_host_srv_count           494021 non-null  int64
 33  dst_host_same_srv_rate       494021 non-null  float64
 34  dst_host_diff_srv_rate       494021 non-null  float64
 35  dst_host_same_src_port_rate  494021 non-null  float64
 36  dst_host_srv_diff_host_rate  494021 non-null  float64
 37  dst_host_serror_rate         494021 non-null  float64
 38  dst_host_srv_serror_rate     494021 non-null  float64
 39  dst_host_rerror_rate         494021 non-null  float64
 40  dst_host_srv_rerror_rate     494021 non-null  float64
 41  outcome                      494021 non-null  object
dtypes: float64(15), int64(23), object(4)
memory usage: 158.3+ MB
```

Comment

Elements with object dtype are categorical

In [ ]:
```
train_10_percent["protocol_type"].value_counts()
```

Out[ ]:
```
icmp    283602
tcp     190065
udp      20354
Name: protocol_type, dtype: int64
```

In [ ]:
```
train_10_percent["service"].value_counts()
```

```
7 clusters:
Finished running k-means++
0.0    493870
3.0        59
6.0        41
4.0        24
2.0        18
5.0         8
1.0         1
dtype: int64
Completed iteration 1
0.0    493871
3.0        59
6.0        39
4.0        24
2.0        18
5.0         9
1.0         1
dtype: int64
Completed iteration 2
0.0    493871
3.0        59
6.0        38
4.0        24
2.0        18
5.0        10
1.0         1
dtype: int64
Completed iteration 3
0.0    493871
3.0        59
6.0        36
4.0        24
2.0        18
5.0        12
1.0         1
dtype: int64
Completed iteration 4
0.0    493869
3.0        59
6.0        36
4.0        24
2.0        18
5.0        14
1.0         1
dtype: int64
Completed iteration 5
0.0    493868
3.0        59
6.0        34
4.0        24
2.0        18
5.0        17
1.0         1
dtype: int64
Completed iteration 6
0.0    493862
3.0        59
6.0        40
4.0        24
2.0        18
5.0        17
1.0         1
dtype: int64
Completed iteration 7
0.0    493859
3.0        59
6.0        43
4.0        24
2.0        18
5.0        17
1.0         1
dtype: int64
Completed iteration 8
0.0    493859
3.0        59
6.0        43
4.0        24
2.0        18
5.0        17
1.0         1
dtype: int64
Completed iteration 9
Epsilon has a maximum value of 0.0
Centroids:
Centroid 1: [4.72894267e+01 4.66957168e-01 2.36751117e+01 7.84210271e+00
 9.02066489e+02 5.70938762e+02 4.45471278e-05 6.43503510e-03
 8.09947779e-06 3.42020698e-02 1.41740861e-04 1.48022006e-01
 7.77752354e-03 1.05293211e-04 2.63233028e-05 8.73933653e-03
 1.07925542e-03 1.09342950e-04 9.92186029e-04 0.00000000e+00
 0.00000000e+00 1.38703557e-03 3.32394181e+02 2.93002142e+02
 1.76737956e-01 1.76660909e-01 5.74497984e-02 5.77351835e-02
 7.91484594e-01 2.09810492e-02 2.89965152e-02 2.32519347e+02
 1.88713254e+02 7.53830243e-01 3.09032133e-02 6.01962969e-01
 6.66761161e-03 1.76804898e-01 1.76491772e-01 5.81319567e-02
 5.74282943e-02]
Centroid 2: [2.0000000e+00 1.0000000e+00 1.7000000e+01 2.0000000e+00 6.9337564e+08
 0.0000000e+00 0.0000000e+00 0.0000000e+00 0.0000000e+00 1.0000000e+00
 0.0000000e+00 0.0000000e+00 0.0000000e+00 0.0000000e+00 0.0000000e+00
 0.0000000e+00 0.0000000e+00 0.0000000e+00 0.0000000e+00 0.0000000e+00
 0.0000000e+00 0.0000000e+00 5.7000000e+01 3.0000000e+00 7.9000000e-01
 6.7000000e-01 2.1000000e-01 3.3000000e-01 5.0000000e-02 3.9000000e-01
 0.0000000e+00 2.5500000e+02 3.0000000e+00 1.0000000e-02 9.0000000e-02
 2.2000000e-01 0.0000000e+00 1.8000000e-01 6.7000000e-01 5.0000000e-02
 3.3000000e-01]
Centroid 3: [5.52277778e+02 1.00000000e+00 2.12777778e+01 9.00000000e+00
 1.08944444e+02 5.00968983e+06 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 1.66666667e-01 1.11111111e-01
 1.00000000e+00 5.55555556e-02 1.11111111e-01 5.00000000e-01
 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 1.11111111e+00 1.11111111e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 1.00000000e+00 0.00000000e+00 0.00000000e+00 4.39444444e+01
 2.61666667e+01 9.03333333e-01 2.22222222e-03 8.33888889e-01
 5.55555556e-04 4.16666667e-02 4.77777778e-02 4.27777778e-02
 0.00000000e+00]
Centroid 4: [5.05167797e+03 1.00000000e+00 2.01186441e+01 8.98305085e+00
 5.13422649e+06 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 2.71186441e+00 0.00000000e+00 1.00000000e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 1.01694915e+00 1.45762712e+00
 1.69491525e-02 1.93220339e-02 0.00000000e+00 0.00000000e+00
 9.91525424e-01 1.69491525e-02 5.76271186e-02 3.15932203e+01
 3.50508475e+01 8.90847458e-01 2.33898305e-02 9.33220339e-01
 1.04406780e-01 1.08474576e-02 2.42372881e-02 2.37288136e-03
 3.38983051e-04]
Centroid 5: [1.03250000e+02 1.00000000e+00 1.90000000e+01 8.79166667e+00
 2.20358567e+06 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 7.50000000e-01
 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 1.70833333e+00 1.62500000e+00
 0.00000000e+00 0.00000000e+00 4.16666667e-02 4.16666667e-02
 9.65416667e-01 6.95833333e-02 0.00000000e+00 1.15166667e+02
 5.90416667e+01 3.37083333e-01 6.87500000e-02 3.37083333e-01
 2.95833333e-02 3.91666667e-02 0.00000000e+00 1.62500000e-02
 8.33333333e-04]
Centroid 6: [5.18823529e+01 1.00000000e+00 5.70000000e+01 9.00000000e+00
 5.52117647e+02 1.79480471e+06 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 1.00000000e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 1.05882353e+00 1.05882353e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 1.00000000e+00 0.00000000e+00 0.00000000e+00 1.54352941e+02
 3.42352941e+01 2.10588235e-01 3.47058824e-02 1.05882353e-02
 5.58823529e-02 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00]
Centroid 7: [8.63302326e+02 1.00000000e+00 4.79069767e+01 8.88372093e+00
 6.73581395e+02 6.14509628e+05 0.00000000e+00 0.00000000e+00
 6.97674419e-02 2.32558140e-02 4.65116279e-02 9.06976744e-01
 2.75813953e+01 4.65116279e-02 6.97674419e-02 2.98372093e+01
 4.65116279e-02 0.00000000e+00 1.86046512e-01 0.00000000e+00
 0.00000000e+00 0.00000000e+00 1.27906977e+00 1.83720930e+00
 3.48837209e-02 2.48837209e-02 0.00000000e+00 0.00000000e+00
 9.88372093e-01 2.32558140e-02 3.34883721e-02 1.25023256e+02
 5.86744186e+01 3.87209302e-01 5.81395349e-02 1.16744186e-01
 2.55813953e-02 2.25581395e-02 3.13953488e-02 2.27906977e-02
 1.67441860e-02]
15 clusters:
Finished running k-means++
0.0     486917
14.0      4216
7.0       2343
11.0       300
9.0         88
3.0         59
4.0         24
13.0        24
2.0         16
6.0         12
12.0        11
5.0          5
8.0          3
10.0         2
1.0          1
dtype: int64
Completed iteration 1
0.0     485775
14.0      5279
7.0       2343
11.0       398
9.0         69
3.0         59
13.0        25
4.0         24
2.0         16
6.0         11
12.0        11
5.0          5
8.0          3
10.0         2
1.0          1
dtype: int64
Completed iteration 2
0.0     484800
14.0      6214
7.0       2343
11.0       443
9.0         67
3.0         59
4.0         24
13.0        22
2.0         16
6.0         11
12.0        11
5.0          5
8.0          3
10.0         2
1.0          1
dtype: int64
Completed iteration 3
0.0     484013
14.0      6957
7.0       2343
11.0       488
9.0         67
3.0         59
4.0         24
13.0        22
2.0         16
12.0        11
6.0         10
5.0          5
8.0          3
10.0         2
1.0          1
dtype: int64
Completed iteration 4
0.0     483507
14.0      7387
7.0       2343
11.0       565
9.0         67
3.0         59
4.0         24
13.0        22
2.0         16
12.0        11
6.0          9
5.0          5
8.0          3
10.0         2
1.0          1
dtype: int64
Completed iteration 5
0.0     483027
14.0      7819
7.0       2343
11.0       615
9.0         65
3.0         59
4.0         24
13.0        22
2.0         16
6.0         10
12.0        10
5.0          5
8.0          3
10.0         2
1.0          1
dtype: int64
Completed iteration 6
0.0     482708
14.0      8115
7.0       2343
11.0       638
9.0         65
3.0         59
4.0         24
13.0        22
2.0         16
6.0         11
12.0         9
5.0          5
8.0          3
10.0         2
1.0          1
dtype: int64
Completed iteration 7
0.0     482502
14.0      8275
7.0       2343
11.0       684
9.0         65
3.0         59
4.0         24
13.0        22
2.0         16
6.0         11
12.0         9
5.0          5
8.0          3
10.0         2
1.0          1
dtype: int64
Completed iteration 8
0.0     482191
14.0      8506
7.0       2343
11.0       762
9.0         67
3.0         59
4.0         24
13.0        22
2.0         16
6.0         11
12.0         9
5.0          5
8.0          3
10.0         2
1.0          1
dtype: int64
Completed iteration 9
0.0     481905
14.0      8734
7.0       2343
11.0       819
9.0         68
3.0         59
4.0         24
13.0        22
2.0         16
6.0         11
12.0         9
5.0          5
8.0          3
10.0         2
1.0          1
dtype: int64
Completed iteration 10
0.0     481669
14.0      8904
7.0       2343
11.0       885
9.0         68
3.0         59
4.0         24
13.0        22
2.0         16
6.0         11
12.0         9
5.0          5
8.0          3
10.0         2
1.0          1
dtype: int64
Completed iteration 11
Reached 11 iterations
Centroids:
Centroid 1: [4.72935335e+01 4.53467007e-01 2.37094104e+01 7.81425419e+00
 6.39994633e+02 1.85632488e+02 4.56745192e-05 6.59789191e-03
 2.07611451e-06 2.57811900e-02 1.43251901e-04 1.26551636e-01
 2.63666543e-04 6.64356643e-05 8.30445804e-06 5.34599486e-03
 6.58128300e-04 1.01729611e-04 9.32175415e-04 0.00000000e+00
 0.00000000e+00 1.42213844e-03 3.40642603e+02 3.00192358e+02
 1.81129344e-01 1.81046881e-01 5.86607816e-02 5.86716812e-02
 7.86221596e-01 2.14874738e-02 2.68823196e-02 2.34929163e+02
 1.87530698e+02 7.48045587e-01 3.16329471e-02 6.15537080e-01
 6.32967868e-03 1.81201344e-01 1.80907532e-01 5.92245297e-02
 5.84252464e-02]
Centroid 2: [2.0000000e+00 1.0000000e+00 1.7000000e+01 2.0000000e+00 6.9337564e+08
 0.0000000e+00 0.0000000e+00 0.0000000e+00 0.0000000e+00 1.0000000e+00
 0.0000000e+00 0.0000000e+00 0.0000000e+00 0.0000000e+00 0.0000000e+00
 0.0000000e+00 0.0000000e+00 0.0000000e+00 0.0000000e+00 0.0000000e+00
 0.0000000e+00 0.0000000e+00 5.7000000e+01 3.0000000e+00 7.9000000e-01
 6.7000000e-01 2.1000000e-01 3.3000000e-01 5.0000000e-02 3.9000000e-01
 0.0000000e+00 2.5500000e+02 3.0000000e+00 1.0000000e-02 9.0000000e-02
 2.2000000e-01 0.0000000e+00 1.8000000e-01 6.7000000e-01 5.0000000e-02
 3.3000000e-01]
Centroid 3: [3.24312500e+02 1.00000000e+00 1.90000000e+01 9.00000000e+00
 0.00000000e+00 5.15038094e+06 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 1.12500000e+00 1.12500000e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 1.00000000e+00 0.00000000e+00 0.00000000e+00 2.53125000e+01
 1.33750000e+01 9.53125000e-01 1.25000000e-03 9.37500000e-01
 0.00000000e+00 4.68750000e-02 5.37500000e-02 0.00000000e+00
 0.00000000e+00]
Centroid 4: [5.05167797e+03 1.00000000e+00 2.01186441e+01 8.98305085e+00
 5.13422649e+06 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 2.71186441e+00 0.00000000e+00 1.00000000e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 1.01694915e+00 1.45762712e+00
 1.69491525e-02 1.93220339e-02 0.00000000e+00 0.00000000e+00
 9.91525424e-01 1.69491525e-02 5.76271186e-02 3.15932203e+01
 3.50508475e+01 8.90847458e-01 2.33898305e-02 9.33220339e-01
 1.04406780e-01 1.08474576e-02 2.42372881e-02 2.37288136e-03
 3.38983051e-04]
Centroid 5: [1.03250000e+02 1.00000000e+00 1.90000000e+01 8.79166667e+00
 2.20358567e+06 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 7.50000000e-01
 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 1.70833333e+00 1.62500000e+00
 0.00000000e+00 0.00000000e+00 4.16666667e-02 4.16666667e-02
 9.65416667e-01 6.95833333e-02 0.00000000e+00 1.15166667e+02
 5.90416667e+01 3.37083333e-01 6.87500000e-02 3.37083333e-01
 2.95833333e-02 3.91666667e-02 0.00000000e+00 1.62500000e-02
 8.33333333e-04]
Centroid 6: [8.3000000e+01 1.0000000e+00 5.7000000e+01 9.0000000e+00 6.7560000e+02
 2.4660582e+06 0.0000000e+00 0.0000000e+00 0.0000000e+00 0.0000000e+00
 0.0000000e+00 1.0000000e+00 0.0000000e+00 0.0000000e+00 0.0000000e+00
 0.0000000e+00 0.0000000e+00 0.0000000e+00 0.0000000e+00 0.0000000e+00
 0.0000000e+00 0.0000000e+00 1.0000000e+00 1.0000000e+00 0.0000000e+00
 0.0000000e+00 0.0000000e+00 0.0000000e+00 1.0000000e+00 0.0000000e+00
 0.0000000e+00 1.3960000e+02 3.1200000e+01 1.9400000e-01 4.6000000e-02
 1.4000000e-02 1.3000000e-01 0.0000000e+00 0.0000000e+00 0.0000000e+00
 0.0000000e+00]
Centroid 7: [3.25454545e+01 1.00000000e+00 4.69090909e+01 9.00000000e+00
 5.05909091e+02 9.74204727e+05 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 8.18181818e-01
 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 1.00000000e+00 1.09090909e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 1.00000000e+00 0.00000000e+00 9.09090909e-02 1.43818182e+02
 4.24545455e+01 4.47272727e-01 1.81818182e-02 2.76363636e-01
 0.00000000e+00 0.00000000e+00 0.00000000e+00 9.09090909e-04
 0.00000000e+00]
Centroid 8: [2.59923175e-01 1.00000000e+00 2.20413999e+01 8.82031583e+00
 5.73948050e+04 7.88849168e+03 0.00000000e+00 0.00000000e+00
 0.00000000e+00 1.83738796e+00 0.00000000e+00 9.88049509e-01
 9.05249680e-01 0.00000000e+00 0.00000000e+00 9.38967136e-03
 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 3.65471618e+00 3.91079812e+00
 3.93085787e-03 4.12291933e-03 3.54844217e-02 8.73836961e-02
 9.98472044e-01 2.31754161e-03 1.12667520e-01 2.01783611e+02
 1.98618865e+02 9.61912079e-01 4.50277422e-03 3.03457106e-02
 1.09261630e-03 2.66752027e-03 2.89372599e-03 4.63593683e-02
 4.60136577e-02]
Centroid 9: [4.50000000e+01 1.00000000e+00 5.70000000e+01 9.00000000e+00
 5.88333333e+02 1.76159700e+06 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 1.00000000e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 1.00000000e+00 1.00000000e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 1.00000000e+00 0.00000000e+00 0.00000000e+00 1.36000000e+02
 3.30000000e+01 2.63333333e-01 3.33333333e-02 1.00000000e-02
 2.66666667e-02 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00]
Centroid 10: [8.00279412e+02 1.00000000e+00 3.84705882e+01 8.89705882e+00
 4.93279412e+02 2.43287397e+05 0.00000000e+00 0.00000000e+00
 0.00000000e+00 2.94117647e-02 0.00000000e+00 9.85294118e-01
 2.42941176e+01 2.94117647e-02 5.88235294e-02 2.72058824e+01
 1.47058824e-01 0.00000000e+00 2.05882353e-01 0.00000000e+00
 0.00000000e+00 0.00000000e+00 3.41176471e+00 4.92647059e+00
 0.00000000e+00 0.00000000e+00 1.47058824e-02 1.63235294e-02
 9.92647059e-01 1.47058824e-02 3.79411765e-02 1.13029412e+02
 1.40279412e+02 6.04264706e-01 4.05882353e-02 5.30882353e-02
 2.89705882e-02 1.22058824e-02 1.63235294e-02 2.20588235e-02
 2.89705882e-02]
Centroid 11: [2.376000e+03 1.000000e+00 3.950000e+01 9.000000e+00 9.805000e+02
 3.884161e+06 0.000000e+00 0.000000e+00 0.000000e+00 0.000000e+00
 1.500000e+00 1.000000e+00 9.000000e+00 5.000000e-01 1.000000e+00
 4.500000e+00 0.000000e+00 0.000000e+00 0.000000e+00 0.000000e+00
 0.000000e+00 0.000000e+00 1.000000e+00 1.000000e+00 0.000000e+00
 0.000000e+00 0.000000e+00 0.000000e+00 1.000000e+00 0.000000e+00
 0.000000e+00 1.930000e+02 1.285000e+02 5.050000e-01 1.000000e-02
 5.000000e-03 5.000000e-03 0.000000e+00 0.000000e+00 3.850000e-01
 0.000000e+00]
Centroid 12: [1.09224859e+02 1.00000000e+00 2.31570621e+01 8.98644068e+00
 2.63368362e+02 4.85504531e+04 0.00000000e+00 0.00000000e+00
 2.25988701e-03 4.51977401e-02 1.12994350e-03 9.98870056e-01
 7.20903955e-01 5.64971751e-03 7.90960452e-03 8.01129944e-01
 5.42372881e-02 0.00000000e+00 1.35593220e-02 0.00000000e+00
 0.00000000e+00 0.00000000e+00 4.69830508e+00 7.44293785e+00
 4.50847458e-03 4.65536723e-03 1.22033898e-03 2.72316384e-03
 9.99435028e-01 1.12994350e-03 1.08090395e-01 1.17658757e+02
 2.42871186e+02 9.72824859e-01 4.21468927e-03 7.56836158e-02
 2.64632768e-02 5.20903955e-03 4.45197740e-03 9.18644068e-03
 9.28813559e-03]
Centroid 13: [3.68888889e+01 1.00000000e+00 5.70000000e+01 9.00000000e+00
 4.71444444e+02 1.43295533e+06 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 1.00000000e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 1.11111111e+00 1.11111111e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 1.00000000e+00 0.00000000e+00 0.00000000e+00 1.68666667e+02
 3.63333333e+01 2.02222222e-01 2.88888889e-02 8.88888889e-03
 2.44444444e-02 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00]
Centroid 14: [9.91590909e+02 1.00000000e+00 4.58636364e+01 8.77272727e+00
 7.42772727e+02 5.55031591e+05 0.00000000e+00 0.00000000e+00
 1.36363636e-01 4.54545455e-02 9.09090909e-02 9.09090909e-01
 1.37272727e+01 4.54545455e-02 4.54545455e-02 1.31818182e+01
 9.09090909e-02 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 1.50000000e+00 2.54545455e+00
 6.81818182e-02 4.86363636e-02 0.00000000e+00 0.00000000e+00
 9.77272727e-01 4.54545455e-02 2.00000000e-02 1.41409091e+02
 7.72727273e+01 4.20454545e-01 2.45454545e-02 5.77272727e-02
 1.86363636e-02 4.27272727e-02 4.59090909e-02 9.09090909e-03
 2.63636364e-02]
Centroid 15: [4.91618374e+01 1.00000000e+00 2.22215858e+01 8.97068733e+00
 2.79928684e+02 1.32584645e+04 0.00000000e+00 0.00000000e+00
 1.12309075e-04 1.41509434e-02 0.00000000e+00 9.98427673e-01
 2.10017969e-02 1.57232704e-03 0.00000000e+00 1.71832884e-02
 1.77448338e-02 5.61545373e-04 2.58310872e-03 0.00000000e+00
 0.00000000e+00 0.00000000e+00 7.40498652e+00 1.03681491e+01
 2.92452830e-03 3.04694519e-03 3.57142857e-03 4.99213836e-03
 9.99752920e-01 4.94159928e-04 1.13386119e-01 1.22390723e+02
 2.44892969e+02 9.90808625e-01 1.11635220e-03 7.39802336e-02
 2.43474843e-02 2.91554358e-03 1.46114106e-03 7.28773585e-03
 1.14544025e-02]
23 clusters:
Finished running k-means++
0.0     438567
21.0     29404
15.0     13155
22.0      5648
18.0      2578
7.0       2335
14.0      1527
19.0       396
11.0       158
9.0         60
3.0         59
17.0        36
16.0        23
2.0         16
13.0        16
6.0         12
12.0        11
20.0         8
5.0          5
8.0          3
10.0         2
1.0          1
4.0          1
dtype: int64
Completed iteration 1
0.0     439910
21.0     28212
15.0     12847
22.0      5660
18.0      2834
7.0       2335
14.0      1374
19.0       454
11.0       147
3.0         59
9.0         49
17.0        41
16.0        23
13.0        19
2.0         16
12.0        11
6.0         10
20.0         8
5.0          5
8.0          3
10.0         2
1.0          1
4.0          1
dtype: int64
Completed iteration 2
0.0     441380
21.0     26423
15.0     13033
22.0      5761
18.0      2883
7.0       2335
14.0      1357
19.0       465
11.0       136
3.0         59
9.0         49
17.0        41
16.0        23
13.0        20
2.0         16
12.0        11
6.0          9
20.0         8
5.0          5
8.0          3
10.0         2
1.0          1
4.0          1
dtype: int64
Completed iteration 3
0.0     442776
21.0     24706
15.0     13241
22.0      5853
18.0      2913
7.0       2335
14.0      1355
19.0       473
11.0       121
3.0         59
9.0         49
17.0        41
16.0        23
13.0        20
2.0         16
12.0        10
6.0         10
20.0         8
5.0          5
8.0          3
10.0         2
1.0          1
4.0          1
dtype: int64
Completed iteration 4
0.0     444040
21.0     23095
15.0     13513
22.0      5917
18.0      2925
7.0       2335
14.0      1370
19.0       467
11.0       111
3.0         59
9.0         49
17.0        41
16.0        23
13.0        20
2.0         16
6.0         11
12.0         9
20.0         8
5.0          5
8.0          3
10.0         2
1.0          1
4.0          1
dtype: int64
Completed iteration 5
0.0     445077
21.0     21591
15.0     13923
22.0      5960
18.0      2946
7.0       2335
14.0      1367
19.0       472
11.0       103
3.0         59
9.0         48
17.0        41
16.0        23
13.0        21
2.0         16
6.0         10
12.0         9
20.0         8
5.0          5
8.0          3
10.0         2
1.0          1
4.0          1
dtype: int64
Completed iteration 6
0.0     446166
21.0     19749
15.0     14635
22.0      5998
18.0      2953
7.0       2335
14.0      1378
19.0       463
11.0        97
3.0         59
9.0         48
17.0        42
16.0        23
13.0        20
2.0         16
6.0         10
12.0         9
20.0         8
5.0          5
8.0          3
10.0         2
1.0          1
4.0          1
dtype: int64
Completed iteration 7
0.0     447610
21.0     17449
15.0     15395
22.0      6092
18.0      2966
7.0       2335
14.0      1372
19.0       460
11.0        96
3.0         59
9.0         47
17.0        42
16.0        23
13.0        20
2.0         16
6.0         10
12.0         9
20.0         8
5.0          5
8.0          3
10.0         2
1.0          1
4.0          1
dtype: int64
Completed iteration 8
0.0     450637
15.0     16956
21.0     12751
22.0      6198
18.0      2980
7.0       2335
14.0      1365
19.0       458
11.0       102
3.0         59
17.0        42
9.0         40
16.0        23
13.0        20
2.0         16
6.0         10
12.0         9
20.0         8
5.0          5
8.0          3
10.0         2
1.0          1
4.0          1
dtype: int64
Completed iteration 9
0.0     455324
15.0     19194
22.0      6330
21.0      5682
18.0      2994
7.0       2335
14.0      1367
19.0       459
11.0       100
3.0         59
17.0        42
9.0         37
16.0        23
13.0        20
2.0         16
6.0         10
12.0         9
20.0         8
5.0          5
8.0          3
10.0         2
1.0          1
4.0          1
dtype: int64
Completed iteration 10
0.0     457093
15.0     20321
22.0      6559
18.0      3011
21.0      2544
7.0       2332
14.0      1368
19.0       458
11.0       101
3.0         59
17.0        42
9.0         35
```

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16.0        23
13.0        20
2.0         16
6.0         10
12.0         9
20.0         8
5.0          5
8.0          3
10.0         2
1.0          1
4.0          1
dtype: int64
Completed iteration 11
Reached 11 iterations
Centroids:
Centroid 1: [4.91435113e+01 4.24082189e-01 2.37386046e+01 7.75074438e+00
 6.20951246e+02 4.77368238e+01 4.81302492e-05 6.95263327e-03
 0.00000000e+00 3.03001796e-03 1.48766225e-04 8.02768802e-02
 1.96896474e-05 8.75095440e-06 4.37547720e-06 5.60498629e-03
 3.95980687e-04 8.75095440e-06 2.73467325e-04 0.00000000e+00
 0.00000000e+00 5.33808218e-04 3.58487435e+02 3.15719477e+02
 1.90779032e-01 1.90673277e-01 6.17649581e-02 6.16771204e-02
 7.74874150e-01 2.24554959e-02 2.26672253e-02 2.40553491e+02
 1.85395541e+02 7.38232067e-01 3.28342810e-02 6.44726828e-01
 5.49023940e-03 1.90821102e-01 1.90568965e-01 6.20909968e-02
 6.11602890e-02]
Centroid 2: [2.0000000e+00 1.0000000e+00 1.7000000e+01 2.0000000e+00 6.9337564e+08
 0.0000000e+00 0.0000000e+00 0.0000000e+00 0.0000000e+00 1.0000000e+00
 0.0000000e+00 0.0000000e+00 0.0000000e+00 0.0000000e+00 0.0000000e+00
 0.0000000e+00 0.0000000e+00 0.0000000e+00 0.0000000e+00 0.0000000e+00
 0.0000000e+00 0.0000000e+00 5.7000000e+01 3.0000000e+00 7.9000000e-01
 6.7000000e-01 2.1000000e-01 3.3000000e-01 5.0000000e-02 3.9000000e-01
 0.0000000e+00 2.5500000e+02 3.0000000e+00 1.0000000e-02 9.0000000e-02
 2.2000000e-01 0.0000000e+00 1.8000000e-01 6.7000000e-01 5.0000000e-02
 3.3000000e-01]
Centroid 3: [3.24312500e+02 1.00000000e+00 1.90000000e+01 9.00000000e+00
 0.00000000e+00 5.15038094e+06 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 1.12500000e+00 1.12500000e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 1.00000000e+00 0.00000000e+00 0.00000000e+00 2.53125000e+01
 1.33750000e+01 9.53125000e-01 1.25000000e-03 9.37500000e-01
 0.00000000e+00 4.68750000e-02 5.37500000e-02 0.00000000e+00
 0.00000000e+00]
Centroid 4: [5.05167797e+03 1.00000000e+00 2.01186441e+01 8.98305085e+00
 5.13422649e+06 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 2.71186441e+00 0.00000000e+00 1.00000000e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 1.01694915e+00 1.45762712e+00
 1.69491525e-02 1.93220339e-02 0.00000000e+00 0.00000000e+00
 9.91525424e-01 1.69491525e-02 5.76271186e-02 3.15932203e+01
 3.50508475e+01 8.90847458e-01 2.33898305e-02 9.33220339e-01
 1.04406780e-01 1.08474576e-02 2.42372881e-02 2.37288136e-03
 3.38983051e-04]
Centroid 5: [2.426000e+03 1.000000e+00 1.900000e+01 4.000000e+00 2.500058e+06
 0.000000e+00 0.000000e+00 0.000000e+00 0.000000e+00 0.000000e+00
 0.000000e+00 1.000000e+00 0.000000e+00 0.000000e+00 0.000000e+00
 0.000000e+00 0.000000e+00 0.000000e+00 0.000000e+00 0.000000e+00
 0.000000e+00 0.000000e+00 1.000000e+00 1.000000e+00 0.000000e+00
 0.000000e+00 1.000000e+00 1.000000e+00 1.000000e+00 0.000000e+00
 0.000000e+00 3.000000e+00 4.300000e+01 1.000000e+00 0.000000e+00
 1.000000e+00 9.000000e-02 0.000000e+00 0.000000e+00 3.300000e-01
 2.000000e-02]
Centroid 6: [8.3000000e+01 1.0000000e+00 5.7000000e+01 9.0000000e+00 6.7560000e+02
 2.4660582e+06 0.0000000e+00 0.0000000e+00 0.0000000e+00 0.0000000e+00
 0.0000000e+00 1.0000000e+00 0.0000000e+00 0.0000000e+00 0.0000000e+00
 0.0000000e+00 0.0000000e+00 0.0000000e+00 0.0000000e+00 0.0000000e+00
 0.0000000e+00 0.0000000e+00 1.0000000e+00 1.0000000e+00 0.0000000e+00
 0.0000000e+00 0.0000000e+00 0.0000000e+00 1.0000000e+00 0.0000000e+00
 0.0000000e+00 1.3960000e+02 3.1200000e+01 1.9400000e-01 4.6000000e-02
 1.4000000e-02 1.3000000e-01 0.0000000e+00 0.0000000e+00 0.0000000e+00
 0.0000000e+00]
Centroid 7: [3.200000e+01 1.000000e+00 4.590000e+01 9.000000e+00 5.110000e+02
 9.947934e+05 0.000000e+00 0.000000e+00 0.000000e+00 0.000000e+00
 0.000000e+00 8.000000e-01 0.000000e+00 0.000000e+00 0.000000e+00
 0.000000e+00 0.000000e+00 0.000000e+00 0.000000e+00 0.000000e+00
 0.000000e+00 0.000000e+00 1.000000e+00 1.100000e+00 0.000000e+00
 0.000000e+00 0.000000e+00 0.000000e+00 1.000000e+00 0.000000e+00
 1.000000e-01 1.405000e+02 4.560000e+01 4.860000e-01 1.700000e-02
 3.030000e-01 0.000000e+00 0.000000e+00 0.000000e+00 1.000000e-03
 0.000000e+00]
Centroid 8: [1.99399657e-01 1.00000000e+00 2.20484563e+01 8.82289880e+00
 5.58336930e+04 7.83177187e+03 0.00000000e+00 0.00000000e+00
 0.00000000e+00 1.84562607e+00 0.00000000e+00 9.89708405e-01
 9.09519726e-01 0.00000000e+00 0.00000000e+00 9.43396226e-03
 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 3.66337907e+00 3.92066895e+00
 3.73499142e-03 3.92795883e-03 3.53301887e-02 8.74742710e-02
 9.98464837e-01 2.32847341e-03 1.13198971e-01 2.01995283e+02
 1.99135506e+02 9.64558319e-01 4.35677530e-03 2.93053173e-02
 1.05060034e-03 2.34991424e-03 2.87307033e-03 4.65608919e-02
 4.62135506e-02]
Centroid 9: [4.50000000e+01 1.00000000e+00 5.70000000e+01 9.00000000e+00
 5.88333333e+02 1.76159700e+06 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 1.00000000e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 1.00000000e+00 1.00000000e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 1.00000000e+00 0.00000000e+00 0.00000000e+00 1.36000000e+02
 3.30000000e+01 2.63333333e-01 3.33333333e-02 1.00000000e-02
 2.66666667e-02 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00]
Centroid 10: [1.11905714e+03 1.00000000e+00 3.10000000e+01 8.80000000e+00
 5.03342857e+02 1.76371543e+05 0.00000000e+00 0.00000000e+00
 0.00000000e+00 5.71428571e-02 0.00000000e+00 9.71428571e-01
 2.19428571e+01 2.85714286e-02 5.71428571e-02 2.44857143e+01
 2.85714286e-01 0.00000000e+00 1.71428571e-01 0.00000000e+00
 0.00000000e+00 0.00000000e+00 4.94285714e+00 8.25714286e+00
 0.00000000e+00 0.00000000e+00 2.85714286e-02 2.85714286e-02
 1.00000000e+00 0.00000000e+00 4.62857143e-02 8.84000000e+01
 1.88285714e+02 7.84285714e-01 1.34285714e-02 4.14285714e-02
 3.00000000e-02 2.31428571e-02 2.22857143e-02 1.51428571e-02
 2.88571429e-02]
Centroid 11: [2.376000e+03 1.000000e+00 3.950000e+01 9.000000e+00 9.805000e+02
 3.884161e+06 0.000000e+00 0.000000e+00 0.000000e+00 0.000000e+00
 1.500000e+00 1.000000e+00 9.000000e+00 5.000000e-01 1.000000e+00
 4.500000e+00 0.000000e+00 0.000000e+00 0.000000e+00 0.000000e+00
 0.000000e+00 0.000000e+00 1.000000e+00 1.000000e+00 0.000000e+00
 0.000000e+00 0.000000e+00 0.000000e+00 1.000000e+00 0.000000e+00
 0.000000e+00 1.930000e+02 1.285000e+02 5.050000e-01 1.000000e-02
 5.000000e-03 5.000000e-03 0.000000e+00 0.000000e+00 3.850000e-01
 0.000000e+00]
Centroid 12: [1.01039604e+02 1.00000000e+00 2.51188119e+01 8.97029703e+00
 2.71326733e+02 9.25399406e+04 0.00000000e+00 0.00000000e+00
 0.00000000e+00 2.97029703e-02 0.00000000e+00 1.00000000e+00
 2.83168317e+00 9.90099010e-03 2.97029703e-02 3.12871287e+00
 3.96039604e-02 0.00000000e+00 4.95049505e-02 0.00000000e+00
 0.00000000e+00 0.00000000e+00 4.76237624e+00 7.04950495e+00
 6.93069307e-04 1.18811881e-03 0.00000000e+00 4.95049505e-03
 1.00000000e+00 0.00000000e+00 9.23762376e-02 7.15247525e+01
 2.26168317e+02 9.37128713e-01 3.46534653e-03 8.32673267e-02
 2.62376238e-02 8.51485149e-03 4.65346535e-03 3.26732673e-03
 7.02970297e-03]
Centroid 13: [3.68888889e+01 1.00000000e+00 5.70000000e+01 9.00000000e+00
 4.71444444e+02 1.43295533e+06 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 1.00000000e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 1.11111111e+00 1.11111111e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 1.00000000e+00 0.00000000e+00 0.00000000e+00 1.68666667e+02
 3.63333333e+01 2.02222222e-01 2.88888889e-02 8.88888889e-03
 2.44444444e-02 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00]
Centroid 14: [1.491500e+02 1.000000e+00 4.650000e+01 8.750000e+00 6.907000e+02
 5.859852e+05 0.000000e+00 0.000000e+00 1.500000e-01 5.000000e-02
 1.000000e-01 9.000000e-01 1.050000e+00 5.000000e-02 0.000000e+00
 6.000000e-01 5.000000e-02 0.000000e+00 0.000000e+00 0.000000e+00
 0.000000e+00 0.000000e+00 1.500000e+00 2.100000e+00 7.500000e-02
 5.350000e-02 0.000000e+00 0.000000e+00 9.750000e-01 5.000000e-02
 6.500000e-03 1.331000e+02 6.960000e+01 3.995000e-01 2.550000e-02
 6.350000e-02 2.050000e-02 2.900000e-02 2.750000e-02 1.000000e-02
 2.900000e-02]
Centroid 15: [4.83172515e+01 1.00000000e+00 2.24766082e+01 8.98026316e+00
 2.48828216e+02 2.81579474e+04 0.00000000e+00 0.00000000e+00
 0.00000000e+00 4.75146199e-02 0.00000000e+00 9.99269006e-01
 4.97076023e-02 3.65497076e-03 0.00000000e+00 5.48245614e-02
 5.48245614e-02 7.30994152e-04 1.46198830e-03 0.00000000e+00
 0.00000000e+00 0.00000000e+00 5.50292398e+00 8.20321637e+00
 5.99415205e-03 5.21929825e-03 1.68128655e-03 2.67543860e-03
 1.00000000e+00 0.00000000e+00 1.11147661e-01 1.36971491e+02
 2.46602339e+02 9.89035088e-01 1.04532164e-03 7.16593567e-02
 2.34137427e-02 3.72076023e-03 1.19883041e-03 7.84356725e-03
 1.00365497e-02]
Centroid 16: [1.47747650e+01 1.00000000e+00 2.20312977e+01 8.99694897e+00
 2.81433837e+02 2.76998676e+03 0.00000000e+00 0.00000000e+00
 4.92101767e-05 5.42591408e-01 4.92101767e-05 9.99803159e-01
 5.51153979e-03 1.37788495e-03 9.84203533e-05 5.90522120e-04
 2.01761724e-03 1.96840707e-04 1.44185818e-02 0.00000000e+00
 0.00000000e+00 2.17016879e-02 9.24255696e+00 1.21759264e+01
 1.51665764e-03 1.96889917e-03 8.91196299e-04 3.02691797e-03
 9.99319423e-01 9.68456277e-04 9.17661532e-02 1.32641799e+02
 2.41743959e+02 9.78007972e-01 2.37931204e-03 5.13065302e-02
 2.19590571e-02 1.47433689e-03 9.09404065e-04 5.14049505e-03
 8.09950298e-03]
Centroid 17: [2.26086957e+00 1.00000000e+00 1.90000000e+01 9.00000000e+00
 2.19069557e+06 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 7.39130435e-01
 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 1.73913043e+00 1.65217391e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 9.63913043e-01 7.26086957e-02 0.00000000e+00 1.20043478e+02
 5.97391304e+01 3.08260870e-01 7.17391304e-02 3.08260870e-01
 2.69565217e-02 4.08695652e-02 0.00000000e+00 2.60869565e-03
 0.00000000e+00]
Centroid 18: [8.12428571e+02 1.00000000e+00 4.28333333e+01 9.00000000e+00
 4.81500000e+02 2.96928643e+05 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 1.00000000e+00
 2.77380952e+01 2.38095238e-02 7.14285714e-02 3.02619048e+01
 2.38095238e-02 0.00000000e+00 1.90476190e-01 0.00000000e+00
 0.00000000e+00 0.00000000e+00 2.47619048e+00 2.95238095e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 2.61904762e-03
 9.88095238e-01 2.38095238e-02 3.45238095e-02 1.36523810e+02
 1.14238095e+02 4.99047619e-01 5.59523810e-02 5.40476190e-02
 2.57142857e-02 9.28571429e-03 1.90476190e-02 2.30952381e-02
 2.28571429e-02]
Centroid 19: [2.77715045e+01 1.00000000e+00 2.23012288e+01 8.97874460e+00
 2.63996679e+02 1.55117987e+04 0.00000000e+00 0.00000000e+00
 0.00000000e+00 7.97077383e-03 0.00000000e+00 9.99335769e-01
 1.16240452e-02 6.64231152e-04 0.00000000e+00 2.65692461e-03
 2.75655928e-02 0.00000000e+00 3.98538691e-03 0.00000000e+00
 0.00000000e+00 0.00000000e+00 7.01826636e+00 9.83626702e+00
 3.61673863e-03 3.48721355e-03 1.52441049e-03 2.69013617e-03
 9.99833942e-01 3.32115576e-04 1.07289937e-01 1.24018931e+02
 2.42994022e+02 9.91208901e-01 1.12255065e-03 7.88973763e-02
 2.33477250e-02 4.37396214e-03 1.73364331e-03 6.43307871e-03
 9.72434407e-03]
Centroid 20: [1.60360262e+02 1.00000000e+00 2.32423581e+01 8.98689956e+00
 2.81901747e+02 4.76091900e+04 0.00000000e+00 0.00000000e+00
 4.36681223e-03 1.96506550e-02 2.18340611e-03 1.00000000e+00
 7.51091703e-01 8.73362445e-03 8.73362445e-03 8.53711790e-01
 6.11353712e-02 0.00000000e+00 1.52838428e-02 0.00000000e+00
 0.00000000e+00 0.00000000e+00 5.02401747e+00 7.73580786e+00
 4.01746725e-03 4.36681223e-03 1.50655022e-03 3.71179039e-03
 9.98908297e-01 2.18340611e-03 1.07510917e-01 1.03737991e+02
 2.42259825e+02 9.70895197e-01 6.46288210e-03 9.22489083e-02
 2.92794760e-02 6.65938865e-03 6.96506550e-03 1.20087336e-02
 1.05240175e-02]
Centroid 21: [1.800000e+01 1.000000e+00 1.675000e+01 8.625000e+00 5.228475e+05
 2.697500e+04 0.000000e+00 0.000000e+00 0.000000e+00 0.000000e+00
 0.000000e+00 6.250000e-01 0.000000e+00 0.000000e+00 0.000000e+00
 0.000000e+00 0.000000e+00 0.000000e+00 0.000000e+00 0.000000e+00
 0.000000e+00 0.000000e+00 1.750000e+00 1.750000e+00 6.250000e-02
 6.250000e-02 0.000000e+00 0.000000e+00 1.000000e+00 0.000000e+00
 0.000000e+00 1.265000e+02 6.575000e+01 3.262500e-01 3.750000e-02
 3.262500e-01 1.250000e-02 3.750000e-03 8.750000e-03 0.000000e+00
 0.000000e+00]
Centroid 22: [2.11753145e+00 1.00000000e+00 3.29095912e+01 8.96422956e+00
 7.26995991e+03 2.61976415e+02 0.00000000e+00 0.00000000e+00
 0.00000000e+00 8.25471698e-03 0.00000000e+00 8.78144654e-01
 3.14465409e-03 0.00000000e+00 0.00000000e+00 0.00000000e+00
 3.34119497e-02 1.61163522e-02 1.21855346e-02 0.00000000e+00
 0.00000000e+00 0.00000000e+00 5.28970126e+00 5.53812893e+00
 2.38600629e-03 1.84355346e-03 3.05817610e-03 3.36477987e-03
 9.79304245e-01 2.55188679e-02 2.19626572e-01 1.24099057e+02
 9.82582547e+01 5.09602987e-01 6.98506289e-02 2.37075472e-01
 1.80738994e-02 8.75000000e-03 3.50628931e-03 1.12853774e-02
 2.43710692e-03]
Centroid 23: [4.75807288e+01 1.00000000e+00 2.21305077e+01 8.97926513e+00
 2.65411343e+02 8.30047949e+03 0.00000000e+00 0.00000000e+00
 1.52462266e-04 7.92803781e-03 0.00000000e+00 9.98017991e-01
 1.37216039e-02 1.06723586e-03 0.00000000e+00 1.11297454e-02
 3.96401891e-03 6.09849062e-04 1.37216039e-03 0.00000000e+00
 0.00000000e+00 0.00000000e+00 7.96234182e+00 1.10425370e+01
 1.94694313e-03 2.44549474e-03 3.49291050e-03 4.83762769e-03
 9.99664583e-01 6.70833969e-04 1.12096356e-01 1.17428724e+02
 2.46052599e+02 9.91186156e-01 1.20140265e-03 7.29974081e-02
 2.57234335e-02 1.98048483e-03 1.34776643e-03 7.50419271e-03
 1.16801342e-02]
31 clusters:
Finished running k-means++
26.0    291590
0.0     154152
21.0     22230
15.0     13154
22.0      5648
18.0      2578
7.0       2314
14.0      1527
19.0       396
11.0       158
3.0         59
9.0         50
29.0        33
16.0        22
23.0        21
2.0         16
13.0        13
17.0         9
6.0          8
20.0         8
27.0         7
30.0         6
12.0         5
5.0          4
24.0         4
8.0          3
10.0         2
1.0          1
25.0         1
28.0         1
4.0          1
dtype: int64
Completed iteration 1
26.0    291427
0.0     155472
21.0     22927
15.0     11143
22.0      5660
18.0      2834
7.0       2314
14.0      1374
19.0       454
11.0       142
3.0         59
9.0         46
29.0        37
16.0        22
23.0        21
2.0         16
17.0        10
13.0        10
27.0         9
20.0         8
30.0         7
6.0          7
12.0         5
5.0          4
24.0         4
8.0          3
10.0         2
1.0          1
25.0         1
28.0         1
4.0          1
dtype: int64
Completed iteration 2
26.0    291384
0.0     156996
21.0     22568
15.0     10045
22.0      5604
18.0      2883
7.0       2314
14.0      1357
19.0       454
11.0       142
3.0         59
9.0         44
29.0        39
16.0        22
23.0        21
2.0         16
17.0        10
27.0        10
13.0         9
20.0         8
30.0         7
6.0          7
12.0         5
5.0          4
24.0         4
8.0          3
10.0         2
1.0          1
25.0         1
28.0         1
4.0          1
dtype: int64
Completed iteration 3
26.0    291348
0.0     157914
21.0     22743
15.0      9106
22.0      5478
18.0      2900
7.0       2314
14.0      1352
19.0       450
11.0       142
3.0         59
9.0         44
29.0        39
16.0        22
23.0        21
2.0         16
17.0        10
27.0        10
13.0        10
20.0         8
30.0         7
6.0          6
12.0         5
5.0          4
24.0         4
8.0          3
10.0         2
1.0          1
25.0         1
28.0         1
4.0          1
dtype: int64
Completed iteration 4
26.0    291324
0.0     159283
21.0     22017
15.0      8614
22.0      5384
18.0      2868
7.0       2314
14.0      1351
19.0       450
11.0       142
3.0         59
9.0         44
29.0        39
16.0        22
23.0        21
2.0         16
17.0        10
27.0        10
13.0        10
20.0         8
30.0         7
6.0          6
12.0         5
5.0          4
24.0         4
8.0          3
10.0         2
1.0          1
25.0         1
28.0         1
4.0          1
dtype: int64
Completed iteration 5
26.0    291295
0.0     160135
21.0     21560
15.0      8411
22.0      5252
18.0      2841
7.0       2314
14.0      1347
19.0       450
11.0       142
3.0         59
9.0         44
29.0        39
16.0        22
23.0        21
2.0         16
17.0        10
27.0        10
13.0        10
20.0         8
30.0         7
6.0          6
12.0         5
5.0          4
24.0         4
8.0          3
10.0         2
1.0          1
25.0         1
28.0         1
4.0          1
dtype: int64
Completed iteration 6
26.0    291274
0.0     160582
21.0     21416
15.0      8252
22.0      5155
18.0      2819
7.0       2314
14.0      1343
19.0       450
11.0       142
3.0         59
9.0         44
29.0        39
16.0        22
23.0        21
2.0         16
17.0        10
27.0        10
13.0        10
20.0         8
30.0         7
6.0          6
12.0         5
5.0          4
24.0         4
8.0          3
10.0         2
1.0          1
25.0         1
28.0         1
4.0          1
dtype: int64
Completed iteration 7
26.0    291257
0.0     160873
21.0     21381
15.0      8087
22.0      5111
18.0      2792
7.0       2314
14.0      1340
19.0       450
11.0       142
3.0         59
9.0         44
29.0        39
16.0        22
23.0        21
2.0         16
17.0        10
27.0        10
13.0        10
20.0         8
30.0         7
6.0          6
12.0         5
5.0          4
24.0         4
8.0          3
10.0         2
1.0          1
25.0         1
28.0         1
4.0          1
dtype: int64
Completed iteration 8
26.0    291251
0.0     161140
21.0     21290
15.0      7980
22.0      5062
18.0      2778
7.0       2314
14.0      1340
19.0       450
11.0       142
3.0         59
9.0         44
29.0        39
16.0        22
23.0        21
2.0         16
17.0        10
27.0        10
13.0        10
20.0         8
30.0         7
6.0          6
12.0         5
5.0          4
24.0         4
8.0          3
10.0         2
1.0          1
25.0         1
28.0         1
4.0          1
dtype: int64
Completed iteration 9
26.0    291243
0.0     161313
21.0     21326
15.0      7825
22.0      5036
18.0      2760
7.0       2314
14.0      1338
19.0       450
11.0       142
3.0         59
9.0         44
29.0        39
16.0        22
23.0        21
2.0         16
17.0        10
27.0        10
13.0        10
20.0         8
30.0         7
6.0          6
12.0         5
5.0          4
24.0         4
8.0          3
10.0         2
1.0          1
25.0         1
28.0         1
4.0          1
dtype: int64
Completed iteration 10
26.0    291238
0.0     161445
21.0     21600
15.0      7507
22.0      4963
18.0      2759
7.0       2314
14.0      1329
19.0       450
11.0       142
3.0         59
9.0         44
29.0        39
16.0        22
23.0        21
2.0         16
17.0        10
27.0        10
13.0        10
20.0         8
30.0         7
6.0          6
12.0         5
5.0          4
24.0         4
8.0          3
10.0         2
1.0          1
25.0         1
28.0         1
4.0          1
dtype: int64
Completed iteration 11
Reached 11 iterations
Centroids:
Centroid 1: [1.39160662e+02 1.10995076e+00 3.95902691e+01 5.46311128e+00
 5.41218434e+01 7.00838985e+01 1.36269318e-04 1.80804608e-02
 0.00000000e+00 4.68270928e-03 4.15002013e-04 1.37681563e-01
 3.71643594e-05 0.00000000e+00 1.23881198e-05 1.57267181e-02
 2.29180216e-04 1.23881198e-05 2.10598036e-04 0.00000000e+00
 0.00000000e+00 8.91944625e-04 1.32556598e+02 1.13162191e+01
 5.40073400e-01 5.39734646e-01 1.74848834e-01 1.74504630e-01
 3.63437022e-01 6.20797176e-02 3.98833659e-02 2.25663037e+02
 6.48116944e+01 2.78073214e-01 8.92398030e-02 8.12257425e-02
 1.37895258e-02 5.39793614e-01 5.39406299e-01 1.75251138e-01
 1.72779460e-01]
Centroid 2: [2.0000000e+00 1.0000000e+00 1.7000000e+01 2.0000000e+00 6.9337564e+08
 0.0000000e+00 0.0000000e+00 0.0000000e+00 0.0000000e+00 1.0000000e+00
 0.0000000e+00 0.0000000e+00 0.0000000e+00 0.0000000e+00 0.0000000e+00
 0.0000000e+00 0.0000000e+00 0.0000000e+00 0.0000000e+00 0.0000000e+00
 0.0000000e+00 0.0000000e+00 5.7000000e+01 3.0000000e+00 7.9000000e-01
 6.7000000e-01 2.1000000e-01 3.3000000e-01 5.0000000e-02 3.9000000e-01
 0.0000000e+00 2.5500000e+02 3.0000000e+00 1.0000000e-02 9.0000000e-02
 2.2000000e-01 0.0000000e+00 1.8000000e-01 6.7000000e-01 5.0000000e-02
 3.3000000e-01]
Centroid 3: [3.24312500e+02 1.00000000e+00 1.90000000e+01 9.00000000e+00
 0.00000000e+00 5.15038094e+06 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 1.12500000e+00 1.12500000e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 1.00000000e+00 0.00000000e+00 0.00000000e+00 2.53125000e+01
 1.33750000e+01 9.53125000e-01 1.25000000e-03 9.37500000e-01
 0.00000000e+00 4.68750000e-02 5.37500000e-02 0.00000000e+00
 0.00000000e+00]
Centroid 4: [5.05167797e+03 1.00000000e+00 2.01186441e+01 8.98305085e+00
 5.13422649e+06 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 2.71186441e+00 0.00000000e+00 1.00000000e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 1.01694915e+00 1.45762712e+00
 1.69491525e-02 1.93220339e-02 0.00000000e+00 0.00000000e+00
 9.91525424e-01 1.69491525e-02 5.76271186e-02 3.15932203e+01
 3.50508475e+01 8.90847458e-01 2.33898305e-02 9.33220339e-01
 1.04406780e-01 1.08474576e-02 2.42372881e-02 2.37288136e-03
 3.38983051e-04]
Centroid 5: [2.426000e+03 1.000000e+00 1.900000e+01 4.000000e+00 2.500058e+06
 0.000000e+00 0.000000e+00 0.000000e+00 0.000000e+00 0.000000e+00
 0.000000e+00 1.000000e+00 0.000000e+00 0.000000e+00 0.000000e+00
 0.000000e+00 0.000000e+00 0.000000e+00 0.000000e+00 0.000000e+00
 0.000000e+00 0.000000e+00 1.000000e+00 1.000000e+00 0.000000e+00
 0.000000e+00 1.000000e+00 1.000000e+00 1.000000e+00 0.000000e+00
 0.000000e+00 3.000000e+00 4.300000e+01 1.000000e+00 0.000000e+00
 1.000000e+00 9.000000e-02 0.000000e+00 0.000000e+00 3.300000e-01
 2.000000e-02]
Centroid 6: [7.7000000e+01 1.0000000e+00 5.7000000e+01 9.0000000e+00 6.9825000e+02
 2.4171715e+06 0.0000000e+00 0.0000000e+00 0.0000000e+00 0.0000000e+00
 0.0000000e+00 1.0000000e+00 0.0000000e+00 0.0000000e+00 0.0000000e+00
 0.0000000e+00 0.0000000e+00 0.0000000e+00 0.0000000e+00 0.0000000e+00
 0.0000000e+00 0.0000000e+00 1.0000000e+00 1.0000000e+00 0.0000000e+00
 0.0000000e+00 0.0000000e+00 0.0000000e+00 1.0000000e+00 0.0000000e+00
 0.0000000e+00 1.3175000e+02 2.7250000e+01 1.7500000e-01 5.2500000e-02
 1.5000000e-02 1.6250000e-01 0.0000000e+00 0.0000000e+00 0.0000000e+00
 0.0000000e+00]
Centroid 7: [4.10000000e+01 1.00000000e+00 5.70000000e+01 9.00000000e+00
 6.40500000e+02 7.85400833e+05 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 1.00000000e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 1.16666667e+00 1.00000000e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 9.16666667e-01 1.66666667e-01 0.00000000e+00 1.55666667e+02
 2.95000000e+01 3.06666667e-01 2.33333333e-02 1.71666667e-01
 4.16666667e-02 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00]
Centroid 8: [1.98789974e-01 1.00000000e+00 2.20319793e+01 8.81936041e+00
 5.45953760e+04 7.89350519e+03 0.00000000e+00 0.00000000e+00
 0.00000000e+00 1.86041487e+00 0.00000000e+00 9.90492653e-01
 9.16594641e-01 0.00000000e+00 0.00000000e+00 9.50734659e-03
 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 3.67977528e+00 3.92610199e+00
 3.76404494e-03 3.95851340e-03 3.59291271e-02 8.84788245e-02
 9.98452895e-01 2.34658600e-03 1.12026793e-01 2.02823682e+02
 2.00161625e+02 9.69286949e-01 3.54796889e-03 2.71910112e-02
 9.03197926e-04 2.66205704e-03 2.86084702e-03 4.69403630e-02
 4.65816768e-02]
Centroid 9: [4.50000000e+01 1.00000000e+00 5.70000000e+01 9.00000000e+00
 5.88333333e+02 1.76159700e+06 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 1.00000000e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 1.00000000e+00 1.00000000e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 1.00000000e+00 0.00000000e+00 0.00000000e+00 1.36000000e+02
 3.30000000e+01 2.63333333e-01 3.33333333e-02 1.00000000e-02
 2.66666667e-02 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00]
Centroid 10: [6.44818182e+02 1.00000000e+00 2.75681818e+01 8.93181818e+00
 3.63000000e+02 1.45278432e+05 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 1.00000000e+00
 1.74545455e+01 2.27272727e-02 4.54545455e-02 1.94772727e+01
 2.27272727e-01 0.00000000e+00 1.36363636e-01 0.00000000e+00
 0.00000000e+00 0.00000000e+00 5.84090909e+00 9.25000000e+00
 1.59090909e-03 1.59090909e-03 0.00000000e+00 0.00000000e+00
 1.00000000e+00 0.00000000e+00 7.59090909e-02 7.63409091e+01
 2.10181818e+02 8.67500000e-01 7.95454545e-03 4.86363636e-02
 2.88636364e-02 2.06818182e-02 1.52272727e-02 9.54545455e-03
 1.47727273e-02]
Centroid 11: [2.376000e+03 1.000000e+00 3.950000e+01 9.000000e+00 9.805000e+02
 3.884161e+06 0.000000e+00 0.000000e+00 0.000000e+00 0.000000e+00
 1.500000e+00 1.000000e+00 9.000000e+00 5.000000e-01 1.000000e+00
 4.500000e+00 0.000000e+00 0.000000e+00 0.000000e+00 0.000000e+00
 0.000000e+00 0.000000e+00 1.000000e+00 1.000000e+00 0.000000e+00
 0.000000e+00 0.000000e+00 0.000000e+00 1.000000e+00 0.000000e+00
 0.000000e+00 1.930000e+02 1.285000e+02 5.050000e-01 1.000000e-02
 5.000000e-03 5.000000e-03 0.000000e+00 0.000000e+00 3.850000e-01
 0.000000e+00]
Centroid 12: [2.52253521e+02 1.00000000e+00 2.44647887e+01 9.00000000e+00
 3.07316901e+02 7.58161831e+04 0.00000000e+00 0.00000000e+00
 0.00000000e+00 2.81690141e-02 7.04225352e-03 1.00000000e+00
 2.01408451e+00 1.40845070e-02 2.11267606e-02 2.22535211e+00
 3.52112676e-02 0.00000000e+00 4.22535211e-02 0.00000000e+00
 0.00000000e+00 0.00000000e+00 6.24647887e+00 8.31690141e+00
 1.40845070e-03 1.76056338e-03 0.00000000e+00 4.22535211e-03
 9.96478873e-01 7.04225352e-03 7.54929577e-02 7.90000000e+01
 2.30633803e+02 9.48450704e-01 4.78873239e-03 8.10563380e-02
 3.05633803e-02 1.01408451e-02 1.17605634e-02 5.84507042e-03
 5.91549296e-03]
Centroid 13: [3.2400000e+01 1.0000000e+00 5.7000000e+01 9.0000000e+00 4.3600000e+02
 1.3693628e+06 0.0000000e+00 0.0000000e+00 0.0000000e+00 0.0000000e+00
 0.0000000e+00 1.0000000e+00 0.0000000e+00 0.0000000e+00 0.0000000e+00
 0.0000000e+00 0.0000000e+00 0.0000000e+00 0.0000000e+00 0.0000000e+00
 0.0000000e+00 0.0000000e+00 1.2000000e+00 1.2000000e+00 0.0000000e+00
 0.0000000e+00 0.0000000e+00 0.0000000e+00 1.0000000e+00 0.0000000e+00
 0.0000000e+00 1.7740000e+02 3.4800000e+01 1.8400000e-01 3.0000000e-02
 8.0000000e-03 0.0000000e+00 0.0000000e+00 0.0000000e+00 0.0000000e+00
 0.0000000e+00]
Centroid 14: [3.220000e+01 1.000000e+00 4.330000e+01 8.500000e+00 6.724000e+02
 6.171878e+05 0.000000e+00 0.000000e+00 0.000000e+00 0.000000e+00
 0.000000e+00 9.000000e-01 0.000000e+00 0.000000e+00 0.000000e+00
 0.000000e+00 0.000000e+00 0.000000e+00 0.000000e+00 0.000000e+00
 0.000000e+00 0.000000e+00 1.900000e+00 3.200000e+00 1.500000e-01
 1.070000e-01 0.000000e+00 0.000000e+00 1.000000e+00 0.000000e+00
 1.300000e-02 1.377000e+02 9.230000e+01 4.840000e-01 1.700000e-02
 1.600000e-02 1.100000e-02 5.600000e-02 5.500000e-02 2.000000e-02
 5.800000e-02]
Centroid 15: [4.97351392e+01 1.00000000e+00 2.24905944e+01 8.97968397e+00
 2.50104590e+02 2.77549601e+04 0.00000000e+00 0.00000000e+00
 0.00000000e+00 4.89089541e-02 0.00000000e+00 9.99247555e-01
 5.11662904e-02 3.76222724e-03 0.00000000e+00 5.64334086e-02
 5.64334086e-02 7.52445448e-04 1.50489090e-03 0.00000000e+00
 0.00000000e+00 0.00000000e+00 5.53273138e+00 8.25959368e+00
 5.73363431e-03 5.04138450e-03 1.73062453e-03 2.75395034e-03
 1.00000000e+00 0.00000000e+00 1.12430399e-01 1.35027088e+02
 2.46419865e+02 9.88713318e-01 1.07599699e-03 7.45297216e-02
 2.38826185e-02 3.79984951e-03 1.21896163e-03 7.84048157e-03
 1.01128668e-02]
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Centroid 16: [9.27747436e+00 1.00000000e+00 2.21132277e+01 8.99360597e+00
 2.67168376e+02 4.78686333e+03 0.00000000e+00 0.00000000e+00
 0.00000000e+00 1.68909018e-01 1.33209005e-04 9.99467164e-01
 3.86306114e-03 1.46529905e-03 1.33209005e-04 9.32463035e-04
 1.59850806e-03 0.00000000e+00 1.33209005e-04 0.00000000e+00
 0.00000000e+00 6.12761423e-03 8.59158119e+00 1.15664047e+01
 1.48927668e-03 2.25123218e-03 1.32942587e-03 2.03809778e-03
 9.99489810e-01 9.07153324e-04 1.00825896e-01 1.09949647e+02
 2.45021846e+02 9.89906754e-01 1.41467963e-03 7.19688291e-02
 2.68496070e-02 1.45997069e-03 1.00572799e-03 6.08765153e-03
 9.05288397e-03]
Centroid 17: [2.27272727e+00 1.00000000e+00 1.90000000e+01 9.00000000e+00
 2.19461900e+06 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 7.72727273e-01
 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 1.72727273e+00 1.63636364e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 9.62272727e-01 7.59090909e-02 0.00000000e+00 1.15818182e+02
 6.20000000e+01 3.21363636e-01 7.45454545e-02 3.21363636e-01
 1.90909091e-02 0.00000000e+00 0.00000000e+00 2.72727273e-03
 0.00000000e+00]
Centroid 18: [1.494900e+03 1.000000e+00 5.350000e+01 9.000000e+00 7.058000e+02
 3.496967e+05 0.000000e+00 0.000000e+00 0.000000e+00 0.000000e+00
 0.000000e+00 1.000000e+00 8.840000e+01 1.000000e-01 2.000000e-01
 9.930000e+01 0.000000e+00 0.000000e+00 8.000000e-01 0.000000e+00
 0.000000e+00 0.000000e+00 1.100000e+00 1.100000e+00 0.000000e+00
 0.000000e+00 0.000000e+00 0.000000e+00 1.000000e+00 0.000000e+00
 0.000000e+00 6.830000e+01 3.560000e+01 2.480000e-01 1.760000e-01
 7.100000e-02 6.900000e-02 3.000000e-03 3.400000e-02 7.700000e-02
 1.400000e-02]
Centroid 19: [1.90434940e+01 1.00000000e+00 2.23113447e+01 8.97970279e+00
 2.61541863e+02 1.57676122e+04 0.00000000e+00 0.00000000e+00
 0.00000000e+00 8.69880391e-03 0.00000000e+00 9.99275100e-01
 1.19608554e-02 7.24900326e-04 0.00000000e+00 2.89960130e-03
 2.10221095e-02 0.00000000e+00 4.34940196e-03 0.00000000e+00
 0.00000000e+00 0.00000000e+00 6.97825299e+00 9.75715839e+00
 3.89633925e-03 3.77673070e-03 1.25045306e-03 2.51540413e-03
 9.99818775e-01 3.62450163e-04 1.06266763e-01 1.25872418e+02
 2.43098586e+02 9.91341066e-01 1.13809351e-03 7.61833998e-02
 2.31315694e-02 4.09931134e-03 1.52229069e-03 5.42587894e-03
 8.20949619e-03]
Centroid 20: [1.06173333e+02 1.00000000e+00 2.29533333e+01 8.98666667e+00
 2.63637778e+02 4.43474267e+04 0.00000000e+00 0.00000000e+00
 4.44444444e-03 1.77777778e-02 0.00000000e+00 1.00000000e+00
 7.64444444e-01 6.66666667e-03 8.88888889e-03 8.68888889e-01
 6.00000000e-02 0.00000000e+00 1.33333333e-02 0.00000000e+00
 0.00000000e+00 0.00000000e+00 4.45555556e+00 7.28000000e+00
 4.93333333e-03 4.97777778e-03 1.53333333e-03 3.55555556e-03
 1.00000000e+00 0.00000000e+00 1.12577778e-01 1.12948889e+02
 2.44848889e+02 9.77777778e-01 5.62222222e-03 8.96888889e-02
 2.65777778e-02 5.31111111e-03 4.46666667e-03 1.18000000e-02
 1.10666667e-02]
Centroid 21: [1.800000e+01 1.000000e+00 1.675000e+01 8.625000e+00 5.228475e+05
 2.697500e+04 0.000000e+00 0.000000e+00 0.000000e+00 0.000000e+00
 0.000000e+00 6.250000e-01 0.000000e+00 0.000000e+00 0.000000e+00
 0.000000e+00 0.000000e+00 0.000000e+00 0.000000e+00 0.000000e+00
 0.000000e+00 0.000000e+00 1.750000e+00 1.750000e+00 6.250000e-02
 6.250000e-02 0.000000e+00 0.000000e+00 1.000000e+00 0.000000e+00
 0.000000e+00 1.265000e+02 6.575000e+01 3.262500e-01 3.750000e-02
 3.262500e-01 1.250000e-02 3.750000e-03 8.750000e-03 0.000000e+00
 0.000000e+00]
Centroid 22: [1.01008333e+01 1.00000000e+00 2.19989352e+01 8.99875000e+00
 2.79838611e+02 1.85183884e+03 0.00000000e+00 0.00000000e+00
 4.62962963e-05 4.80462963e-01 4.62962963e-05 9.99861111e-01
 4.25925926e-03 9.72222222e-04 4.62962963e-05 3.24074074e-04
 2.22222222e-03 2.77777778e-04 1.36111111e-02 0.00000000e+00
 0.00000000e+00 2.29166667e-02 9.72097222e+00 1.26637037e+01
 1.48518519e-03 1.82083333e-03 5.34722222e-04 3.01944444e-03
 9.99366667e-01 8.90740741e-04 8.87791667e-02 1.41483102e+02
 2.41622037e+02 9.77450926e-01 2.73009259e-03 4.25541667e-02
 1.98939815e-02 1.46759259e-03 8.75925926e-04 4.62129630e-03
 7.72129630e-03]
Centroid 23: [6.69175902e+01 1.00000000e+00 2.21212976e+01 8.96252267e+00
 3.01474108e+02 9.24560911e+03 0.00000000e+00 0.00000000e+00
 2.01491034e-04 1.32984082e-02 0.00000000e+00 9.97582108e-01
 1.89401572e-02 1.41043724e-03 0.00000000e+00 1.45073544e-02
 8.26113238e-03 8.05964135e-04 1.81341930e-03 0.00000000e+00
 0.00000000e+00 0.00000000e+00 7.88031433e+00 1.09772315e+01
 1.83759823e-03 2.31311707e-03 5.42816845e-03 6.96353012e-03
 9.99657465e-01 6.85069514e-04 1.17886359e-01 1.18106186e+02
 2.45413258e+02 9.90465444e-01 1.16663308e-03 7.17146887e-02
 2.52206327e-02 2.06125327e-03 1.47894419e-03 8.17247632e-03
 1.33649003e-02]
Centroid 24: [2.38095238e-01 1.00000000e+00 2.50952381e+01 9.00000000e+00
 1.88549905e+05 6.50000000e+01 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 8.57142857e-01
 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 1.61904762e+00 3.04761905e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 1.00000000e+00 0.00000000e+00 2.26190476e-01 1.15857143e+02
 7.92380952e+01 3.91428571e-01 9.71428571e-02 2.65238095e-01
 1.76190476e-02 2.85714286e-03 4.28571429e-03 0.00000000e+00
 9.52380952e-04]
Centroid 25: [4.250000e+01 1.000000e+00 5.700000e+01 9.000000e+00 5.157500e+02
 1.512446e+06 0.000000e+00 0.000000e+00 0.000000e+00 0.000000e+00
 0.000000e+00 1.000000e+00 0.000000e+00 0.000000e+00 0.000000e+00
 0.000000e+00 0.000000e+00 0.000000e+00 0.000000e+00 0.000000e+00
 0.000000e+00 0.000000e+00 1.000000e+00 1.000000e+00 0.000000e+00
 0.000000e+00 0.000000e+00 0.000000e+00 1.000000e+00 0.000000e+00
 0.000000e+00 1.577500e+02 3.825000e+01 2.250000e-01 2.750000e-02
 1.000000e-02 5.500000e-02 0.000000e+00 0.000000e+00 0.000000e+00
 0.000000e+00]
Centroid 26: [1.070000e+02 1.000000e+00 5.700000e+01 9.000000e+00 5.850000e+02
 2.661605e+06 0.000000e+00 0.000000e+00 0.000000e+00 0.000000e+00
 0.000000e+00 1.000000e+00 0.000000e+00 0.000000e+00 0.000000e+00
 0.000000e+00 0.000000e+00 0.000000e+00 0.000000e+00 0.000000e+00
 0.000000e+00 0.000000e+00 1.000000e+00 1.000000e+00 0.000000e+00
 0.000000e+00 0.000000e+00 0.000000e+00 1.000000e+00 0.000000e+00
 0.000000e+00 1.710000e+02 4.700000e+01 2.700000e-01 2.000000e-02
 1.000000e-02 0.000000e+00 0.000000e+00 0.000000e+00 0.000000e+00
 0.000000e+00]
Centroid 27: [8.65683736e-02 3.51568133e-02 1.50733009e+01 8.99984892e+00
 1.00084463e+03 1.03004828e+01 0.00000000e+00 8.89307027e-04
 0.00000000e+00 5.15042680e-05 0.00000000e+00 3.34743406e-02
 0.00000000e+00 0.00000000e+00 0.00000000e+00 7.55395930e-05
 7.55395930e-04 1.40778332e-04 4.12034144e-04 0.00000000e+00
 0.00000000e+00 0.00000000e+00 4.88958292e+02 4.88974282e+02
 3.10055693e-05 3.80101498e-05 1.57259698e-05 2.20094905e-05
 9.99371614e-01 1.03468641e-03 1.32146217e-02 2.50179640e+02
 2.50092924e+02 9.85426593e-01 2.60851949e-03 9.68004107e-01
 6.65297798e-04 3.07137118e-04 9.17119332e-05 3.04252879e-04
 4.97187867e-05]
Centroid 28: [2.141200e+03 1.000000e+00 4.620000e+01 9.000000e+00 8.273000e+02
 4.619446e+05 0.000000e+00 0.000000e+00 3.000000e-01 1.000000e-01
 2.000000e-01 9.000000e-01 3.020000e+01 1.000000e-01 1.000000e-01
 2.900000e+01 2.000000e-01 0.000000e+00 0.000000e+00 0.000000e+00
 0.000000e+00 0.000000e+00 1.100000e+00 2.200000e+00 0.000000e+00
 0.000000e+00 0.000000e+00 0.000000e+00 1.000000e+00 0.000000e+00
 3.100000e-02 1.414000e+02 7.070000e+01 4.060000e-01 3.000000e-02
 1.090000e-01 5.000000e-03 3.800000e-02 4.600000e-02 0.000000e+00
 0.000000e+00]
Centroid 29: [2.00000e+00 1.00000e+00 1.90000e+01 9.00000e+00 2.10438e+06 0.00000e+00
 0.00000e+00 0.00000e+00 0.00000e+00 0.00000e+00 0.00000e+00 0.00000e+00
 0.00000e+00 0.00000e+00 0.00000e+00 0.00000e+00 0.00000e+00 0.00000e+00
 0.00000e+00 0.00000e+00 0.00000e+00 0.00000e+00 2.00000e+00 2.00000e+00
 0.00000e+00 0.00000e+00 0.00000e+00 0.00000e+00 1.00000e+00 0.00000e+00
 0.00000e+00 2.13000e+02 1.00000e+01 2.00000e-02 1.00000e-02 2.00000e-02
 2.00000e-01 9.40000e-01 0.00000e+00 0.00000e+00 0.00000e+00]
Centroid 30: [2.85897436e+02 1.00000000e+00 3.90512821e+01 8.82051282e+00
 4.44717949e+02 2.52348410e+05 0.00000000e+00 0.00000000e+00
 0.00000000e+00 5.12820513e-02 0.00000000e+00 9.74358974e-01
 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 3.20512821e+00 3.51282051e+00
 0.00000000e+00 0.00000000e+00 2.56410256e-02 2.84615385e-02
 9.87179487e-01 2.56410256e-02 4.38461538e-02 1.35410256e+02
 1.41179487e+02 5.91794872e-01 1.92307692e-02 5.25641026e-02
 1.84615385e-02 5.12820513e-04 3.33333333e-03 7.94871795e-03
 3.02564103e-02]
Centroid 31: [2.75714286e+01 1.00000000e+00 4.11428571e+01 9.00000000e+00
 4.38000000e+02 1.06045971e+06 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 7.14285714e-01
 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 1.00000000e+00 1.14285714e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 1.00000000e+00 0.00000000e+00 1.42857143e-01 1.38285714e+02
 5.14285714e+01 4.90000000e-01 1.85714286e-02 2.90000000e-01
 0.00000000e+00 0.00000000e+00 0.00000000e+00 1.42857143e-03
 0.00000000e+00]
45 clusters:
Finished running k-means++
26.0    289979
0.0     150430
21.0     19140
15.0      8437
43.0      7761
22.0      5628
40.0      3334
18.0      2578
7.0       2309
35.0      1625
14.0       943
32.0       532
31.0       445
37.0       281
19.0       167
11.0        86
3.0         59
33.0        53
39.0        39
9.0         28
16.0        22
38.0        19
23.0        17
2.0         16
29.0        16
42.0         9
17.0         9
20.0         7
27.0         7
13.0         7
12.0         5
36.0         4
6.0          4
24.0         4
5.0          4
30.0         3
8.0          3
41.0         2
44.0         2
10.0         2
34.0         1
28.0         1
1.0          1
4.0          1
25.0         1
dtype: int64
Completed iteration 1
26.0    290039
0.0     150635
21.0     18024
43.0     10755
15.0      6795
22.0      5197
40.0      3314
18.0      2627
7.0       2309
35.0      1390
14.0      1022
32.0       555
31.0       485
37.0       294
19.0       144
11.0        89
3.0         59
33.0        54
39.0        41
9.0         24
16.0        22
29.0        21
23.0        17
38.0        16
2.0         16
17.0        10
42.0         9
20.0         7
13.0         7
27.0         6
12.0         5
36.0         4
6.0          4
24.0         4
5.0          4
30.0         3
8.0          3
41.0         2
44.0         2
10.0         2
34.0         1
28.0         1
1.0          1
4.0          1
25.0         1
dtype: int64
Completed iteration 2
26.0    290093
0.0     150251
21.0     18668
43.0     11333
15.0      6226
22.0      4857
40.0      3304
18.0      2640
7.0       2309
35.0      1314
14.0      1066
32.0       576
31.0       510
37.0       308
19.0       134
11.0        85
3.0         59
33.0        55
39.0        40
16.0        22
29.0        22
9.0         22
23.0        17
38.0        17
2.0         16
17.0        10
42.0         9
20.0         7
13.0         7
27.0         6
12.0         5
36.0         4
6.0          4
24.0         4
5.0          4
30.0         3
8.0          3
41.0         2
44.0         2
10.0         2
34.0         1
28.0         1
1.0          1
4.0          1
25.0         1
dtype: int64
Completed iteration 3
26.0    290122
0.0     150135
21.0     19033
43.0     11504
15.0      5961
22.0      4608
40.0      3356
18.0      2624
7.0       2309
35.0      1292
14.0      1064
32.0       623
31.0       520
37.0       309
19.0       132
11.0        82
3.0         59
33.0        55
39.0        40
29.0        23
16.0        22
9.0         20
38.0        18
23.0        17
2.0         16
17.0        10
42.0         9
20.0         7
13.0         7
27.0         6
12.0         5
36.0         4
6.0          4
24.0         4
5.0          4
30.0         3
8.0          3
41.0         2
44.0         2
10.0         2
34.0         1
28.0         1
1.0          1
4.0          1
25.0         1
dtype: int64
Completed iteration 4
26.0    290154
0.0     150218
21.0     19224
43.0     11513
15.0      5808
22.0      4459
40.0      3368
18.0      2575
7.0       2309
35.0      1262
14.0      1086
32.0       648
31.0       523
37.0       314
19.0       133
11.0        80
3.0         59
33.0        55
39.0        39
29.0        24
16.0        22
9.0         20
38.0        18
23.0        17
2.0         16
17.0        10
42.0         9
20.0         7
13.0         7
27.0         6
12.0         5
36.0         4
6.0          4
24.0         4
5.0          4
30.0         3
8.0          3
41.0         2
44.0         2
10.0         2
34.0         1
28.0         1
1.0          1
4.0          1
25.0         1
dtype: int64
Completed iteration 5
26.0    290154
0.0     150410
21.0     19356
43.0     11377
15.0      5748
22.0      4327
40.0      3369
18.0      2515
7.0       2309
35.0      1260
14.0      1104
32.0       694
31.0       524
37.0       315
19.0       133
11.0        79
3.0         59
33.0        55
39.0        39
29.0        24
16.0        22
9.0         20
38.0        18
23.0        17
2.0         16
17.0        10
42.0         9
20.0         7
13.0         7
27.0         6
12.0         5
36.0         4
6.0          4
24.0         4
5.0          4
30.0         3
8.0          3
41.0         2
44.0         2
10.0         2
34.0         1
28.0         1
1.0          1
4.0          1
25.0         1
dtype: int64
Completed iteration 6
26.0    290151
0.0     150569
21.0     19456
43.0     11273
15.0      5688
22.0      4221
40.0      3370
18.0      2500
7.0       2308
35.0      1261
14.0      1105
32.0       718
31.0       525
37.0       317
19.0       134
11.0        78
3.0         59
33.0        55
39.0        39
29.0        24
16.0        22
9.0         20
38.0        18
23.0        17
2.0         16
17.0        10
42.0         9
20.0         7
13.0         7
27.0         6
12.0         5
36.0         4
6.0          4
24.0         4
5.0          4
30.0         3
8.0          3
41.0         2
44.0         2
10.0         2
34.0         1
28.0         1
1.0          1
4.0          1
25.0         1
dtype: int64
Completed iteration 7
26.0    290149
0.0     150690
21.0     19590
43.0     11199
15.0      5682
22.0      4040
40.0      3371
18.0      2492
7.0       2308
35.0      1261
14.0      1106
32.0       730
31.0       526
37.0       319
19.0       133
11.0        78
3.0         59
33.0        55
39.0        39
29.0        24
16.0        22
9.0         20
38.0        18
23.0        17
2.0         16
17.0        10
42.0         9
20.0         7
13.0         7
27.0         6
12.0         5
36.0         4
6.0          4
24.0         4
5.0          4
30.0         3
8.0          3
41.0         2
44.0         2
10.0         2
34.0         1
28.0         1
1.0          1
4.0          1
25.0         1
dtype: int64
Completed iteration 8
26.0    290145
0.0     150807
21.0     19673
43.0     11285
15.0      5515
22.0      3936
40.0      3371
18.0      2474
7.0       2308
35.0      1261
14.0      1106
32.0       737
31.0       526
37.0       319
19.0       133
11.0        78
3.0         59
33.0        55
39.0        39
29.0        24
16.0        22
9.0         20
38.0        18
23.0        17
2.0         16
17.0        10
42.0         9
20.0         7
13.0         7
27.0         6
12.0         5
36.0         4
6.0          4
24.0         4
5.0          4
30.0         3
8.0          3
41.0         2
44.0         2
10.0         2
34.0         1
28.0         1
1.0          1
4.0          1
25.0         1
dtype: int64
Completed iteration 9
26.0    290140
0.0     150912
21.0     19800
43.0     11228
15.0      5462
22.0      3832
40.0      3372
18.0      2452
7.0       2308
35.0      1261
14.0      1111
32.0       738
31.0       526
37.0       321
19.0       133
11.0        78
3.0         59
33.0        55
39.0        39
29.0        24
16.0        22
9.0         20
38.0        18
23.0        17
2.0         16
17.0        10
42.0         9
20.0         7
13.0         7
27.0         6
12.0         5
36.0         4
6.0          4
24.0         4
5.0          4
30.0         3
8.0          3
41.0         2
44.0         2
10.0         2
34.0         1
28.0         1
1.0          1
4.0          1
25.0         1
dtype: int64
Completed iteration 10
26.0    290136
0.0     151031
21.0     19892
43.0     11142
15.0      5413
22.0      3777
40.0      3373
18.0      2433
7.0       2308
35.0      1261
14.0      1108
32.0       742
31.0       526
37.0       321
19.0       133
11.0        78
3.0         59
33.0        55
39.0        39
29.0        24
16.0        22
9.0         20
38.0        18
23.0        17
2.0         16
17.0        10
42.0         9
20.0         7
13.0         7
27.0         6
12.0         5
36.0         4
6.0          4
24.0         4
5.0          4
30.0         3
8.0          3
41.0         2
44.0         2
10.0         2
34.0         1
28.0         1
1.0          1
4.0          1
25.0         1
dtype: int64
Completed iteration 11
Reached 11 iterations
Centroids:
Centroid 1: [5.46497077e+00 1.09262999e+00 4.02959459e+01 5.22183525e+00
 4.23236554e+01 4.09459051e+01 1.45665459e-04 1.93271580e-02
 0.00000000e+00 8.80613914e-04 4.36996378e-04 1.03720428e-01
 3.97269435e-05 0.00000000e+00 1.32423145e-05 1.67978759e-02
 1.78771246e-04 1.32423145e-05 1.39044302e-04 0.00000000e+00
 0.00000000e+00 3.31057862e-05 1.41150320e+02 1.14035794e+01
 5.77261754e-01 5.76883024e-01 1.86376837e-01 1.85991022e-01
 3.21776390e-01 6.41460362e-02 3.79249955e-02 2.28565943e+02
 5.86411531e+01 2.54646066e-01 7.58440982e-02 6.05596202e-02
 1.38788063e-02 5.76951950e-01 5.76563553e-01 1.86653535e-01
 1.83884037e-01]
Centroid 2: [2.0000000e+00 1.0000000e+00 1.7000000e+01 2.0000000e+00 6.9337564e+08
 0.0000000e+00 0.0000000e+00 0.0000000e+00 0.0000000e+00 1.0000000e+00
 0.0000000e+00 0.0000000e+00 0.0000000e+00 0.0000000e+00 0.0000000e+00
 0.0000000e+00 0.0000000e+00 0.0000000e+00 0.0000000e+00 0.0000000e+00
 0.0000000e+00 0.0000000e+00 5.7000000e+01 3.0000000e+00 7.9000000e-01
 6.7000000e-01 2.1000000e-01 3.3000000e-01 5.0000000e-02 3.9000000e-01
 0.0000000e+00 2.5500000e+02 3.0000000e+00 1.0000000e-02 9.0000000e-02
 2.2000000e-01 0.0000000e+00 1.8000000e-01 6.7000000e-01 5.0000000e-02
 3.3000000e-01]
Centroid 3: [3.24312500e+02 1.00000000e+00 1.90000000e+01 9.00000000e+00
 0.00000000e+00 5.15038094e+06 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 1.12500000e+00 1.12500000e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 1.00000000e+00 0.00000000e+00 0.00000000e+00 2.53125000e+01
 1.33750000e+01 9.53125000e-01 1.25000000e-03 9.37500000e-01
 0.00000000e+00 4.68750000e-02 5.37500000e-02 0.00000000e+00
 0.00000000e+00]
Centroid 4: [5.05167797e+03 1.00000000e+00 2.01186441e+01 8.98305085e+00
 5.13422649e+06 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 2.71186441e+00 0.00000000e+00 1.00000000e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 1.01694915e+00 1.45762712e+00
 1.69491525e-02 1.93220339e-02 0.00000000e+00 0.00000000e+00
 9.91525424e-01 1.69491525e-02 5.76271186e-02 3.15932203e+01
 3.50508475e+01 8.90847458e-01 2.33898305e-02 9.33220339e-01
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 3.38983051e-04]
Centroid 5: [2.426000e+03 1.000000e+00 1.900000e+01 4.000000e+00 2.500058e+06
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 0.000000e+00 1.000000e+00 0.000000e+00 0.000000e+00 0.000000e+00
 0.000000e+00 0.000000e+00 0.000000e+00 0.000000e+00 0.000000e+00
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 0.000000e+00 1.000000e+00 1.000000e+00 1.000000e+00 0.000000e+00
 0.000000e+00 3.000000e+00 4.300000e+01 1.000000e+00 0.000000e+00
 1.000000e+00 9.000000e-02 0.000000e+00 0.000000e+00 3.300000e-01
 2.000000e-02]
Centroid 6: [7.7000000e+01 1.0000000e+00 5.7000000e+01 9.0000000e+00 6.9825000e+02
 2.4171715e+06 0.0000000e+00 0.0000000e+00 0.0000000e+00 0.0000000e+00
 0.0000000e+00 1.0000000e+00 0.0000000e+00 0.0000000e+00 0.0000000e+00
 0.0000000e+00 0.0000000e+00 0.0000000e+00 0.0000000e+00 0.0000000e+00
 0.0000000e+00 0.0000000e+00 1.0000000e+00 1.0000000e+00 0.0000000e+00
 0.0000000e+00 0.0000000e+00 0.0000000e+00 1.0000000e+00 0.0000000e+00
 0.0000000e+00 1.3175000e+02 2.7250000e+01 1.7500000e-01 5.2500000e-02
 1.5000000e-02 1.6250000e-01 0.0000000e+00 0.0000000e+00 0.0000000e+00
 0.0000000e+00]
Centroid 7: [4.125000e+01 1.000000e+00 5.700000e+01 9.000000e+00 6.247500e+02
 8.232585e+05 0.000000e+00 0.000000e+00 0.000000e+00 0.000000e+00
 0.000000e+00 1.000000e+00 0.000000e+00 0.000000e+00 0.000000e+00
 0.000000e+00 0.000000e+00 0.000000e+00 0.000000e+00 0.000000e+00
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 0.000000e+00 0.000000e+00 0.000000e+00 1.000000e+00 0.000000e+00
 0.000000e+00 1.535000e+02 2.675000e+01 3.725000e-01 1.750000e-02
 2.525000e-01 0.000000e+00 0.000000e+00 0.000000e+00 0.000000e+00
 0.000000e+00]
Centroid 8: [1.96707106e-01 1.00000000e+00 2.19969671e+01 8.82235702e+00
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 0.00000000e+00 1.86481802e+00 0.00000000e+00 9.90901213e-01
 9.18977470e-01 0.00000000e+00 0.00000000e+00 9.53206239e-03
 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 3.67807626e+00 3.92374350e+00
 3.74783362e-03 3.94280763e-03 3.56975737e-02 8.83838821e-02
 9.98448873e-01 2.35268631e-03 1.11559792e-01 2.02922010e+02
 2.00351386e+02 9.70069324e-01 3.34055459e-03 2.69410745e-02
 8.83882149e-04 2.34835355e-03 2.85961872e-03 4.70450607e-02
 4.66854419e-02]
Centroid 9: [4.50000000e+01 1.00000000e+00 5.70000000e+01 9.00000000e+00
 5.88333333e+02 1.76159700e+06 0.00000000e+00 0.00000000e+00
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 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 1.00000000e+00 1.00000000e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 1.00000000e+00 0.00000000e+00 0.00000000e+00 1.36000000e+02
 3.30000000e+01 2.63333333e-01 3.33333333e-02 1.00000000e-02
 2.66666667e-02 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00]
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Centroid 10: [7.600000e+02 1.000000e+00 2.725000e+01 9.000000e+00 3.397000e+02
 1.592944e+05 0.000000e+00 0.000000e+00 0.000000e+00 0.000000e+00
 0.000000e+00 1.000000e+00 3.835000e+01 5.000000e-02 1.000000e-01
 4.285000e+01 0.000000e+00 0.000000e+00 3.000000e-01 0.000000e+00
 0.000000e+00 0.000000e+00 4.600000e+00 7.450000e+00 0.000000e+00
 0.000000e+00 0.000000e+00 0.000000e+00 1.000000e+00 0.000000e+00
 3.900000e-02 8.520000e+01 2.081500e+02 8.720000e-01 9.500000e-03
 4.400000e-02 3.050000e-02 1.500000e-03 1.500000e-03 2.050000e-02
 2.800000e-02]
Centroid 11: [2.376000e+03 1.000000e+00 3.950000e+01 9.000000e+00 9.805000e+02
 3.884161e+06 0.000000e+00 0.000000e+00 0.000000e+00 0.000000e+00
 1.500000e+00 1.000000e+00 9.000000e+00 5.000000e-01 1.000000e+00
 4.500000e+00 0.000000e+00 0.000000e+00 0.000000e+00 0.000000e+00
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 0.000000e+00 0.000000e+00 0.000000e+00 1.000000e+00 0.000000e+00
 0.000000e+00 1.930000e+02 1.285000e+02 5.050000e-01 1.000000e-02
 5.000000e-03 5.000000e-03 0.000000e+00 0.000000e+00 3.850000e-01
 0.000000e+00]
Centroid 12: [6.73500000e+02 1.00000000e+00 2.51410256e+01 9.00000000e+00
 4.72230769e+02 6.31583462e+04 0.00000000e+00 0.00000000e+00
 0.00000000e+00 7.69230769e-02 1.28205128e-02 1.00000000e+00
 7.69230769e-02 2.56410256e-02 0.00000000e+00 7.69230769e-02
 4.10256410e-01 0.00000000e+00 1.28205128e-02 0.00000000e+00
 0.00000000e+00 0.00000000e+00 7.78205128e+00 9.08974359e+00
 2.56410256e-03 2.56410256e-03 0.00000000e+00 1.28205128e-03
 9.93589744e-01 1.28205128e-02 5.87179487e-02 8.55512821e+01
 2.25589744e+02 9.42307692e-01 1.76923077e-02 9.16666667e-02
 3.62820513e-02 1.12820513e-02 1.94871795e-02 1.34615385e-02
 4.87179487e-03]
Centroid 13: [3.2400000e+01 1.0000000e+00 5.7000000e+01 9.0000000e+00 4.3600000e+02
 1.3693628e+06 0.0000000e+00 0.0000000e+00 0.0000000e+00 0.0000000e+00
 0.0000000e+00 1.0000000e+00 0.0000000e+00 0.0000000e+00 0.0000000e+00
 0.0000000e+00 0.0000000e+00 0.0000000e+00 0.0000000e+00 0.0000000e+00
 0.0000000e+00 0.0000000e+00 1.2000000e+00 1.2000000e+00 0.0000000e+00
 0.0000000e+00 0.0000000e+00 0.0000000e+00 1.0000000e+00 0.0000000e+00
 0.0000000e+00 1.7740000e+02 3.4800000e+01 1.8400000e-01 3.0000000e-02
 8.0000000e-03 0.0000000e+00 0.0000000e+00 0.0000000e+00 0.0000000e+00
 0.0000000e+00]
Centroid 14: [4.75714286e+01 1.00000000e+00 5.20000000e+01 9.00000000e+00
 6.87571429e+02 5.19249286e+05 0.00000000e+00 0.00000000e+00
 0.00000000e+00 1.42857143e-01 0.00000000e+00 1.00000000e+00
 0.00000000e+00 1.42857143e-01 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 1.00000000e+00 1.00000000e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 1.00000000e+00 0.00000000e+00 0.00000000e+00 1.66428571e+02
 6.50000000e+01 2.90000000e-01 2.71428571e-02 7.14285714e-03
 7.14285714e-03 2.85714286e-03 0.00000000e+00 0.00000000e+00
 0.00000000e+00]
Centroid 15: [4.99855596e+01 1.00000000e+00 2.25333935e+01 8.97833935e+00
 2.55929603e+02 2.20477870e+04 0.00000000e+00 0.00000000e+00
 0.00000000e+00 2.16606498e-02 0.00000000e+00 9.98194946e-01
 5.77617329e-02 1.80505415e-03 0.00000000e+00 6.85920578e-02
 4.87364621e-02 9.02527076e-04 1.80505415e-03 0.00000000e+00
 0.00000000e+00 0.00000000e+00 6.10830325e+00 8.77075812e+00
 6.11010830e-03 5.20758123e-03 1.74187726e-03 1.79602888e-03
 1.00000000e+00 0.00000000e+00 1.04819495e-01 1.16527076e+02
 2.44599278e+02 9.89196751e-01 1.87725632e-03 9.58303249e-02
 2.61732852e-02 4.73826715e-03 2.11191336e-03 7.74368231e-03
 1.05595668e-02]
Centroid 16: [9.46425272e-01 1.00000000e+00 2.21368927e+01 8.99852208e+00
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 4.98799187e-03 5.54221319e-04 0.00000000e+00 5.54221319e-04
 1.84740440e-04 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 8.78200628e+00 1.18499908e+01
 1.71254388e-03 2.27046000e-03 7.03861075e-04 1.57583595e-03
 9.99754295e-01 4.93256974e-04 1.01577683e-01 1.14053390e+02
 2.47341216e+02 9.93739146e-01 9.66192500e-04 7.25752817e-02
 2.60465546e-02 1.58507297e-03 9.58802882e-04 6.23129503e-03
 9.24256420e-03]
Centroid 17: [2.27272727e+00 1.00000000e+00 1.90000000e+01 9.00000000e+00
 2.19461900e+06 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 7.72727273e-01
 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 1.72727273e+00 1.63636364e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 9.62272727e-01 7.59090909e-02 0.00000000e+00 1.15818182e+02
 6.20000000e+01 3.21363636e-01 7.45454545e-02 3.21363636e-01
 1.90909091e-02 0.00000000e+00 0.00000000e+00 2.72727273e-03
 0.00000000e+00]
Centroid 18: [1.494900e+03 1.000000e+00 5.350000e+01 9.000000e+00 7.058000e+02
 3.496967e+05 0.000000e+00 0.000000e+00 0.000000e+00 0.000000e+00
 0.000000e+00 1.000000e+00 8.840000e+01 1.000000e-01 2.000000e-01
 9.930000e+01 0.000000e+00 0.000000e+00 8.000000e-01 0.000000e+00
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 7.100000e-02 6.900000e-02 3.000000e-03 3.400000e-02 7.700000e-02
 1.400000e-02]
Centroid 19: [2.01812577e+01 1.00000000e+00 2.22486642e+01 8.98027127e+00
 2.67688039e+02 1.45594509e+04 0.00000000e+00 0.00000000e+00
 0.00000000e+00 7.80928894e-03 0.00000000e+00 1.00000000e+00
 9.86436498e-03 8.22030415e-04 0.00000000e+00 2.05507604e-03
 3.41142622e-02 0.00000000e+00 4.93218249e-03 0.00000000e+00
 0.00000000e+00 0.00000000e+00 7.30661734e+00 1.01689273e+01
 3.48951911e-03 3.36621455e-03 1.06452939e-03 2.44965064e-03
 9.99794492e-01 4.11015208e-04 1.06222770e-01 1.26955199e+02
 2.42825319e+02 9.92770242e-01 7.35717222e-04 7.48664201e-02
 2.27661323e-02 4.01561858e-03 1.27825730e-03 6.17755857e-03
 9.55199342e-03]
Centroid 20: [1.56639098e+02 1.00000000e+00 2.30526316e+01 8.95488722e+00
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 0.00000000e+00 0.00000000e+00 3.75939850e-02 0.00000000e+00
 0.00000000e+00 0.00000000e+00 4.89473684e+00 8.48872180e+00
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 1.00000000e+00 0.00000000e+00 1.46842105e-01 8.80000000e+01
 2.44097744e+02 9.76390977e-01 1.20300752e-03 1.18195489e-01
 2.81203008e-02 1.27819549e-02 1.10526316e-02 6.24060150e-03
 8.79699248e-03]
Centroid 21: [0.00000000e+00 1.00000000e+00 1.90000000e+01 8.57142857e+00
 4.95362857e+05 0.00000000e+00 0.00000000e+00 0.00000000e+00
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 0.00000000e+00 0.00000000e+00 1.85714286e+00 1.85714286e+00
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 7.50000000e+01 3.71428571e-01 3.14285714e-02 3.71428571e-01
 1.42857143e-02 2.85714286e-03 1.00000000e-02 0.00000000e+00
 0.00000000e+00]
Centroid 22: [5.46551377e-01 1.00000000e+00 2.20078423e+01 8.99899457e+00
 2.63230193e+02 1.19591162e+03 0.00000000e+00 0.00000000e+00
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 1.20651518e-03 2.01085864e-04 5.02714659e-05 1.00542932e-04
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 9.99543535e-01 6.92238086e-04 9.17906696e-02 1.41781219e+02
 2.45710235e+02 9.88464709e-01 1.80876734e-03 3.99612910e-02
 1.99125276e-02 1.09189624e-03 7.59099135e-04 4.70641464e-03
 7.89764730e-03]
Centroid 23: [2.21157003e+01 1.00000000e+00 2.21517077e+01 8.97987821e+00
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 2.64760392e-04 8.20757215e-03 0.00000000e+00 9.99205719e-01
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 2.38284353e-03 1.05904157e-03 2.11808313e-03 0.00000000e+00
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 1.75271379e-03 2.27164416e-03 3.16123908e-03 4.56976436e-03
 9.99814668e-01 3.70664549e-04 1.24596240e-01 1.15678581e+02
 2.45739476e+02 9.91869208e-01 7.65157532e-04 7.32433148e-02
 2.62748213e-02 1.79242785e-03 1.22054541e-03 6.87582738e-03
 1.08392904e-02]
Centroid 24: [0.00000000e+00 1.00000000e+00 1.90000000e+01 9.00000000e+00
 1.73920941e+05 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 8.23529412e-01
 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 1.76470588e+00 3.23529412e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
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 6.93529412e+01 3.21176471e-01 8.94117647e-02 3.20588235e-01
 1.64705882e-02 3.52941176e-03 5.29411765e-03 0.00000000e+00
 0.00000000e+00]
Centroid 25: [4.250000e+01 1.000000e+00 5.700000e+01 9.000000e+00 5.157500e+02
 1.512446e+06 0.000000e+00 0.000000e+00 0.000000e+00 0.000000e+00
 0.000000e+00 1.000000e+00 0.000000e+00 0.000000e+00 0.000000e+00
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 0.000000e+00 0.000000e+00 0.000000e+00 1.000000e+00 0.000000e+00
 0.000000e+00 1.577500e+02 3.825000e+01 2.250000e-01 2.750000e-02
 1.000000e-02 5.500000e-02 0.000000e+00 0.000000e+00 0.000000e+00
 0.000000e+00]
Centroid 26: [1.070000e+02 1.000000e+00 5.700000e+01 9.000000e+00 5.850000e+02
 2.661605e+06 0.000000e+00 0.000000e+00 0.000000e+00 0.000000e+00
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 0.000000e+00]
Centroid 27: [7.92904017e-02 3.14921278e-02 1.50416598e+01 8.99995864e+00
 9.58000355e+02 9.43051879e+00 0.00000000e+00 8.92684810e-04
 0.00000000e+00 4.13599140e-05 0.00000000e+00 3.04857033e-02
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 4.85978989e-04 1.41313039e-04 3.41219290e-04 0.00000000e+00
 0.00000000e+00 0.00000000e+00 4.90791474e+02 4.90807232e+02
 1.52687016e-05 2.76766758e-05 3.44665950e-06 8.03071663e-06
 9.99434679e-01 9.71992445e-04 1.28921609e-02 2.50662772e+02
 2.50755353e+02 9.87543773e-01 2.35427524e-03 9.70370929e-01
 5.82623321e-04 2.67633110e-04 8.28576943e-05 2.59740260e-04
 3.58797254e-05]
Centroid 28: [3.55116667e+03 1.00000000e+00 4.48333333e+01 9.00000000e+00
 1.00333333e+03 4.41105833e+05 0.00000000e+00 0.00000000e+00
 5.00000000e-01 0.00000000e+00 3.33333333e-01 8.33333333e-01
 5.03333333e+01 0.00000000e+00 1.66666667e-01 4.83333333e+01
 3.33333333e-01 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 1.16666667e+00 3.00000000e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 1.00000000e+00 0.00000000e+00 5.16666667e-02 1.39500000e+02
 5.85000000e+01 4.20000000e-01 3.16666667e-02 1.75000000e-01
 0.00000000e+00 6.00000000e-02 7.66666667e-02 0.00000000e+00
 0.00000000e+00]
Centroid 29: [2.00000e+00 1.00000e+00 1.90000e+01 9.00000e+00 2.10438e+06 0.00000e+00
 0.00000e+00 0.00000e+00 0.00000e+00 0.00000e+00 0.00000e+00 0.00000e+00
 0.00000e+00 0.00000e+00 0.00000e+00 0.00000e+00 0.00000e+00 0.00000e+00
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 0.00000e+00 0.00000e+00 0.00000e+00 0.00000e+00 1.00000e+00 0.00000e+00
 0.00000e+00 2.13000e+02 1.00000e+01 2.00000e-02 1.00000e-02 2.00000e-02
 2.00000e-01 9.40000e-01 0.00000e+00 0.00000e+00 0.00000e+00]
Centroid 30: [9.95833333e+00 1.00000000e+00 3.80416667e+01 9.00000000e+00
 3.41208333e+02 2.71515125e+05 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 1.00000000e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 2.16666667e+00 2.54166667e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 4.58333333e-03
 9.79166667e-01 4.16666667e-02 4.75000000e-02 1.63125000e+02
 1.48500000e+02 6.07916667e-01 1.79166667e-02 6.12500000e-02
 1.37500000e-02 0.00000000e+00 0.00000000e+00 8.33333333e-03
 3.41666667e-02]
Centroid 31: [2.90000000e+01 1.00000000e+00 4.43333333e+01 9.00000000e+00
 5.07333333e+02 1.13835233e+06 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 6.66666667e-01
 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 1.00000000e+00 1.00000000e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 1.00000000e+00 0.00000000e+00 0.00000000e+00 9.33333333e+01
 1.33333333e+01 3.76666667e-01 2.66666667e-02 3.40000000e-01
 0.00000000e+00 0.00000000e+00 0.00000000e+00 3.33333333e-03
 0.00000000e+00]
Centroid 32: [1.70791559e+04 1.79847909e+00 4.01444867e+01 8.15399240e+00
 1.93840304e+02 3.89374525e+02 0.00000000e+00 0.00000000e+00
 0.00000000e+00 1.21673004e-01 0.00000000e+00 4.94296578e-02
 5.70342205e-03 0.00000000e+00 0.00000000e+00 0.00000000e+00
 1.33079848e-02 0.00000000e+00 1.90114068e-03 0.00000000e+00
 0.00000000e+00 2.09125475e-02 1.73574144e+00 1.34410646e+00
 0.00000000e+00 0.00000000e+00 1.66349810e-01 1.67300380e-01
 9.06825095e-01 9.41825095e-02 3.51711027e-03 2.43652091e+02
 4.14258555e+00 2.49049430e-02 6.77927757e-01 8.97528517e-01
 2.47148289e-04 6.74904943e-03 4.94296578e-03 1.40475285e-01
 1.56958175e-01]
Centroid 33: [3.41725067e+01 1.00000000e+00 2.24716981e+01 8.98113208e+00
 2.35816712e+02 3.04853962e+04 0.00000000e+00 0.00000000e+00
 0.00000000e+00 6.19946092e-02 0.00000000e+00 9.98652291e-01
 1.75202156e-02 4.04312668e-03 0.00000000e+00 2.69541779e-03
 2.83018868e-02 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 4.88140162e+00 7.66846361e+00
 4.38005391e-03 4.36657682e-03 1.84636119e-03 3.78706199e-03
 1.00000000e+00 0.00000000e+00 1.25566038e-01 1.46408356e+02
 2.47303235e+02 9.86064690e-01 1.05121294e-03 5.69002695e-02
 2.18194070e-02 3.31536388e-03 1.18598383e-03 8.19407008e-03
 9.93261456e-03]
Centroid 34: [1.71054545e+02 1.00000000e+00 2.39090909e+01 9.00000000e+00
 2.61618182e+02 8.16358182e+04 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 1.00000000e+00
 5.00000000e+00 1.81818182e-02 3.63636364e-02 5.56363636e+00
 0.00000000e+00 0.00000000e+00 9.09090909e-02 0.00000000e+00
 0.00000000e+00 0.00000000e+00 4.18181818e+00 6.14545455e+00
 0.00000000e+00 9.09090909e-04 0.00000000e+00 9.09090909e-03
 1.00000000e+00 0.00000000e+00 8.01818182e-02 4.01818182e+01
 2.36272727e+02 9.58545455e-01 2.90909091e-03 9.25454545e-02
 3.23636364e-02 1.27272727e-03 5.45454545e-04 5.27272727e-03
```

```
 1.05454545e-02]
Centroid 35: [1.4400e+02 1.0000e+00 1.0000e+00 9.0000e+00 7.1524e+05 2.1580e+05
 0.0000e+00 0.0000e+00 0.0000e+00 0.0000e+00 0.0000e+00 0.0000e+00
 0.0000e+00 0.0000e+00 0.0000e+00 0.0000e+00 0.0000e+00 0.0000e+00
 0.0000e+00 0.0000e+00 0.0000e+00 0.0000e+00 1.0000e+00 1.0000e+00
 0.0000e+00 0.0000e+00 0.0000e+00 0.0000e+00 1.0000e+00 0.0000e+00
 0.0000e+00 9.0000e+01 1.0000e+00 1.0000e-02 8.0000e-02 1.0000e-02
 0.0000e+00 1.0000e-02 0.0000e+00 0.0000e+00 0.0000e+00]
Centroid 36: [1.96907216e+00 1.00000000e+00 2.64639175e+01 8.93259318e+00
 1.10982728e+04 3.07214116e+02 0.00000000e+00 0.00000000e+00
 0.00000000e+00 1.66534496e-02 0.00000000e+00 8.39809675e-01
 6.34417129e-03 0.00000000e+00 0.00000000e+00 0.00000000e+00
 6.42347343e-02 0.00000000e+00 1.74464711e-02 0.00000000e+00
 0.00000000e+00 0.00000000e+00 6.09357653e+00 6.23869944e+00
 3.69547978e-03 2.45836638e-03 6.16970658e-03 6.78826328e-03
 9.83750991e-01 1.77081681e-02 1.36193497e-01 1.23897700e+02
 8.39476606e+01 4.56391753e-01 6.88421887e-02 3.07890563e-01
 2.09833466e-02 1.09357653e-02 2.32355274e-03 1.30293418e-02
 3.95717684e-03]
Centroid 37: [1.25000e+00 1.00000e+00 5.10000e+01 9.00000e+00 2.50723e+05 3.41250e+02
 0.00000e+00 0.00000e+00 0.00000e+00 0.00000e+00 0.00000e+00 1.00000e+00
 0.00000e+00 0.00000e+00 0.00000e+00 0.00000e+00 0.00000e+00 0.00000e+00
 0.00000e+00 0.00000e+00 0.00000e+00 0.00000e+00 1.00000e+00 2.25000e+00
 0.00000e+00 0.00000e+00 0.00000e+00 0.00000e+00 1.00000e+00 0.00000e+00
 7.50000e-01 8.92500e+01 1.21250e+02 6.90000e-01 1.30000e-01 3.00000e-02
 2.25000e-02 0.00000e+00 0.00000e+00 0.00000e+00 5.00000e-03]
Centroid 38: [1.15576324e+00 1.00000000e+00 2.26822430e+01 9.00000000e+00
 2.34006231e+02 4.03116542e+04 0.00000000e+00 0.00000000e+00
 6.23052960e-03 1.86915888e-02 0.00000000e+00 1.00000000e+00
 6.23052960e-03 0.00000000e+00 0.00000000e+00 6.23052960e-03
 0.00000000e+00 0.00000000e+00 3.11526480e-03 0.00000000e+00
 0.00000000e+00 0.00000000e+00 4.25233645e+00 6.75389408e+00
 3.17757009e-03 3.33333333e-03 2.14953271e-03 4.98442368e-03
 1.00000000e+00 0.00000000e+00 9.59501558e-02 1.28728972e+02
 2.47208723e+02 9.82149533e-01 4.54828660e-03 7.31152648e-02
 2.46417445e-02 1.68224299e-03 8.09968847e-04 1.22429907e-02
 1.10903427e-02]
Centroid 39: [1.33505556e+03 1.00000000e+00 3.95000000e+01 8.61111111e+00
 6.85500000e+02 2.17492889e+05 0.00000000e+00 0.00000000e+00
 0.00000000e+00 1.11111111e-01 0.00000000e+00 9.44444444e-01
 5.55555556e-02 0.00000000e+00 0.00000000e+00 0.00000000e+00
 5.55555556e-01 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 5.33333333e+00 8.55555556e+00
 0.00000000e+00 0.00000000e+00 5.55555556e-02 5.55555556e-02
 1.00000000e+00 0.00000000e+00 4.11111111e-02 9.91111111e+01
 1.37555556e+02 5.87777778e-01 2.11111111e-02 3.38888889e-02
 2.38888889e-02 4.33333333e-02 4.16666667e-02 6.66666667e-03
 2.50000000e-02]
Centroid 40: [1.30000000e+01 1.00000000e+00 2.64871795e+01 8.92307692e+00
 2.92025641e+02 1.15246410e+05 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 1.00000000e+00
 1.79487179e-01 0.00000000e+00 2.56410256e-02 1.53846154e-01
 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 5.56410256e+00 8.71794872e+00
 1.79487179e-03 1.79487179e-03 0.00000000e+00 0.00000000e+00
 1.00000000e+00 0.00000000e+00 1.18461538e-01 1.01435897e+02
 2.14717949e+02 8.95641026e-01 4.87179487e-03 4.53846154e-02
 2.05128205e-02 2.00000000e-02 1.07692308e-02 1.02564103e-03
 3.33333333e-03]
Centroid 41: [3.89988793e+03 1.99051290e+00 4.07171657e+01 8.98843759e+00
 1.53272754e+02 1.30800771e+02 0.00000000e+00 0.00000000e+00
 0.00000000e+00 9.04239549e-02 2.96471983e-04 8.59768752e-03
 0.00000000e+00 0.00000000e+00 2.96471983e-04 0.00000000e+00
 2.96471983e-03 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 6.22591165e-03 1.57545212e+00 1.20515861e+00
 0.00000000e+00 0.00000000e+00 1.75807886e-03 2.03379781e-03
 9.15496591e-01 8.25970946e-02 6.43344204e-04 2.51525941e+02
 2.12481471e+00 7.51260006e-03 7.63877854e-01 9.58292321e-01
 0.00000000e+00 9.78357545e-04 0.00000000e+00 9.93181144e-04
 1.91520901e-03]
Centroid 42: [4.75000e+01 1.00000e+00 5.70000e+01 9.00000e+00 6.75000e+02 1.03276e+06
 0.00000e+00 0.00000e+00 0.00000e+00 0.00000e+00 0.00000e+00 1.00000e+00
 0.00000e+00 0.00000e+00 0.00000e+00 0.00000e+00 0.00000e+00 0.00000e+00
 0.00000e+00 0.00000e+00 0.00000e+00 0.00000e+00 1.00000e+00 1.00000e+00
 0.00000e+00 0.00000e+00 0.00000e+00 0.00000e+00 1.00000e+00 0.00000e+00
 0.00000e+00 2.15000e+02 3.10000e+01 1.50000e-01 2.50000e-02 5.00000e-03
 0.00000e+00 0.00000e+00 0.00000e+00 0.00000e+00 0.00000e+00]
Centroid 43: [1.94444444e+01 1.00000000e+00 4.17777778e+01 8.44444444e+00
 6.12000000e+02 6.58812778e+05 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 8.88888889e-01
 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 2.11111111e+00 3.44444444e+00
 1.66666667e-01 1.18888889e-01 0.00000000e+00 0.00000000e+00
 9.44444444e-01 1.11111111e-01 1.44444444e-02 1.23222222e+02
 9.93333333e+01 5.22222222e-01 1.77777778e-02 1.88888889e-02
```

```
 4.00000000e-02 6.22222222e-02 6.11111111e-02 2.22222222e-02
 6.44444444e-02]
Centroid 44: [1.11209837e+00 1.00000000e+00 2.19867169e+01 8.99838449e+00
 2.97687130e+02 2.89127787e+03 0.00000000e+00 0.00000000e+00
 8.97504936e-05 9.60509783e-01 0.00000000e+00 9.99820499e-01
 7.44929097e-03 2.24376234e-03 0.00000000e+00 8.97504936e-04
 3.41051876e-03 2.69251481e-04 2.60276432e-02 0.00000000e+00
 0.00000000e+00 3.76952073e-02 8.94121343e+00 1.18640280e+01
 1.68012924e-03 2.12529169e-03 5.87865733e-04 3.41949381e-03
 9.99131215e-01 1.33638485e-03 9.27284150e-02 1.33356220e+02
 2.37584545e+02 9.65784419e-01 3.66630766e-03 5.24833962e-02
 2.18318076e-02 1.42972536e-03 9.90845450e-04 4.57996769e-03
 7.09657153e-03]
Centroid 45: [5.500000e+00 1.000000e+00 2.050000e+01 9.000000e+00 9.700000e+01
 9.713205e+05 0.000000e+00 0.000000e+00 0.000000e+00 0.000000e+00
 0.000000e+00 5.000000e-01 0.000000e+00 0.000000e+00 0.000000e+00
 0.000000e+00 0.000000e+00 0.000000e+00 0.000000e+00 0.000000e+00
 0.000000e+00 0.000000e+00 1.000000e+00 1.500000e+00 0.000000e+00
 0.000000e+00 0.000000e+00 0.000000e+00 1.000000e+00 0.000000e+00
 5.000000e-01 1.290000e+02 1.290000e+02 1.000000e+00 0.000000e+00
 5.000000e-01 0.000000e+00 0.000000e+00 0.000000e+00 0.000000e+00
 0.000000e+00]
```

one-hot encoded run

```python
clusters = [7, 15, 23, 31, 45]
epsilon = 0.1
for k in clusters:
    print(f"{k} clusters:")
    mu_t, C = k_means(
        oe_train_10_percent.to_numpy(),
        k,
        epsilon,
        max_iterations=10,
        fname="one-hot_encoded_kmeans",
    )
    print("Centroids:")
    for i in range(k):
        print(f"Centroid {i+1}: {mu_t[i]}")
```

```
7 clusters:
Finished running k-means++
0.0    493870
3.0        59
6.0        41
4.0        24
2.0        18
5.0         8
1.0         1
dtype: int64
Completed iteration 1
0.0    493871
3.0        59
6.0        39
4.0        24
2.0        18
5.0         9
1.0         1
dtype: int64
Completed iteration 2
0.0    493871
3.0        59
6.0        38
4.0        24
2.0        18
5.0        10
1.0         1
dtype: int64
Completed iteration 3
0.0    493871
3.0        59
6.0        36
4.0        24
2.0        18
5.0        12
1.0         1
dtype: int64
Completed iteration 4
0.0    493869
3.0        59
6.0        36
4.0        24
2.0        18
5.0        14
1.0         1
dtype: int64
Completed iteration 5
0.0    493868
3.0        59
6.0        34
4.0        24
2.0        18
5.0        17
1.0         1
dtype: int64
Completed iteration 6
0.0    493862
3.0        59
6.0        40
4.0        24
2.0        18
5.0        17
1.0         1
dtype: int64
Completed iteration 7
0.0    493859
3.0        59
6.0        43
4.0        24
2.0        18
5.0        17
1.0         1
dtype: int64
Completed iteration 8
0.0    493859
3.0        59
6.0        43
4.0        24
2.0        18
5.0        17
1.0         1
dtype: int64
Completed iteration 9
Epsilon has a maximum value of 0.0
Centroids:
Centroid 1: [4.72894267e+01 9.02066489e+02 5.70938762e+02 4.45471278e-05
```

```
 6.43503510e-03 8.09947779e-06 3.42020698e-02 1.41740861e-04
 1.48022006e-01 7.77752354e-03 1.05293211e-04 2.63233028e-05
 8.73933653e-03 1.07925542e-03 1.09342950e-04 9.92186029e-04
 0.00000000e+00 0.00000000e+00 1.38703557e-03 3.32394181e+02
 2.93002142e+02 1.76737956e-01 1.76660909e-01 5.74497984e-02
 5.77351835e-02 7.91484594e-01 2.09810492e-02 2.89965152e-02
 2.32519347e+02 1.88713254e+02 7.53830243e-01 3.09032133e-02
 6.01962969e-01 6.66761161e-03 1.76804898e-01 1.76491772e-01
 5.81319567e-02 5.74282943e-02 5.74257025e-01 3.84528783e-01
 4.12141927e-02 8.70693862e-05 2.22735639e-05 1.86287989e-04
 6.64157178e-04 2.14636161e-04 2.18685900e-04 2.55133550e-04
 1.96412336e-04 2.08561553e-04 2.34884856e-04 2.34884856e-04
 1.18718096e-02 2.26785378e-04 3.32483563e-03 5.69798262e-01
 2.08561553e-04 2.00462075e-04 1.35463766e-03 1.61584582e-03
 9.35894658e-03 2.36909725e-04 2.10586422e-04 1.30168732e-01
 2.00462075e-04 0.00000000e+00 2.34884856e-04 2.32859986e-04
 2.14636161e-04 1.98437206e-04 2.04511814e-04 2.06536684e-04
 2.10586422e-04 2.16661031e-04 1.98437206e-04 2.00462075e-04
 2.06536684e-04 2.16661031e-04 1.92362597e-04 2.12611292e-04
 2.18685900e-04 7.69450390e-04 1.46479056e-02 2.02486945e-06
 2.04511814e-04 4.09023628e-04 2.20710770e-04 2.24543848e-01
 2.02486945e-06 2.42984334e-04 2.24760509e-04 2.26785378e-04
 1.96878056e-02 2.22735639e-04 2.12611292e-04 2.16661031e-04
 2.12611292e-04 2.32859986e-04 9.37514554e-04 2.02486945e-06
 1.41740861e-05 3.17904503e-04 2.83481723e-05 1.08937976e-03
 2.14636161e-04 2.14636161e-04 2.14636161e-04 2.22735639e-04
 1.61989556e-05 5.44183664e-02 1.17037454e-03 2.22735639e-05
 1.82643224e-03 1.76177816e-01 1.13392689e-04 4.65719973e-05
 1.82238250e-05 7.65973689e-01 2.16661031e-04]
Centroid 2: [2.0000000e+00 6.9337564e+08 0.0000000e+00 0.0000000e+00 0.0000000e+00
 0.0000000e+00 1.0000000e+00 0.0000000e+00 0.0000000e+00 0.0000000e+00
 0.0000000e+00 0.0000000e+00 0.0000000e+00 0.0000000e+00 0.0000000e+00
 0.0000000e+00 0.0000000e+00 0.0000000e+00 0.0000000e+00 5.7000000e+01
 3.0000000e+00 7.9000000e-01 6.7000000e-01 2.1000000e-01 3.3000000e-01
 5.0000000e-02 3.9000000e-01 0.0000000e+00 2.5500000e+02 3.0000000e+00
 1.0000000e-02 9.0000000e-02 2.2000000e-01 0.0000000e+00 1.8000000e-01
 6.7000000e-01 5.0000000e-02 3.3000000e-01 0.0000000e+00 1.0000000e+00
 0.0000000e+00 0.0000000e+00 0.0000000e+00 0.0000000e+00 0.0000000e+00
 0.0000000e+00 0.0000000e+00 0.0000000e+00 0.0000000e+00 0.0000000e+00
 0.0000000e+00 0.0000000e+00 0.0000000e+00 0.0000000e+00 0.0000000e+00
 0.0000000e+00 0.0000000e+00 0.0000000e+00 1.0000000e+00 0.0000000e+00
 0.0000000e+00 0.0000000e+00 0.0000000e+00 0.0000000e+00 0.0000000e+00
 0.0000000e+00 0.0000000e+00 0.0000000e+00 0.0000000e+00 0.0000000e+00
 0.0000000e+00 0.0000000e+00 0.0000000e+00 0.0000000e+00 0.0000000e+00
 0.0000000e+00 0.0000000e+00 0.0000000e+00 0.0000000e+00 0.0000000e+00
 0.0000000e+00 0.0000000e+00 0.0000000e+00 0.0000000e+00 0.0000000e+00
 0.0000000e+00 0.0000000e+00 0.0000000e+00 0.0000000e+00 0.0000000e+00
 0.0000000e+00 0.0000000e+00 0.0000000e+00 0.0000000e+00 0.0000000e+00
 0.0000000e+00 0.0000000e+00 0.0000000e+00 0.0000000e+00 0.0000000e+00
 0.0000000e+00 0.0000000e+00 0.0000000e+00 0.0000000e+00 0.0000000e+00
 0.0000000e+00 0.0000000e+00 0.0000000e+00 0.0000000e+00 0.0000000e+00
 1.0000000e+00 0.0000000e+00 0.0000000e+00 0.0000000e+00 0.0000000e+00
 0.0000000e+00 0.0000000e+00 0.0000000e+00 0.0000000e+00]
Centroid 3: [5.52277778e+02 1.08944444e+02 5.00968983e+06 0.00000000e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 1.66666667e-01
 1.11111111e-01 1.00000000e+00 5.55555556e-02 1.11111111e-01
 5.00000000e-01 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 1.11111111e+00
 1.11111111e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 1.00000000e+00 0.00000000e+00 0.00000000e+00
 4.39444444e+01 2.61666667e+01 9.03333333e-01 2.22222222e-03
 8.33888889e-01 5.55555556e-04 4.16666667e-02 4.77777778e-02
 4.27777778e-02 0.00000000e+00 0.00000000e+00 1.00000000e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 8.88888889e-01 0.00000000e+00 0.00000000e+00 5.55555556e-02
 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
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Centroid 4: [5.05167797e+03 5.13422649e+06 0.00000000e+00 0.00000000e+00
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 1.45762712e+00 1.69491525e-02 1.93220339e-02 0.00000000e+00
 0.00000000e+00 9.91525424e-01 1.69491525e-02 5.76271186e-02
 3.15932203e+01 3.50508475e+01 8.90847458e-01 2.33898305e-02
 9.33220339e-01 1.04406780e-01 1.08474576e-02 2.42372881e-02
 2.37288136e-03 3.38983051e-04 0.00000000e+00 1.00000000e+00
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 1.69491525e-02 9.83050847e-01 0.00000000e+00]
Centroid 5: [1.03250000e+02 2.20358567e+06 0.00000000e+00 0.00000000e+00
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 4.16666667e-02 9.65416667e-01 6.95833333e-02 0.00000000e+00
 1.15166667e+02 5.90416667e+01 3.37083333e-01 6.87500000e-02
 3.37083333e-01 2.95833333e-02 3.91666667e-02 0.00000000e+00
 1.62500000e-02 8.33333333e-04 0.00000000e+00 1.00000000e+00
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Centroid 6: [5.18823529e+01 5.52117647e+02 1.79480471e+06 0.00000000e+00
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 1.54352941e+02 3.42352941e+01 2.10588235e-01 3.47058824e-02
 1.05882353e-02 5.58823529e-02 0.00000000e+00 0.00000000e+00
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 0.00000000e+00 1.00000000e+00 0.00000000e+00]
Centroid 7: [8.63302326e+02 6.73581395e+02 6.14509628e+05 0.00000000e+00
 0.00000000e+00 6.97674419e-02 2.32558140e-02 4.65116279e-02
 9.06976744e-01 2.75813953e+01 4.65116279e-02 6.97674419e-02
 2.98372093e+01 4.65116279e-02 0.00000000e+00 1.86046512e-01
 0.00000000e+00 0.00000000e+00 0.00000000e+00 1.27906977e+00
 1.83720930e+00 3.48837209e-02 2.48837209e-02 0.00000000e+00
 0.00000000e+00 9.88372093e-01 2.32558140e-02 3.34883721e-02
 1.25023256e+02 5.86744186e+01 3.87209302e-01 5.81395349e-02
 1.16744186e-01 2.55813953e-02 2.25581395e-02 3.13953488e-02
 2.27906977e-02 1.67441860e-02 0.00000000e+00 1.00000000e+00
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 0.00000000e+00 0.00000000e+00 2.32558140e-02 0.00000000e+00
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 0.00000000e+00 0.00000000e+00 2.32558140e-02 2.32558140e-02
 0.00000000e+00 9.53488372e-01 0.00000000e+00]
15 clusters:
Finished running k-means++
0.0     486917
14.0      4216
7.0       2343
11.0       300
9.0         88
3.0         59
4.0         24
13.0        24
2.0         16
6.0         12
12.0        11
5.0          5
8.0          3
10.0         2
1.0          1
dtype: int64
Completed iteration 1
0.0     485775
14.0      5279
7.0       2343
11.0       398
9.0         69
3.0         59
13.0        25
4.0         24
2.0         16
6.0         11
12.0        11
5.0          5
8.0          3
10.0         2
1.0          1
dtype: int64
Completed iteration 2
0.0     484800
14.0      6214
7.0       2343
11.0       443
9.0         67
3.0         59
4.0         24
13.0        22
2.0         16
6.0         11
12.0        11
5.0          5
8.0          3
10.0         2
1.0          1
dtype: int64
Completed iteration 3
0.0     484013
14.0      6957
```

```
7.0       2343
11.0       488
9.0         67
3.0         59
4.0         24
13.0        22
2.0         16
12.0        11
6.0         10
5.0          5
8.0          3
10.0         2
1.0          1
dtype: int64
Completed iteration 4
0.0     483507
14.0      7387
7.0       2343
11.0       565
9.0         67
3.0         59
4.0         24
13.0        22
2.0         16
12.0        11
6.0          9
5.0          5
8.0          3
10.0         2
1.0          1
dtype: int64
Completed iteration 5
0.0     483027
14.0      7819
7.0       2343
11.0       615
9.0         65
3.0         59
4.0         24
13.0        22
2.0         16
6.0         10
12.0        10
5.0          5
8.0          3
10.0         2
1.0          1
dtype: int64
Completed iteration 6
0.0     482708
14.0      8115
7.0       2343
11.0       638
9.0         65
3.0         59
4.0         24
13.0        22
2.0         16
6.0         11
12.0         9
5.0          5
8.0          3
10.0         2
1.0          1
dtype: int64
Completed iteration 7
0.0     482502
14.0      8275
7.0       2343
11.0       684
9.0         65
3.0         59
4.0         24
13.0        22
2.0         16
6.0         11
12.0         9
5.0          5
8.0          3
10.0         2
1.0          1
dtype: int64
Completed iteration 8
0.0     482191
14.0      8506
7.0       2343
11.0       762
9.0         67
3.0         59
4.0         24
13.0        22
2.0         16
6.0         11
12.0         9
5.0          5
8.0          3
10.0         2
1.0          1
dtype: int64
Completed iteration 9
0.0     481905
14.0      8734
7.0       2343
11.0       819
9.0         68
3.0         59
4.0         24
13.0        22
2.0         16
6.0         11
12.0         9
5.0          5
8.0          3
10.0         2
1.0          1
dtype: int64
Completed iteration 10
0.0     481669
14.0      8904
7.0       2343
11.0       885
9.0         68
3.0         59
4.0         24
13.0        22
2.0         16
6.0         11
12.0         9
5.0          5
8.0          3
10.0         2
1.0          1
dtype: int64
Completed iteration 11
Reached 11 iterations
Centroids:
Centroid 1: [4.72935335e+01 6.39994633e+02 1.85632488e+02 4.56745192e-05
 6.59789191e-03 2.07611451e-06 2.57811900e-02 1.43251901e-04
 1.26551636e-01 2.63666543e-04 6.64356643e-05 8.30445804e-06
 5.34599486e-03 6.58128300e-04 1.01729611e-04 9.32175415e-04
 0.00000000e+00 0.00000000e+00 1.42213844e-03 3.40642603e+02
 3.00192358e+02 1.81129344e-01 1.81046881e-01 5.86607816e-02
 5.86716812e-02 7.86221596e-01 2.14874738e-02 2.68823196e-02
 2.34929163e+02 1.87530698e+02 7.48045587e-01 3.16329471e-02
 6.15537080e-01 6.32967868e-03 1.81201344e-01 1.80907532e-01
 5.92245297e-02 5.84252464e-02 5.88790227e-01 3.68952538e-01
 4.22572347e-02 4.15222902e-05 1.03805726e-05 1.91002535e-04
 6.80965559e-04 2.20068138e-04 2.24220367e-04 2.61590428e-04
 2.01383107e-04 2.13839795e-04 2.40829283e-04 2.40829283e-04
 1.21722594e-02 2.32524825e-04 3.40898003e-03 5.84218623e-01
 2.13839795e-04 2.05535337e-04 1.38892061e-03 1.65673938e-03
 9.33005861e-03 2.42905398e-04 2.15915909e-04 1.08794629e-01
 2.05535337e-04 0.00000000e+00 2.38753169e-04 2.38753169e-04
 2.20068138e-04 2.03459222e-04 2.09687566e-04 2.11763680e-04
 2.13839795e-04 2.22144253e-04 2.03459222e-04 2.05535337e-04
 2.11763680e-04 2.22144253e-04 1.97230878e-04 2.17992024e-04
 2.24220367e-04 7.88923514e-04 1.50144601e-02 2.07611451e-06
 2.09687566e-04 3.94461757e-04 2.26296482e-04 2.30226566e-01
 2.07611451e-06 2.49133741e-04 2.30448711e-04 2.32524825e-04
 2.01445391e-02 2.28372596e-04 2.15915909e-04 2.22144253e-04
 2.17992024e-04 2.38753169e-04 7.24563964e-04 2.07611451e-06
 1.45328016e-05 3.25949978e-04 2.90656031e-05 1.11694961e-03
 2.20068138e-04 2.20068138e-04 2.20068138e-04 2.28372596e-04
 1.66089161e-05 5.57955775e-02 1.19584196e-03 2.28372596e-05
 1.64428269e-03 1.80636495e-01 3.52939467e-05 2.90656031e-05
 1.45328016e-05 7.60387320e-01 2.22144253e-04]
Centroid 2: [2.0000000e+00 6.9337564e+08 0.0000000e+00 0.0000000e+00 0.0000000e+00
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 3.0000000e+00 7.9000000e-01 6.7000000e-01 2.1000000e-01 3.3000000e-01
 5.0000000e-02 3.9000000e-01 0.0000000e+00 2.5500000e+02 3.0000000e+00
 1.0000000e-02 9.0000000e-02 2.2000000e-01 0.0000000e+00 1.8000000e-01
 6.7000000e-01 5.0000000e-02 3.3000000e-01 0.0000000e+00 1.0000000e+00
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Centroid 3: [3.24312500e+02 0.00000000e+00 5.15038094e+06 0.00000000e+00
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 9.37500000e-01 0.00000000e+00 4.68750000e-02 5.37500000e-02
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 0.00000000e+00 1.00000000e+00 0.00000000e+00]
Centroid 4: [5.05167797e+03 5.13422649e+06 0.00000000e+00 0.00000000e+00
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 1.45762712e+00 1.69491525e-02 1.93220339e-02 0.00000000e+00
 0.00000000e+00 9.91525424e-01 1.69491525e-02 5.76271186e-02
 3.15932203e+01 3.50508475e+01 8.90847458e-01 2.33898305e-02
 9.33220339e-01 1.04406780e-01 1.08474576e-02 2.42372881e-02
 2.37288136e-03 3.38983051e-04 0.00000000e+00 1.00000000e+00
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 1.69491525e-02 9.83050847e-01 0.00000000e+00]
Centroid 5: [1.03250000e+02 2.20358567e+06 0.00000000e+00 0.00000000e+00
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 1.62500000e+00 0.00000000e+00 0.00000000e+00 4.16666667e-02
 4.16666667e-02 9.65416667e-01 6.95833333e-02 0.00000000e+00
 1.15166667e+02 5.90416667e+01 3.37083333e-01 6.87500000e-02
 3.37083333e-01 2.95833333e-02 3.91666667e-02 0.00000000e+00
 1.62500000e-02 8.33333333e-04 0.00000000e+00 1.00000000e+00
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 4.16666667e-02 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 9.58333333e-01 0.00000000e+00]
Centroid 6: [8.3000000e+01 6.7560000e+02 2.4660582e+06 0.0000000e+00 0.0000000e+00
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 1.9400000e-01 4.6000000e-02 1.4000000e-02 1.3000000e-01 0.0000000e+00
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Centroid 7: [3.25454545e+01 5.05909091e+02 9.74204727e+05 0.00000000e+00
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 1.43818182e+02 4.24545455e+01 4.47272727e-01 1.81818182e-02
 2.76363636e-01 0.00000000e+00 0.00000000e+00 0.00000000e+00
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Centroid 8: [2.59923175e-01 5.73948050e+04 7.88849168e+03 0.00000000e+00
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 9.38967136e-03 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 3.65471618e+00
 3.91079812e+00 3.93085787e-03 4.12291933e-03 3.54844217e-02
 8.73836961e-02 9.98472044e-01 2.31754161e-03 1.12667520e-01
 2.01783611e+02 1.98618865e+02 9.61912079e-01 4.50277422e-03
 3.03457106e-02 1.09261630e-03 2.66752027e-03 2.89372599e-03
 4.63593683e-02 4.60136577e-02 0.00000000e+00 1.00000000e+00
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 3.32906530e-02 0.00000000e+00 2.98762271e-03 2.13401622e-03
 0.00000000e+00 9.61587708e-01 0.00000000e+00]
Centroid 9: [4.50000000e+01 5.88333333e+02 1.76159700e+06 0.00000000e+00
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Centroid 10: [8.00279412e+02 4.93279412e+02 2.43287397e+05 0.00000000e+00
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 9.85294118e-01 2.42941176e+01 2.94117647e-02 5.88235294e-02
 2.72058824e+01 1.47058824e-01 0.00000000e+00 2.05882353e-01
 0.00000000e+00 0.00000000e+00 0.00000000e+00 3.41176471e+00
 4.92647059e+00 0.00000000e+00 0.00000000e+00 1.47058824e-02
 1.63235294e-02 9.92647059e-01 1.47058824e-02 3.79411765e-02
 1.13029412e+02 1.40279412e+02 6.04264706e-01 4.05882353e-02
 5.30882353e-02 2.89705882e-02 1.22058824e-02 1.63235294e-02
 2.20588235e-02 2.89705882e-02 0.00000000e+00 1.00000000e+00
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 0.00000000e+00 9.85294118e-01 0.00000000e+00]
Centroid 11: [2.376000e+03 9.805000e+02 3.884161e+06 0.000000e+00 0.000000e+00
 0.000000e+00 0.000000e+00 1.500000e+00 1.000000e+00 9.000000e+00
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 5.050000e-01 1.000000e-02 5.000000e-03 5.000000e-03 0.000000e+00
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Centroid 12: [1.09224859e+02 2.63368362e+02 4.85504531e+04 0.00000000e+00
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 9.98870056e-01 7.20903955e-01 5.64971751e-03 7.90960452e-03
 8.01129944e-01 5.42372881e-02 0.00000000e+00 1.35593220e-02
 0.00000000e+00 0.00000000e+00 0.00000000e+00 4.69830508e+00
 7.44293785e+00 4.50847458e-03 4.65536723e-03 1.22033898e-03
 2.72316384e-03 9.99435028e-01 1.12994350e-03 1.08090395e-01
 1.17658757e+02 2.42871186e+02 9.72824859e-01 4.21468927e-03
 7.56836158e-02 2.64632768e-02 5.20903955e-03 4.45197740e-03
 9.18644068e-03 9.28813559e-03 0.00000000e+00 1.00000000e+00
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 0.00000000e+00 9.95480226e-01 0.00000000e+00]
Centroid 13: [3.68888889e+01 4.71444444e+02 1.43295533e+06 0.00000000e+00
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 8.88888889e-03 2.44444444e-02 0.00000000e+00 0.00000000e+00
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Centroid 14: [9.91590909e+02 7.42772727e+02 5.55031591e+05 0.00000000e+00
 0.00000000e+00 1.36363636e-01 4.54545455e-02 9.09090909e-02
 9.09090909e-01 1.37272727e+01 4.54545455e-02 4.54545455e-02
 1.31818182e+01 9.09090909e-02 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 1.50000000e+00
 2.54545455e+00 6.81818182e-02 4.86363636e-02 0.00000000e+00
 0.00000000e+00 9.77272727e-01 4.54545455e-02 2.00000000e-02
 1.41409091e+02 7.72727273e+01 4.20454545e-01 2.45454545e-02
 5.77272727e-02 1.86363636e-02 4.27272727e-02 4.59090909e-02
 9.09090909e-03 2.63636364e-02 0.00000000e+00 1.00000000e+00
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 0.00000000e+00 0.00000000e+00 6.81818182e-01 0.00000000e+00
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 0.00000000e+00 0.00000000e+00 4.54545455e-02 4.54545455e-02
 0.00000000e+00 9.09090909e-01 0.00000000e+00]
Centroid 15: [4.91618374e+01 2.79928684e+02 1.32584645e+04 0.00000000e+00
 0.00000000e+00 1.12309075e-04 1.41509434e-02 0.00000000e+00
 9.98427673e-01 2.10017969e-02 1.57232704e-03 0.00000000e+00
 1.71832884e-02 1.77448338e-02 5.61545373e-04 2.58310872e-03
 0.00000000e+00 0.00000000e+00 0.00000000e+00 7.40498652e+00
 1.03681491e+01 2.92452830e-03 3.04694519e-03 3.57142857e-03
 4.99213836e-03 9.99752920e-01 4.94159928e-04 1.13386119e-01
 1.22390723e+02 2.44892969e+02 9.90808625e-01 1.11635220e-03
 7.39802336e-02 2.43474843e-02 2.91554358e-03 1.46114106e-03
 7.28773585e-03 1.14544025e-02 0.00000000e+00 1.00000000e+00
 0.00000000e+00 2.35849057e-03 1.12309075e-04 0.00000000e+00
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 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 4.49236298e-04 0.00000000e+00 0.00000000e+00 9.88544474e-01
 0.00000000e+00 0.00000000e+00 1.12309075e-04 0.00000000e+00
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 0.00000000e+00 1.34770889e-03 0.00000000e+00 0.00000000e+00
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 0.00000000e+00 0.00000000e+00 1.12309075e-04 0.00000000e+00
 0.00000000e+00 0.00000000e+00 6.96316262e-03 0.00000000e+00
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 0.00000000e+00 0.00000000e+00 1.12309075e-04 0.00000000e+00
 3.59389039e-03 0.00000000e+00 3.14465409e-03 4.49236298e-04
 2.24618149e-04 9.92475292e-01 0.00000000e+00]
23 clusters:
Finished running k-means++
0.0     461930
15.0     21149
21.0      4572
7.0       2315
18.0      1701
14.0      1527
19.0       396
11.0       158
9.0         60
3.0         59
17.0        36
16.0        23
22.0        20
13.0        16
2.0         16
6.0         12
12.0        11
20.0         8
5.0          5
8.0          3
10.0         2
1.0          1
4.0          1
dtype: int64
Completed iteration 1
0.0     463627
15.0     18248
21.0      5597
7.0       2314
18.0      2084
14.0      1281
19.0       454
11.0       147
3.0         59
9.0         49
17.0        41
16.0        23
22.0        21
13.0        19
2.0         16
12.0        11
6.0         10
20.0         8
5.0          5
8.0          3
10.0         2
1.0          1
4.0          1
dtype: int64
Completed iteration 2
0.0     462789
15.0     18572
21.0      5968
7.0       2314
18.0      2280
14.0      1232
19.0       461
11.0       136
3.0         59
9.0         49
17.0        41
16.0        23
22.0        21
13.0        20
2.0         16
12.0        11
6.0          9
20.0         8
5.0          5
8.0          3
10.0         2
1.0          1
4.0          1
dtype: int64
Completed iteration 3
0.0     461799
15.0     19175
21.0      6228
18.0      2412
7.0       2314
14.0      1246
19.0       457
11.0       121
3.0         59
9.0         49
17.0        41
16.0        23
22.0        21
13.0        20
2.0         16
12.0        10
6.0         10
20.0         8
5.0          5
8.0          3
10.0         2
1.0          1
4.0          1
dtype: int64
Completed iteration 4
0.0     460925
15.0     19747
21.0      6292
18.0      2649
7.0       2314
14.0      1258
19.0       461
11.0       106
3.0         59
9.0         49
17.0        41
16.0        23
22.0        21
13.0        20
2.0         16
6.0         11
12.0         9
20.0         8
5.0          5
8.0          3
10.0         2
1.0          1
4.0          1
dtype: int64
Completed iteration 5
0.0     460100
15.0     20278
21.0      6422
18.0      2801
7.0       2314
14.0      1283
19.0       458
11.0        97
3.0         59
9.0         48
17.0        41
16.0        23
13.0        21
22.0        21
2.0         16
6.0         10
12.0         9
20.0         8
5.0          5
8.0          3
10.0         2
1.0          1
4.0          1
dtype: int64
Completed iteration 6
0.0     459198
15.0     20918
21.0      6572
18.0      2902
7.0       2314
14.0      1301
19.0       453
11.0        96
3.0         59
9.0         47
17.0        42
16.0        23
22.0        21
13.0        20
2.0         16
6.0         10
12.0         9
20.0         8
5.0          5
8.0          3
10.0         2
1.0          1
4.0          1
dtype: int64
Completed iteration 7
0.0     458338
15.0     21555
21.0      6720
18.0      2969
7.0       2314
14.0      1311
19.0       452
11.0       102
3.0         59
17.0        42
9.0         40
16.0        23
22.0        21
13.0        20
2.0         16
6.0         10
12.0         9
20.0         8
5.0          5
8.0          3
10.0         2
1.0          1
4.0          1
dtype: int64
Completed iteration 8
0.0     457835
15.0     21906
21.0      6807
18.0      3028
```

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7.0       2314
14.0      1318
19.0       456
11.0       100
3.0         59
17.0        42
9.0         37
16.0        23
22.0        21
13.0        20
2.0         16
6.0         10
12.0         9
20.0         8
5.0          5
8.0          3
10.0         2
1.0          1
4.0          1
dtype: int64
Completed iteration 9
0.0     457482
15.0     22165
21.0      6860
18.0      3059
7.0       2314
14.0      1331
19.0       454
11.0       101
3.0         59
17.0        42
9.0         35
16.0        23
22.0        21
13.0        20
2.0         16
6.0         10
12.0         9
20.0         8
5.0          5
8.0          3
10.0         2
1.0          1
4.0          1
dtype: int64
Completed iteration 10
0.0     457224
15.0     22356
21.0      6885
18.0      3094
7.0       2314
14.0      1338
19.0       457
11.0        99
3.0         59
17.0        42
9.0         34
16.0        23
22.0        21
13.0        20
2.0         16
6.0         10
12.0         9
20.0         8
5.0          5
8.0          3
10.0         2
1.0          1
4.0          1
dtype: int64
Completed iteration 11
Reached 11 iterations
Centroids:
Centroid 1: [4.91402092e+01 6.59239854e+02 4.19844081e+01 4.81164593e-05
 6.95064126e-03 0.00000000e+00 3.02040138e-03 1.48723602e-04
 7.98645740e-02 1.74968943e-05 0.00000000e+00 4.37422358e-06
 5.60338040e-03 5.66461953e-04 9.40458069e-05 3.36815215e-04
 0.00000000e+00 0.00000000e+00 5.33655276e-04 3.58359933e+02
 3.15589871e+02 1.90731939e-01 1.90620943e-01 6.17510673e-02
 6.16477700e-02 7.74824353e-01 2.25893216e-02 2.33931071e-02
 2.40437357e+02 1.84601410e+02 7.35621752e-01 3.32017567e-02
 6.45661908e-01 5.48396410e-03 1.90806301e-01 1.90528603e-01
 6.21110003e-02 6.11081658e-02 6.20269277e-01 3.35214249e-01
 4.45164733e-02 2.40582297e-05 1.09355589e-05 2.01214284e-04
 7.17372666e-04 2.31833849e-04 2.36208073e-04 2.75576085e-04
 2.12149843e-04 2.25272514e-04 2.53704967e-04 2.53704967e-04
 1.28230364e-02 2.44956520e-04 3.59123756e-03 6.15453257e-01
 2.25272514e-04 2.16524067e-04 1.46317779e-03 7.82986020e-04
 9.80044792e-03 2.55892079e-04 2.27459626e-04 6.23829895e-02
 2.16524067e-04 0.00000000e+00 2.51517856e-04 2.51517856e-04
 2.31833849e-04 2.14336955e-04 2.20898291e-04 2.23085402e-04
 2.23085402e-04 2.34020961e-04 2.14336955e-04 2.16524067e-04
 2.23085402e-04 2.34020961e-04 2.07775620e-04 2.29646738e-04
 2.36208073e-04 8.31102479e-04 1.58171924e-02 2.18711179e-06
 2.20898291e-04 3.52124998e-04 2.38395185e-04 2.42535387e-01
 2.18711179e-06 2.62453415e-04 2.42769408e-04 2.44956520e-04
 2.12215457e-02 2.40582297e-04 2.27459626e-04 2.34020961e-04
 2.29646738e-04 2.51517856e-04 6.03642853e-04 2.18711179e-06
 1.53097825e-05 3.43376551e-04 3.06195650e-05 1.17666614e-03
 2.31833849e-04 2.31833849e-04 2.31833849e-04 2.40582297e-04
 1.74968943e-05 5.87786293e-02 1.25102794e-03 2.40582297e-05
 1.71688275e-03 1.90294035e-01 2.62453415e-05 2.84324532e-05
 1.09355589e-05 7.47618235e-01 2.34020961e-04]
Centroid 2: [2.0000000e+00 6.9337564e+08 0.0000000e+00 0.0000000e+00 0.0000000e+00
 0.0000000e+00 1.0000000e+00 0.0000000e+00 0.0000000e+00 0.0000000e+00
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 3.0000000e+00 7.9000000e-01 6.7000000e-01 2.1000000e-01 3.3000000e-01
 5.0000000e-02 3.9000000e-01 0.0000000e+00 2.5500000e+02 3.0000000e+00
 1.0000000e-02 9.0000000e-02 2.2000000e-01 0.0000000e+00 1.8000000e-01
 6.7000000e-01 5.0000000e-02 3.3000000e-01 0.0000000e+00 1.0000000e+00
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Centroid 3: [3.24312500e+02 0.00000000e+00 5.15038094e+06 0.00000000e+00
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 2.53125000e+01 1.33750000e+01 9.53125000e-01 1.25000000e-03
 9.37500000e-01 0.00000000e+00 4.68750000e-02 5.37500000e-02
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Centroid 4: [5.05167797e+03 5.13422649e+06 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 2.71186441e+00 0.00000000e+00
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 1.45762712e+00 1.69491525e-02 1.93220339e-02 0.00000000e+00
 0.00000000e+00 9.91525424e-01 1.69491525e-02 5.76271186e-02
 3.15932203e+01 3.50508475e+01 8.90847458e-01 2.33898305e-02
 9.33220339e-01 1.04406780e-01 1.08474576e-02 2.42372881e-02
 2.37288136e-03 3.38983051e-04 0.00000000e+00 1.00000000e+00
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 1.69491525e-02 9.83050847e-01 0.00000000e+00]
Centroid 5: [2.426000e+03 2.500058e+06 0.000000e+00 0.000000e+00 0.000000e+00
 0.000000e+00 0.000000e+00 0.000000e+00 1.000000e+00 0.000000e+00
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Centroid 6: [8.3000000e+01 6.7560000e+02 2.4660582e+06 0.0000000e+00 0.0000000e+00
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 1.0000000e+00 0.0000000e+00 0.0000000e+00 1.3960000e+02 3.1200000e+01
 1.9400000e-01 4.6000000e-02 1.4000000e-02 1.3000000e-01 0.0000000e+00
 0.0000000e+00 0.0000000e+00 0.0000000e+00 0.0000000e+00 1.0000000e+00
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Centroid 7: [3.200000e+01 5.110000e+02 9.947934e+05 0.000000e+00 0.000000e+00
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 1.000000e+00 0.000000e+00 1.000000e-01 1.405000e+02 4.560000e+01
 4.860000e-01 1.700000e-02 3.030000e-01 0.000000e+00 0.000000e+00
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Centroid 8: [1.98789974e-01 5.45953760e+04 7.89350519e+03 0.00000000e+00
 0.00000000e+00 0.00000000e+00 1.86041487e+00 0.00000000e+00
 9.90492653e-01 9.16594641e-01 0.00000000e+00 0.00000000e+00
 9.50734659e-03 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 3.67977528e+00
 3.92610199e+00 3.76404494e-03 3.95851340e-03 3.59291271e-02
 8.84788245e-02 9.98452895e-01 2.34658600e-03 1.12026793e-01
 2.02823682e+02 2.00161625e+02 9.69286949e-01 3.54796889e-03
 2.71910112e-02 9.03197926e-04 2.66205704e-03 2.86084702e-03
 4.69403630e-02 4.65816768e-02 0.00000000e+00 1.00000000e+00
 0.00000000e+00 8.64304235e-04 1.72860847e-03 0.00000000e+00
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 3.37078652e-02 0.00000000e+00 2.59291271e-03 2.16076059e-03
 0.00000000e+00 9.61538462e-01 0.00000000e+00]
Centroid 9: [4.50000000e+01 5.88333333e+02 1.76159700e+06 0.00000000e+00
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Centroid 10: [1.15197059e+03 5.10794118e+02 1.77604618e+05 0.00000000e+00
 0.00000000e+00 0.00000000e+00 5.88235294e-02 0.00000000e+00
 9.70588235e-01 2.25882353e+01 2.94117647e-02 5.88235294e-02
 2.52058824e+01 2.94117647e-01 0.00000000e+00 1.76470588e-01
 0.00000000e+00 0.00000000e+00 0.00000000e+00 5.02941176e+00
 8.44117647e+00 0.00000000e+00 0.00000000e+00 2.94117647e-02
 2.94117647e-02 1.00000000e+00 0.00000000e+00 4.76470588e-02
 9.00588235e+01 1.86323529e+02 7.77941176e-01 1.38235294e-02
 4.17647059e-02 2.97058824e-02 2.38235294e-02 2.29411765e-02
 1.55882353e-02 2.97058824e-02 0.00000000e+00 1.00000000e+00
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 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 9.70588235e-01 0.00000000e+00]
Centroid 11: [2.376000e+03 9.805000e+02 3.884161e+06 0.000000e+00 0.000000e+00
 0.000000e+00 0.000000e+00 1.500000e+00 1.000000e+00 9.000000e+00
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Centroid 12: [1.03080808e+02 2.72232323e+02 9.36545556e+04 0.00000000e+00
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 1.00000000e+00 2.88888889e+00 1.01010101e-02 3.03030303e-02
 3.19191919e+00 4.04040404e-02 0.00000000e+00 5.05050505e-02
 0.00000000e+00 0.00000000e+00 0.00000000e+00 4.64646465e+00
 6.96969697e+00 7.07070707e-04 1.21212121e-03 0.00000000e+00
 5.05050505e-03 1.00000000e+00 0.00000000e+00 9.02020202e-02
 7.30000000e+01 2.25828283e+02 9.35858586e-01 3.53535354e-03
 7.93939394e-02 2.58585859e-02 8.68686869e-03 4.64646465e-03
 3.33333333e-03 7.17171717e-03 0.00000000e+00 1.00000000e+00
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 0.00000000e+00 0.00000000e+00 1.01010101e-02 0.00000000e+00
 0.00000000e+00 9.89898990e-01 0.00000000e+00]
Centroid 13: [3.68888889e+01 4.71444444e+02 1.43295533e+06 0.00000000e+00
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 1.68666667e+02 3.63333333e+01 2.02222222e-01 2.88888889e-02
 8.88888889e-03 2.44444444e-02 0.00000000e+00 0.00000000e+00
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Centroid 14: [1.491500e+02 6.907000e+02 5.859852e+05 0.000000e+00 0.000000e+00
 1.500000e-01 5.000000e-02 1.000000e-01 9.000000e-01 1.050000e+00
 5.000000e-02 0.000000e+00 6.000000e-01 5.000000e-02 0.000000e+00
 0.000000e+00 0.000000e+00 0.000000e+00 0.000000e+00 1.500000e+00
 2.100000e+00 7.500000e-02 5.350000e-02 0.000000e+00 0.000000e+00
 9.750000e-01 5.000000e-02 6.500000e-03 1.331000e+02 6.960000e+01
 3.995000e-01 2.550000e-02 6.350000e-02 2.050000e-02 2.900000e-02
 2.750000e-02 1.000000e-02 2.900000e-02 0.000000e+00 1.000000e+00
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 5.000000e-02 0.000000e+00 9.000000e-01 0.000000e+00]
Centroid 15: [4.94005979e+01 2.49142750e+02 2.83456256e+04 0.00000000e+00
 0.00000000e+00 0.00000000e+00 4.85799701e-02 0.00000000e+00
 9.99252616e-01 5.08221226e-02 3.73692078e-03 0.00000000e+00
 5.60538117e-02 5.60538117e-02 7.47384155e-04 1.49476831e-03
 0.00000000e+00 0.00000000e+00 0.00000000e+00 5.46113602e+00
 8.05082212e+00 4.01345291e-03 3.72197309e-03 1.71898356e-03
 2.73542601e-03 1.00000000e+00 0.00000000e+00 1.10201794e-01
 1.35795217e+02 2.46458894e+02 9.88789238e-01 1.06875934e-03
 7.28400598e-02 2.35351271e-02 3.47533632e-03 1.11360239e-03
 7.92227205e-03 9.85052317e-03 0.00000000e+00 1.00000000e+00
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 0.00000000e+00 0.00000000e+00 2.98953662e-03 7.47384155e-04
 7.47384155e-04 9.95515695e-01 0.00000000e+00]
Centroid 16: [1.30402129e+01 2.80750045e+02 2.57115593e+03 0.00000000e+00
 0.00000000e+00 4.47307211e-05 4.93514045e-01 4.47307211e-05
 9.99821077e-01 4.96511004e-03 1.43138307e-03 8.94614421e-05
 4.47307211e-04 2.14707461e-03 2.68384326e-04 1.31955627e-02
 0.00000000e+00 0.00000000e+00 1.97262480e-02 9.37860082e+00
 1.23145464e+01 1.47477187e-03 1.89971372e-03 8.47647164e-04
 3.12444087e-03 9.99363929e-01 9.15637860e-04 9.15865987e-02
 1.34052738e+02 2.41960682e+02 9.79277599e-01 2.38504205e-03
 4.91827697e-02 2.16371444e-02 1.47790302e-03 9.24136697e-04
 5.08275183e-03 8.21971730e-03 0.00000000e+00 1.00000000e+00
 0.00000000e+00 3.13115047e-04 0.00000000e+00 0.00000000e+00
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 2.68384326e-04 0.00000000e+00 0.00000000e+00 9.75711218e-01
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 0.00000000e+00 9.84075863e-04 0.00000000e+00 0.00000000e+00
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 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 2.99695831e-03 0.00000000e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 1.34192163e-04 0.00000000e+00
 2.68384326e-04 0.00000000e+00 1.78922884e-04 4.47307211e-05
 8.94614421e-05 9.99284308e-01 0.00000000e+00]
Centroid 17: [2.26086957e+00 2.19069557e+06 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 7.39130435e-01 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 1.73913043e+00
 1.65217391e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 9.63913043e-01 7.26086957e-02 0.00000000e+00
 1.20043478e+02 5.97391304e+01 3.08260870e-01 7.17391304e-02
 3.08260870e-01 2.69565217e-02 4.08695652e-02 0.00000000e+00
 2.60869565e-03 0.00000000e+00 0.00000000e+00 1.00000000e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
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 1.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
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 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 1.00000000e+00 0.00000000e+00]
Centroid 18: [8.12428571e+02 4.81500000e+02 2.96928643e+05 0.00000000e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 1.00000000e+00 2.77380952e+01 2.38095238e-02 7.14285714e-02
 3.02619048e+01 2.38095238e-02 0.00000000e+00 1.90476190e-01
 0.00000000e+00 0.00000000e+00 0.00000000e+00 2.47619048e+00
 2.95238095e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 2.61904762e-03 9.88095238e-01 2.38095238e-02 3.45238095e-02
 1.36523810e+02 1.14238095e+02 4.99047619e-01 5.59523810e-02
 5.40476190e-02 2.57142857e-02 9.28571429e-03 1.90476190e-02
 2.30952381e-02 2.28571429e-02 0.00000000e+00 1.00000000e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
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 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 4.04761905e-01
 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
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 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 5.95238095e-01 0.00000000e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
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 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 1.00000000e+00 0.00000000e+00]
Centroid 19: [2.70265029e+01 2.63350032e+02 1.55252246e+04 0.00000000e+00
 0.00000000e+00 0.00000000e+00 7.75694893e-03 0.00000000e+00
 9.99353588e-01 1.13122172e-02 6.46412411e-04 0.00000000e+00
 2.58564964e-03 2.68261151e-02 0.00000000e+00 3.87847447e-03
 0.00000000e+00 0.00000000e+00 0.00000000e+00 7.04266322e+00
 9.90917906e+00 4.43438914e-03 4.19844861e-03 1.48351648e-03
 2.61797027e-03 9.99838397e-01 3.23206206e-04 1.07588882e-01
 1.24406270e+02 2.42579832e+02 9.91444732e-01 1.09243697e-03
 7.81577246e-02 2.31868132e-02 4.39883646e-03 1.74208145e-03
 6.30252101e-03 9.64770524e-03 0.00000000e+00 1.00000000e+00
 0.00000000e+00 3.23206206e-04 3.23206206e-04 0.00000000e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
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 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 9.89980608e-01
 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
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 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 1.61603103e-03 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 7.75694893e-03 0.00000000e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 1.29282482e-03 0.00000000e+00 5.49450549e-03 6.46412411e-04
 3.23206206e-04 9.92243051e-01 0.00000000e+00]
Centroid 20: [1.60711160e+02 2.82021882e+02 4.78391597e+04 0.00000000e+00
 0.00000000e+00 4.37636761e-03 1.96936543e-02 2.18818381e-03
 1.00000000e+00 7.52735230e-01 8.75273523e-03 8.75273523e-03
 8.55579869e-01 6.12691466e-02 0.00000000e+00 1.53172867e-02
 0.00000000e+00 0.00000000e+00 0.00000000e+00 5.05908096e+00
 7.77899344e+00 4.02625821e-03 4.37636761e-03 1.50984683e-03
 3.71991247e-03 9.98905908e-01 2.18818381e-03 1.08621444e-01
 1.03385120e+02 2.42601751e+02 9.70831510e-01 6.47702407e-03
 9.33916849e-02 2.93654267e-02 6.67396061e-03 7.00218818e-03
 1.20350109e-02 1.05470460e-02 0.00000000e+00 1.00000000e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
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 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 9.62800875e-01
 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 2.18818381e-03 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
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 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 3.50109409e-02 0.00000000e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 4.37636761e-03 0.00000000e+00
 0.00000000e+00 9.95623632e-01 0.00000000e+00]
Centroid 21: [1.800000e+01 5.228475e+05 2.697500e+04 0.000000e+00 0.000000e+00
 0.000000e+00 0.000000e+00 0.000000e+00 6.250000e-01 0.000000e+00
 0.000000e+00 0.000000e+00 0.000000e+00 0.000000e+00 0.000000e+00
 0.000000e+00 0.000000e+00 0.000000e+00 0.000000e+00 1.750000e+00
 1.750000e+00 6.250000e-02 6.250000e-02 0.000000e+00 0.000000e+00
 1.000000e+00 0.000000e+00 0.000000e+00 1.265000e+02 6.575000e+01
 3.262500e-01 3.750000e-02 3.262500e-01 1.250000e-02 3.750000e-03
 8.750000e-03 0.000000e+00 0.000000e+00 0.000000e+00 1.000000e+00
 0.000000e+00 0.000000e+00 1.250000e-01 0.000000e+00 0.000000e+00
 0.000000e+00 0.000000e+00 0.000000e+00 0.000000e+00 0.000000e+00
 0.000000e+00 0.000000e+00 0.000000e+00 0.000000e+00 0.000000e+00
 0.000000e+00 0.000000e+00 0.000000e+00 0.000000e+00 0.000000e+00
 8.750000e-01 0.000000e+00 0.000000e+00 0.000000e+00 0.000000e+00
 0.000000e+00 0.000000e+00 0.000000e+00 0.000000e+00 0.000000e+00
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 0.000000e+00 0.000000e+00 0.000000e+00 0.000000e+00 0.000000e+00
 0.000000e+00 0.000000e+00 0.000000e+00 0.000000e+00 1.250000e-01
 0.000000e+00 0.000000e+00 8.750000e-01 0.000000e+00]
Centroid 22: [4.66596950e+01 2.88940015e+02 8.12700015e+03 0.00000000e+00
 0.00000000e+00 1.45243282e-04 1.00217865e-02 0.00000000e+00
 9.98111837e-01 1.45243282e-02 1.01670298e-03 0.00000000e+00
 1.08932462e-02 3.77632534e-03 5.80973130e-04 1.30718954e-03
 0.00000000e+00 0.00000000e+00 0.00000000e+00 7.95003631e+00
 1.10318083e+01 1.92156863e-03 2.45315904e-03 3.97385621e-03
 5.30718954e-03 9.99680465e-01 6.39070443e-04 1.12004357e-01
 1.16167320e+02 2.46175599e+02 9.91282498e-01 1.19099492e-03
 7.39709513e-02 2.59360930e-02 1.91721133e-03 1.31299927e-03
 7.47131445e-03 1.15323166e-02 0.00000000e+00 1.00000000e+00
 0.00000000e+00 3.19535221e-03 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 1.59767611e-03 0.00000000e+00 0.00000000e+00 9.88671024e-01
 0.00000000e+00 0.00000000e+00 1.45243282e-04 0.00000000e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 1.88816267e-03 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 1.45243282e-04 0.00000000e+00
 0.00000000e+00 0.00000000e+00 4.35729847e-03 0.00000000e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 2.90486565e-04 0.00000000e+00
 4.21205519e-03 0.00000000e+00 1.30718954e-03 1.45243282e-04
 0.00000000e+00 9.94045025e-01 0.00000000e+00]
Centroid 23: [2.38095238e-01 1.88549905e+05 6.50000000e+01 0.00000000e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 8.57142857e-01 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 1.61904762e+00
 3.04761905e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 1.00000000e+00 0.00000000e+00 2.26190476e-01
 1.15857143e+02 7.92380952e+01 3.91428571e-01 9.71428571e-02
 2.65238095e-01 1.76190476e-02 2.85714286e-03 4.28571429e-03
 0.00000000e+00 9.52380952e-04 0.00000000e+00 1.00000000e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
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 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 8.09523810e-01 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
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 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 1.90476190e-01 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
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 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 1.00000000e+00 0.00000000e+00]
31 clusters:
Finished running k-means++
26.0    290704
0.0     169218
15.0     20859
21.0      4544
7.0       2247
18.0      1701
14.0      1527
30.0      1413
24.0       946
19.0       396
11.0       158
9.0         60
3.0         59
17.0        36
28.0        34
16.0        23
23.0        17
2.0         16
13.0        16
12.0         9
20.0         8
6.0          5
5.0          5
29.0         5
22.0         4
8.0          3
10.0         2
25.0         2
27.0         2
4.0          1
1.0          1
dtype: int64
Completed iteration 1
26.0    289953
0.0     172298
15.0     17421
21.0      5558
7.0       2271
18.0      2084
14.0      1281
30.0      1182
24.0      1068
19.0       454
11.0       147
3.0         59
9.0         49
17.0        41
28.0        35
16.0        23
23.0        17
2.0         16
```

```
13.0        13
12.0         9
20.0         8
6.0          8
5.0          5
22.0         4
29.0         4
8.0          3
25.0         3
27.0         3
10.0         2
4.0          1
1.0          1
dtype: int64
Completed iteration 2
26.0    289719
0.0     172426
15.0     17005
21.0      5903
18.0      2277
7.0       2273
14.0      1232
24.0      1219
30.0      1066
19.0       461
11.0       136
3.0         59
9.0         49
17.0        39
28.0        35
16.0        23
23.0        17
2.0         16
13.0        13
12.0         9
6.0          9
20.0         8
5.0          5
22.0         4
25.0         4
29.0         4
8.0          3
27.0         3
10.0         2
4.0          1
1.0          1
dtype: int64
Completed iteration 3
26.0    289708
0.0     172047
15.0     17145
21.0      6057
18.0      2404
7.0       2274
14.0      1245
24.0      1229
30.0      1030
19.0       457
11.0       121
3.0         59
9.0         47
17.0        40
28.0        35
16.0        23
23.0        17
2.0         16
13.0        14
12.0         9
6.0          9
20.0         8
5.0          5
22.0         4
25.0         4
29.0         4
8.0          3
27.0         3
10.0         2
4.0          1
1.0          1
dtype: int64
Completed iteration 4
26.0    289711
0.0     171370
15.0     17596
21.0      6141
18.0      2548
7.0       2274
14.0      1258
24.0      1233
30.0      1019
19.0       461
11.0       106
3.0         59
9.0         47
17.0        40
28.0        35
16.0        23
23.0        17
2.0         16
13.0        13
6.0         10
12.0         9
20.0         8
5.0          5
22.0         4
25.0         4
29.0         4
8.0          3
27.0         3
10.0         2
4.0          1
1.0          1
dtype: int64
Completed iteration 5
26.0    289697
0.0     170651
15.0     18078
21.0      6203
18.0      2712
7.0       2274
14.0      1274
24.0      1259
30.0      1015
19.0       458
11.0        96
3.0         59
9.0         47
17.0        40
28.0        35
16.0        23
23.0        17
2.0         16
13.0        13
6.0         10
12.0         9
20.0         8
5.0          5
22.0         4
25.0         4
29.0         4
8.0          3
27.0         3
10.0         2
4.0          1
1.0          1
dtype: int64
Completed iteration 6
26.0    289718
0.0     170060
15.0     18421
21.0      6299
18.0      2833
7.0       2274
14.0      1290
24.0      1260
30.0      1015
19.0       453
11.0        95
3.0         59
9.0         46
17.0        40
28.0        35
16.0        23
23.0        17
2.0         16
13.0        13
6.0         10
12.0         9
20.0         8
5.0          5
22.0         4
25.0         4
29.0         4
8.0          3
27.0         3
10.0         2
4.0          1
1.0          1
dtype: int64
Completed iteration 7
26.0    289730
0.0     169490
15.0     18779
21.0      6413
18.0      2909
7.0       2274
14.0      1304
24.0      1260
30.0      1014
19.0       450
11.0        95
3.0         59
9.0         46
17.0        40
28.0        35
16.0        23
23.0        17
2.0         16
13.0        13
6.0         10
12.0         9
20.0         8
5.0          5
22.0         4
25.0         4
29.0         4
8.0          3
27.0         3
10.0         2
4.0          1
1.0          1
dtype: int64
Completed iteration 8
26.0    289748
0.0     169076
15.0     18992
21.0      6538
18.0      2960
7.0       2274
14.0      1312
24.0      1260
30.0      1013
19.0       451
11.0        94
3.0         59
9.0         46
17.0        40
28.0        35
16.0        23
23.0        17
2.0         16
13.0        13
6.0         10
12.0         9
20.0         8
5.0          5
22.0         4
25.0         4
29.0         4
8.0          3
27.0         3
10.0         2
4.0          1
1.0          1
dtype: int64
Completed iteration 9
26.0    289759
0.0     168748
15.0     19188
21.0      6602
18.0      3012
7.0       2274
14.0      1317
24.0      1260
30.0      1013
19.0       451
11.0        94
3.0         59
9.0         46
17.0        40
28.0        35
16.0        23
23.0        17
2.0         16
13.0        13
6.0         10
12.0         9
20.0         8
5.0          5
22.0         4
25.0         4
29.0         4
8.0          3
27.0         3
10.0         2
4.0          1
1.0          1
dtype: int64
Completed iteration 10
26.0    289766
0.0     168370
15.0     19469
21.0      6654
18.0      3045
7.0       2274
14.0      1322
24.0      1260
30.0      1013
19.0       451
11.0        94
3.0         59
9.0         46
17.0        40
28.0        35
16.0        23
23.0        17
2.0         16
13.0        13
6.0         10
12.0         9
20.0         8
5.0          5
22.0         4
25.0         4
29.0         4
8.0          3
27.0         3
10.0         2
4.0          1
1.0          1
dtype: int64
Completed iteration 11
Reached 11 iterations
Centroids:
Centroid 1: [5.89756251e+01 6.42557997e+01 1.21327630e+02 1.30664608e-04
 1.73368177e-02 0.00000000e+00 7.79236206e-03 4.03872424e-04
 1.78862030e-01 5.34537032e-05 2.37572014e-05 1.18786007e-05
 1.50917622e-02 3.08843618e-04 2.37572014e-05 2.31632714e-04
 0.00000000e+00 0.00000000e+00 1.38385698e-03 1.27560527e+02
 1.14437251e+01 5.17927125e-01 5.17621132e-01 1.67225337e-01
 1.66977906e-01 3.90119261e-01 5.90590366e-02 4.28787789e-02
 2.21482265e+02 7.33896953e+01 3.12359149e-01 8.17087961e-02
 7.42512918e-02 1.41250223e-02 5.17642929e-01 5.17253786e-01
 1.67830374e-01 1.65593039e-01 1.53055770e-02 8.69228485e-01
 1.15465938e-01 7.12716042e-05 2.96965018e-05 5.46415632e-04
 1.94809051e-03 6.29565837e-04 6.35505137e-04 7.42412544e-04
 5.76112134e-04 6.11747936e-04 6.88958841e-04 6.88958841e-04
 3.48102394e-02 6.65201639e-04 9.75233118e-03 2.22723763e-03
 6.05808636e-04 5.87990735e-04 3.97339193e-03 2.06093722e-03
 1.46641326e-02 6.94898141e-04 6.17687236e-04 1.87901645e-01
 5.87990735e-04 0.00000000e+00 6.77080240e-04 6.83019540e-04
 6.29565837e-04 5.82051434e-04 5.99869335e-04 6.05808636e-04
 6.05808636e-04 6.35505137e-04 5.82051434e-04 5.87990735e-04
 6.05808636e-04 6.35505137e-04 5.64233533e-04 6.23626537e-04
 6.41444438e-04 2.25693413e-03 3.72097167e-02 5.93930035e-06
 5.99869335e-04 9.68105957e-04 6.41444438e-04 6.58347687e-01
 5.93930035e-06 7.12716042e-04 6.59262339e-04 6.65201639e-04
 1.06729227e-02 6.53323039e-04 6.17687236e-04 6.35505137e-04
 6.17687236e-04 6.83019540e-04 1.67488270e-03 5.93930035e-06
 4.15751025e-05 9.32470155e-04 8.31502049e-05 3.19534359e-03
 6.23626537e-04 6.29565837e-04 6.29565837e-04 6.53323039e-04
 4.75144028e-05 1.59618697e-01 3.39134050e-03 5.93930035e-05
 4.20502465e-03 5.16760706e-01 5.34537032e-05 6.53323039e-05
 2.37572014e-05 3.15139277e-01 6.35505137e-04]
Centroid 2: [2.0000000e+00 6.9337564e+08 0.0000000e+00 0.0000000e+00 0.0000000e+00
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 3.0000000e+00 7.9000000e-01 6.7000000e-01 2.1000000e-01 3.3000000e-01
 5.0000000e-02 3.9000000e-01 0.0000000e+00 2.5500000e+02 3.0000000e+00
 1.0000000e-02 9.0000000e-02 2.2000000e-01 0.0000000e+00 1.8000000e-01
 6.7000000e-01 5.0000000e-02 3.3000000e-01 0.0000000e+00 1.0000000e+00
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Centroid 3: [3.24312500e+02 0.00000000e+00 5.15038094e+06 0.00000000e+00
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Centroid 4: [5.05167797e+03 5.13422649e+06 0.00000000e+00 0.00000000e+00
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 1.45762712e+00 1.69491525e-02 1.93220339e-02 0.00000000e+00
 0.00000000e+00 9.91525424e-01 1.69491525e-02 5.76271186e-02
 3.15932203e+01 3.50508475e+01 8.90847458e-01 2.33898305e-02
 9.33220339e-01 1.04406780e-01 1.08474576e-02 2.42372881e-02
 2.37288136e-03 3.38983051e-04 0.00000000e+00 1.00000000e+00
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Centroid 5: [2.426000e+03 2.500058e+06 0.000000e+00 0.000000e+00 0.000000e+00
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Centroid 6: [8.3000000e+01 6.7560000e+02 2.4660582e+06 0.0000000e+00 0.0000000e+00
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 1.9400000e-01 4.6000000e-02 1.4000000e-02 1.3000000e-01 0.0000000e+00
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Centroid 7: [2.740000e+01 6.395000e+02 6.497916e+05 0.000000e+00 0.000000e+00
 0.000000e+00 0.000000e+00 0.000000e+00 9.000000e-01 0.000000e+00
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 3.200000e+00 1.500000e-01 1.070000e-01 0.000000e+00 0.000000e+00
 9.500000e-01 1.000000e-01 1.300000e-02 1.343000e+02 9.200000e+01
 4.810000e-01 1.800000e-02 1.700000e-02 3.600000e-02 5.600000e-02
 5.500000e-02 2.000000e-02 5.800000e-02 0.000000e+00 1.000000e+00
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 1.000000e-01 0.000000e+00 8.000000e-01 0.000000e+00]
Centroid 8: [1.43359719e-01 5.40817801e+04 8.01533026e+03 0.00000000e+00
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 9.92963940e-01 9.32717678e-01 0.00000000e+00 0.00000000e+00
 4.39753738e-04 0.00000000e+00 0.00000000e+00 0.00000000e+00
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 3.85664028e+00 3.83025506e-03 4.02814424e-03 3.62313105e-02
 8.97053650e-02 9.98425682e-01 2.38786280e-03 1.11855761e-01
 2.04351803e+02 2.02315303e+02 9.78029903e-01 2.08883026e-03
 2.23834653e-02 6.20052770e-04 2.31750220e-03 2.90237467e-03
 4.77308707e-02 4.73658751e-02 0.00000000e+00 1.00000000e+00
 0.00000000e+00 8.79507476e-04 1.31926121e-03 0.00000000e+00
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 3.38610378e-02 0.00000000e+00 2.63852243e-03 2.19876869e-03
 0.00000000e+00 9.61301671e-01 0.00000000e+00]
Centroid 9: [4.50000000e+01 5.88333333e+02 1.76159700e+06 0.00000000e+00
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 1.00000000e-02 2.66666667e-02 0.00000000e+00 0.00000000e+00
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Centroid 10: [8.51000000e+02 4.31521739e+02 1.60072174e+05 0.00000000e+00
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 9.78260870e-01 1.66956522e+01 2.17391304e-02 4.34782609e-02
 1.86304348e+01 2.17391304e-01 0.00000000e+00 1.30434783e-01
 0.00000000e+00 0.00000000e+00 0.00000000e+00 5.76086957e+00
 8.97826087e+00 1.52173913e-03 1.52173913e-03 2.17391304e-02
 2.17391304e-02 1.00000000e+00 0.00000000e+00 6.32608696e-02
 7.83478261e+01 2.01521739e+02 8.36739130e-01 1.06521739e-02
 4.47826087e-02 2.97826087e-02 1.91304348e-02 1.58695652e-02
 1.06521739e-02 1.93478261e-02 0.00000000e+00 1.00000000e+00
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 0.00000000e+00 0.00000000e+00 2.17391304e-02 0.00000000e+00
 0.00000000e+00 9.56521739e-01 0.00000000e+00]
Centroid 11: [2.376000e+03 9.805000e+02 3.884161e+06 0.000000e+00 0.000000e+00
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 5.000000e-01 1.000000e+00 4.500000e+00 0.000000e+00 0.000000e+00
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 5.050000e-01 1.000000e-02 5.000000e-03 5.000000e-03 0.000000e+00
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Centroid 12: [1.91542553e+02 2.84617021e+02 8.62453085e+04 0.00000000e+00
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 1.00000000e+00 3.04255319e+00 1.06382979e-02 3.19148936e-02
 3.36170213e+00 4.25531915e-02 0.00000000e+00 6.38297872e-02
 0.00000000e+00 0.00000000e+00 0.00000000e+00 4.47872340e+00
 6.59574468e+00 0.00000000e+00 5.31914894e-04 0.00000000e+00
 5.31914894e-03 1.00000000e+00 0.00000000e+00 8.55319149e-02
 7.03297872e+01 2.22340426e+02 9.23936170e-01 7.44680851e-03
 9.29787234e-02 3.23404255e-02 8.40425532e-03 8.40425532e-03
 3.51063830e-03 7.55319149e-03 0.00000000e+00 1.00000000e+00
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Centroid 13: [3.68888889e+01 4.71444444e+02 1.43295533e+06 0.00000000e+00
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 8.88888889e-03 2.44444444e-02 0.00000000e+00 0.00000000e+00
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Centroid 14: [1.65930769e+03 8.14000000e+02 4.69170000e+05 0.00000000e+00
 0.00000000e+00 2.30769231e-01 7.69230769e-02 1.53846154e-01
 9.23076923e-01 2.32307692e+01 7.69230769e-02 7.69230769e-02
 2.23076923e+01 1.53846154e-01 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 1.07692308e+00
 1.92307692e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 1.00000000e+00 0.00000000e+00 2.38461538e-02
 1.50000000e+02 6.17692308e+01 3.51538462e-01 3.00000000e-02
 8.53846154e-02 3.84615385e-03 2.92307692e-02 3.53846154e-02
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 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 1.00000000e+00 0.00000000e+00]
Centroid 15: [4.99984871e+01 2.49169440e+02 2.83860703e+04 0.00000000e+00
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 9.99243570e-01 5.14372163e-02 3.78214826e-03 0.00000000e+00
 5.67322239e-02 5.67322239e-02 7.56429652e-04 1.51285930e-03
 0.00000000e+00 0.00000000e+00 0.00000000e+00 5.42133132e+00
 8.02496218e+00 4.06202723e-03 3.76701967e-03 1.73978820e-03
 2.76853253e-03 1.00000000e+00 0.00000000e+00 1.10612708e-01
 1.36157337e+02 2.46501513e+02 9.88653555e-01 1.08169440e-03
 7.30181543e-02 2.35249622e-02 3.50983359e-03 1.11951589e-03
 8.01059002e-03 9.96974281e-03 0.00000000e+00 1.00000000e+00
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 0.00000000e+00 0.00000000e+00 3.02571861e-03 7.56429652e-04
 7.56429652e-04 9.95461422e-01 0.00000000e+00]
Centroid 16: [4.31480816e+00 2.82218809e+02 2.80553095e+03 0.00000000e+00
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 9.99845909e-01 5.49591659e-03 1.43818378e-03 1.02727413e-04
 5.13637064e-04 2.10591196e-03 2.05454826e-04 1.50495660e-02
 0.00000000e+00 0.00000000e+00 2.20863938e-02 9.25270944e+00
 1.22050439e+01 1.43304741e-03 1.91843443e-03 7.55560121e-04
 2.99399045e-03 9.99293749e-01 1.00210591e-03 9.22204530e-02
 1.32577842e+02 2.41974575e+02 9.78039961e-01 2.40125327e-03
 5.16379886e-02 2.20483846e-02 1.32672454e-03 9.04001233e-04
 5.05059325e-03 7.92233808e-03 0.00000000e+00 1.00000000e+00
 0.00000000e+00 2.56818532e-04 0.00000000e+00 0.00000000e+00
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 0.00000000e+00 0.00000000e+00 1.02727413e-04 0.00000000e+00
 1.54091119e-04 0.00000000e+00 1.54091119e-04 5.13637064e-05
 1.02727413e-04 9.99434999e-01 0.00000000e+00]
Centroid 17: [2.26086957e+00 2.19069557e+06 0.00000000e+00 0.00000000e+00
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 1.65217391e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
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 1.20043478e+02 5.97391304e+01 3.08260870e-01 7.17391304e-02
 3.08260870e-01 2.69565217e-02 4.08695652e-02 0.00000000e+00
 2.60869565e-03 0.00000000e+00 0.00000000e+00 1.00000000e+00
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 0.00000000e+00 1.00000000e+00 0.00000000e+00]
Centroid 18: [3.81925000e+02 4.54625000e+02 2.81996225e+05 0.00000000e+00
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 2.75000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
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 1.34375000e+02 1.12625000e+02 4.93500000e-01 5.75000000e-02
 5.65000000e-02 2.85000000e-02 7.50000000e-04 1.00000000e-02
 2.52500000e-02 2.70000000e-02 0.00000000e+00 1.00000000e+00
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Centroid 19: [2.09343186e+01 2.62550082e+02 1.56261478e+04 0.00000000e+00
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 2.62725780e-03 2.72577997e-02 0.00000000e+00 3.94088670e-03
 0.00000000e+00 0.00000000e+00 0.00000000e+00 7.02955665e+00
 9.89195402e+00 4.50574713e-03 4.15763547e-03 1.17898194e-03
 2.33169130e-03 9.99835796e-01 3.28407225e-04 1.07724138e-01
 1.24738588e+02 2.43253530e+02 9.91809524e-01 1.07060755e-03
 7.80722496e-02 2.32840722e-02 4.23645320e-03 1.60919540e-03
 6.37438424e-03 9.68144499e-03 0.00000000e+00 1.00000000e+00
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 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 7.55336617e-03 0.00000000e+00
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 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 9.85221675e-04 0.00000000e+00 5.58292282e-03 6.56814450e-04
 3.28407225e-04 9.92446634e-01 0.00000000e+00]
Centroid 20: [1.45478936e+02 2.78813747e+02 4.73652262e+04 0.00000000e+00
 0.00000000e+00 4.43458980e-03 1.99556541e-02 0.00000000e+00
 1.00000000e+00 7.62749446e-01 8.86917960e-03 8.86917960e-03
 8.66962306e-01 6.20842572e-02 0.00000000e+00 1.33037694e-02
 0.00000000e+00 0.00000000e+00 0.00000000e+00 5.01552106e+00
 7.76940133e+00 4.07982262e-03 4.43458980e-03 1.52993348e-03
 3.76940133e-03 9.98891353e-01 2.21729490e-03 1.09179601e-01
 1.04545455e+02 2.43711752e+02 9.76053215e-01 5.65410200e-03
 9.14412417e-02 2.79822616e-02 6.76274945e-03 6.34146341e-03
 1.21951220e-02 1.06873614e-02 0.00000000e+00 1.00000000e+00
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 2.21729490e-03 0.00000000e+00 0.00000000e+00 0.00000000e+00
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 0.00000000e+00 0.00000000e+00 2.88248337e-02 0.00000000e+00
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 0.00000000e+00 0.00000000e+00 4.43458980e-03 0.00000000e+00
 0.00000000e+00 9.95565410e-01 0.00000000e+00]
Centroid 21: [1.800000e+01 5.228475e+05 2.697500e+04 0.000000e+00 0.000000e+00
 0.000000e+00 0.000000e+00 0.000000e+00 6.250000e-01 0.000000e+00
 0.000000e+00 0.000000e+00 0.000000e+00 0.000000e+00 0.000000e+00
 0.000000e+00 0.000000e+00 0.000000e+00 0.000000e+00 1.750000e+00
 1.750000e+00 6.250000e-02 6.250000e-02 0.000000e+00 0.000000e+00
 1.000000e+00 0.000000e+00 0.000000e+00 1.265000e+02 6.575000e+01
 3.262500e-01 3.750000e-02 3.262500e-01 1.250000e-02 3.750000e-03
 8.750000e-03 0.000000e+00 0.000000e+00 0.000000e+00 1.000000e+00
 0.000000e+00 0.000000e+00 1.250000e-01 0.000000e+00 0.000000e+00
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 0.000000e+00 0.000000e+00 0.000000e+00 0.000000e+00 1.250000e-01
 0.000000e+00 0.000000e+00 8.750000e-01 0.000000e+00]
Centroid 22: [7.68485122e+00 2.59870905e+02 8.26311843e+03 0.00000000e+00
 0.00000000e+00 1.50285543e-04 7.81484821e-03 0.00000000e+00
 9.98797716e-01 1.41268410e-02 1.05199880e-03 0.00000000e+00
 1.12714157e-02 1.50285543e-03 6.01142170e-04 1.20228434e-03
 0.00000000e+00 0.00000000e+00 0.00000000e+00 7.96588518e+00
 1.10471897e+01 1.96874061e-03 2.46017433e-03 1.41418696e-03
 2.66456267e-03 9.99744515e-01 5.10970845e-04 1.12216712e-01
 1.17366546e+02 2.46605801e+02 9.92921551e-01 9.49804629e-04
 7.35272017e-02 2.58461076e-02 1.91463781e-03 1.15419297e-03
 6.81544935e-03 1.01157199e-02 0.00000000e+00 1.00000000e+00
 0.00000000e+00 1.05199880e-03 0.00000000e+00 0.00000000e+00
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 1.65314097e-03 0.00000000e+00 0.00000000e+00 9.91133153e-01
 0.00000000e+00 0.00000000e+00 1.50285543e-04 0.00000000e+00
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 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 1.05199880e-03 0.00000000e+00 1.35256988e-03 1.50285543e-04
 0.00000000e+00 9.97445146e-01 0.00000000e+00]
Centroid 23: [1.25000e+00 2.50723e+05 3.41250e+02 0.00000e+00 0.00000e+00 0.00000e+00
 0.00000e+00 0.00000e+00 1.00000e+00 0.00000e+00 0.00000e+00 0.00000e+00
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 0.00000e+00 1.00000e+00 0.00000e+00 7.50000e-01 8.92500e+01 1.21250e+02
 6.90000e-01 1.30000e-01 3.00000e-02 2.25000e-02 0.00000e+00 0.00000e+00
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 0.00000e+00 0.00000e+00 0.00000e+00 1.00000e+00 0.00000e+00]
Centroid 24: [0.00000000e+00 1.73920941e+05 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 8.23529412e-01 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 1.76470588e+00
 3.23529412e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 1.00000000e+00 0.00000000e+00 1.02941176e-01
 1.22117647e+02 6.93529412e+01 3.21176471e-01 8.94117647e-02
 3.20588235e-01 1.64705882e-02 3.52941176e-03 5.29411765e-03
 0.00000000e+00 0.00000000e+00 0.00000000e+00 1.00000000e+00
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 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 1.00000000e+00 0.00000000e+00]
Centroid 25: [1.97063492e+00 1.10804302e+04 3.07457937e+02 0.00000000e+00
 0.00000000e+00 0.00000000e+00 1.66666667e-02 0.00000000e+00
 8.39682540e-01 6.34920635e-03 0.00000000e+00 0.00000000e+00
 0.00000000e+00 6.42857143e-02 0.00000000e+00 1.74603175e-02
 0.00000000e+00 0.00000000e+00 0.00000000e+00 6.08492063e+00
 6.23015873e+00 3.65079365e-03 2.41269841e-03 6.17460317e-03
 6.79365079e-03 9.83738095e-01 1.77222222e-02 1.36301587e-01
 1.23793651e+02 8.39325397e+01 4.56436508e-01 6.88809524e-02
 3.07817460e-01 2.10000000e-02 1.09444444e-02 2.31746032e-03
 1.30396825e-02 3.96031746e-03 0.00000000e+00 1.00000000e+00
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 7.51587302e-01 0.00000000e+00 0.00000000e+00 1.26984127e-02
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 0.00000000e+00 0.00000000e+00 1.11111111e-02 0.00000000e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
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 2.24603175e-01 0.00000000e+00 0.00000000e+00 0.00000000e+00
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 0.00000000e+00 0.00000000e+00 7.93650794e-04 0.00000000e+00
 1.11111111e-02 0.00000000e+00 7.93650794e-04 7.93650794e-04
 0.00000000e+00 9.86507937e-01 0.00000000e+00]
Centroid 26: [4.125000e+01 6.247500e+02 8.232585e+05 0.000000e+00 0.000000e+00
 0.000000e+00 0.000000e+00 0.000000e+00 1.000000e+00 0.000000e+00
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 1.000000e+00 0.000000e+00 0.000000e+00 0.000000e+00 0.000000e+00
 1.000000e+00 0.000000e+00 0.000000e+00 1.535000e+02 2.675000e+01
 3.725000e-01 1.750000e-02 2.525000e-01 0.000000e+00 0.000000e+00
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 0.000000e+00 0.000000e+00 1.000000e+00 0.000000e+00]
Centroid 27: [7.71173982e-02 9.58215705e+02 9.02531353e+00 0.00000000e+00
 8.93824672e-04 0.00000000e+00 4.14127261e-05 0.00000000e+00
 2.92511889e-02 0.00000000e+00 0.00000000e+00 0.00000000e+00
 7.24722707e-05 4.58991048e-04 1.41493481e-04 3.27850749e-04
 0.00000000e+00 0.00000000e+00 0.00000000e+00 4.91416633e+02
 4.91431631e+02 1.52881981e-05 2.59864856e-05 3.45106051e-06
 8.04097099e-06 9.99445449e-01 9.50215001e-04 1.23795062e-02
 2.50822999e+02 2.50907815e+02 9.88008117e-01 2.26106583e-03
 9.71564607e-01 5.68769283e-04 2.60313494e-04 8.07203053e-05
 2.45197849e-04 3.42345203e-05 9.69834280e-01 3.00759924e-02
 8.97275733e-05 0.00000000e+00 0.00000000e+00 0.00000000e+00
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 0.00000000e+00 0.00000000e+00 0.00000000e+00 9.69834280e-01
 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 3.67537944e-03 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 3.45106051e-06 0.00000000e+00
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 2.63177875e-02 0.00000000e+00 0.00000000e+00 0.00000000e+00
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 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 1.03531815e-05 3.45106051e-06
 3.45106051e-06 9.99982745e-01 0.00000000e+00]
Centroid 28: [2.90000000e+01 5.07333333e+02 1.13835233e+06 0.00000000e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 6.66666667e-01 0.00000000e+00 0.00000000e+00 0.00000000e+00
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 1.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 1.00000000e+00 0.00000000e+00 0.00000000e+00
 9.33333333e+01 1.33333333e+01 3.76666667e-01 2.66666667e-02
 3.40000000e-01 0.00000000e+00 0.00000000e+00 0.00000000e+00
 3.33333333e-03 0.00000000e+00 0.00000000e+00 1.00000000e+00
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 0.00000000e+00 0.00000000e+00 6.66666667e-01 0.00000000e+00
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 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 1.00000000e+00 0.00000000e+00]
Centroid 29: [3.65714286e+00 9.14642857e+04 9.93142857e+02 0.00000000e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 8.57142857e-01 0.00000000e+00 0.00000000e+00 0.00000000e+00
 6.00000000e-01 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 8.51428571e+00
 8.65714286e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 1.00000000e+00 0.00000000e+00 8.91428571e-02
 1.11514286e+02 6.99714286e+01 4.36571429e-01 8.51428571e-02
 3.33714286e-01 1.80000000e-02 4.28571429e-03 2.85714286e-04
 1.14285714e-03 1.14285714e-03 0.00000000e+00 1.00000000e+00
 0.00000000e+00 0.00000000e+00 2.85714286e-02 0.00000000e+00
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 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 7.71428571e-01 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 2.85714286e-02 0.00000000e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 1.71428571e-01 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 1.00000000e+00 0.00000000e+00]
Centroid 30: [2.65000000e+01 3.86000000e+02 1.00204025e+06 0.00000000e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 7.50000000e-01 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 1.00000000e+00
 1.25000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 1.00000000e+00 0.00000000e+00 2.50000000e-01
 1.72000000e+02 8.00000000e+01 5.75000000e-01 1.25000000e-02
 2.52500000e-01 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 1.00000000e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 2.50000000e-01 0.00000000e+00 0.00000000e+00 2.50000000e-01
 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 5.00000000e-01 0.00000000e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 1.00000000e+00 0.00000000e+00]
Centroid 31: [1.28440750e+04 1.90530109e+02 3.36441264e+02 0.00000000e+00
 0.00000000e+00 0.00000000e+00 1.83613031e-01 0.00000000e+00
 4.44225074e-02 2.96150049e-03 0.00000000e+00 0.00000000e+00
 0.00000000e+00 1.57946693e-02 0.00000000e+00 9.87166831e-04
 0.00000000e+00 0.00000000e+00 2.17176703e-02 1.66041461e+00
 1.27443238e+00 0.00000000e+00 0.00000000e+00 9.23000987e-02
 9.27936821e-02 9.11273445e-01 8.77591313e-02 1.82625864e-03
 2.45428430e+02 3.30404738e+00 1.89239882e-02 6.81549852e-01
 9.03938796e-01 1.28331688e-04 5.51826259e-03 2.81342547e-03
 7.41263574e-02 8.52221125e-02 0.00000000e+00 1.24383021e-01
 8.75616979e-01 1.67818361e-02 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 9.87166831e-04 9.87166831e-04
 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 1.97433366e-03 0.00000000e+00 0.00000000e+00 0.00000000e+00
 9.87166831e-04 0.00000000e+00 0.00000000e+00 2.17176703e-02
 9.87166831e-04 0.00000000e+00 0.00000000e+00 9.87166831e-04
 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 8.92398815e-01 0.00000000e+00
 0.00000000e+00 9.87166831e-04 9.87166831e-04 4.63968411e-02
 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 9.87166831e-04 0.00000000e+00 1.18460020e-02 0.00000000e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 9.87166831e-04 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 2.96150049e-03 9.87166831e-04
 8.88450148e-02 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 9.07206318e-01 0.00000000e+00]
45 clusters:
Finished running k-means++
26.0    290703
0.0     153229
35.0     21938
15.0     11892
38.0      4299
7.0       2247
34.0      1804
21.0      1462
30.0      1292
18.0      1222
14.0      1214
24.0       946
33.0       792
19.0       396
11.0       135
41.0       119
3.0         59
37.0        44
36.0        39
28.0        34
16.0        23
9.0         21
23.0        17
2.0         16
17.0        12
32.0         9
31.0         9
20.0         7
12.0         6
29.0         5
22.0         4
13.0         4
5.0          3
40.0         3
27.0         2
25.0         2
10.0         2
8.0          2
6.0          2
1.0          1
39.0         1
4.0          1
42.0         1
43.0         1
44.0         1
dtype: int64
Completed iteration 1
26.0    290345
0.0     154633
35.0     21481
15.0     10691
38.0      4343
7.0       2271
34.0      2214
21.0      1537
30.0      1273
18.0      1164
24.0      1068
14.0      1064
33.0       913
19.0       415
41.0       143
11.0       132
3.0         59
37.0        46
28.0        35
36.0        35
9.0         25
16.0        23
23.0        17
2.0         16
17.0        12
32.0         9
31.0         9
20.0         7
12.0         5
40.0         4
22.0         4
29.0         4
13.0         4
27.0         3
5.0          3
25.0         2
10.0         2
8.0          2
6.0          2
1.0          1
39.0         1
4.0          1
42.0         1
43.0         1
44.0         1
dtype: int64
Completed iteration 2
26.0    290151
0.0     155475
35.0     20844
15.0     10039
38.0      4485
34.0      2442
7.0       2273
21.0      1645
30.0      1301
24.0      1219
18.0      1200
33.0       952
14.0       950
19.0       410
41.0       164
11.0       135
3.0         59
37.0        48
28.0        35
36.0        32
9.0         29
16.0        23
23.0        17
2.0         16
17.0        11
32.0         9
31.0         9
20.0         7
40.0         5
22.0         4
29.0         4
13.0         4
12.0         4
27.0         3
5.0          3
25.0         2
10.0         2
8.0          2
6.0          2
1.0          1
39.0         1
4.0          1
42.0         1
43.0         1
44.0         1
dtype: int64
Completed iteration 3
26.0    290127
0.0     155840
35.0     20401
15.0      9769
38.0      4601
34.0      2591
7.0       2274
21.0      1738
30.0      1294
24.0      1229
18.0      1226
33.0      1000
14.0       843
19.0       399
41.0       211
11.0       141
3.0         59
37.0        50
28.0        35
36.0        33
9.0         28
16.0        23
23.0        17
2.0         16
17.0        10
32.0         9
31.0         9
20.0         7
40.0         5
22.0         4
29.0         4
13.0         4
12.0         4
27.0         3
5.0          3
25.0         2
10.0         2
8.0          2
6.0          2
1.0          1
39.0         1
4.0          1
42.0         1
43.0         1
44.0         1
dtype: int64
Completed iteration 4
26.0    290108
0.0     155894
35.0     20122
15.0      9730
38.0      4602
34.0      2748
7.0       2274
21.0      1796
30.0      1338
18.0      1302
24.0      1233
33.0       967
14.0       799
19.0       379
41.0       245
11.0       147
3.0         59
37.0        52
28.0        35
36.0        32
9.0         27
16.0        23
23.0        17
2.0         16
17.0        10
32.0         9
31.0         9
20.0         7
40.0         5
22.0         4
29.0         4
13.0         4
12.0         4
27.0         3
5.0          3
25.0         2
10.0         2
8.0          2
6.0          2
1.0          1
39.0         1
4.0          1
42.0         1
43.0         1
44.0         1
dtype: int64
Completed iteration 5
26.0    290079
0.0     155781
35.0     20007
15.0      9682
38.0      4629
34.0      2872
7.0       2274
21.0      1904
30.0      1392
18.0      1307
24.0      1259
33.0       926
14.0       769
19.0       372
41.0       282
11.0       149
3.0         59
37.0        53
28.0        35
36.0        32
9.0         26
16.0        23
23.0        17
2.0         16
17.0        10
32.0         9
31.0         9
20.0         7
40.0         5
22.0         4
29.0         4
13.0         4
12.0         4
27.0         3
5.0          3
25.0         2
10.0         2
8.0          2
6.0          2
1.0          1
39.0         1
4.0          1
42.0         1
43.0         1
44.0         1
dtype: int64
Completed iteration 6
26.0    290078
0.0     155641
35.0     19931
15.0      9597
38.0      4710
34.0      3003
7.0       2274
21.0      1986
30.0      1422
18.0      1291
24.0      1260
33.0       910
14.0       741
19.0       369
41.0       322
11.0       149
3.0         59
37.0        53
28.0        35
36.0        31
9.0         27
16.0        23
23.0        17
2.0         16
17.0        10
32.0         9
31.0         9
20.0         7
40.0         5
22.0         4
29.0         4
13.0         4
12.0         4
27.0         3
5.0          3
25.0         2
10.0         2
8.0          2
6.0          2
1.0          1
39.0         1
4.0          1
42.0         1
43.0         1
44.0         1
dtype: int64
Completed iteration 7
26.0    290080
0.0     155521
35.0     19787
15.0      9647
38.0      4771
34.0      3088
7.0       2274
21.0      2040
30.0      1453
18.0      1307
24.0      1260
33.0       897
14.0       702
19.0       365
41.0       343
11.0       149
3.0         59
37.0        53
28.0        35
36.0        31
9.0         27
16.0        23
23.0        17
2.0         16
17.0        10
```

```
32.0         9
31.0         9
20.0         7
40.0         5
22.0         4
29.0         4
13.0         4
12.0         4
27.0         3
5.0          3
25.0         2
10.0         2
8.0          2
6.0          2
1.0          1
39.0         1
4.0          1
42.0         1
43.0         1
44.0         1
dtype: int64
Completed iteration 8
26.0    290080
0.0     155390
35.0     19677
15.0      9729
38.0      4838
34.0      3149
7.0       2274
21.0      2065
30.0      1464
18.0      1328
24.0      1260
33.0       911
14.0       652
19.0       363
41.0       355
11.0       149
3.0         59
37.0        53
28.0        35
36.0        31
9.0         27
16.0        23
23.0        17
2.0         16
17.0        10
32.0         9
31.0         9
20.0         7
40.0         5
22.0         4
29.0         4
13.0         4
12.0         4
27.0         3
5.0          3
25.0         2
10.0         2
8.0          2
6.0          2
1.0          1
39.0         1
4.0          1
42.0         1
43.0         1
44.0         1
dtype: int64
Completed iteration 9
26.0    290083
0.0     155235
35.0     19637
15.0      9841
38.0      4865
34.0      3195
7.0       2274
21.0      2097
30.0      1461
18.0      1338
24.0      1260
33.0       906
14.0       624
41.0       360
19.0       359
11.0       149
3.0         59
37.0        53
28.0        35
36.0        31
9.0         27
16.0        23
23.0        17
2.0         16
17.0        10
32.0         9
31.0         9
20.0         7
40.0         5
22.0         4
29.0         4
13.0         4
12.0         4
27.0         3
5.0          3
25.0         2
10.0         2
8.0          2
6.0          2
1.0          1
39.0         1
4.0          1
42.0         1
43.0         1
44.0         1
dtype: int64
Completed iteration 10
26.0    290087
0.0     155088
35.0     19420
15.0     10119
38.0      4908
34.0      3231
7.0       2274
21.0      2130
30.0      1461
18.0      1319
24.0      1260
33.0       912
14.0       620
41.0       361
19.0       345
11.0       149
3.0         59
37.0        53
28.0        35
36.0        31
9.0         27
16.0        23
23.0        17
2.0         16
17.0        10
32.0         9
31.0         9
20.0         7
40.0         5
22.0         4
29.0         4
13.0         4
12.0         4
27.0         3
5.0          3
25.0         2
10.0         2
8.0          2
6.0          2
1.0          1
39.0         1
4.0          1
42.0         1
43.0         1
44.0         1
dtype: int64
Completed iteration 11
Reached 11 iterations
Centroids:
Centroid 1: [3.99310649e+01 4.66574654e+01 4.89713904e+01 1.41854947e-04
 1.88215723e-02 0.00000000e+00 9.28505107e-04 4.25564841e-04
 1.13741876e-01 3.86877128e-05 0.00000000e+00 1.28959043e-05
 1.63649025e-02 1.99886516e-04 1.28959043e-05 2.06334468e-04
 0.00000000e+00 0.00000000e+00 3.86877128e-05 1.37623820e+02
 1.13053621e+01 5.62176119e-01 5.61816582e-01 1.81505081e-01
 1.81136838e-01 3.38425023e-01 6.35276101e-02 3.84731894e-02
 2.27794929e+02 6.02898999e+01 2.60654145e-01 8.46945605e-02
 7.26761581e-02 1.37757273e-02 5.61874033e-01 5.61489928e-01
 1.81812842e-01 1.79148548e-01 1.66163726e-02 8.63155112e-01
 1.20228515e-01 7.09274734e-05 3.22397607e-05 5.93211596e-04
 2.11492830e-03 6.83482926e-04 6.89930878e-04 8.05994016e-04
 6.25451357e-04 6.64139069e-04 7.47962447e-04 7.47962447e-04
 3.77721036e-02 7.22170639e-04 1.05875374e-02 2.41798205e-03
 6.57691117e-04 6.38347261e-04 4.29433612e-03 7.67306304e-04
 1.58684102e-02 7.54410399e-04 6.70587022e-04 1.27166512e-01
 6.38347261e-04 0.00000000e+00 7.35066543e-04 7.41514495e-04
 6.83482926e-04 6.31899309e-04 6.51243165e-04 6.57691117e-04
 6.57691117e-04 6.89930878e-04 6.31899309e-04 6.38347261e-04
 6.57691117e-04 6.89930878e-04 6.12555452e-04 6.77034974e-04
 6.96378830e-04 2.45022181e-03 3.52767461e-02 6.44795213e-06
 6.51243165e-04 1.02522439e-03 6.96378830e-04 7.14729702e-01
 6.44795213e-06 7.73754256e-04 7.15722686e-04 7.22170639e-04
 9.56231301e-03 7.09274734e-04 6.70587022e-04 6.89930878e-04
 6.70587022e-04 7.41514495e-04 1.74094708e-03 6.44795213e-06
 4.51356649e-05 1.01232848e-03 9.02713298e-05 3.46899825e-03
 6.77034974e-04 6.83482926e-04 6.83482926e-04 7.09274734e-04
 5.15836170e-05 1.73288714e-01 3.67533271e-03 6.44795213e-05
 4.55225420e-03 5.61016971e-01 4.51356649e-05 7.09274734e-05
 2.57918085e-05 2.56518880e-01 6.89930878e-04]
Centroid 2: [2.0000000e+00 6.9337564e+08 0.0000000e+00 0.0000000e+00 0.0000000e+00
 0.0000000e+00 1.0000000e+00 0.0000000e+00 0.0000000e+00 0.0000000e+00
 0.0000000e+00 0.0000000e+00 0.0000000e+00 0.0000000e+00 0.0000000e+00
 0.0000000e+00 0.0000000e+00 0.0000000e+00 0.0000000e+00 5.7000000e+01
 3.0000000e+00 7.9000000e-01 6.7000000e-01 2.1000000e-01 3.3000000e-01
 5.0000000e-02 3.9000000e-01 0.0000000e+00 2.5500000e+02 3.0000000e+00
 1.0000000e-02 9.0000000e-02 2.2000000e-01 0.0000000e+00 1.8000000e-01
 6.7000000e-01 5.0000000e-02 3.3000000e-01 0.0000000e+00 1.0000000e+00
 0.0000000e+00 0.0000000e+00 0.0000000e+00 0.0000000e+00 0.0000000e+00
 0.0000000e+00 0.0000000e+00 0.0000000e+00 0.0000000e+00 0.0000000e+00
 0.0000000e+00 0.0000000e+00 0.0000000e+00 0.0000000e+00 0.0000000e+00
 0.0000000e+00 0.0000000e+00 0.0000000e+00 1.0000000e+00 0.0000000e+00
 0.0000000e+00 0.0000000e+00 0.0000000e+00 0.0000000e+00 0.0000000e+00
 0.0000000e+00 0.0000000e+00 0.0000000e+00 0.0000000e+00 0.0000000e+00
 0.0000000e+00 0.0000000e+00 0.0000000e+00 0.0000000e+00 0.0000000e+00
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 0.0000000e+00 0.0000000e+00 0.0000000e+00 0.0000000e+00 0.0000000e+00
 0.0000000e+00 0.0000000e+00 0.0000000e+00 0.0000000e+00 0.0000000e+00
 1.0000000e+00 0.0000000e+00 0.0000000e+00 0.0000000e+00 0.0000000e+00
 0.0000000e+00 0.0000000e+00 0.0000000e+00 0.0000000e+00]
Centroid 3: [3.24312500e+02 0.00000000e+00 5.15038094e+06 0.00000000e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 1.12500000e+00
 1.12500000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 1.00000000e+00 0.00000000e+00 0.00000000e+00
 2.53125000e+01 1.33750000e+01 9.53125000e-01 1.25000000e-03
 9.37500000e-01 0.00000000e+00 4.68750000e-02 5.37500000e-02
 0.00000000e+00 0.00000000e+00 0.00000000e+00 1.00000000e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
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Centroid 4: [5.05167797e+03 5.13422649e+06 0.00000000e+00 0.00000000e+00
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 1.45762712e+00 1.69491525e-02 1.93220339e-02 0.00000000e+00
 0.00000000e+00 9.91525424e-01 1.69491525e-02 5.76271186e-02
 3.15932203e+01 3.50508475e+01 8.90847458e-01 2.33898305e-02
 9.33220339e-01 1.04406780e-01 1.08474576e-02 2.42372881e-02
 2.37288136e-03 3.38983051e-04 0.00000000e+00 1.00000000e+00
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 1.69491525e-02 9.83050847e-01 0.00000000e+00]
Centroid 5: [2.426000e+03 2.500058e+06 0.000000e+00 0.000000e+00 0.000000e+00
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Centroid 6: [6.60000000e+01 7.14666667e+02 2.38039400e+06 0.00000000e+00
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Centroid 7: [4.25000e+01 6.07000e+02 7.94316e+05 0.00000e+00 0.00000e+00 0.00000e+00
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Centroid 8: [1.43359719e-01 5.40817801e+04 8.01533026e+03 0.00000000e+00
 0.00000000e+00 0.00000000e+00 1.89270009e+00 0.00000000e+00
 9.92963940e-01 9.32717678e-01 0.00000000e+00 0.00000000e+00
 4.39753738e-04 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 3.60949868e+00
 3.85664028e+00 3.83025506e-03 4.02814424e-03 3.62313105e-02
 8.97053650e-02 9.98425682e-01 2.38786280e-03 1.11855761e-01
 2.04351803e+02 2.02315303e+02 9.78029903e-01 2.08883026e-03
 2.23834653e-02 6.20052770e-04 2.31750220e-03 2.90237467e-03
 4.77308707e-02 4.73658751e-02 0.00000000e+00 1.00000000e+00
 0.00000000e+00 8.79507476e-04 1.31926121e-03 0.00000000e+00
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 0.00000000e+00 9.61301671e-01 0.00000000e+00]
Centroid 9: [4.1000000e+01 6.0200000e+02 1.6990015e+06 0.0000000e+00 0.0000000e+00
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 3.2500000e-01 4.0000000e-02 1.0000000e-02 0.0000000e+00 0.0000000e+00
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Centroid 10: [1.44859259e+03 5.45259259e+02 1.80639370e+05 0.00000000e+00
 0.00000000e+00 0.00000000e+00 7.40740741e-02 0.00000000e+00
 9.62962963e-01 2.84444444e+01 3.70370370e-02 7.40740741e-02
 3.17407407e+01 3.70370370e-01 0.00000000e+00 2.22222222e-01
 0.00000000e+00 0.00000000e+00 0.00000000e+00 4.81481481e+00
 8.29629630e+00 0.00000000e+00 0.00000000e+00 3.70370370e-02
 3.70370370e-02 1.00000000e+00 0.00000000e+00 5.33333333e-02
 7.88518519e+01 1.85592593e+02 7.85925926e-01 1.59259259e-02
 4.96296296e-02 3.07407407e-02 2.96296296e-02 2.62962963e-02
 1.81481481e-02 3.29629630e-02 0.00000000e+00 1.00000000e+00
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 0.00000000e+00 9.62962963e-01 0.00000000e+00]
Centroid 11: [2.376000e+03 9.805000e+02 3.884161e+06 0.000000e+00 0.000000e+00
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 5.050000e-01 1.000000e-02 5.000000e-03 5.000000e-03 0.000000e+00
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Centroid 12: [3.52664430e+02 3.66429530e+02 6.67104362e+04 0.00000000e+00
 0.00000000e+00 0.00000000e+00 4.02684564e-02 6.71140940e-03
 1.00000000e+00 4.02684564e-02 1.34228188e-02 0.00000000e+00
 4.02684564e-02 2.14765101e-01 0.00000000e+00 1.34228188e-02
 0.00000000e+00 0.00000000e+00 0.00000000e+00 6.59731544e+00
 8.42953020e+00 1.34228188e-03 1.67785235e-03 0.00000000e+00
 4.02684564e-03 9.96644295e-01 6.71140940e-03 7.55033557e-02
 7.08120805e+01 2.33912752e+02 9.64966443e-01 9.93288591e-03
 8.00000000e-02 3.52348993e-02 6.71140940e-03 1.06040268e-02
 1.17449664e-02 1.01342282e-02 0.00000000e+00 1.00000000e+00
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Centroid 13: [4.250000e+01 5.157500e+02 1.512446e+06 0.000000e+00 0.000000e+00
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 2.250000e-01 2.750000e-02 1.000000e-02 5.500000e-02 0.000000e+00
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Centroid 14: [5.70000e+01 7.14000e+02 5.42367e+05 0.00000e+00 0.00000e+00 0.00000e+00
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 0.00000e+00 1.00000e+00 0.00000e+00 0.00000e+00 1.61500e+02 8.85000e+01
 3.72500e-01 2.00000e-02 7.50000e-03 1.25000e-02 5.00000e-03 0.00000e+00
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 0.00000e+00 0.00000e+00 0.00000e+00 1.00000e+00 0.00000e+00]
Centroid 15: [4.09177419e+01 2.35764516e+02 3.24204871e+04 0.00000000e+00
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 3.22580645e-03 3.38709677e-02 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 4.48225806e+00
 7.19354839e+00 4.79032258e-03 4.90322581e-03 1.93548387e-03
 3.75806452e-03 1.00000000e+00 0.00000000e+00 1.16322581e-01
 1.49175806e+02 2.46862903e+02 9.83935484e-01 1.24193548e-03
 4.92580645e-02 2.15322581e-02 3.48387097e-03 1.08064516e-03
 7.25806452e-03 8.16129032e-03 0.00000000e+00 1.00000000e+00
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 0.00000000e+00 0.00000000e+00 4.83870968e-03 0.00000000e+00
 0.00000000e+00 9.95161290e-01 0.00000000e+00]
Centroid 16: [1.35685344e+00 3.00104259e+02 3.06740379e+03 0.00000000e+00
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 9.99802352e-01 5.53414369e-03 2.27295187e-03 9.88239945e-05
 9.88239945e-04 3.65648780e-03 2.96471983e-04 2.86589584e-02
 0.00000000e+00 0.00000000e+00 3.79484139e-02 8.86974998e+00
 1.17297164e+01 1.43492440e-03 1.98833877e-03 5.56379089e-04
 3.53493428e-03 9.99215337e-01 1.31732385e-03 9.18984089e-02
 1.34688704e+02 2.37473169e+02 9.65452120e-01 3.39954541e-03
 5.21069276e-02 2.12965708e-02 1.38551240e-03 9.57604506e-04
 4.63879830e-03 6.50064236e-03 0.00000000e+00 1.00000000e+00
 0.00000000e+00 9.88239945e-05 0.00000000e+00 0.00000000e+00
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 9.88239945e-05 0.00000000e+00 1.97647989e-04 9.88239945e-05
 1.97647989e-04 9.99407056e-01 0.00000000e+00]
Centroid 17: [2.26086957e+00 2.19069557e+06 0.00000000e+00 0.00000000e+00
 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 7.39130435e-01 0.00000000e+00 0.00000000e+00 0.00000000e+00
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 1.65217391e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 9.63913043e-01 7.26086957e-02 0.00000000e+00
 1.20043478e+02 5.97391304e+01 3.08260870e-01 7.17391304e-02
 3.08260870e-01 2.69565217e-02 4.08695652e-02 0.00000000e+00
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Centroid 18: [1.494900e+03 7.058000e+02 3.496967e+05 0.000000e+00 0.000000e+00
 0.000000e+00 0.000000e+00 0.000000e+00 1.000000e+00 8.840000e+01
 1.000000e-01 2.000000e-01 9.930000e+01 0.000000e+00 0.000000e+00
 8.000000e-01 0.000000e+00 0.000000e+00 0.000000e+00 1.100000e+00
 1.100000e+00 0.000000e+00 0.000000e+00 0.000000e+00 0.000000e+00
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 2.480000e-01 1.760000e-01 7.100000e-02 6.900000e-02 3.000000e-03
 3.400000e-02 7.700000e-02 1.400000e-02 0.000000e+00 1.000000e+00
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Centroid 19: [1.04958302e+01 2.64432904e+02 1.73884792e+04 0.00000000e+00
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 9.98483700e-01 1.51630023e-02 1.51630023e-03 0.00000000e+00
 3.79075057e-03 1.66793025e-02 0.00000000e+00 7.58150114e-04
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 9.44882487e+00 3.42683851e-03 2.85064443e-03 7.58150114e-04
 1.99393480e-03 9.99620925e-01 7.58150114e-04 1.08642911e-01
 1.19498863e+02 2.45954511e+02 9.90310842e-01 9.17361638e-04
 8.53146323e-02 2.45185747e-02 4.98862775e-03 1.64518575e-03
 4.87490523e-03 8.67323730e-03 0.00000000e+00 1.00000000e+00
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 7.58150114e-04 0.00000000e+00 4.54890068e-03 1.51630023e-03
 0.00000000e+00 9.93176649e-01 0.00000000e+00]
Centroid 20: [6.13855072e+01 2.41269565e+02 4.45150232e+04 0.00000000e+00
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 1.00000000e+00 9.91304348e-01 5.79710145e-03 1.15942029e-02
 1.12753623e+00 0.00000000e+00 0.00000000e+00 1.73913043e-02
 0.00000000e+00 0.00000000e+00 0.00000000e+00 4.27826087e+00
 7.20869565e+00 4.75362319e-03 5.21739130e-03 2.00000000e-03
 4.63768116e-03 1.00000000e+00 0.00000000e+00 1.13855072e-01
 1.10214493e+02 2.45846377e+02 9.76434783e-01 4.46376812e-03
 1.00782609e-01 2.75942029e-02 6.17391304e-03 4.78260870e-03
 1.07536232e-02 1.03188406e-02 0.00000000e+00 1.00000000e+00
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 0.00000000e+00 0.00000000e+00 5.79710145e-03 0.00000000e+00
 0.00000000e+00 9.94202899e-01 0.00000000e+00]
Centroid 21: [0.00000000e+00 4.95362857e+05 0.00000000e+00 0.00000000e+00
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 1.85714286e+00 7.14285714e-02 7.14285714e-02 0.00000000e+00
 0.00000000e+00 1.00000000e+00 0.00000000e+00 0.00000000e+00
 1.31714286e+02 7.50000000e+01 3.71428571e-01 3.14285714e-02
 3.71428571e-01 1.42857143e-02 2.85714286e-03 1.00000000e-02
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 0.00000000e+00 0.00000000e+00 1.42857143e-01 0.00000000e+00
 0.00000000e+00 8.57142857e-01 0.00000000e+00]
Centroid 22: [3.34737089e+01 2.63185915e+02 1.28492455e+04 0.00000000e+00
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 0.00000000e+00 2.86384977e-02 0.00000000e+00 5.16431925e-03
 0.00000000e+00 0.00000000e+00 0.00000000e+00 7.40469484e+00
 1.04995305e+01 3.16431925e-03 3.46009390e-03 2.75586854e-03
 3.85915493e-03 9.99765258e-01 4.69483568e-04 1.05103286e-01
 1.26080282e+02 2.41513146e+02 9.92352113e-01 6.94835681e-04
 6.92394366e-02 2.24835681e-02 3.29577465e-03 1.50704225e-03
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 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 2.34741784e-03 0.00000000e+00 3.75586854e-03 0.00000000e+00
 4.69483568e-04 9.93427230e-01 0.00000000e+00]
Centroid 23: [1.25000e+00 2.50723e+05 3.41250e+02 0.00000e+00 0.00000e+00 0.00000e+00
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 0.00000e+00 0.00000e+00 0.00000e+00 0.00000e+00 0.00000e+00 0.00000e+00
 0.00000e+00 1.00000e+00 2.25000e+00 0.00000e+00 0.00000e+00 0.00000e+00
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```
Centroid 24: [0.00000000e+00 1.73920941e+05 0.00000000e+00 0.00000000e+00 ...]
Centroid 25: [1.97063492e+00 1.10804302e+04 3.07457937e+02 0.00000000e+00 ...]
Centroid 26: [4.00000e+01 6.62500e+02 8.52201e+05 0.00000e+00 0.00000e+00 0.00000e+00 ...]
Centroid 27: [7.90831716e+02 9.58034348e+02 9.38012045e+00 0.00000000e+00 ...]
Centroid 28: [2.90000000e+01 5.07333333e+02 1.13835233e+06 0.00000000e+00 ...]
Centroid 29: [3.65714286e+00 9.14642857e+00 9.93142857e+02 0.00000000e+00 ...]
Centroid 30: [2.65000000e+01 3.86000000e+02 1.00204025e+06 0.00000000e+00 ...]
Centroid 31: [6.70835729e+03 1.71562628e+02 2.16100616e+02 0.00000000e+00 ...]
Centroid 32: [1.94444444e+01 6.12000000e+02 6.58812778e+05 0.00000000e+00 ...]
Centroid 33: [2.37911111e+03 8.86333333e+02 4.56879111e+05 0.00000000e+00 ...]
Centroid 34: [5.84440789e+01 2.57132675e+02 2.43590373e+04 0.00000000e+00 ...]
Centroid 35: [4.99319096e+02 5.58787372e+02 9.16183782e+03 0.00000000e+00 ...]
Centroid 36: [6.78990731e-01 2.63962204e+02 1.32344660e+03 0.00000000e+00 ...]
Centroid 37: [1.15483871e+01 3.79451613e+02 2.63526226e+05 0.00000000e+00 ...]
Centroid 38: [1.86811321e+02 2.85207547e+02 1.13390642e+05 0.00000000e+00 ...]
Centroid 39: [1.86878566e+00 2.58213733e+02 5.91128688e+03 0.00000000e+00 ...]
Centroid 40: [5.300000e+01 5.610000e+02 1.886788e+06 0.000000e+00 0.000000e+00 ...]
Centroid 41: [3.2400000e+01 4.3600000e+02 1.3693628e+06 0.0000000e+00 0.0000000e+00 ...]
Centroid 42: [1.93778753e+04 1.96523546e+02 3.77476454e+02 0.00000000e+00 ...]
Centroid 43: [1.4400e+02 7.1524e+05 2.1580e+05 0.0000e+00 0.0000e+00 0.0000e+00 ...]
Centroid 44: [1.070000e+02 5.850000e+02 2.661600e+06 0.000000e+00 0.000000e+00 ...]
Centroid 45: [1.100000e+02 6.490000e+02 2.527504e+06 0.000000e+00 0.000000e+00 ...]
 0.000000e+00 0.000000e+00 0.000000e+00 0.000000e+00 0.000000e+00
 0.000000e+00 0.000000e+00 1.000000e+00 0.000000e+00]
```

Spectral

Functions

```python
def get_similarity_matrix(data, affinity, gamma=1.0):
    if affinity == "additive_chi2":
        return additive_chi2_kernel(data, data)
    elif affinity == "chi2":
        return chi2_kernel(data, data, gamma=gamma)
    elif affinity == "cosine_similarity":
        return cosine_similarity(data, data)
    elif affinity == "laplacian":
        return laplacian_kernel(data, data, gamma=gamma)
    elif affinity == "linear":
        return linear_kernel(data, data)
    elif affinity == "poly":
        return polynomial_kernel(data, data, gamma=gamma)
    elif affinity == "rbf":
        return rbf_kernel(data, data, gamma=gamma)
    elif affinity == "sigmoid":
        return sigmoid_kernel(data, data, gamma=gamma)
    else:
        print(f"Error, unknown similarity matrix '{affinity}'.")
```

```python
def spectral_clustering(
    data, cuts=23, fname="label_encoded_spectral_clustering", affinity="rbf", gamma=1.0
):
    similarity_matrix = get_similarity_matrix(data, affinity, gamma)
    degree_matrix = jnp.diag(jnp.sum(similarity_matrix, axis=1))
    laplace_matrix = degree_matrix - similarity_matrix
    asymmetric_laplacian_matrix = jnp.dot(jnp.linalg.inv(degree_matrix), laplace_matrix)
    u, s, vh = jnp.linalg.svd(asymmetric_laplacian_matrix)
    eigenvalues = np.array((s**2)[-cuts:])
    eigenvectors = np.array((vh.T)[:, -cuts:])
    print(f"eigenvalues: {eigenvalues}.")
    row_norm = np.linalg.norm(eigenvectors, axis=1)
    row_norm[row_norm == 0] = np.finfo(float).eps  # epsilon to avoid dividing by 0
    normalized_eigenvectors = (eigenvectors.T / row_norm).T
    mu_t, C = k_means(
        normalized_eigenvectors,
        cuts,
        0.01,
        max_iterations=20,
        fname=f"{fname}_{affinity}_{gamma}",
    )
    print("Centroids:")
    for i in range(cuts):
        print(f"Centroid {i+1}: {mu_t[i]}")
```

label encoded run

```
eigenvalues: [9.9994218e-01 9.9993670e-01 9.9993050e-01 9.9992669e-01 9.9992478e-01
 9.9991786e-01 9.9990880e-01 9.9990809e-01 9.9989295e-01 9.9989140e-01
 9.9988294e-01 9.9987543e-01 9.9986076e-01 9.9985075e-01 9.9984241e-01
 9.9981344e-01 9.9978900e-01 9.9978054e-01 9.9957687e-01 9.9945992e-01
 9.9930036e-01 9.9831045e-01 4.1195020e-13].
Finished running k-means++
2.0     6179
0.0      871
13.0     684
8.0      490
1.0      463
15.0     462
11.0     415
17.0     327
4.0      294
9.0      288
21.0     286
3.0      247
20.0     233
10.0     216
7.0      200
22.0     181
12.0     155
19.0     137
5.0      100
16.0      93
14.0      16
18.0       8
6.0        5
dtype: int64
Completed iteration 1
2.0     5711
0.0      874
13.0     758
1.0      489
15.0     474
8.0      414
3.0      391
11.0     376
21.0     369
10.0     305
17.0     300
9.0      297
4.0      288
22.0     255
20.0     245
7.0      192
12.0     167
19.0     144
16.0     118
5.0      104
14.0      59
18.0      14
6.0        6
dtype: int64
Completed iteration 2
2.0     5688
0.0      825
13.0     780
15.0     458
3.0      450
1.0      444
21.0     393
8.0      385
11.0     350
10.0     323
17.0     290
4.0      289
9.0      285
22.0     274
20.0     251
7.0      188
12.0     177
19.0     142
5.0      118
16.0     104
14.0     101
18.0      27
6.0        8
dtype: int64
Completed iteration 3
2.0     5685
0.0      789
13.0     782
3.0      469
15.0     455
1.0      419
21.0     403
8.0      360
10.0     336
11.0     315
4.0      288
17.0     281
9.0      279
22.0     269
20.0     244
7.0      188
12.0     186
14.0     142
19.0     142
5.0      140
16.0      93
18.0      71
6.0       14
dtype: int64
Completed iteration 4
2.0     5680
13.0     768
0.0      762
3.0      463
15.0     454
21.0     418
1.0      397
8.0      352
10.0     334
11.0     292
4.0      286
9.0      276
17.0     264
22.0     263
20.0     246
7.0      186
14.0     182
12.0     178
5.0      154
19.0     142
18.0     131
16.0      92
6.0       30
dtype: int64
Completed iteration 5
2.0     5676
13.0     761
0.0      741
15.0     458
3.0      450
21.0     420
1.0      389
8.0      339
10.0     334
11.0     284
4.0      284
9.0      274
17.0     260
22.0     258
20.0     244
14.0     203
7.0      185
12.0     181
5.0      165
18.0     154
19.0     138
16.0      94
6.0       58
dtype: int64
Completed iteration 6
2.0     5672
13.0     755
0.0      722
15.0     461
3.0      426
21.0     410
1.0      395
8.0      347
10.0     332
22.0     288
4.0      284
9.0      275
11.0     272
17.0     255
20.0     239
14.0     208
7.0      186
12.0     170
5.0      168
18.0     165
19.0     139
16.0      93
6.0       88
dtype: int64
Completed iteration 7
2.0     5672
13.0     755
0.0      707
15.0     454
3.0      424
21.0     403
1.0      390
8.0      366
10.0     336
22.0     307
4.0      283
9.0      270
11.0     261
17.0     252
20.0     237
14.0     206
7.0      186
5.0      170
18.0     161
12.0     154
19.0     139
6.0      123
16.0      94
dtype: int64
Completed iteration 8
2.0     5672
13.0     752
0.0      699
15.0     450
3.0      420
8.0      406
1.0      395
21.0     393
10.0     329
22.0     312
4.0      279
9.0      273
11.0     259
17.0     252
20.0     235
14.0     205
7.0      186
5.0      171
18.0     161
6.0      146
19.0     137
12.0     122
16.0      96
dtype: int64
Completed iteration 9
2.0     5669
13.0     759
0.0      691
15.0     450
3.0      416
8.0      409
1.0      392
21.0     386
10.0     326
22.0     305
9.0      276
4.0      271
11.0     259
17.0     248
20.0     236
14.0     202
7.0      186
6.0      177
5.0      171
18.0     159
19.0     137
12.0     133
16.0      92
dtype: int64
Completed iteration 10
2.0     5670
13.0     765
0.0      680
15.0     441
3.0      423
8.0      423
1.0      393
21.0     376
10.0     323
22.0     308
9.0      281
4.0      270
11.0     258
17.0     248
20.0     236
14.0     203
6.0      187
7.0      186
5.0      171
18.0     156
19.0     137
12.0     124
16.0      91
dtype: int64
Completed iteration 11
2.0     5673
13.0     765
0.0      673
15.0     441
8.0      436
3.0      427
1.0      390
21.0     360
10.0     325
22.0     311
9.0      282
4.0      269
11.0     260
17.0     249
20.0     236
14.0     205
6.0      194
7.0      186
5.0      171
18.0     155
19.0     137
12.0     115
16.0      90
dtype: int64
Completed iteration 12
2.0     5676
13.0     763
0.0      670
15.0     450
8.0      444
3.0      432
1.0      395
21.0     341
10.0     323
22.0     313
9.0      280
4.0      269
11.0     260
17.0     249
20.0     237
14.0     203
6.0      196
7.0      186
5.0      171
18.0     153
19.0     137
12.0     112
16.0      90
dtype: int64
Completed iteration 13
2.0     5675
13.0     763
0.0      645
3.0      459
15.0     457
8.0      451
1.0      400
21.0     325
10.0     316
22.0     315
9.0      281
4.0      269
11.0     258
17.0     247
20.0     239
14.0     201
6.0      198
7.0      186
5.0      172
18.0     153
19.0     137
12.0     113
16.0      90
dtype: int64
Completed iteration 14
2.0     5675
13.0     762
0.0      613
3.0      493
15.0     466
8.0      454
1.0      399
22.0     320
10.0     311
21.0     311
9.0      283
4.0      269
11.0     255
17.0     246
20.0     238
6.0      203
14.0     200
7.0      186
5.0      172
18.0     153
19.0     137
12.0     114
16.0      90
dtype: int64
Completed iteration 15
2.0     5676
13.0     761
0.0      597
3.0      509
15.0     466
8.0      454
1.0      401
22.0     322
10.0     305
21.0     304
9.0      283
4.0      269
11.0     254
17.0     246
20.0     236
6.0      204
14.0     204
7.0      186
5.0      174
18.0     153
19.0     138
12.0     117
16.0      91
dtype: int64
Completed iteration 16
2.0     5681
13.0     759
0.0      592
3.0      510
15.0     468
8.0      454
1.0      402
22.0     320
10.0     303
21.0     297
9.0      285
4.0      269
11.0     254
17.0     246
20.0     236
6.0      208
14.0     207
7.0      186
5.0      173
18.0     152
19.0     138
12.0     117
16.0      93
dtype: int64
Completed iteration 17
2.0     5684
13.0     760
0.0      591
3.0      510
15.0     467
8.0      454
1.0      404
22.0     319
10.0     296
21.0     293
9.0      292
4.0      269
11.0     253
17.0     246
20.0     235
14.0     210
6.0      208
7.0      186
5.0      172
18.0     152
19.0     138
12.0     117
16.0      94
dtype: int64
Completed iteration 18
2.0     5687
13.0     759
0.0      592
3.0      505
15.0     468
8.0      454
1.0      406
22.0     318
9.0      300
10.0     291
21.0     285
4.0      269
11.0     253
17.0     247
20.0     235
14.0     212
6.0      210
7.0      186
5.0      172
18.0     149
19.0     138
12.0     118
16.0      96
dtype: int64
Completed iteration 19
2.0     5690
13.0     757
0.0      588
3.0      502
15.0     468
8.0      454
1.0      407
22.0     316
9.0      304
10.0     290
21.0     284
4.0      270
11.0     252
17.0     249
20.0     235
14.0     213
6.0      210
7.0      186
5.0      172
18.0     147
19.0     138
12.0     120
16.0      98
dtype: int64
Completed iteration 20
2.0     5691
13.0     756
0.0      583
3.0      505
15.0     468
8.0      454
1.0      407
22.0     316
9.0      308
21.0     285
10.0     284
4.0      270
11.0     252
17.0     249
20.0     234
14.0     213
6.0      212
7.0      186
5.0      172
18.0     146
19.0     138
12.0     120
16.0     101
dtype: int64
Completed iteration 21
Reached 21 iterations
Centroids:
Centroid 1: [ 0.28514713 -0.18069117 -0.15389861 -0.08750899  0.11163341  0.17381547
 -0.02895392  0.17345738  0.10964786  0.23656648 -0.14085485  0.05136389
  0.03091529  0.10472327 -0.03802721  0.23230593 -0.01771987 -0.03319596
 -0.04966518 -0.09205013 -0.12191413 -0.03971363 -0.5011531 ]
Centroid 2: [ 0.07542242 -0.01711862  0.07386716 -0.04943624 -0.0487682   0.26643774
  0.05274289 -0.029153    0.06344163 -0.08164991  0.10519463 -0.16997477
  0.00688508 -0.06690391 -0.01697146 -0.24593201 -0.13219447  0.00787737
  0.3079539   0.02293106  0.11792402  0.00543383 -0.5123373 ]
Centroid 3: [-2.1530056e-02 -2.2431277e-03 -2.8056839e-02  2.2227917e-02
  1.2964101e-02  5.8800310e-02  9.9987099e-03 -2.4562951e-02
 -6.1562996e-02  6.8002203e-03 -1.7578980e-02 -2.3856154e-02
 -1.7898456e-03 -3.8780421e-02 -6.8707205e-04 -5.6268167e-02
  1.4375560e-02  1.6735668e-03 -5.8197412e-03 -7.6546587e-02
  8.5550502e-02  4.2461712e-02 -9.7630543e-01]
Centroid 4: [ 0.19097781 -0.15880136  0.06272624  0.11724388  0.08644132  0.08243783
  0.03109437  0.01033783 -0.04894367  0.25957444 -0.22463274 -0.10195479
  0.00797447  0.09911811  0.01037801 -0.10115594 -0.10918856 -0.03381241
  0.04690276 -0.01956131  0.04546812 -0.02023405 -0.56236154]
Centroid 5: [-0.04262105  0.04116641  0.5312512   0.07179745 -0.34092274  0.1605547
 -0.02981906  0.06809829  0.30197477  0.0498917   0.00117458 -0.00149445
 -0.0767061   0.10983924 -0.01052236  0.0949542   0.45960587  0.0122174
  0.15565613  0.06724001 -0.14246851 -0.03189332 -0.2658933 ]
Centroid 6: [-0.07338633 -0.02396343 -0.09685034 -0.00094368  0.02389873  0.02427353
  0.01302105  0.01601106  0.01703625 -0.01013107 -0.00455397 -0.00605435
 -0.01688276  0.02261023 -0.5300666   0.02070287  0.07508828 -0.00952524
 -0.04131122  0.02588775  0.02613541 -0.41039455 -0.24369386]
Centroid 7: [-2.9804683e-04  2.1655701e-01  1.4054295e-01  1.0528839e-01
  1.7369764e-01 -8.4174208e-02 -4.3156110e-02 -4.6682741e-02
 -1.5236038e-01  7.8716977e-03  3.2640658e-02  6.7810394e-02
  2.3365375e-02  3.1358562e-02  2.6678776e-02  1.0599695e-01
  3.6216587e-02 -4.6811411e-03 -2.6531193e-01  4.1361749e-02
 -4.9114559e-02  5.3354674e-03 -4.1277385e-01]
Centroid 8: [ 0.23356634 -0.13485576 -0.08041141 -0.02400908 -0.02025606  0.08915251
 -0.12065948  0.19951138  0.13336687  0.3822594  -0.22019279 -0.050151
 -0.08247543 -0.42914578 -0.02653076 -0.12973742 -0.37282878 -0.00703931
  0.0417752   0.04493316  0.07805625 -0.09871048 -0.2517448 ]
Centroid 9: [ 0.05057345 -0.01171496 -0.2286528  -0.1314666   0.3684326  -0.4045681
 -0.04188097 -0.00133054  0.1334635  -0.06332856  0.11989358  0.14840367
  0.02691648  0.3136311   0.06435081  0.1449818   0.05755914 -0.07363793
  0.04446456  0.111641   -0.3320632  -0.06940798 -0.4994556 ]
Centroid 10: [-0.1543499  -0.05776308 -0.04679297  0.00841805  0.03254462  0.25669464
  0.04093575 -0.04832078 -0.05348705 -0.00777331 -0.01831598 -0.29155782
  0.03683439 -0.03166247  0.47002292 -0.11445013  0.02564558  0.02232456
  0.03372225 -0.14880446  0.05590301  0.08772686 -0.30480263]
Centroid 11: [ 0.07209245 -0.05465394  0.18038726 -0.04251322 -0.07409994 -0.27788824
  0.01420565  0.07397801  0.02955782  0.01736979 -0.01884975 -0.12571846
  0.00787193 -0.045009    0.45710626 -0.05780606 -0.0966194  -0.00057938
  0.03611253 -0.04616335  0.05269744  0.05212092 -0.32581672]
Centroid 12: [-0.20582412  0.01969107 -0.24350633 -0.11729282 -0.04937524 -0.16238537
 -0.06482883 -0.21541606 -0.05002507 -0.2124851   0.18960518  0.01739996
 -0.01450436  0.00149936  0.00342195  0.06876671 -0.3920037  -0.01714311
 -0.24991307  0.24957816 -0.1911456  -0.07162721 -0.32397547]
Centroid 13: [ 0.05016219 -0.13975972  0.03170668 -0.17024142  0.03004329 -0.13980404
 -0.05841266  0.17662254  0.16560006  0.01388178  0.04430504  0.05994169
 -0.01435559  0.27590364  0.10109791  0.16288209  0.1357151  -0.02612073
  0.1343579   0.20671819 -0.30686823  0.04372491 -0.4480096 ]
Centroid 14: [-0.02388059  0.17674217 -0.10024931 -0.24468245 -0.0503551   0.10285546
 -0.07437991 -0.00831735  0.01707725 -0.2452222   0.3656722   0.07068284
 -0.02575306 -0.04321397  0.03755373  0.11641432  0.06421235  0.02926037
 -0.14379121  0.04204467 -0.04512832 -0.00612505 -0.49880648]
Centroid 15: [-1.2282205e-01  1.9539770e-02 -2.5289157e-01  8.3675474e-02
  4.9444921e-02  2.1592598e-01  2.6705697e-02 -8.5990369e-02
  1.2316432e-01  5.2639835e-02  7.5295987e-03 -3.1657722e-03
 -2.4002519e-02 -3.4974277e-04  1.6539161e-01  1.8027675e-01
  2.9655688e-02 -1.8006140e-02 -1.8442532e-01  2.4769746e-01
 -6.1816402e-02  2.2085387e-02 -3.8004264e-01]
Centroid 16: [-3.3389288e-01 -6.2568098e-02  1.1294897e-01  2.2202961e-01
 -1.0224666e-01 -3.1062722e-01  9.9134669e-02 -2.0604135e-01
 -3.6176495e-02  6.1906245e-02 -1.7770971e-01 -7.1242474e-02
  4.4997782e-03 -1.2264980e-01  3.6610294e-02 -1.7323154e-01
  3.5389658e-04  4.0388383e-02  3.3675119e-02  4.6385046e-02
  4.2742290e-02 -1.2971330e-03 -4.6886235e-01]
Centroid 17: [ 0.40946096  0.00983919 -0.10657371  0.1261531  -0.21280025  0.02097956
 -0.1769386  -0.0740561  -0.03650018 -0.03426474 -0.06633473 -0.10944712
 -0.04004095 -0.07159109 -0.01209199 -0.04068398 -0.01361112 -0.02164477
 -0.0208965  -0.09035768 -0.013952   -0.0662789  -0.3996005 ]
Centroid 18: [ 0.01230301  0.04765417 -0.0703303   0.09893849  0.02688508  0.12673627
 -0.01073722 -0.01730864 -0.02333301  0.02512586 -0.03699141  0.22850597
  0.00806007  0.04089789 -0.49131045 -0.04142559  0.02654755  0.01335175
 -0.00813899  0.04128082 -0.02625514  0.44749084 -0.26700088]
Centroid 19: [ 0.16673192  0.03535646  0.17890634 -0.14452231 -0.09192736 -0.36797217
 -0.01364722  0.12969913  0.13451947 -0.05818357  0.12022495  0.21058823
  0.00483183  0.0466714  -0.21504427  0.07140646 -0.06629178 -0.00828703
  0.0251275   0.18805796 -0.16056989 -0.02135487 -0.24561161]
Centroid 20: [ 0.16150542 -0.07226415 -0.208179   -0.06333136 -0.08024096 -0.2270519
  0.1756878   0.0410895  -0.5067146  -0.2764345   0.03230367  0.15256894
 -0.04947916  0.34536618  0.06999779  0.08272529 -0.10325205  0.00594254
 -0.15656705  0.09253323 -0.1191536  -0.03463995 -0.25109625]
Centroid 21: [-0.02888228 -0.01709936  0.09336176  0.08635551 -0.01428635  0.02415105
  0.02159725 -0.03541176 -0.14495422 -0.01301219 -0.09227767  0.08241975
 -0.00926112 -0.01062032 -0.4728939  -0.20437434 -0.0595029   0.01859338
  0.13031669 -0.28233474  0.10201204 -0.12115817 -0.34293324]
Centroid 22: [ 0.15833212  0.24193738  0.16255605 -0.0145309   0.12282783  0.06732632
  0.08370266 -0.06558172 -0.17760846 -0.01546581  0.16035518 -0.02344106
 -0.02071624 -0.04383478  0.06049037 -0.23061872  0.11380862  0.0223012
  0.14979172  0.02631115  0.11836152 -0.0011     -0.6047031 ]
Centroid 23: [-0.35720044  0.04740158 -0.02862477  0.05151265 -0.1274586  -0.31439453
  0.11885796 -0.06078839 -0.07651099  0.01940922 -0.0675519   0.20216587
 -0.03994173  0.01752728  0.06282159  0.16577998  0.15328535  0.05645141
 -0.15771164 -0.05465448 -0.02079011  0.02350913 -0.49256366]
```

In [ ]:

```
spectral_clustering(
    le_X_train025,
    cuts=len(np.unique(le_y_train025)),
    fname="label_encoded_spectral_clustering",
    affinity="additive_chi2",
)
```

```
eigenvalues: [9.9989295e-01 9.9989140e-01 9.9988294e-01 9.9987543e-01 9.9986076e-01
 9.9985075e-01 9.9984241e-01 9.9981344e-01 9.9978900e-01 9.9978054e-01
 9.9957687e-01 9.9945992e-01 9.9930036e-01 9.9831045e-01 4.1195020e-13].
Finished running k-means++
6.0     7023
0.0     1224
9.0      849
4.0      632
11.0     519
13.0     426
10.0     415
7.0      261
2.0      249
1.0      210
8.0      210
12.0     197
5.0       93
3.0       22
14.0      20
dtype: int64
Completed iteration 1
6.0     6161
4.0     1083
9.0      970
11.0     700
0.0      673
13.0     555
12.0     435
10.0     423
7.0      315
2.0      293
1.0      272
8.0      244
5.0       85
14.0      75
3.0       66
dtype: int64
Completed iteration 2
6.0     6039
4.0      961
9.0      929
0.0      744
11.0     658
13.0     541
12.0     439
10.0     413
7.0      385
2.0      352
1.0      315
8.0      256
14.0     147
3.0       90
5.0       81
dtype: int64
Completed iteration 3
6.0     5969
4.0      890
9.0      864
0.0      776
11.0     575
13.0     503
12.0     485
7.0      474
2.0      416
10.0     400
1.0      320
8.0      261
14.0     227
3.0      105
5.0       85
dtype: int64
Completed iteration 4
6.0     5916
4.0      859
0.0      800
9.0      785
11.0     521
7.0      512
12.0     506
13.0     491
2.0      483
10.0     395
1.0      312
14.0     312
8.0      264
3.0      108
```

```
5.0      86
dtype: int64
Completed iteration 5
6.0     5891
4.0      843
0.0      798
9.0      749
7.0      527
12.0     513
2.0      510
13.0     495
11.0     489
10.0     407
14.0     357
1.0      305
8.0      272
3.0      106
5.0       88
dtype: int64
Completed iteration 6
6.0     5870
4.0      836
0.0      794
9.0      742
2.0      541
7.0      522
12.0     516
13.0     495
11.0     471
10.0     418
14.0     378
1.0      294
8.0      279
3.0      104
5.0       90
dtype: int64
Completed iteration 7
6.0     5843
4.0      829
0.0      791
9.0      730
2.0      575
7.0      520
12.0     514
13.0     493
11.0     449
10.0     439
14.0     401
8.0      288
1.0      280
3.0      105
5.0       93
dtype: int64
Completed iteration 8
6.0     5829
4.0      826
0.0      790
9.0      716
2.0      587
12.0     515
7.0      510
13.0     495
10.0     476
11.0     429
14.0     413
8.0      291
1.0      272
3.0      105
5.0       96
dtype: int64
Completed iteration 9
6.0     5816
4.0      826
0.0      792
9.0      697
2.0      587
10.0     512
12.0     512
7.0      510
13.0     495
14.0     429
11.0     412
8.0      291
1.0      270
3.0      103
5.0       98
```

```
dtype: int64
Completed iteration 10
6.0     5805
4.0      828
0.0      792
9.0      665
2.0      566
10.0     545
7.0      520
12.0     512
13.0     499
14.0     453
11.0     401
8.0      293
1.0      265
3.0      103
5.0      103
dtype: int64
Completed iteration 11
6.0     5786
4.0      837
0.0      794
9.0      613
10.0     580
2.0      559
7.0      516
12.0     515
13.0     505
14.0     491
11.0     390
8.0      290
1.0      261
5.0      108
3.0      105
dtype: int64
Completed iteration 12
6.0     5770
4.0      849
0.0      784
10.0     606
9.0      605
2.0      566
13.0     517
12.0     509
7.0      505
14.0     483
11.0     381
8.0      286
1.0      257
5.0      121
3.0      111
dtype: int64
Completed iteration 13
6.0     5762
4.0      857
0.0      773
9.0      617
10.0     612
2.0      574
13.0     527
12.0     505
7.0      495
14.0     470
11.0     366
8.0      280
1.0      253
5.0      144
3.0      115
dtype: int64
Completed iteration 14
6.0     5756
4.0      863
0.0      764
9.0      628
10.0     616
2.0      575
13.0     531
12.0     503
7.0      493
14.0     454
11.0     357
8.0      267
1.0      249
5.0      179
3.0      115
dtype: int64
```

```
Completed iteration 15
6.0     5754
4.0      866
0.0      762
9.0      632
10.0     616
2.0      573
13.0     536
12.0     499
7.0      490
14.0     439
11.0     350
8.0      267
1.0      243
5.0      209
3.0      114
dtype: int64
Completed iteration 16
6.0     5751
4.0      867
0.0      761
9.0      638
10.0     616
2.0      563
13.0     539
12.0     496
7.0      486
14.0     431
11.0     348
8.0      269
1.0      240
5.0      229
3.0      116
dtype: int64
Completed iteration 17
6.0     5752
4.0      866
0.0      759
9.0      638
10.0     615
2.0      557
13.0     541
12.0     490
7.0      484
14.0     425
11.0     348
8.0      274
5.0      246
1.0      235
3.0      120
dtype: int64
Completed iteration 18
6.0     5752
4.0      864
0.0      760
9.0      641
10.0     614
2.0      551
13.0     543
12.0     485
7.0      483
14.0     419
11.0     348
8.0      276
5.0      257
1.0      235
3.0      122
dtype: int64
Completed iteration 19
6.0     5752
4.0      865
0.0      760
9.0      644
10.0     615
2.0      550
13.0     541
12.0     482
7.0      480
14.0     413
11.0     346
8.0      283
5.0      264
1.0      234
3.0      121
dtype: int64
Completed iteration 20
```

```
6.0     5752
4.0      869
0.0      760
9.0      646
10.0     614
2.0      550
13.0     541
12.0     480
7.0      479
14.0     407
11.0     345
8.0      283
5.0      269
1.0      236
3.0      119
dtype: int64
Completed iteration 21
Reached 21 iterations
Centroids:
Centroid 1: [ 0.05547455  0.27378738 -0.19709216  0.13541356  0.01787536  0.11522041
  0.00291053  0.30109546  0.0561123  -0.01125744 -0.1414224  -0.07112274
 -0.1360056  -0.02529034 -0.6079219 ]
Centroid 2: [-0.02187854  0.02917358 -0.03245586  0.30135676  0.0045855   0.04000616
 -0.61333185 -0.05460232  0.01590568  0.01271162 -0.00130555  0.05942523
 -0.02645708  0.4317698  -0.31992242]
Centroid 3: [-0.2241525   0.00316806 -0.00165121  0.03340722 -0.02325301 -0.13049476
  0.05390043 -0.25914595  0.16066049  0.03872783  0.09097803  0.0312052
  0.17901646  0.01773887 -0.6955883 ]
Centroid 4: [ 0.06798826  0.02752126  0.0225045   0.05800094  0.01822501  0.02816764
  0.16502559 -0.0022322  -0.02958119 -0.0031442  -0.06314334  0.06807132
 -0.08377533  0.6672014  -0.28870603]
Centroid 5: [ 0.2600728  -0.02910638  0.09551259  0.11812797 -0.01355707  0.30301437
  0.05024161  0.17188402  0.25669733 -0.04640679  0.12059606  0.14249471
 -0.3447579  -0.06297918 -0.5329336 ]
Centroid 6: [ 0.04321339 -0.01960499  0.01104218  0.02848968 -0.01628996  0.0312911
 -0.550443    0.03384899  0.0388132  -0.02286614 -0.04187242  0.08049693
 -0.00273016 -0.35439622 -0.34054524]
Centroid 7: [-0.06119025  0.0071822  -0.01898504 -0.02486701 -0.00154632 -0.03912511
 -0.00106541 -0.05561407  0.01384898  0.0012461  -0.00655354 -0.07756451
  0.08405071  0.04203648 -0.98077226]
Centroid 8: [ 1.2904124e-01 -7.5219981e-02  9.6123815e-02 -2.2058032e-01
  5.0106563e-04 -6.3738711e-02 -1.7710432e-02 -2.7171490e-01
 -1.4052877e-01  1.2650718e-02  3.4457073e-01  5.8882743e-02
  7.4734382e-02 -4.3446943e-03 -6.1673486e-01]
Centroid 9: [-0.18429615 -0.02931456 -0.08526613  0.04620909  0.00417531 -0.0204008
 -0.4259438  -0.22295183 -0.0553491   0.01662172  0.15670073 -0.37818384
  0.13343549 -0.13414179 -0.39491126]
Centroid 10: [-0.22370072 -0.23206294  0.15491529  0.13860683 -0.02203809  0.02053576
  0.07937287  0.15913543  0.07503178  0.01581524 -0.34695482  0.13477099
 -0.04651099 -0.016811   -0.5106217 ]
Centroid 11: [-0.02487226  0.02083351 -0.02842904 -0.27569225  0.02513787 -0.05145758
  0.56073505 -0.09373589 -0.03029115  0.02911879  0.03805726 -0.11705206
  0.0662678   0.03751553 -0.38983607]
Centroid 12: [ 0.11688399  0.33371106 -0.2537976  -0.11200262 -0.0514884  -0.37122816
 -0.03495626 -0.17912257 -0.32615513 -0.00742296 -0.01096971  0.05066043
  0.05787081 -0.07006042 -0.43009108]
Centroid 13: [-0.05212009  0.31253752 -0.32411152 -0.10397045 -0.01312783  0.16826703
  0.03144068 -0.10259642 -0.08239416 -0.0242653   0.13131791 -0.04514756
  0.05966106 -0.01605783 -0.6570604 ]
Centroid 14: [ 0.10693272 -0.27697024  0.49134237  0.06986236 -0.0409622   0.02078462
  0.03345255  0.13247308  0.03341002  0.04015931 -0.02601064 -0.0063438
 -0.09408318 -0.00334646 -0.5934533 ]
Centroid 15: [ 0.02160918 -0.15469772  0.18428317  0.00666924  0.00856497 -0.01270393
  0.02190612  0.07885531 -0.39817655 -0.02097904 -0.2654244   0.30440494
 -0.21883559 -0.0740258  -0.42534265]
```

chi2 (gamma=1.0)

In [ ]:
```python
spectral_clustering(
    le_X_train025,
    cuts=23,
    fname="label_encoded_spectral_clustering",
    affinity="chi2",
    gamma=1.0,
)
```

```
eigenvalues: [2.6221762e-19 2.4052815e-19 2.2685185e-19 1.3915577e-19 9.3171291e-20
 3.4807156e-20 2.3142795e-20 2.1908691e-20 1.9799733e-20 1.1253153e-20
 9.7675304e-21 5.5794883e-21 1.3039654e-21 1.9227013e-23 1.6587635e-23
 1.9446219e-26 8.0945478e-28 4.7445640e-28 2.4413591e-31 1.1103889e-41
 5.2969082e-43 0.0000000e+00 0.0000000e+00].
Finished running k-means++
0.0     5394
8.0     1764
12.0     801
4.0      534
3.0      514
13.0     420
10.0     373
6.0      275
2.0      235
20.0     233
5.0      218
16.0     206
22.0     206
7.0      175
15.0     138
21.0     134
9.0      129
18.0     111
11.0     108
17.0     105
1.0       98
14.0      95
19.0      84
dtype: int64
Completed iteration 1
0.0     5255
8.0     1672
12.0     742
4.0      573
3.0      393
13.0     367
10.0     341
5.0      333
6.0      309
20.0     272
15.0     232
22.0     222
2.0      218
7.0      193
19.0     182
16.0     174
9.0      166
18.0     135
1.0      124
21.0     118
11.0     118
17.0     114
14.0      97
dtype: int64
Completed iteration 2
0.0     5234
8.0     1647
12.0     681
4.0      566
10.0     393
3.0      385
5.0      336
13.0     329
6.0      324
20.0     255
22.0     248
2.0      229
15.0     226
19.0     206
7.0      199
9.0      168
16.0     159
18.0     152
1.0      139
11.0     134
17.0     118
21.0     118
14.0     104
dtype: int64
Completed iteration 3
0.0     5233
8.0     1637
12.0     658
4.0      554
10.0     402
```

```
3.0      386
5.0      349
6.0      332
13.0     306
22.0     256
20.0     245
2.0      242
15.0     215
7.0      200
19.0     194
18.0     174
16.0     162
1.0      155
9.0      144
11.0     141
17.0     124
21.0     124
14.0     117
dtype: int64
Completed iteration 4
0.0     5229
8.0     1632
12.0     637
4.0      555
10.0     421
3.0      387
5.0      346
6.0      333
13.0     305
22.0     259
2.0      243
20.0     237
7.0      212
15.0     206
18.0     201
1.0      171
19.0     170
16.0     162
11.0     144
9.0      138
21.0     123
17.0     122
14.0     117
dtype: int64
Completed iteration 5
0.0     5226
8.0     1632
12.0     623
4.0      555
10.0     425
3.0      390
5.0      345
6.0      337
13.0     301
22.0     256
2.0      244
20.0     232
7.0      214
18.0     208
15.0     201
1.0      177
19.0     165
16.0     157
11.0     149
9.0      139
21.0     127
17.0     125
14.0     122
dtype: int64
Completed iteration 6
0.0     5229
8.0     1633
12.0     615
4.0      554
10.0     423
3.0      395
5.0      342
6.0      340
13.0     294
22.0     253
2.0      245
20.0     230
7.0      214
18.0     212
15.0     204
1.0      175
```

```
19.0     161
16.0     156
11.0     154
9.0      139
17.0     131
21.0     131
14.0     120
dtype: int64
Completed iteration 7
0.0     5229
8.0     1631
12.0     612
4.0      555
10.0     420
3.0      396
5.0      342
6.0      341
13.0     289
22.0     253
2.0      247
20.0     228
7.0      215
15.0     210
18.0     208
1.0      182
19.0     161
16.0     154
11.0     153
9.0      142
21.0     134
17.0     127
14.0     121
dtype: int64
Completed iteration 8
0.0     5227
8.0     1629
12.0     610
4.0      554
10.0     424
3.0      397
6.0      342
5.0      338
13.0     285
22.0     252
2.0      246
20.0     228
15.0     218
18.0     212
7.0      210
1.0      183
19.0     162
16.0     151
11.0     148
9.0      144
21.0     138
17.0     127
14.0     125
dtype: int64
Completed iteration 9
0.0     5223
8.0     1625
12.0     610
4.0      554
10.0     425
3.0      396
5.0      344
6.0      344
13.0     289
22.0     250
2.0      246
20.0     228
15.0     215
18.0     214
7.0      211
1.0      186
19.0     162
16.0     147
11.0     146
9.0      143
21.0     142
17.0     128
14.0     122
dtype: int64
Completed iteration 10
0.0     5220
8.0     1625
```

```
12.0     609
4.0      554
10.0     425
3.0      396
5.0      344
6.0      344
13.0     292
22.0     247
2.0      246
20.0     229
18.0     217
15.0     209
7.0      204
1.0      175
19.0     167
21.0     151
11.0     147
9.0      143
16.0     143
14.0     137
17.0     126
dtype: int64
Completed iteration 11
0.0     5212
8.0     1623
12.0     609
4.0      551
10.0     426
3.0      399
6.0      345
5.0      342
13.0     293
22.0     246
2.0      246
20.0     229
18.0     220
15.0     205
7.0      200
1.0      168
19.0     168
21.0     158
11.0     150
9.0      147
14.0     147
16.0     141
17.0     125
dtype: int64
Completed iteration 12
0.0     5208
8.0     1623
12.0     608
4.0      550
10.0     426
3.0      398
6.0      345
5.0      340
13.0     296
2.0      247
22.0     241
20.0     225
18.0     219
15.0     203
7.0      199
14.0     167
19.0     167
1.0      164
21.0     160
9.0      148
11.0     148
16.0     144
17.0     124
dtype: int64
Completed iteration 13
0.0     5203
8.0     1623
12.0     607
4.0      549
10.0     429
3.0      400
6.0      348
5.0      338
13.0     302
2.0      247
22.0     239
20.0     224
18.0     219
```

```
7.0      199
15.0     198
14.0     183
19.0     168
21.0     155
1.0      152
11.0     150
9.0      148
16.0     146
17.0     123
dtype: int64
Completed iteration 14
0.0     5197
8.0     1621
12.0     607
4.0      549
10.0     431
3.0      400
6.0      346
5.0      340
13.0     306
2.0      247
22.0     235
18.0     219
20.0     218
15.0     197
14.0     195
7.0      194
19.0     168
1.0      155
11.0     155
21.0     153
9.0      148
16.0     146
17.0     123
dtype: int64
Completed iteration 15
0.0     5195
8.0     1620
12.0     608
4.0      549
10.0     433
3.0      400
6.0      344
5.0      342
13.0     309
2.0      247
22.0     234
18.0     220
20.0     214
14.0     198
7.0      196
15.0     196
19.0     168
11.0     157
1.0      154
21.0     149
9.0      148
16.0     146
17.0     123
dtype: int64
Completed iteration 16
0.0     5194
8.0     1619
12.0     608
4.0      548
10.0     433
3.0      399
5.0      342
6.0      342
13.0     312
2.0      248
22.0     232
18.0     224
20.0     212
7.0      198
14.0     198
15.0     196
19.0     168
11.0     157
1.0      152
21.0     152
9.0      148
16.0     145
17.0     123
dtype: int64
```

```
Completed iteration 17
0.0     5194
8.0     1618
12.0     608
4.0      548
10.0     434
3.0      399
6.0      343
5.0      340
13.0     314
2.0      248
22.0     226
18.0     223
20.0     213
7.0      199
14.0     199
15.0     197
19.0     169
11.0     158
1.0      152
21.0     152
9.0      148
16.0     145
17.0     123
dtype: int64
Completed iteration 18
0.0     5194
8.0     1617
12.0     609
4.0      548
10.0     435
3.0      399
5.0      344
6.0      341
13.0     315
2.0      249
18.0     223
22.0     223
20.0     213
15.0     199
7.0      199
14.0     198
19.0     168
11.0     160
1.0      154
9.0      149
16.0     145
21.0     144
17.0     124
dtype: int64
Completed iteration 19
0.0     5190
8.0     1618
12.0     609
4.0      548
10.0     435
3.0      398
5.0      345
6.0      340
13.0     317
2.0      247
18.0     222
22.0     221
20.0     211
14.0     203
7.0      200
15.0     199
19.0     168
11.0     161
1.0      154
9.0      150
16.0     146
21.0     142
17.0     126
dtype: int64
Completed iteration 20
0.0     5188
8.0     1617
12.0     609
4.0      549
10.0     434
3.0      397
5.0      349
6.0      343
13.0     319
2.0      246
```

```
18.0     222
22.0     222
20.0     210
7.0      205
14.0     202
15.0     198
19.0     168
11.0     159
1.0      154
9.0      149
16.0     147
21.0     138
17.0     125
dtype: int64
Completed iteration 21
Reached 21 iterations
Centroids:
Centroid 1: [-9.5672112e-05  2.9234699e-04 -8.7734754e-04 -4.5843311e-03
  5.4007582e-04 -1.6901856e-04 -1.2832009e-03 -1.7892366e-04
 -9.7797448e-03  4.3284226e-02  4.5319038e-04 -9.6534681e-01
  6.0106424e-04 -8.4127963e-04  3.8138762e-04 -2.5280472e-04
  5.6345920e-07  1.2851717e-04  4.2688396e-05  9.9843295e-05
 -1.2940697e-04 -2.9312164e-04  2.2426045e-04]
Centroid 2: [-0.00746395  0.13787198  0.07112502  0.12746687  0.01595246  0.00698992
  0.09814245 -0.00512899 -0.07641572 -0.13468915  0.01061122 -0.05802014
  0.0035945  -0.02547408 -0.02123718 -0.05636442 -0.4502831  -0.00071794
  0.00085025 -0.00134732  0.05245461  0.02042806 -0.00274529]
Centroid 3: [ 1.7534728e-03 -1.5687590e-02  8.1750620e-03  6.3000143e-02
  6.6145128e-03 -3.8136763e-03  9.4792563e-03 -5.4352190e-03
 -1.6892207e-01 -4.5587912e-01  9.9134054e-03  6.1122859e-01
 -7.8183555e-05 -2.0103514e-02 -1.9770637e-03  8.7551754e-03
  3.0541763e-02  2.4063278e-04  2.1002344e-03  4.5479969e-03
 -5.2861456e-04 -3.6407774e-03 -3.1802258e-03]
Centroid 4: [-0.0076554  -0.10328725  0.16701369 -0.12195025 -0.17423248  0.00059175
  0.14260593 -0.12554067  0.13954702  0.09609353 -0.00468948 -0.02316858
 -0.07450651  0.4553961  -0.02837631 -0.5336876  -0.059871   -0.00339825
  0.04014296 -0.01601049 -0.03028427 -0.13358521  0.03801369]
Centroid 5: [-2.2762197e-03 -4.1525576e-02  3.2594875e-02 -5.3007957e-02
 -6.4948946e-02 -1.7326805e-03  8.6044529e-03 -5.1706426e-02
  6.3289016e-02  3.6907852e-02 -2.8404053e-02 -1.8115599e-02
 -2.8848071e-02  1.6832678e-01  1.4168877e-02 -8.6503422e-01
 -3.7856091e-02 -2.2824996e-05  1.7176105e-02 -1.1356364e-02
 -2.4958281e-03 -5.6232870e-02  1.5093812e-02]
Centroid 6: [-0.00544717 -0.11864921  0.09683655 -0.1231902  -0.21617426  0.0010094
  0.0341486  -0.13047843  0.17133     0.11020523 -0.0584032  -0.01524823
 -0.12155154  0.5840478  -0.05137502 -0.03942171 -0.10687806  0.020913
  0.04880716 -0.02592425 -0.03645794 -0.12382994  0.03962624]
Centroid 7: [ 0.00205689 -0.00653076 -0.01230091  0.0513025   0.00510804  0.00146829
 -0.0170856  -0.00220147 -0.1375509  -0.6582279  -0.00258073 -0.11957297
  0.00701757 -0.01559275 -0.00568401  0.00602009  0.04398964 -0.00135877
  0.00152333 -0.00406152  0.02310481 -0.00526906 -0.00199427]
Centroid 8: [ 1.9707865e-04  4.1088067e-02  2.5000453e-01 -1.5466494e-03
 -3.5316434e-02 -3.5243700e-03  3.5628700e-01 -1.9991372e-02
  1.8345909e-02  5.7045840e-02  4.7940344e-02  6.3476630e-02
 -2.6172472e-03  1.3624638e-01 -2.3221036e-02  4.0088519e-02
  3.0204299e-01  2.3954382e-02  6.5268730e-03  9.0574007e-03
 -1.2789761e-02 -2.8901337e-02  7.3630605e-03]
Centroid 9: [-8.9101365e-04 -2.0053340e-03 -6.0287520e-04 -5.1400193e-04
 -1.1188010e-05 -3.7129092e-05 -1.7530150e-03 -7.0615887e-04
 -2.3960644e-02 -9.6024834e-02  9.9688850e-04  9.5232338e-01
 -2.1609366e-04 -1.5258129e-03  2.1543123e-03 -1.0190227e-03
 -5.2275960e-03  1.9361691e-03  2.5970474e-04 -7.8059518e-04
  1.2325866e-03 -9.6473965e-04  6.8042468e-04]
Centroid 10: [ 4.9776137e-03 -3.8761754e-02  3.3365943e-02 -4.1285452e-02
 -3.7152424e-02  4.3314166e-04  2.4909137e-02 -2.9940045e-02
  5.7358447e-02  1.4542190e-02 -6.9629192e-01 -2.5632035e-02
 -7.1809078e-03  9.3502961e-02 -4.2613443e-02 -6.5947443e-02
 -1.6308891e-02 -3.2032546e-04  9.2592249e-03 -2.1510620e-02
 -3.3832487e-02 -2.3278836e-02 -2.7393240e-03]
Centroid 11: [-7.44121242e-03 -1.12891614e-01  1.61833853e-01 -1.16142966e-01
 -1.74450427e-01  2.85181508e-04  1.22905590e-01 -1.25025421e-01
  1.46564543e-01  9.67691764e-02 -3.20689916e-03 -3.27856615e-02
 -7.26193562e-02  4.63949084e-01 -2.54316125e-02  4.89263743e-01
 -9.40965116e-02 -1.75558694e-03  4.42198217e-02 -2.42582150e-02
 -4.56112884e-02 -1.29580081e-01  4.36299555e-02]
Centroid 12: [-0.00411199 -0.07782848 -0.00578566  0.06795383 -0.00209609  0.00260888
 -0.01738606 -0.01073787 -0.45338804  0.28090653 -0.01247827  0.01732619
 -0.02375082  0.04424187 -0.0036751  -0.01599087  0.06012007  0.05521214
  0.0011302   0.00126714 -0.0569579  -0.00298718 -0.00238202]
Centroid 13: [-0.00124231 -0.03391432  0.03683604 -0.05690328 -0.06309732 -0.00178687
  0.0134298  -0.04840118  0.05914016  0.03035478 -0.00336851 -0.0150223
 -0.02704501  0.1602055  -0.01502327  0.86449647 -0.040247    0.00278477
  0.01698526 -0.00240626 -0.0089112  -0.05243593  0.01585858]
Centroid 14: [ 1.51333190e-03 -1.28642609e-02  3.49066071e-02  1.27965081e-02
 -3.83953028e-03  3.14053090e-04  4.38069925e-02 -6.04675245e-03
  2.09404945e-01  6.60710156e-01 -5.12184110e-03  1.20829366e-01
```

```
  2.69609713e-03  8.18405766e-03  2.70533492e-03  5.13547985e-03
 -2.51717190e-03  3.18097766e-03  1.63347635e-03 -3.83628416e-03
 -1.91648176e-03 -7.37693906e-03 -1.28286134e-03]
Centroid 15: [ 0.0019556  -0.05098216  0.27346826 -0.03169918  0.04707135 -0.0031374
  0.3759988  -0.00703362 -0.02199399 -0.14982289  0.00628299 -0.31987238
  0.00347134 -0.15825614  0.00083898 -0.02768697 -0.00276036 -0.00080143
  0.00299804  0.00561518  0.00800578 -0.01154522  0.00461238]
Centroid 16: [ 0.00152228  0.04124458 -0.17828989 -0.00902784 -0.02991913  0.00341239
 -0.2592345  -0.00978869  0.11625756  0.43394998 -0.02184281 -0.30546668
 -0.04359046  0.06427895  0.01083973 -0.01292489 -0.09089775 -0.03801694
  0.0035366  -0.00344206  0.0303202  -0.01287168 -0.00115322]
Centroid 17: [-4.4302712e-04 -1.1762727e-02  2.5738573e-02 -6.5354899e-02
 -3.8267672e-02 -1.8026336e-03  1.7496496e-02 -3.0906262e-02
  4.2459026e-02  2.5636811e-02  6.9194508e-01 -6.4708577e-03
 -7.0013441e-03  1.0423709e-01  4.3016132e-02 -3.9184850e-02
 -3.3267237e-02 -3.1729010e-03  7.9494761e-03 -2.1023259e-03
 -2.5145296e-02 -3.4092635e-02  1.8555413e-03]
Centroid 18: [ 0.00613276 -0.01242688 -0.00658849 -0.0219258  -0.03502553  0.00096558
 -0.02561727 -0.02670646  0.02185632  0.02253198  0.01647524 -0.00395669
 -0.00651623  0.0967876  -0.6595223  -0.07674992 -0.0151695  -0.02439265
  0.00773146 -0.00608308  0.03896818 -0.02780831  0.00570009]
Centroid 19: [-0.00072568 -0.04944979 -0.08399832  0.20830883 -0.00451555 -0.00717434
 -0.10697911  0.0124308   0.24818644  0.03597359  0.01312214  0.07536224
  0.02794201  0.00870479 -0.01505921  0.00047033  0.11508851  0.00344816
  0.0006977   0.00282968 -0.033542    0.00883028 -0.00380085]
Centroid 20: [ 6.4260731e-03 -5.9976242e-03  3.2423993e-04 -1.7336776e-02
 -3.8222224e-02 -4.9372213e-03 -1.7343204e-02 -2.3894021e-02
  4.2765208e-02 -7.7618919e-03 -3.7862640e-02 -1.2566519e-03
 -1.2765078e-02  1.1650887e-01  6.7102110e-01  5.7083521e-02
 -4.3156505e-02 -1.6944049e-02  7.9572471e-03  7.3739477e-03
  2.7080167e-02 -2.7059382e-02  2.1240786e-02]
Centroid 21: [-0.01003536  0.0304446   0.02639048 -0.04422926  0.15161325 -0.00371969
  0.03260249 -0.00687313  0.02973527  0.17665368 -0.01325551  0.10122854
  0.08444184 -0.5096038  -0.01155154 -0.00170817 -0.07114495 -0.0153859
  0.00107884  0.00558238  0.04582888  0.00715347 -0.00232731]
Centroid 22: [ 3.2905021e-03 -6.6138901e-02  1.5328433e-02 -4.0842715e-01
 -5.7408314e-02  1.5037142e-04  8.0384118e-03 -1.9254604e-02
  1.2343780e-02 -2.4850340e-01  3.2038957e-02 -1.1348782e-01
 -4.7222003e-02  2.0690072e-01 -2.5879417e-02  1.1966069e-02
 -4.2886823e-02 -1.7769385e-02  6.7728767e-03  1.6364900e-02
 -6.1999265e-02 -3.2827962e-02  9.4099417e-03]
Centroid 23: [-2.17881915e-03  2.87434272e-02 -3.05725366e-01 -4.10716124e-02
  4.07571830e-02  4.59964480e-03 -4.41634983e-01 -1.23889325e-02
 -2.64476221e-02 -1.72852755e-01 -1.48239825e-02 -6.54955581e-02
  3.56971212e-02 -1.35412797e-01 -1.64845842e-03 -3.63468789e-02
  3.20633389e-02  4.42638621e-03  4.66376916e-03 -5.54097025e-03
 -2.44758539e-02 -7.58236507e-04 -2.04573473e-04]
```

In [ ]:

```
spectral_clustering(
    le_X_train025,
    cuts=len(np.unique(le_y_train025)),
    fname="label_encoded_spectral_clustering",
    affinity="chi2",
    gamma=1.0,
)
```

```
eigenvalues: [1.9799733e-20 1.1253153e-20 9.7675304e-21 5.5794883e-21 1.3039654e-21
 1.9227013e-23 1.6587635e-23 1.9446219e-26 8.0945478e-28 4.7445640e-28
 2.4413591e-31 1.1103889e-41 5.2969082e-43 0.0000000e+00 0.0000000e+00].
Finished running k-means++
0.0     5464
7.0     1872
12.0    1067
10.0     694
3.0      542
2.0      472
5.0      337
13.0     327
6.0      322
9.0      295
8.0      222
1.0      216
4.0      213
14.0     197
11.0     110
dtype: int64
Completed iteration 1
0.0     5326
7.0     1751
12.0     925
10.0     688
2.0      595
3.0      555
6.0      353
13.0     342
11.0     285
5.0      284
8.0      265
9.0      261
1.0      249
14.0     244
4.0      227
dtype: int64
Completed iteration 2
0.0     5319
7.0     1731
12.0     864
10.0     686
2.0      568
3.0      492
13.0     388
6.0      359
11.0     359
1.0      303
5.0      273
9.0      270
8.0      256
14.0     247
4.0      235
dtype: int64
Completed iteration 3
0.0     5321
7.0     1718
12.0     840
10.0     673
2.0      544
3.0      446
13.0     426
11.0     391
6.0      366
1.0      320
9.0      286
5.0      277
8.0      266
14.0     239
4.0      237
dtype: int64
Completed iteration 4
0.0     5322
7.0     1713
12.0     820
10.0     674
2.0      534
13.0     438
3.0      423
11.0     398
6.0      384
1.0      324
5.0      290
9.0      288
8.0      263
14.0     240
```

```
4.0      239
dtype: int64
Completed iteration 5
0.0     5320
7.0     1710
12.0     809
10.0     679
2.0      528
13.0     439
6.0      414
3.0      409
11.0     397
1.0      324
9.0      291
5.0      286
8.0      267
14.0     242
4.0      235
dtype: int64
Completed iteration 6
0.0     5318
7.0     1711
12.0     797
10.0     684
2.0      525
13.0     441
6.0      436
3.0      396
11.0     396
1.0      326
9.0      295
5.0      280
8.0      267
14.0     247
4.0      231
dtype: int64
Completed iteration 7
0.0     5323
7.0     1714
12.0     790
10.0     688
2.0      525
6.0      454
13.0     442
3.0      384
11.0     369
1.0      328
9.0      311
5.0      278
8.0      266
14.0     250
4.0      228
dtype: int64
Completed iteration 8
0.0     5324
7.0     1713
12.0     784
10.0     694
2.0      523
6.0      462
13.0     441
3.0      380
11.0     357
1.0      329
9.0      318
5.0      278
8.0      266
14.0     249
4.0      232
dtype: int64
Completed iteration 9
0.0     5322
7.0     1711
12.0     782
10.0     695
2.0      524
6.0      465
13.0     445
3.0      376
11.0     357
1.0      332
9.0      314
5.0      275
8.0      270
14.0     248
4.0      234
```

```
dtype: int64
Completed iteration 10
0.0     5321
7.0     1709
12.0     778
10.0     695
2.0      530
6.0      466
13.0     446
3.0      375
11.0     358
1.0      331
9.0      314
5.0      274
8.0      271
14.0     248
4.0      234
dtype: int64
Completed iteration 11
0.0     5320
7.0     1706
12.0     775
10.0     695
2.0      534
6.0      470
13.0     445
3.0      376
11.0     361
1.0      327
9.0      309
5.0      275
8.0      272
14.0     251
4.0      234
dtype: int64
Completed iteration 12
0.0     5321
7.0     1703
12.0     771
10.0     697
2.0      534
6.0      470
13.0     443
3.0      375
11.0     361
1.0      331
9.0      306
5.0      276
8.0      273
14.0     255
4.0      234
dtype: int64
Completed iteration 13
0.0     5320
7.0     1704
12.0     768
10.0     699
2.0      536
6.0      473
13.0     443
3.0      374
11.0     359
1.0      333
9.0      306
5.0      274
8.0      273
14.0     255
4.0      233
dtype: int64
Completed iteration 14
0.0     5320
7.0     1704
12.0     766
10.0     699
2.0      536
6.0      474
13.0     443
3.0      371
11.0     358
1.0      334
9.0      305
5.0      277
8.0      272
14.0     258
4.0      233
dtype: int64
```

```
Completed iteration 15
0.0     5320
7.0     1704
12.0     763
10.0     698
2.0      536
6.0      473
13.0     445
3.0      369
11.0     358
1.0      335
9.0      307
5.0      280
8.0      271
14.0     258
4.0      233
dtype: int64
Completed iteration 16
0.0     5320
7.0     1705
12.0     754
10.0     699
2.0      538
6.0      475
13.0     444
3.0      362
11.0     355
1.0      347
9.0      306
5.0      280
8.0      269
14.0     263
4.0      233
dtype: int64
Completed iteration 17
0.0     5320
7.0     1706
12.0     742
10.0     700
2.0      537
6.0      477
13.0     444
1.0      360
3.0      358
11.0     355
9.0      309
5.0      281
8.0      265
14.0     263
4.0      233
dtype: int64
Completed iteration 18
0.0     5321
7.0     1706
12.0     735
10.0     700
2.0      537
6.0      482
13.0     442
1.0      366
3.0      353
11.0     350
9.0      312
5.0      283
14.0     266
8.0      263
4.0      234
dtype: int64
Completed iteration 19
0.0     5322
7.0     1707
12.0     728
10.0     700
2.0      537
6.0      486
13.0     443
1.0      379
11.0     347
3.0      345
9.0      311
5.0      282
14.0     269
8.0      262
4.0      232
dtype: int64
Completed iteration 20
```

```
0.0     5323
7.0     1705
12.0     721
10.0     700
2.0      540
6.0      488
13.0     443
1.0      389
11.0     344
3.0      341
9.0      314
5.0      282
14.0     267
8.0      261
4.0      232
dtype: int64
Completed iteration 21
Reached 21 iterations
Centroids:
Centroid 1: [-9.6449917e-03  4.3700315e-02  1.0508609e-03 -9.6055216e-01
  5.1030749e-04 -2.3772228e-03  5.3195399e-04 -1.2907540e-05
  1.1750760e-05 -5.4847443e-04  8.2516446e-05 -5.8720914e-05
 -1.5583986e-05 -7.8356679e-04  4.0570102e-04]
Centroid 2: [ 0.18535104  0.03040675 -0.02767629 -0.01299036 -0.08759174  0.5518196
 -0.10928614 -0.41307518 -0.16211921 -0.01310565  0.04555108 -0.0147056
 -0.0513595  -0.14717315  0.0404908 ]
Centroid 3: [ 0.15300241  0.66423285 -0.01021842  0.027407   -0.00364154 -0.03166247
 -0.00338643 -0.00264951 -0.00949298 -0.01532631  0.00126872 -0.00278584
 -0.00195508 -0.00375267 -0.00338741]
Centroid 4: [ 0.12339842  0.25679514 -0.02231687 -0.01536136 -0.13583769  0.639993
 -0.00305681 -0.02153186  0.01180589  0.02764796  0.04434628 -0.02820788
  0.0009095  -0.10980053  0.03631858]
Centroid 5: [ 0.04516863  0.02004251 -0.60586315 -0.03510778  0.00463382  0.09316356
 -0.15635607 -0.06716774 -0.04346523  0.01455978  0.00866112 -0.00474805
 -0.04027427 -0.03034061 -0.00447505]
Centroid 6: [-0.21112207 -0.48147032  0.0122039   0.5556038   0.00705011  0.00809396
  0.00719378  0.00508579  0.01314059  0.00920168  0.00248198  0.00858899
  0.00718469 -0.00913288  0.00241166]
Centroid 7: [-1.4010654e-01 -6.3872164e-01  7.7099809e-03 -1.8389970e-01
 -1.1418626e-02 -5.8609983e-03 -1.5453597e-02 -1.2528795e-02
 -2.6099309e-02 -5.4640393e-04  1.2124430e-03  1.2473699e-04
  1.3878180e-02 -2.1991984e-03 -2.0377962e-03]
Centroid 8: [-2.1423861e-02 -9.1386102e-02 -3.3698385e-04  9.4794077e-01
  4.6496587e-03 -5.2896645e-03  9.8003680e-04 -1.5316254e-03
 -3.5664320e-03  3.9718868e-03  3.8391462e-04 -1.1062825e-03
 -6.9357496e-04 -1.8789897e-03  5.1592203e-04]
Centroid 9: [-0.0087762   0.01322269  0.08952747  0.0064984  -0.0090463   0.11087702
  0.60311496 -0.00733395 -0.06571935 -0.01462117  0.00697138 -0.00846979
  0.03829991 -0.00875888  0.01472969]
Centroid 10: [-0.1085612   0.041483    0.36411124 -0.02283587  0.01020143  0.08192667
 -0.25235522 -0.01498551 -0.0405452   0.01125866 -0.00131278  0.00061866
 -0.02264079 -0.04226119  0.00141468]
Centroid 11: [ 0.06211528  0.03391504 -0.0041993  -0.01673117 -0.0309206   0.17896669
 -0.01269254  0.86267865 -0.04319101  0.00447377  0.02023448 -0.00257457
 -0.00859904 -0.06005226  0.01884224]
Centroid 12: [-1.6177809e-02  3.1608041e-02 -8.4797479e-03  3.5841105e-04
  6.4425163e-02 -5.0536817e-01 -3.3882394e-02  5.5289622e-03
 -1.7081858e-01 -4.5150896e-03  1.8556984e-03  3.4941400e-03
  1.3722860e-02  3.8607746e-02 -2.7106365e-03]
Centroid 13: [ 0.07598282  0.04943273 -0.02413835 -0.02335979 -0.04042378  0.21222393
  0.01416399 -0.8466938  -0.04009781  0.00087484  0.02042448 -0.0123574
 -0.00162194 -0.06893034  0.01907859]
Centroid 14: [ 0.19113332  0.06954016 -0.01141509 -0.05074041 -0.07938713  0.5474677
 -0.04527957  0.47193173 -0.12674356  0.00391931  0.05026515 -0.02176257
 -0.06621371 -0.14618413  0.04635913]
Centroid 15: [ 2.1244420e-01 -1.0732965e-01  1.9448798e-02 -1.7829388e-02
 -2.1044756e-03 -5.4234900e-02  1.9850500e-02 -4.8181468e-05
  4.7897437e-01  5.5442667e-03  4.1460353e-03  8.5909218e-03
 -1.5841199e-02 -1.9144388e-02  2.1751386e-03]
```

cosine similarity

In [ ]:

```
spectral_clustering(
    le_X_train025,
    cuts=23,
    fname="label_encoded_spectral_clustering",
    affinity="cosine_similarity",
)
```

```
eigenvalues: [9.9997211e-01 9.9997127e-01 9.9996638e-01 9.9996495e-01 9.9996364e-01
 9.9995828e-01 9.9995637e-01 9.9994946e-01 9.9994898e-01 9.9993622e-01
 9.9993587e-01 9.9991393e-01 9.9985385e-01 9.9974275e-01 9.9957317e-01
 9.8984689e-01 9.8099512e-01 9.2098027e-01 8.4413648e-01 6.5789407e-01
 4.5537400e-01 2.8281984e-01 1.5033727e-10].
Finished running k-means++
17.0    3003
2.0     2637
4.0     1153
1.0      989
3.0      730
0.0      710
8.0      468
6.0      325
16.0     301
5.0      256
20.0     253
12.0     251
22.0     243
11.0     232
21.0     219
9.0      204
10.0     130
7.0       93
19.0      50
15.0      40
13.0      32
14.0      20
18.0      11
dtype: int64
Completed iteration 1
2.0     2908
17.0    2727
4.0     1143
1.0      978
3.0      706
0.0      615
8.0      511
22.0     300
16.0     294
6.0      275
20.0     263
11.0     257
12.0     228
21.0     217
9.0      203
5.0      201
10.0     152
7.0      110
18.0      82
19.0      59
15.0      50
14.0      37
13.0      34
dtype: int64
Completed iteration 2
2.0     3048
17.0    2587
4.0     1140
1.0      985
3.0      699
0.0      552
8.0      524
22.0     358
16.0     288
20.0     281
11.0     267
6.0      262
21.0     206
9.0      205
12.0     203
5.0      192
10.0     160
7.0      130
18.0      77
14.0      55
15.0      51
19.0      46
13.0      34
dtype: int64
Completed iteration 3
2.0     3090
17.0    2546
4.0     1138
1.0      986
3.0      696
```

```
8.0      535
0.0      507
22.0     401
20.0     285
16.0     280
11.0     273
6.0      241
9.0      207
21.0     201
5.0      188
10.0     176
7.0      172
12.0     168
18.0      75
14.0      59
15.0      51
19.0      41
13.0      34
dtype: int64
Completed iteration 4
2.0     3103
17.0    2533
4.0     1138
1.0      984
3.0      693
8.0      538
0.0      477
22.0     428
20.0     285
11.0     275
16.0     272
6.0      216
7.0      208
9.0      207
21.0     200
10.0     190
5.0      190
12.0     148
18.0      75
14.0      65
15.0      50
19.0      41
13.0      34
dtype: int64
Completed iteration 5
2.0     3114
17.0    2522
4.0     1138
1.0      985
3.0      695
8.0      540
0.0      462
22.0     441
20.0     284
11.0     280
16.0     266
7.0      245
9.0      207
6.0      207
10.0     198
21.0     198
5.0      187
12.0     116
18.0      75
14.0      66
15.0      49
19.0      41
13.0      34
dtype: int64
Completed iteration 6
2.0     3121
17.0    2515
4.0     1138
1.0      985
3.0      697
8.0      540
22.0     443
0.0      440
20.0     284
11.0     280
16.0     263
7.0      259
9.0      207
6.0      204
10.0     201
21.0     198
```

```
5.0      181
12.0     128
18.0      75
14.0      65
15.0      50
19.0      41
13.0      35
dtype: int64
Completed iteration 7
2.0     3126
17.0    2510
4.0     1138
1.0      985
3.0      699
8.0      540
22.0     440
0.0      433
20.0     284
11.0     281
16.0     261
7.0      259
6.0      208
9.0      207
21.0     198
10.0     197
5.0      181
12.0     137
18.0      75
14.0      65
15.0      50
19.0      41
13.0      35
dtype: int64
Completed iteration 8
2.0     3127
17.0    2509
4.0     1138
1.0      985
3.0      699
8.0      540
22.0     441
0.0      426
20.0     284
11.0     282
16.0     261
7.0      259
6.0      209
9.0      207
21.0     198
10.0     196
5.0      180
12.0     143
18.0      75
14.0      65
15.0      50
19.0      41
13.0      35
dtype: int64
Completed iteration 9
2.0     3127
17.0    2509
4.0     1138
1.0      985
3.0      699
8.0      540
22.0     440
0.0      423
20.0     284
11.0     282
16.0     261
7.0      259
6.0      211
9.0      207
21.0     198
10.0     194
5.0      180
12.0     148
18.0      75
14.0      65
15.0      49
19.0      41
13.0      35
dtype: int64
Completed iteration 10
2.0     3127
17.0    2509
```

```
4.0     1138
1.0      985
3.0      699
8.0      540
22.0     440
0.0      422
20.0     284
11.0     282
16.0     261
7.0      259
6.0      211
9.0      207
21.0     198
10.0     194
5.0      180
12.0     150
18.0      75
14.0      65
15.0      48
19.0      41
13.0      35
dtype: int64
Completed iteration 11
2.0     3127
17.0    2509
4.0     1138
1.0      985
3.0      699
8.0      540
22.0     442
0.0      420
20.0     284
11.0     282
16.0     261
7.0      259
6.0      210
9.0      207
21.0     198
10.0     195
5.0      180
12.0     150
18.0      75
14.0      65
15.0      48
19.0      41
13.0      35
dtype: int64
Completed iteration 12
Epsilon has a maximum value of 0.0018077269196510315
Centroids:
Centroid 1: [ 0.04132895  0.27773783  0.22541595  0.19690083 -0.03400415 -0.0605997
 -0.01971176 -0.02642917 -0.01613299  0.01266287  0.02390819 -0.00230741
 -0.01891787 -0.00255373 -0.0025438  -0.07555892  0.24585666 -0.29534099
  0.0139335   0.04972533  0.62242246  0.22452551 -0.35710737]
Centroid 2: [ 3.60182603e-03  1.00382948e-02 -1.87262800e-02 -1.72350835e-02
 -1.73813049e-02 -1.03219114e-02  1.48400330e-04 -1.16041200e-02
  1.16997641e-02  3.27517791e-03  5.94593678e-03  2.46673194e-03
  1.38666518e-02  8.44220107e-04  4.49756067e-03 -2.20182985e-02
  6.82146698e-02  9.18406695e-02  1.01134226e-01  3.27981450e-02
  1.23436429e-01 -8.39683652e-01 -2.91719586e-01]
Centroid 3: [ 0.00878728 -0.00720447  0.0594797   0.00610742  0.00141375  0.08809382
  0.09345526  0.0366392   0.05979038  0.00787616 -0.04473107  0.00410103
 -0.00872247 -0.00868095  0.01946556  0.0229141   0.01052174 -0.03142258
  0.16262424  0.04302547 -0.57091916  0.19918977 -0.7496984 ]
Centroid 4: [ 0.00484402  0.09088016  0.1613519   0.11990172  0.01293511 -0.03213966
 -0.02494622 -0.00217789 -0.0108543   0.01503923  0.02136065  0.00133709
  0.0101395   0.00078328  0.11735114  0.05925041 -0.46620354  0.31486735
  0.18421873  0.06700497  0.53116     0.2278394  -0.34730268]
Centroid 5: [-2.9090059e-03  7.8500984e-03  2.9209298e-03  1.3039706e-03
 -5.0705262e-03 -1.3970652e-02 -2.7040718e-02  1.6863588e-02
  5.0236210e-03  1.6586224e-02 -2.9364778e-04  3.6089546e-03
  1.3013117e-02 -2.2083689e-02 -6.5485105e-02 -1.0761639e-01
  6.1715806e-01  5.7353491e-01 -3.7501704e-02  5.1238660e-02
 -1.6892542e-01  1.5585566e-01 -4.4751713e-01]
Centroid 6: [-0.01388441 -0.29394135  0.01177427 -0.03424226 -0.00108559  0.01938397
 -0.00385081  0.00984155  0.01990807 -0.01462154  0.00406134  0.00140014
 -0.00109159 -0.00356165  0.45941335  0.2590378   0.09530427 -0.22819087
 -0.28356445  0.01141607  0.1662511   0.01361064 -0.1637779 ]
Centroid 7: [-0.00441132 -0.02459823  0.01202152 -0.01633452  0.01636097 -0.02207515
  0.04837491 -0.02466491 -0.12774374  0.0015826  -0.03351437  0.001376
  0.01189927  0.00842008 -0.09621318  0.06585488 -0.4993265  -0.65893066
  0.14283475 -0.0094717  -0.2833278  -0.05254089 -0.23449613]
Centroid 8: [-0.00095006 -0.39843643  0.05454133 -0.05775062  0.03437188  0.01766548
 -0.00937961 -0.02713022  0.02192804 -0.03406379  0.00313813 -0.00147145
 -0.00791582  0.00208011 -0.44662273 -0.04656772  0.20888987 -0.2525976
  0.00931318  0.04042895  0.51009434  0.18331721 -0.29175898]
```

```
Centroid 9: [ 3.4735650e-03  9.3408786e-02 -2.6193139e-01 -1.1943067e-01
 -3.4657188e-03  4.6814270e-02  3.2134362e-02  5.1428147e-02
  6.9556898e-03 -5.0299945e-03 -2.5346117e-02 -7.9018828e-03
  1.3195174e-03 -4.2767779e-04  1.2313707e-01  5.7470448e-02
 -4.4615415e-01  2.8610152e-01  1.7947091e-01  6.5819390e-02
  5.3334224e-01  2.2663727e-01 -3.4546944e-01]
Centroid 10: [ 0.00597658  0.02993796 -0.09357934  0.00797694 -0.01924026 -0.16516648
 -0.24344988 -0.03191198 -0.04111089  0.01404227  0.11923634 -0.00555143
  0.02582845 -0.01558033 -0.04979358 -0.06856977  0.54127824  0.502646
 -0.08175602  0.05010214 -0.18818137  0.16179642 -0.48268917]
Centroid 11: [-0.01938501  0.07115382 -0.06638484  0.02696265  0.01116769 -0.04635326
 -0.04375947  0.04186909  0.06383429 -0.01278965  0.06388001  0.00920446
  0.01201779  0.00984229 -0.13549672 -0.00335864 -0.5463819  -0.61387545
  0.11686452 -0.00856953 -0.291429   -0.0871347  -0.24191098]
Centroid 12: [-0.01202871  0.07957029 -0.01454211 -0.00529069  0.0069363   0.00345369
 -0.00115174 -0.00316229 -0.02240773 -0.00293023  0.00109864 -0.00447251
  0.03029563 -0.00395272 -0.1945973   0.16798149 -0.12258691 -0.44376743
 -0.6301839   0.00633448  0.13941665 -0.14347954 -0.28622982]
Centroid 13: [-7.0826579e-03 -1.9707667e-02  1.5289732e-02  1.0325685e-02
 -8.4831230e-03  1.5225262e-06 -6.1160913e-03  1.6509106e-02
  1.0485652e-02 -5.0627619e-02  3.1981801e-03  6.6936072e-03
 -1.4900599e-03 -3.7226846e-04  5.3847086e-02 -7.9637557e-02
  4.6033090e-01 -6.4270341e-01 -9.0138271e-02  6.7382767e-03
  2.6277643e-01  8.1206009e-02 -1.8778461e-01]
Centroid 14: [-4.1257357e-03 -5.7854801e-02  4.6982807e-03 -2.5608575e-02
  1.1140952e-02  7.6246174e-04  6.7688210e-04  6.4256467e-04
  5.2881911e-03 -3.4595034e-03  8.0932083e-04  8.5391952e-03
  9.1293668e-03  1.3573644e-03 -1.6366686e-01 -6.6963428e-01
 -1.1483886e-01 -5.4841168e-02 -2.3251925e-01 -4.8960424e-03
  4.3038726e-02 -1.5055065e-02 -8.1241913e-02]
Centroid 15: [-0.03495179 -0.07996697  0.02562492  0.01531944 -0.02793277  0.0026797
  0.01133341  0.02206266 -0.01529238 -0.02158736 -0.02690276 -0.00164717
 -0.01798613  0.01938667  0.00266913  0.00015218  0.01241538  0.01451088
  0.0055036   0.0062249   0.00562173 -0.00262955 -0.06142288]
Centroid 16: [ 0.0126105  -0.10272148  0.02713775 -0.0041475  -0.01622902 -0.01880875
  0.01623344 -0.02835489  0.03277895  0.02508352 -0.02772592 -0.01772464
  0.02423995 -0.00731103 -0.05566711  0.10805497  0.5958502   0.07162809
 -0.501211    0.02527229  0.13967136 -0.01034825 -0.20385385]
Centroid 17: [-0.01616794 -0.42433536  0.06989514 -0.06520964  0.05629356  0.02352928
 -0.01983307 -0.01061822  0.01899912 -0.01474098  0.00484585 -0.00308592
  0.00954366  0.00268835 -0.24838296  0.06372456 -0.403546    0.26015878
  0.16186804  0.05737373  0.45909512  0.19608459 -0.29834062]
Centroid 18: [-0.00301619  0.01507281 -0.05061025 -0.03767918  0.00883678 -0.07551108
 -0.12059232 -0.03850443 -0.0563078  -0.00079051  0.04213734  0.02033863
 -0.00366357 -0.00565107  0.02143856  0.02271025  0.01073087 -0.03154276
  0.1626077   0.04298644 -0.5704076   0.19904521 -0.74911004]
Centroid 19: [-2.4300897e-03  3.3402529e-02  8.9429073e-02 -1.3679813e-01
 -1.1947026e-02 -8.5725598e-02  3.4105539e-02  2.5334123e-01
 -2.7217576e-02  4.5437682e-02  5.3403284e-03  1.5447360e-02
 -2.1822327e-03 -5.8184788e-03  2.1622230e-03  4.3059867e-03
 -6.9038477e-03 -4.2531647e-05 -1.4143712e-02 -8.6319011e-01
  3.9929133e-02 -5.0657024e-03 -1.0126493e-01]
Centroid 20: [-0.01496268 -0.075464   -0.1572046   0.23848881  0.03027999  0.14616631
 -0.06131517 -0.43078098  0.04405602 -0.07687934 -0.01162056 -0.02814653
  0.00149459  0.01067179 -0.00734335  0.00568802  0.00941003  0.00789092
  0.00087495 -0.7509736   0.0356186   0.00362803 -0.08348791]
Centroid 21: [-0.00288425  0.15826342 -0.02016371  0.02072592 -0.00543421 -0.0143962
  0.01749866 -0.00528906 -0.01231729  0.01214895 -0.00473379 -0.00296028
  0.03569721 -0.00064057 -0.07474502  0.03906494 -0.3442327   0.09116428
 -0.6251216   0.02458848 -0.0943957  -0.23933467 -0.23518555]
Centroid 22: [-0.04909371 -0.13111721  0.01046124  0.03676538  0.02487189 -0.03471787
 -0.0150691   0.00797434 -0.02520027 -0.0168315   0.02927818  0.00850353
  0.03655341  0.01380732  0.04061407  0.1650205   0.10216311 -0.23550771
 -0.2865111   0.02397857  0.128598   -0.6279829  -0.4355707 ]
Centroid 23: [ 0.0324821   0.2826761  -0.25749907 -0.06814658 -0.05198942  0.03316759
  0.04132838  0.02349456 -0.00130897 -0.01692763 -0.03613768  0.00137226
 -0.01636296 -0.00177329 -0.00455088 -0.07678094  0.25630885 -0.30339646
  0.01110301  0.04976358  0.6256846   0.22532694 -0.35867986]
```

In [ ]:

```python
spectral_clustering(
    le_X_train025,
    cuts=len(np.unique(le_y_train025)),
    fname="label_encoded_spectral_clustering",
    affinity="cosine_similarity",
)
```

```
eigenvalues: [9.9994898e-01 9.9993622e-01 9.9993587e-01 9.9991393e-01 9.9985385e-01
 9.9974275e-01 9.9957317e-01 9.8984689e-01 9.8099512e-01 9.2098027e-01
 8.4413648e-01 6.5789407e-01 4.5537400e-01 2.8281984e-01 1.5033727e-10].
Finished running k-means++
2.0     5645
6.0     1376
5.0     1267
0.0     1015
1.0      928
8.0      435
7.0      414
9.0      320
13.0     289
4.0      275
10.0     169
3.0      115
12.0      81
11.0      14
14.0       7
dtype: int64
Completed iteration 1
2.0     5641
6.0     1374
5.0     1140
0.0     1014
1.0      980
8.0      424
7.0      417
13.0     413
4.0      270
9.0      264
10.0     170
3.0      116
12.0      93
14.0      18
11.0      16
dtype: int64
Completed iteration 2
2.0     5639
6.0     1373
5.0     1063
1.0     1007
0.0     1000
13.0     486
7.0      412
8.0      408
4.0      270
9.0      258
10.0     162
3.0      116
12.0     110
14.0      29
11.0      17
dtype: int64
Completed iteration 3
2.0     5639
6.0     1372
1.0     1028
5.0     1015
0.0      992
13.0     533
7.0      411
8.0      407
4.0      266
9.0      248
10.0     152
3.0      116
12.0     116
14.0      38
11.0      17
dtype: int64
Completed iteration 4
2.0     5639
6.0     1372
1.0     1052
0.0      987
5.0      978
13.0     566
8.0      412
7.0      405
4.0      260
9.0      224
10.0     147
12.0     121
3.0      116
14.0      54
```

```
11.0      17
dtype: int64
Completed iteration 5
2.0     5639
6.0     1373
1.0     1068
0.0      983
5.0      952
13.0     590
8.0      427
7.0      404
4.0      258
9.0      197
10.0     145
12.0     124
3.0      115
14.0      58
11.0      17
dtype: int64
Completed iteration 6
2.0     5638
6.0     1373
1.0     1079
0.0      956
5.0      937
13.0     603
8.0      434
7.0      405
4.0      258
9.0      178
12.0     151
10.0     145
3.0      115
14.0      61
11.0      17
dtype: int64
Completed iteration 7
2.0     5638
6.0     1373
1.0     1079
0.0      943
5.0      933
13.0     608
8.0      437
7.0      407
4.0      258
9.0      174
12.0     159
10.0     147
3.0      115
14.0      62
11.0      17
dtype: int64
Completed iteration 8
2.0     5638
6.0     1372
1.0     1079
0.0      936
5.0      925
13.0     617
8.0      438
7.0      414
4.0      258
9.0      172
12.0     159
10.0     147
3.0      115
14.0      63
11.0      17
dtype: int64
Completed iteration 9
2.0     5638
6.0     1372
1.0     1080
0.0      933
5.0      916
13.0     626
8.0      438
7.0      415
4.0      258
9.0      171
12.0     161
10.0     147
3.0      115
14.0      63
11.0      17
```

```
dtype: int64
Completed iteration 10
Epsilon has a maximum value of 0.006995618343353271 5
Centroids:
Centroid 1: [-8.0357455e-03 -1.0227947e-02 -7.5277351e-03 -6.1314629e-04
 -1.9252304e-02 -2.3718060e-03 -6.7192679e-03 -8.3673142e-02
  3.2760847e-01 -3.6741108e-01 -1.6006830e-03  5.2230719e-02
  6.7390180e-01  2.4075001e-01 -3.8530487e-01]
Centroid 2: [ 9.8707080e-03 -5.4395827e-04  8.2915984e-03  3.6055788e-03
  1.5617510e-02  2.4624132e-03  1.3257070e-02 -5.1913951e-03
  9.0367801e-02  7.0116706e-02  8.0460981e-02  3.3835240e-02
  1.3448587e-01 -8.6351460e-01 -3.1765997e-01]
Centroid 3: [ 0.00816196  0.00406585 -0.00607785  0.01151615 -0.00655574 -0.0074543
  0.02076467  0.02326306  0.01083169 -0.0320077   0.16554739  0.04376176
 -0.5807131   0.20261373 -0.7625592 ]
Centroid 4: [-1.22282491e-03  1.79663948e-05 -2.84704060e-04 -1.02242091e-04
 -1.26688194e-03 -2.92081881e-04 -1.37979677e-03  5.85489348e-03
 -7.11982546e-04  2.14301446e-03 -9.85416770e-03 -9.68804955e-01
  4.53871116e-02 -2.07679882e-03 -1.12259656e-01]
Centroid 5: [ 0.02644861 -0.03702062  0.00355595 -0.00245201 -0.00912735  0.00232428
 -0.52778274 -0.06470042  0.24329911 -0.29169437  0.01068645  0.0475588
  0.59789735  0.21523292 -0.34265056]
Centroid 6: [-1.0692426e-03  5.2574505e-03  1.0163962e-03 -5.1225547e-04
  1.0229967e-02  5.8915390e-04  1.1914299e-01  9.8163821e-02
 -5.3079444e-01  3.8294750e-01  2.0011187e-01  6.8585038e-02
  5.1395977e-01  2.2581412e-01 -3.4313580e-01]
Centroid 7: [-0.00257028  0.0157259   0.01888382  0.0012786   0.01586879 -0.02059695
 -0.06389023 -0.1001324   0.61482465  0.5642056  -0.05136562  0.05136883
 -0.16993241  0.15619123 -0.4553415 ]
Centroid 8: [-0.03667092 -0.0059172   0.01464346  0.00566811  0.01443876  0.01111155
 -0.12122957  0.0226443  -0.514962   -0.666749    0.13079412 -0.0093991
 -0.28320104 -0.06345439 -0.24346733]
Centroid 9: [-0.0199382  -0.00443483  0.00723585 -0.00282773  0.03123631 -0.00108046
 -0.1182244   0.23954585 -0.0446974  -0.41363567 -0.6245212   0.01070382
  0.15324183 -0.20515108 -0.31787795]
Centroid 10: [-1.3715727e-02  2.5629606e-02 -6.2498804e-03 -6.2760399e-03
  6.8032682e-02  2.7521510e-04 -1.3302502e-01 -6.8458326e-02
 -4.7699246e-01 -3.5118159e-02 -4.0592101e-01  2.1649230e-02
 -1.4262666e-01 -5.1567101e-01 -3.6841828e-01]
Centroid 11: [-7.9477616e-03 -1.9300027e-03 -2.7432262e-03  4.0128892e-03
  6.6948701e-03 -8.1421476e-04  8.7927963e-04  1.2784508e-01
 -1.9933818e-01  2.3418500e-01 -8.6857110e-01  3.0422155e-02
 -4.8701670e-02 -1.3745555e-02 -1.2687306e-01]
Centroid 12: [ 0.10635882  0.7082729   0.14985399  0.07152937 -0.01346769  0.02849921
 -0.00732481  0.00650023 -0.00973125  0.03301553  0.03759557  0.01754479
 -0.00686557  0.02209112 -0.18542711]
Centroid 13: [ 0.02772138 -0.02257619  0.00548578  0.00895811 -0.00776415 -0.00949066
  0.5221906   0.06718644  0.21717982 -0.462234   -0.13196012  0.00334901
  0.16414368  0.02267119 -0.17285517]
Centroid 14: [ 0.00244523 -0.00112869  0.00370733 -0.00721876  0.00243055  0.00084692
 -0.0238135   0.0289     -0.40176123  0.2099448   0.18255329  0.07362575
  0.64997286  0.26678407 -0.40839356]
Centroid 15: [-0.03194784 -0.179739   -0.08846559 -0.01463646 -0.01522805  0.00691461
 -0.10078852 -0.41494632 -0.08373524 -0.05154358 -0.124925    0.00141061
  0.0025776  -0.01897741 -0.12216428]
```

laplacian (gamma=1.0)

In [ ]:

```python
spectral_clustering(
    le_X_train025,
    cuts=23,
    fname="label_encoded_spectral_clustering",
    affinity="laplacian",
    gamma=1.0,
)
```

```
eigenvalues: [5.7334851e-19 5.5113447e-19 5.0807765e-19 4.9898192e-19 2.0943001e-19
 1.3833109e-19 1.0561118e-19 5.8463038e-20 4.7164481e-20 4.3019899e-20
 3.8184838e-20 2.6893362e-20 2.0205838e-20 1.1847787e-20 2.0182436e-21
 1.2437433e-21 8.0380534e-23 6.3748079e-24 9.5652944e-25 7.5414136e-31
 4.0227215e-40 0.0000000e+00 0.0000000e+00].
Finished running k-means++
10.0    3546
0.0     1834
19.0    1143
16.0     505
9.0      461
11.0     431
15.0     428
18.0     403
17.0     374
14.0     362
8.0      331
2.0      318
5.0      288
13.0     285
20.0     260
12.0     233
22.0     219
21.0     211
1.0      200
3.0      164
6.0      145
4.0      105
7.0      104
dtype: int64
Completed iteration 1
10.0    3294
0.0     1635
19.0    1108
9.0      483
17.0     450
16.0     439
15.0     430
11.0     426
18.0     396
14.0     393
2.0      388
5.0      386
8.0      343
20.0     294
13.0     261
21.0     239
22.0     237
1.0      235
12.0     231
3.0      200
7.0      176
6.0      169
4.0      137
dtype: int64
Completed iteration 2
10.0    3264
0.0     1603
19.0    1125
15.0     446
9.0      443
17.0     421
16.0     418
5.0      407
14.0     406
11.0     395
2.0      393
18.0     390
8.0      360
20.0     333
22.0     254
21.0     253
1.0      246
13.0     241
12.0     230
3.0      208
7.0      200
6.0      167
4.0      147
dtype: int64
Completed iteration 3
10.0    3240
0.0     1592
19.0    1127
15.0     450
9.0      421
```

```
2.0      420
14.0     419
17.0     401
16.0     399
18.0     396
11.0     395
5.0      382
20.0     362
8.0      360
21.0     261
1.0      253
22.0     247
13.0     244
12.0     220
3.0      212
7.0      207
6.0      184
4.0      158
dtype: int64
Completed iteration 4
10.0    3225
0.0     1585
19.0    1130
15.0     452
14.0     438
11.0     414
2.0      413
9.0      407
16.0     396
17.0     393
18.0     392
20.0     379
5.0      334
8.0      294
21.0     267
1.0      262
13.0     262
22.0     254
3.0      223
12.0     217
4.0      211
7.0      210
6.0      192
dtype: int64
Completed iteration 5
10.0    3195
0.0     1582
19.0    1130
15.0     456
14.0     452
11.0     421
9.0      402
2.0      400
16.0     398
18.0     390
20.0     388
17.0     377
8.0      297
5.0      286
21.0     276
22.0     264
13.0     263
4.0      260
1.0      258
3.0      229
12.0     214
7.0      213
6.0      199
dtype: int64
Completed iteration 6
10.0    3186
0.0     1581
19.0    1133
14.0     468
15.0     465
11.0     418
9.0      413
2.0      397
16.0     396
20.0     395
18.0     392
17.0     372
8.0      301
4.0      280
21.0     272
1.0      268
```

```
22.0     266
13.0     261
3.0      234
5.0      225
7.0      217
12.0     205
6.0      205
dtype: int64
Completed iteration 7
10.0    3176
0.0     1579
19.0    1145
14.0     474
15.0     458
11.0     415
9.0      413
2.0      396
16.0     388
18.0     387
20.0     382
17.0     375
8.0      308
4.0      293
22.0     273
21.0     271
1.0      269
13.0     258
3.0      234
7.0      231
12.0     211
5.0      211
6.0      203
dtype: int64
Completed iteration 8
10.0    3170
0.0     1607
19.0    1124
14.0     476
15.0     456
9.0      423
11.0     407
2.0      393
18.0     391
16.0     383
20.0     367
17.0     366
8.0      311
4.0      299
1.0      281
22.0     274
21.0     271
13.0     254
7.0      234
3.0      232
12.0     215
5.0      210
6.0      206
dtype: int64
Completed iteration 9
10.0    3161
0.0     1614
19.0    1123
14.0     474
15.0     453
9.0      426
11.0     410
18.0     393
2.0      391
16.0     374
17.0     366
20.0     357
8.0      315
4.0      313
1.0      290
22.0     278
21.0     267
13.0     247
7.0      237
3.0      230
12.0     217
5.0      210
6.0      204
dtype: int64
Completed iteration 10
10.0    3153
0.0     1618
19.0    1120
14.0     471
15.0     450
9.0      423
11.0     408
18.0     400
2.0      389
16.0     368
17.0     359
20.0     342
4.0      324
8.0      318
1.0      306
22.0     281
21.0     263
7.0      247
13.0     244
3.0      231
12.0     220
5.0      209
6.0      206
dtype: int64
Completed iteration 11
10.0    3150
0.0     1619
19.0    1120
14.0     476
15.0     450
9.0      422
18.0     402
11.0     397
2.0      397
16.0     366
17.0     355
20.0     335
4.0      332
8.0      316
1.0      311
22.0     278
7.0      262
21.0     259
13.0     240
3.0      227
12.0     221
6.0      208
5.0      207
dtype: int64
Completed iteration 12
10.0    3143
0.0     1619
19.0    1120
14.0     466
15.0     451
9.0      409
18.0     408
2.0      406
11.0     396
16.0     361
17.0     361
4.0      341
20.0     328
1.0      313
8.0      311
7.0      279
22.0     277
21.0     256
13.0     238
12.0     228
3.0      227
6.0      206
5.0      206
dtype: int64
Completed iteration 13
10.0    3141
0.0     1620
19.0    1121
15.0     454
14.0     453
2.0      424
9.0      412
18.0     408
11.0     385
17.0     364
16.0     350
4.0      347
8.0      323
20.0     318
1.0      312
7.0      294
22.0     273
21.0     248
13.0     234
3.0      228
12.0     227
6.0      208
5.0      206
dtype: int64
Completed iteration 14
10.0    3141
0.0     1621
19.0    1120
15.0     457
14.0     447
2.0      435
9.0      415
18.0     407
11.0     385
17.0     358
16.0     350
4.0      345
8.0      325
1.0      317
20.0     314
7.0      305
22.0     273
21.0     240
12.0     231
3.0      226
13.0     223
6.0      209
5.0      206
dtype: int64
Completed iteration 15
10.0    3141
0.0     1621
19.0    1119
15.0     452
14.0     443
2.0      441
9.0      424
18.0     407
11.0     386
17.0     361
16.0     345
4.0      344
1.0      326
8.0      322
7.0      311
20.0     308
22.0     273
21.0     237
12.0     232
3.0      225
13.0     218
6.0      208
5.0      206
dtype: int64
Completed iteration 16
10.0    3141
0.0     1621
19.0    1119
15.0     450
14.0     443
2.0      440
9.0      439
18.0     407
11.0     381
17.0     362
4.0      341
16.0     339
1.0      324
8.0      323
7.0      314
20.0     311
22.0     275
12.0     236
21.0     235
3.0      224
13.0     215
6.0      205
5.0      205
dtype: int64
Completed iteration 17
10.0    3141
0.0     1621
19.0    1120
15.0     448
14.0     448
2.0      440
9.0      439
18.0     407
11.0     379
17.0     357
4.0      347
16.0     336
1.0      333
7.0      322
8.0      318
20.0     307
22.0     273
12.0     234
21.0     231
3.0      225
13.0     214
6.0      205
5.0      205
dtype: int64
Completed iteration 18
10.0    3142
0.0     1621
19.0    1118
2.0      447
14.0     446
9.0      444
15.0     443
18.0     407
11.0     378
17.0     352
4.0      346
1.0      335
16.0     332
7.0      330
8.0      313
20.0     308
22.0     276
12.0     238
21.0     229
3.0      220
13.0     215
6.0      205
5.0      205
dtype: int64
Completed iteration 19
10.0    3142
0.0     1621
19.0    1118
14.0     452
2.0      447
9.0      445
15.0     440
18.0     407
11.0     379
17.0     351
4.0      345
1.0      336
7.0      332
16.0     326
8.0      311
20.0     307
22.0     278
12.0     238
21.0     229
3.0      222
13.0     216
6.0      204
5.0      204
dtype: int64
Completed iteration 20
10.0    3143
0.0     1621
19.0    1118
9.0      457
2.0      454
14.0     449
15.0     442
18.0     407
11.0     381
17.0     350
4.0      343
1.0      334
7.0      327
16.0     312
8.0      310
20.0     305
22.0     278
12.0     238
21.0     233
3.0      223
13.0     217
6.0      204
5.0      204
dtype: int64
Completed iteration 21
Reached 21 iterations
Centroids:
Centroid 1: [ 1.5976243e-03  4.8191642e-04  8.0819828e-03  3.8910343e-04
  1.3181263e-04  9.8318803e-01  2.5253603e-04  2.5727395e-05
  3.1252563e-04 -3.0237123e-05  4.3909348e-04  3.6069591e-04
 -8.7696761e-02  3.5980198e-04  4.1967200e-04  3.2063987e-04
  1.2085109e-03  2.2214651e-03  2.2892037e-04  7.0329569e-04
  3.1969589e-04 -5.0851092e-04 -6.3678948e-05]
Centroid 2: [ 0.1333692   0.00058631 -0.2057515   0.00864099 -0.00168302 -0.16265583
  0.01796171  0.01398037 -0.01109537  0.01743015 -0.01205661  0.00303435
  0.04756109 -0.05823696  0.00404231 -0.00717188 -0.01155704  0.07864345
  0.22486469 -0.00785422  0.01113402  0.42677838  0.00269657]
Centroid 3: [ 9.6900888e-02 -1.3454140e-02 -9.8928893e-03  3.0159708e-02
  3.0573055e-03 -3.0031662e-02 -6.8369256e-03  2.4085669e-02
  1.5944091e-03 -2.3459846e-02  2.8146848e-02 -1.1002722e-02
  2.3066239e-02 -1.6847797e-02 -2.2845399e-03  1.2235146e-02
 -7.6735732e-03  7.3958477e-03 -3.0588746e-01  2.7968283e-04
 -1.6038736e-02 -5.0627863e-01  1.3494698e-03]
Centroid 4: [-0.09341882 -0.00116178 -0.00087145 -0.00628652 -0.00428681  0.04817001
 -0.00429763  0.03727042 -0.01339624 -0.03003101  0.04984568  0.00319856
 -0.04691983 -0.03098998 -0.43887994 -0.00362447 -0.03333693  0.00364814
 -0.10611518  0.02395828  0.04223967 -0.06987637 -0.00477307]
Centroid 5: [-0.01576508 -0.0204069   0.04200844  0.1321966   0.0192356   0.01549168
  0.01644009  0.01496515 -0.01718523  0.02711707  0.01719551  0.1012238
 -0.01693582 -0.02585338  0.20931664 -0.02911336 -0.04565188  0.01977199
  0.03320553 -0.0663103  -0.08677898 -0.03660908  0.01548309]
Centroid 6: [-2.0806314e-03  4.8226323e-03  3.0657290e-03  9.3615323e-04
  2.2796676e-05  2.9313236e-01 -1.8929383e-03 -1.7069280e-03
  1.9508990e-03  3.6061236e-03 -2.1232152e-03 -2.1928232e-03
  8.5868716e-01 -4.6684588e-03  1.6319586e-03 -3.1567961e-03
  3.0733328e-04 -3.3097313e-04 -4.4915839e-03  4.1650035e-03
  3.7110301e-03 -6.0846466e-03 -1.6899648e-04]
Centroid 7: [ 0.01593177 -0.00128949  0.01857451 -0.12087113  0.00503807 -0.03868078
 -0.06714621  0.01920756  0.06819544 -0.11106562 -0.39724442  0.03974606
  0.01944124  0.05283598 -0.00535244  0.05149431 -0.01902768 -0.00286787
 -0.04764454 -0.00896209 -0.03642748  0.01060776  0.00565837]
Centroid 8: [ 0.30633628  0.00507613 -0.13616063 -0.0330537  -0.00587856  0.01739328
  0.00850329 -0.00874455 -0.00783929 -0.01312738  0.02619695  0.00149532
 -0.00458183  0.01011539 -0.05179409 -0.00945964 -0.0029387   0.0599143
  0.2998372   0.01769677  0.01160269 -0.35404527 -0.01273872]
Centroid 9: [-1.33856079e-02 -1.60605845e-03 -5.09284377e-01  9.06374678e-03
  3.68966081e-04  3.43794450e-02 -2.90416228e-03  2.38743853e-02
  5.57810720e-03 -2.84129381e-02 -3.96987759e-02 -1.60583779e-02
 -1.24186445e-02  1.91383027e-02  2.66505368e-02  1.57553721e-02
 -5.00342548e-02  8.61207396e-02 -1.42557546e-01  2.60821469e-02
  8.94374680e-03  4.55392450e-02  5.03875664e-04]
Centroid 10: [-0.07294957 -0.00221229 -0.0652567   0.01762601  0.00758712 -0.03281185
  0.00580201  0.0006675   0.01015     0.00375387 -0.00337663  0.00127692
  0.00369025 -0.00569431 -0.00678265 -0.01067466  0.00702298  0.01591067
  0.6117603   0.00114172  0.01037388 -0.04105053  0.00068864]
Centroid 11: [-2.5997323e-03 -5.5928127e-04 -1.3954007e-02 -9.7631302e-05
  2.2780796e-04 -7.9707706e-01 -4.4035539e-04  3.0436269e-05
 -9.0775713e-05 -2.8882333e-04  4.1034186e-04 -1.4033740e-04
  5.5130583e-01  8.1854465e-05  2.8026628e-04 -5.5110076e-04
 -1.1632256e-03 -2.9980636e-03 -4.3693194e-04 -5.0716748e-04
 -5.5271672e-04 -8.8645826e-04 -9.7083366e-06]
Centroid 12: [-2.2580028e-01  2.9373466e-04  6.9490941e-03 -3.4219470e-02
  1.4244162e-03  2.6625698e-02  8.6162528e-03 -6.2635345e-03
  2.9269841e-03  1.8275645e-02 -1.3153558e-02 -8.7056421e-03
 -1.9915409e-02 -1.7617276e-02  2.7543927e-02 -5.5413286e-04
  1.9206945e-02  5.8371844e-03  1.5406597e-01 -1.4902993e-02
 -1.2347270e-02 -5.0912970e-01 -1.1380526e-03]
Centroid 13: [-0.05432552  0.01781526 -0.01623664  0.01113557 -0.00305876  0.01969225
  0.0138665  -0.11324683 -0.05282502  0.0531141   0.02348908 -0.01623297
  0.00366593  0.42554894 -0.00455082  0.00860011  0.00600796  0.02814559
  0.03339393  0.05253931  0.08533923  0.06604465  0.00941986]
Centroid 14: [ 0.15177763 -0.01314505 -0.05827757 -0.11892152  0.00268459 -0.06746783
 -0.02389381  0.04358663  0.01420465 -0.03072171  0.258146    0.01082739
  0.04362715  0.02711319  0.04158229  0.01416904  0.26543248  0.1058151
 -0.11377418  0.01954315 -0.00767725  0.05964802 -0.0059123 ]
Centroid 15: [-1.13720946e-01  3.08996788e-03  3.21428366e-02 -2.22084275e-03
 -1.51300069e-03  4.09075618e-03 -2.53729778e-03 -7.98054505e-03
 -5.79801446e-04  1.38397589e-02  9.78954881e-03  8.76878947e-03
  2.75457259e-02 -7.95444008e-03  2.44410820e-02 -5.53039042e-03
 -1.77337730e-03 -1.85052156e-02 -5.97562432e-01 -9.89392051e-04
 -1.01302685e-02 -3.20529416e-02 -7.38236355e-03]
Centroid 16: [-4.9585000e-02 -2.5939403e-04  1.3956902e-02  9.7349053e-03
 -1.4947740e-03  8.4482711e-03  1.8428588e-02  3.5769204e-03
  1.2852416e-03  2.9181151e-02 -3.3579639e-03  1.7262135e-02
 -7.1005868e-03 -1.6036943e-02 -3.3271320e-03  1.2383355e-02
  1.8695332e-02  2.4829388e-02 -3.1980991e-01 -1.9290116e-02
 -1.0285819e-03  5.1705235e-01  2.3898007e-03]
Centroid 17: [ 0.0572962   0.0037216   0.42916352 -0.01406199 -0.00884536  0.00173169
 -0.02705371 -0.00171106 -0.00587654 -0.04199608  0.00516392 -0.02081782
 -0.00102994  0.04982823 -0.03675196 -0.01504459 -0.00376884 -0.10463072
  0.2869141  -0.01565607 -0.0333242  -0.14419071  0.00104469]
Centroid 18: [ 0.02974067 -0.00238988  0.12272607 -0.04018445  0.00191247  0.09715246
 -0.02130966 -0.00391569  0.00064227 -0.00269744 -0.00482277 -0.00169972
 -0.06103999  0.0164586   0.03533722 -0.01259454 -0.02962647 -0.037444
  0.36464348 -0.00465376 -0.00306577  0.44644803  0.00107661]
Centroid 19: [-4.5045773e-03 -1.0985014e-03 -1.2476911e-02  1.5251277e-03
 -2.7121003e-03 -6.5842378e-01 -3.3641339e-03  1.0541421e-03
 -1.6882725e-03 -3.1392006e-03 -2.8475407e-03  2.5192327e-03
 -5.8855599e-01  1.8835937e-03 -3.0096080e-03 -2.1740480e-03
 -1.8532966e-03 -4.9767327e-03 -1.1547749e-03 -1.3026826e-04
  2.7854072e-03  3.8768367e-03 -2.4663963e-04]
Centroid 20: [-7.0400554e-04  4.9041823e-04  3.2415637e-03  1.0376705e-03
 -1.4293251e-04  7.9952270e-01  7.5540789e-05 -7.9226529e-04
 -8.6761772e-04 -7.0372573e-04  5.3322851e-04  3.4903546e-04
 -5.1338065e-01  9.3467237e-04 -1.5141015e-03 -9.7200114e-05
  1.0425846e-04  2.6546894e-03  1.2418281e-03 -2.5808715e-04
 -2.6887879e-04 -6.3880766e-04  1.0521535e-03]
Centroid 21: [-0.46152675 -0.00745796  0.1420885   0.00225008 -0.01449057 -0.01846568
  0.00851293  0.01861025  0.00943655 -0.000544    0.01867155  0.0309114
  0.00459793 -0.02271986  0.04408718  0.00860598  0.00178267 -0.10794698
  0.09436916  0.01580606  0.01619344  0.165768   -0.00118178]
Centroid 22: [ 1.51922293e-02  1.43970409e-02  1.32631823e-01  3.00357305e-02
 -6.77542062e-03 -1.18307464e-04  3.16272676e-02 -8.05083886e-02
  1.26741473e-02  5.58811501e-02  1.73301401e-03 -1.63924068e-01
  1.69549733e-02 -3.80510926e-01  1.97200850e-02  1.44195491e-02
 -2.05646157e-02 -1.03386724e-02 -1.14144623e-01  4.42069471e-02
  4.36231829e-02 -1.08784263e-03 -1.26408110e-03]
Centroid 23: [ 0.39834544  0.01735569  0.07967918  0.01401488  0.00427147  0.08330765
  0.00330667 -0.024106    0.00690284  0.00832829 -0.04993467 -0.01329765
 -0.05460723  0.03935825  0.09503455  0.01938985 -0.03971453 -0.07868991
 -0.2775812   0.03298488  0.03057998  0.15621704 -0.004687  ]
```

In [ ]:

```python
spectral_clustering(
    le_X_train025,
    cuts=len(np.unique(le_y_train025)),
    fname="label_encoded_spectral_clustering",
    affinity="laplacian",
    gamma=1.0,
)
```

```
eigenvalues: [4.7164481e-20 4.3019899e-20 3.8184838e-20 2.6893362e-20 2.0205838e-20
 1.1847787e-20 2.0182436e-21 1.2437433e-21 8.0380534e-23 6.3748079e-24
 9.5652944e-25 7.5414136e-31 4.0227215e-40 0.0000000e+00 0.0000000e+00].
Finished running k-means++
1.0     3572
0.0     3087
14.0     921
2.0      732
11.0     533
4.0      492
5.0      439
8.0      439
9.0      413
12.0     408
3.0      361
10.0     287
13.0     257
6.0      208
7.0      201
dtype: int64
Completed iteration 1
1.0     3488
0.0     2950
14.0     855
2.0      704
4.0      493
11.0     486
8.0      483
12.0     466
9.0      435
5.0      419
6.0      373
3.0      353
10.0     289
13.0     288
7.0      268
dtype: int64
Completed iteration 2
1.0     3484
0.0     2947
14.0     819
2.0      650
8.0      507
12.0     496
4.0      468
11.0     464
6.0      433
9.0      421
5.0      413
3.0      346
7.0      315
13.0     296
10.0     291
dtype: int64
Completed iteration 3
1.0     3482
0.0     2946
14.0     784
2.0      631
8.0      548
12.0     520
11.0     480
6.0      435
4.0      428
9.0      415
5.0      400
7.0      345
3.0      342
13.0     307
10.0     287
dtype: int64
Completed iteration 4
1.0     3481
0.0     2944
14.0     760
2.0      626
8.0      582
12.0     535
11.0     495
6.0      438
9.0      412
4.0      398
5.0      394
7.0      361
3.0      337
13.0     301
10.0     286
dtype: int64
Completed iteration 5
1.0     3482
0.0     2944
14.0     739
2.0      626
8.0      603
12.0     542
11.0     511
6.0      438
9.0      406
5.0      402
4.0      384
7.0      352
3.0      345
13.0     303
10.0     273
dtype: int64
Completed iteration 6
1.0     3482
0.0     2944
14.0     724
2.0      625
8.0      613
12.0     561
11.0     519
6.0      440
5.0      422
9.0      401
4.0      361
3.0      346
7.0      337
13.0     300
10.0     275
dtype: int64
Completed iteration 7
1.0     3480
0.0     2944
14.0     710
2.0      624
8.0      611
12.0     570
11.0     545
6.0      446
5.0      443
9.0      389
3.0      351
4.0      335
7.0      330
13.0     298
10.0     274
dtype: int64
Completed iteration 8
1.0     3480
0.0     2945
14.0     698
2.0      627
8.0      620
12.0     575
11.0     553
5.0      458
6.0      448
9.0      388
3.0      357
7.0      317
4.0      315
13.0     298
10.0     271
dtype: int64
Completed iteration 9
1.0     3480
0.0     2944
14.0     700
2.0      626
8.0      624
12.0     576
11.0     566
5.0      471
6.0      451
9.0      382
3.0      362
7.0      310
4.0      299
13.0     292
10.0     267
dtype: int64
Completed iteration 10
1.0     3479
0.0     2944
14.0     696
2.0      633
8.0      623
11.0     571
12.0     570
5.0      487
6.0      451
9.0      387
3.0      362
7.0      305
13.0     294
4.0      284
10.0     264
dtype: int64
Completed iteration 11
1.0     3479
0.0     2943
14.0     694
2.0      639
8.0      620
11.0     576
12.0     566
5.0      507
6.0      457
9.0      389
3.0      366
7.0      293
13.0     291
4.0      267
10.0     263
dtype: int64
Completed iteration 12
1.0     3479
0.0     2943
14.0     684
2.0      640
8.0      626
11.0     578
12.0     564
5.0      516
6.0      463
9.0      389
3.0      361
7.0      294
13.0     285
4.0      265
10.0     263
dtype: int64
Completed iteration 13
1.0     3479
0.0     2943
14.0     674
2.0      643
8.0      624
11.0     582
12.0     559
5.0      531
6.0      468
9.0      392
3.0      364
13.0     290
7.0      284
10.0     260
4.0      257
dtype: int64
Completed iteration 14
1.0     3481
0.0     2943
14.0     677
2.0      647
8.0      622
11.0     584
12.0     551
5.0      545
6.0      469
9.0      391
3.0      361
13.0     294
7.0      279
10.0     260
4.0      246
dtype: int64
```

```
Completed iteration 15
1.0     3480
0.0     2943
14.0     673
2.0      651
8.0      620
11.0     577
12.0     552
5.0      551
6.0      469
9.0      396
3.0      360
13.0     297
7.0      276
10.0     264
4.0      241
dtype: int64
Completed iteration 16
1.0     3480
0.0     2943
14.0     668
2.0      655
8.0      615
11.0     571
5.0      554
12.0     549
6.0      469
9.0      403
3.0      355
13.0     311
7.0      274
10.0     271
4.0      232
dtype: int64
Completed iteration 17
1.0     3480
0.0     2943
14.0     666
2.0      655
8.0      616
11.0     571
5.0      557
12.0     551
6.0      470
9.0      400
3.0      352
13.0     313
10.0     277
7.0      273
4.0      226
dtype: int64
Completed iteration 18
1.0     3480
0.0     2943
14.0     664
2.0      655
8.0      620
11.0     571
5.0      569
12.0     547
6.0      472
9.0      397
3.0      352
13.0     312
10.0     280
7.0      270
4.0      218
dtype: int64
Completed iteration 19
1.0     3480
0.0     2943
14.0     658
2.0      655
8.0      623
5.0      575
11.0     571
12.0     553
6.0      472
9.0      394
3.0      354
13.0     311
10.0     282
7.0      265
4.0      214
dtype: int64
Completed iteration 20
```

```
1.0     3480
0.0     2944
14.0     653
2.0      643
8.0      616
5.0      593
11.0     571
12.0     551
6.0      469
9.0      396
3.0      352
13.0     311
10.0     291
7.0      268
4.0      212
dtype: int64
Completed iteration 21
Reached 21 iterations
Centroids:
Centroid 1: [-3.74824507e-04 -2.18242494e-04  6.69058762e-04 -1.86199424e-04
 -9.94800329e-01 -1.25306760e-04  4.30602988e-04 -3.50516377e-04
  1.82915735e-03  1.12514375e-02 -2.20058486e-04  1.79931973e-04
  2.99175648e-04  8.70286094e-05  3.18609149e-04]
Centroid 2: [ 3.4065687e-04  2.0086789e-04 -6.2462519e-04 -6.6116062e-04
  9.9511009e-01 -7.4957218e-04 -2.3261896e-04 -4.9537240e-04
 -1.8435920e-03 -5.5496232e-03  4.1577389e-04  3.5962925e-04
  1.6287716e-04 -2.2223656e-04 -1.4100100e-04]
Centroid 3: [-4.09152388e-04 -7.96907023e-03  2.89410865e-03 -1.31225009e-02
 -1.01466915e-02 -3.30537967e-02  1.72367096e-02  7.19325757e-03
  1.11274794e-02 -7.34968483e-03 -1.20589964e-01 -1.41914943e-02
 -2.38971990e-02 -6.46059096e-01 -2.07804120e-03]
Centroid 4: [-0.00071252 -0.0037885  -0.3201857  -0.01662242 -0.03150895  0.3754816
  0.02645454  0.01297674  0.02750166 -0.02822424  0.07275084  0.00349041
 -0.02164336 -0.05706209 -0.00168369]
Centroid 5: [ 0.01274638 -0.03835933  0.09527522  0.03034043 -0.03134495  0.12370616
  0.07966176 -0.01096487  0.47506547  0.13797194 -0.09441675  0.01698504
 -0.02782576  0.14850774  0.00910818]
Centroid 6: [ 1.1418528e-02  1.1676778e-03 -2.1875519e-02  2.3238620e-02
  5.0245709e-04 -2.2333449e-02  6.6296965e-02  3.9308905e-03
 -9.4176251e-03 -2.3671368e-03  6.3014108e-01 -8.0639841e-03
  6.3732634e-03  1.8866606e-01  5.5559189e-04]
Centroid 7: [-0.03949568 -0.05336193  0.20842257 -0.0804342   0.02238454  0.06918619
  0.10065661  0.00062244 -0.15862134 -0.2244229  -0.02088692 -0.03467053
 -0.04239279 -0.02830172  0.00303054]
Centroid 8: [-0.00837096 -0.02106258 -0.04975454  0.00062046  0.06759724 -0.01865102
 -0.03562183 -0.00202518 -0.06736168  0.40716705 -0.05784147 -0.12876892
 -0.23088674 -0.16657059  0.00942147]
Centroid 9: [-0.0057902  -0.0111377   0.01922445 -0.00494631 -0.01045653 -0.00604683
 -0.06197596 -0.03100971  0.01532585 -0.00263518  0.5470577  -0.0147042
 -0.02992856 -0.37593094 -0.00888551]
Centroid 10: [ 0.02539954  0.02751564 -0.08401486 -0.01665129 -0.01689318 -0.358666
  0.25261602  0.03311186 -0.02096961  0.03511202 -0.11627197  0.00368348
 -0.0363541   0.2639378   0.00511516]
Centroid 11: [ 0.02171285  0.00288487  0.06551468  0.07914616  0.02118672 -0.05228621
  0.10571442  0.04903186 -0.00256741  0.00471321  0.07605144  0.24350514
  0.37274987 -0.15608351  0.00392398]
Centroid 12: [-1.4743209e-04  7.4548210e-04 -1.9781990e-02  2.0865338e-02
  6.4628050e-03  3.8841136e-02 -3.5389978e-02  6.2959655e-03
 -1.0667109e-02  2.6471039e-02 -4.3087360e-01  5.4579638e-03
  1.6965186e-02  5.1124698e-01  4.9501508e-03]
Centroid 13: [-3.6209684e-03  5.2928003e-03 -2.0387874e-03  8.2122895e-04
 -1.5279623e-02  4.9973879e-02 -2.0258091e-02 -1.5636921e-02
 -1.3917236e-02  5.5326440e-04  2.3025531e-01 -8.8458937e-03
  1.4243852e-03  6.1159849e-01  4.9877893e-03]
Centroid 14: [ 0.0112974   0.06218099  0.06357165  0.04963541 -0.04541471 -0.04843514
 -0.47295913  0.00602766 -0.03525396 -0.03309976 -0.05603009  0.01564301
  0.04259486  0.00639285 -0.00735314]
Centroid 15: [ 0.00070638  0.00879517  0.00677882 -0.00130137  0.01229084 -0.01752472
  0.02234106 -0.0050103  -0.00243843 -0.0307018  -0.65374213  0.01611061
  0.01365354 -0.1306158  -0.00615214]
```

linear

In [ ]:

```
spectral_clustering(
    le_X_train025,
    cuts=23,
    fname="label_encoded_spectral_clustering",
    affinity="linear",
)
```

```
eigenvalues: [9.9989665e-01 9.9986744e-01 9.9986207e-01 9.9983287e-01 9.9981642e-01
 9.9980986e-01 9.9979889e-01 9.9977648e-01 9.9975729e-01 9.9971628e-01
 9.9965149e-01 9.9960595e-01 9.9957544e-01 9.9951214e-01 9.9909729e-01
 9.9871284e-01 9.9773747e-01 9.7577429e-01 9.6599168e-01 8.1473356e-01
 3.7500587e-01 9.3694995e-05 2.6699167e-11].
Finished running k-means++
1.0     5645
0.0     1127
2.0      896
11.0     856
5.0      644
22.0     492
7.0      271
6.0      256
8.0      236
9.0      226
12.0     224
3.0      199
20.0     192
15.0     170
17.0     170
13.0     160
10.0     138
16.0     121
21.0      94
14.0      87
4.0       86
19.0      39
18.0      21
dtype: int64
Completed iteration 1
1.0     5633
0.0     1135
2.0      897
11.0     769
5.0      717
22.0     494
7.0      272
8.0      210
6.0      209
9.0      203
15.0     202
3.0      200
12.0     190
20.0     183
13.0     178
17.0     171
10.0     137
14.0     119
16.0     108
21.0     103
4.0       90
19.0      74
18.0      56
dtype: int64
Completed iteration 2
1.0     5633
0.0     1140
2.0      897
5.0      776
11.0     704
22.0     497
7.0      271
15.0     240
3.0      202
8.0      201
9.0      191
12.0     186
6.0      184
20.0     167
13.0     164
17.0     146
10.0     137
14.0     117
16.0     108
18.0     103
19.0     102
21.0      98
4.0       86
dtype: int64
Completed iteration 3
1.0     5633
0.0     1139
2.0      897
5.0      823
11.0     659
```

```
22.0     498
7.0      269
15.0     246
3.0      201
8.0      197
12.0     189
9.0      183
6.0      176
20.0     162
13.0     150
10.0     136
18.0     131
17.0     129
14.0     120
19.0     117
16.0     108
21.0      98
4.0       89
dtype: int64
Completed iteration 4
1.0     5633
0.0     1140
2.0      897
5.0      858
11.0     624
22.0     499
7.0      265
15.0     244
3.0      200
8.0      195
12.0     195
9.0      176
6.0      175
20.0     157
13.0     152
18.0     148
10.0     136
17.0     127
14.0     116
19.0     112
16.0     108
21.0     103
4.0       90
dtype: int64
Completed iteration 5
1.0     5633
0.0     1139
2.0      897
5.0      884
11.0     598
22.0     499
7.0      265
15.0     234
3.0      201
8.0      195
12.0     195
6.0      176
9.0      172
20.0     156
18.0     155
13.0     153
10.0     136
17.0     125
14.0     120
19.0     114
16.0     108
21.0     102
4.0       93
dtype: int64
Completed iteration 6
1.0     5633
0.0     1137
5.0      906
2.0      897
11.0     579
22.0     499
7.0      265
15.0     227
3.0      201
8.0      196
12.0     195
6.0      178
9.0      170
18.0     160
20.0     159
13.0     154
```

```
10.0     136
14.0     127
17.0     118
16.0     108
19.0     107
21.0     105
4.0       93
dtype: int64
Completed iteration 7
1.0     5633
0.0     1138
5.0      922
2.0      897
11.0     564
22.0     499
7.0      264
15.0     222
3.0      199
8.0      195
12.0     195
6.0      181
9.0      171
18.0     162
20.0     162
13.0     150
10.0     136
14.0     130
17.0     113
21.0     110
16.0     108
19.0     106
4.0       93
dtype: int64
Completed iteration 8
1.0     5633
0.0     1138
5.0      933
2.0      897
11.0     554
22.0     499
7.0      264
15.0     213
3.0      198
12.0     195
8.0      194
6.0      182
9.0      171
20.0     164
18.0     160
13.0     150
10.0     136
14.0     134
21.0     118
17.0     109
16.0     108
19.0     107
4.0       93
dtype: int64
Completed iteration 9
1.0     5633
0.0     1138
5.0      939
2.0      897
11.0     548
22.0     499
7.0      264
15.0     209
3.0      198
8.0      195
12.0     195
6.0      184
9.0      171
20.0     164
18.0     162
13.0     152
10.0     136
14.0     132
21.0     122
16.0     108
19.0     107
17.0     104
4.0       93
dtype: int64
Completed iteration 10
1.0     5633
0.0     1138
```

```
5.0      944
2.0      897
11.0     543
22.0     499
7.0      264
15.0     209
3.0      198
12.0     195
8.0      194
6.0      183
9.0      172
18.0     164
20.0     162
13.0     154
10.0     136
14.0     132
21.0     123
16.0     108
19.0     107
17.0     102
4.0       93
dtype: int64
Completed iteration 11
1.0     5633
0.0     1138
5.0      949
2.0      897
11.0     538
22.0     499
7.0      264
15.0     205
3.0      198
12.0     195
8.0      194
6.0      184
9.0      172
18.0     166
20.0     161
13.0     156
10.0     136
14.0     133
21.0     122
16.0     108
19.0     107
17.0     102
4.0       93
dtype: int64
Completed iteration 12
1.0     5633
0.0     1138
5.0      952
2.0      897
11.0     535
22.0     499
7.0      264
15.0     200
3.0      198
12.0     195
8.0      194
6.0      183
9.0      172
18.0     165
20.0     162
13.0     159
10.0     136
14.0     134
21.0     123
19.0     108
16.0     108
17.0     102
4.0       93
dtype: int64
Completed iteration 13
1.0     5633
0.0     1138
5.0      958
2.0      897
11.0     529
22.0     499
7.0      264
3.0      198
15.0     198
12.0     195
8.0      194
6.0      184
9.0      172
```

```
18.0     163
20.0     163
13.0     160
14.0     136
10.0     136
21.0     123
16.0     108
19.0     108
17.0     101
4.0       93
dtype: int64
Completed iteration 14
1.0     5633
0.0     1138
5.0      962
2.0      897
11.0     525
22.0     499
7.0      264
15.0     200
3.0      198
12.0     195
8.0      194
6.0      183
9.0      171
20.0     166
13.0     160
18.0     156
14.0     139
10.0     136
21.0     123
19.0     109
16.0     108
17.0     101
4.0       93
dtype: int64
Completed iteration 15
1.0     5633
0.0     1138
5.0      963
2.0      897
11.0     524
22.0     499
7.0      264
15.0     203
3.0      198
12.0     195
8.0      194
6.0      181
9.0      171
20.0     169
13.0     159
18.0     154
14.0     137
10.0     136
21.0     122
19.0     111
16.0     108
17.0     101
4.0       93
dtype: int64
Completed iteration 16
1.0     5633
0.0     1138
5.0      963
2.0      897
11.0     524
22.0     499
7.0      264
15.0     202
3.0      198
8.0      195
12.0     195
6.0      181
9.0      171
20.0     171
13.0     161
18.0     152
10.0     136
14.0     135
21.0     121
19.0     112
16.0     108
17.0     101
4.0       93
dtype: int64
```

```
Completed iteration 17
1.0     5633
0.0     1138
5.0      963
2.0      897
11.0     524
22.0     499
7.0      264
15.0     205
3.0      198
8.0      195
12.0     195
6.0      179
20.0     173
9.0      171
13.0     162
18.0     148
10.0     136
14.0     134
21.0     121
19.0     113
16.0     108
17.0     101
4.0       93
dtype: int64
Completed iteration 18
1.0     5633
0.0     1138
5.0      963
2.0      897
11.0     524
22.0     499
7.0      264
15.0     207
3.0      198
8.0      195
12.0     195
6.0      177
20.0     174
9.0      171
13.0     163
18.0     145
10.0     136
14.0     135
21.0     121
19.0     113
16.0     108
17.0     101
4.0       93
dtype: int64
Completed iteration 19
1.0     5633
0.0     1138
5.0      963
2.0      897
11.0     524
22.0     499
7.0      264
15.0     209
3.0      198
8.0      195
12.0     195
6.0      177
20.0     174
9.0      171
13.0     163
18.0     144
10.0     136
14.0     135
21.0     121
19.0     113
16.0     108
17.0     100
4.0       93
dtype: int64
Completed iteration 20
Epsilon has a maximum value of 0.009180647321045399
Centroids:
Centroid 1: [-1.18672308e-02  3.34746391e-03  2.35731318e-03  1.32084573e-02
  1.09444456e-02  4.35808935e-04  2.53254455e-02  1.65920537e-02
 -1.59081500e-02 -9.59290483e-04 -6.82555092e-03 -3.29848216e-03
  3.37253734e-02 -3.30519006e-02  3.87684535e-03  7.22429529e-02
 -3.02033365e-01 -4.25687134e-01 -2.81820774e-01  5.85958779e-01
 -1.42564336e-02  1.00193895e-01  4.00139391e-01]
Centroid 2: [-1.1333504e-02 -1.3988117e-02 -4.2936083e-02 -3.6780038e-03
 -1.2162708e-02  1.1840872e-02  6.6299804e-02  5.7691643e-03
```

```
 -7.7815386e-03 -1.5073712e-02 -2.5029780e-02  1.3319379e-02
  7.8458311e-03  1.7688643e-03  5.3066725e-04 -1.1597093e-02
  2.2692214e-01  1.0086083e-01  2.3314092e-02 -3.0378687e-01
 -5.8148559e-02  3.6373916e-01  8.3457488e-01]
Centroid 3: [ 0.02403543  0.02913488  0.08685764 -0.01414425 -0.00321852 -0.04810998
 -0.2081269  -0.02346338 -0.03514524  0.03025947  0.00938647 -0.03492413
 -0.01699474 -0.02808416 -0.00236332  0.06319822 -0.7712834   0.08986672
  0.3044308  -0.04833122 -0.03306014  0.18654078  0.44342753]
Centroid 4: [ 0.00468163  0.01271536  0.01002009 -0.01604437  0.00998192  0.00122925
 -0.00728914  0.00625341 -0.00436918 -0.00436091 -0.0061629   0.00948035
 -0.10458309  0.12009042 -0.01806797 -0.5766129   0.07284491 -0.4028985
 -0.13348016  0.11168017 -0.00906959 -0.01476388  0.19203185]
Centroid 5: [-0.07219511 -0.03130636 -0.2190666   0.00069768  0.04593563  0.13028288
  0.50144374  0.02191567  0.12646289  0.01384407 -0.01196135  0.09043624
 -0.01106174 -0.02927164 -0.01690178 -0.02398834 -0.10515083 -0.03038758
 -0.49615258 -0.23200542 -0.01166154  0.01896     0.17458372]
Centroid 6: [-3.91419558e-03  1.35801602e-02  9.98325367e-03  1.49654709e-02
  1.95941509e-04 -8.95455014e-03 -2.45985035e-02  9.40190686e-04
 -3.90455406e-03  2.57511227e-03 -3.07974144e-04 -5.82007971e-03
 -1.41036068e-03  4.18577250e-03  1.62181212e-04 -9.28246882e-03
  3.98193926e-01  3.99379402e-01  1.08223394e-01  6.61254585e-01
 -2.30483990e-02  1.14868216e-01  3.89349729e-01]
Centroid 7: [ 0.08945075  0.08481625 -0.14807752  0.10110636 -0.01663625  0.04071366
  0.09558894  0.0274208   0.1307484   0.00716015  0.01315764  0.07083076
 -0.32536888 -0.16424501 -0.18179485 -0.09547591  0.14004761 -0.20507364
 -0.06519158 -0.1311998  -0.03429806 -0.41311526  0.23730811]
Centroid 8: [-0.00096977  0.01834521  0.08002146  0.03272384 -0.0052695  -0.04205098
 -0.1375148  -0.02617461 -0.04234136  0.0019947  -0.01002606 -0.05528376
  0.11491764 -0.09210984  0.03683941  0.46041512  0.06227765  0.17074561
 -0.44186354 -0.5170499  -0.01362382 -0.01929509  0.23253419]
Centroid 9: [ 0.02431281  0.05009123  0.11687362  0.00993016 -0.02503718 -0.05540054
 -0.34294313 -0.01081713 -0.11004383  0.00799945 -0.00691812 -0.02593894
 -0.04510736  0.07798593 -0.02739124 -0.21239501  0.30010435 -0.35294595
 -0.16382688 -0.35261235 -0.02578137 -0.17778695  0.26565355]
Centroid 10: [ 0.03975133 -0.00674101  0.07552455 -0.00177838 -0.00218625 -0.03160376
 -0.13335718 -0.01404855 -0.07442328 -0.01205526 -0.01819216 -0.0014507
 -0.08188716  0.10792174 -0.00335955 -0.42210785 -0.09794576  0.29076594
 -0.4189807  -0.46560523 -0.01214708  0.02449193  0.1968141 ]
Centroid 11: [ 5.29155193e-04 -5.97466249e-03 -5.46361413e-03  3.91264074e-03
 -1.92105770e-03 -3.24538862e-03 -1.19449822e-02  1.38379983e-03
 -1.11031653e-02 -6.59550773e-04 -2.63635558e-03 -1.69167551e-03
  7.64749572e-03  5.43677062e-03  2.70861271e-03 -3.79694663e-02
  1.16495386e-01 -4.03840035e-01  8.11652243e-01 -2.39844665e-01
 -1.62691921e-02 -3.82107939e-03  1.33343816e-01]
Centroid 12: [-0.02951815  0.00249264 -0.01196709  0.02024275 -0.00156616  0.00509585
  0.04056938  0.00134426  0.00367474  0.00635771 -0.00387732  0.00120724
  0.01858521 -0.02187764  0.00092052  0.07504688  0.06137761  0.3053437
  0.10815404  0.755199   -0.02659093  0.13473019  0.46834162]
Centroid 13: [-0.04015658  0.01262057 -0.06420794  0.03562005  0.0231182   0.03110927
  0.11414161 -0.00449457  0.04036654  0.01749337  0.00390425  0.00259019
  0.07097026 -0.09337153  0.00186451  0.46334743  0.32727894 -0.57632166
 -0.12692395 -0.1867459  -0.01921442 -0.12669705  0.22977003]
Centroid 14: [-0.03422976  0.1154908   0.08835132 -0.2240185  -0.0325058  -0.0033346
 -0.02757604 -0.0535196   0.0335215   0.1264103   0.05525846 -0.34485763
  0.20801193  0.1294917   0.07633396 -0.04976313  0.0071105   0.01980195
  0.00233033 -0.01233006 -0.02892205 -0.42148662  0.15466738]
Centroid 15: [ 0.04981385 -0.0073505  -0.01600618  0.08176935 -0.05082889 -0.01280945
 -0.01504147  0.05080002  0.07773137  0.023682    0.02798377 -0.10653897
 -0.20328802  0.03753247  0.3454938   0.02970302 -0.01733486  0.08402368
  0.03497853 -0.00252211 -0.0248046  -0.37753114  0.12441085]
Centroid 16: [ 0.01567882 -0.06585243 -0.06536008 -0.13115874  0.11037742  0.01727849
  0.13677421 -0.02901656  0.20249413 -0.23783396  0.03789813  0.09849723
  0.16839702  0.06670412  0.16282395 -0.12055937  0.14198564 -0.04935117
  0.00126729 -0.23255327 -0.03201532 -0.36719105  0.2379476 ]
Centroid 17: [ 8.0676805e-03  6.3787363e-03  8.8935075e-03  1.0877086e-03
  8.0216834e-03 -3.0796321e-03  1.1711993e-02 -1.6869552e-02
  7.7158185e-03  3.8057733e-03 -8.1070099e-04 -4.9095559e-03
 -7.4628689e-03 -1.5488364e-02 -8.0080545e-03  1.6831392e-02
 -4.3837827e-02  1.8723162e-02 -1.7257662e-01 -6.8572991e-02
  9.2982244e-01 -6.6915095e-02  1.3530353e-01]
Centroid 18: [ 0.00550572  0.03824805 -0.09934464  0.10676298 -0.01763164  0.19475324
 -0.10434476 -0.05533613  0.0068623   0.00688699  0.12240343  0.13599916
  0.11934506 -0.02005901 -0.51024234 -0.06290073  0.03210378  0.05221285
  0.0212485  -0.0828623  -0.02966059 -0.40604487  0.17295253]
Centroid 19: [-0.07086305 -0.16375229 -0.03329865 -0.1009432  -0.05988023  0.10160202
  0.05252515  0.01606797 -0.13294132 -0.06628907 -0.02291898  0.13023707
 -0.01627173  0.41177928 -0.07998278  0.10814919 -0.00392292  0.02708156
  0.01139893  0.00122081 -0.02794222 -0.41372606  0.14537267]
Centroid 20: [-1.1343707e-02  1.1560476e-01  6.5138482e-02 -7.0677362e-02
  2.1621476e-01 -7.5651653e-02 -3.5753587e-04 -5.0135992e-02
 -1.3921767e-02  5.1552795e-02  7.3194101e-02 -2.3802593e-01
 -3.0122799e-01  5.2403877e-03 -1.7276207e-01  6.2412102e-02
 -1.9876841e-02  6.9383569e-02  3.5819370e-02  1.8466884e-02
 -2.4860779e-02 -3.7846410e-01  1.2189221e-01]
Centroid 21: [ 0.02742217 -0.23878759 -0.00310213 -0.01953245 -0.08685913 -0.18975417
  0.05866642  0.16514248 -0.05570914  0.06880535 -0.07997523  0.04880248
```

```
 0.02564235 -0.27917758 -0.06439357 -0.04953273 -0.01749677  0.05997978
 0.02568607  0.01690686 -0.02521527 -0.38744074  0.1272603 ]
Centroid 22: [ 0.08139005  0.20208198  0.04633217  0.04200547 -0.01785978  0.06003715
-0.04154022 -0.13311526 -0.03988206  0.00275275 -0.01355802  0.25079232
 0.12796897 -0.08848397  0.07244334 -0.01243077 -0.03327302  0.04713603
 0.01295437  0.04422255 -0.01702646 -0.27961192  0.08310224]
Centroid 23: [-6.4197062e-03 -1.1985157e-02  3.7295237e-02 -7.1150707e-03
 4.4472385e-02 -3.6630090e-03 -7.0672482e-02 -4.0686268e-02
-1.3593725e-02  1.3515457e-02  3.0131074e-02 -1.0021867e-04
-2.0028125e-02  9.1652367e-03  4.4444767e-03 -4.8710901e-02
-7.5275916e-01 -2.7091958e-02  2.5855082e-01 -1.4422287e-01
-3.4922205e-02  1.8922138e-01  4.7785163e-01]
```

In [ ]:

```
spectral_clustering(
    le_X_train025,
    cuts=len(np.unique(le_y_train025)),
    fname="label_encoded_spectral_clustering",
    affinity="linear",
)
```

```
eigenvalues: [9.9975729e-01 9.9971628e-01 9.9965149e-01 9.9960595e-01 9.9957544e-01
 9.9951214e-01 9.9909729e-01 9.9871284e-01 9.9773747e-01 9.7577429e-01
 9.6599168e-01 8.1473356e-01 3.7500587e-01 9.3694995e-05 2.6699167e-11].
Finished running k-means++
2.0     5645
5.0     1505
3.0     1407
0.0     1194
7.0      356
13.0     342
1.0      323
12.0     305
9.0      281
10.0     242
8.0      200
4.0      190
6.0      143
11.0     109
14.0     108
dtype: int64
Completed iteration 1
2.0     5638
5.0     1480
3.0     1403
0.0     1169
7.0      359
1.0      341
13.0     331
9.0      276
12.0     264
10.0     259
4.0      203
14.0     195
8.0      184
6.0      139
11.0     109
dtype: int64
Completed iteration 2
2.0     5637
5.0     1477
3.0     1403
0.0     1164
7.0      364
1.0      333
13.0     331
9.0      275
12.0     263
10.0     259
4.0      213
14.0     207
8.0      176
6.0      139
11.0     109
dtype: int64
Completed iteration 3
2.0     5637
5.0     1474
3.0     1403
0.0     1164
7.0      366
1.0      332
13.0     331
12.0     277
9.0      273
10.0     230
4.0      223
14.0     212
8.0      180
6.0      139
11.0     109
dtype: int64
Completed iteration 4
2.0     5637
5.0     1474
3.0     1403
0.0     1164
7.0      370
13.0     331
1.0      326
12.0     291
9.0      273
4.0      230
10.0     212
14.0     211
8.0      180
6.0      139
11.0     109
dtype: int64
Completed iteration 5
2.0     5637
5.0     1474
3.0     1403
0.0     1163
7.0      377
13.0     331
1.0      325
12.0     292
9.0      273
4.0      240
14.0     206
10.0     205
8.0      176
6.0      139
11.0     109
dtype: int64
Completed iteration 6
2.0     5637
5.0     1474
3.0     1403
0.0     1163
7.0      386
13.0     331
1.0      322
12.0     292
9.0      273
4.0      240
10.0     199
14.0     199
8.0      183
6.0      139
11.0     109
dtype: int64
Completed iteration 7
2.0     5637
5.0     1474
3.0     1403
0.0     1163
7.0      385
13.0     331
1.0      317
12.0     288
9.0      275
4.0      249
8.0      198
10.0     197
14.0     185
6.0      139
11.0     109
dtype: int64
Completed iteration 8
2.0     5637
5.0     1474
3.0     1403
0.0     1162
7.0      388
13.0     331
1.0      311
12.0     287
9.0      276
4.0      248
8.0      216
10.0     193
14.0     176
6.0      139
11.0     109
dtype: int64
Completed iteration 9
2.0     5637
5.0     1474
3.0     1403
0.0     1162
7.0      398
13.0     331
1.0      311
12.0     282
9.0      276
4.0      241
8.0      223
10.0     194
14.0     171
6.0      138
11.0     109
dtype: int64
Completed iteration 10
2.0     5637
5.0     1474
3.0     1403
0.0     1162
7.0      409
13.0     331
1.0      308
12.0     279
9.0      276
4.0      230
8.0      228
10.0     194
14.0     172
6.0      138
11.0     109
dtype: int64
Completed iteration 11
2.0     5637
5.0     1474
3.0     1403
0.0     1162
7.0      413
13.0     331
1.0      311
9.0      276
12.0     275
4.0      226
8.0      224
10.0     194
14.0     177
6.0      138
11.0     109
dtype: int64
Completed iteration 12
2.0     5637
5.0     1474
3.0     1403
0.0     1162
7.0      404
13.0     331
1.0      317
9.0      276
12.0     270
4.0      235
8.0      218
10.0     194
14.0     182
6.0      138
11.0     109
dtype: int64
Completed iteration 13
2.0     5637
5.0     1474
3.0     1403
0.0     1162
7.0      399
13.0     331
1.0      316
9.0      276
12.0     272
4.0      240
8.0      214
10.0     194
14.0     185
6.0      138
11.0     109
dtype: int64
Completed iteration 14
2.0     5637
5.0     1474
3.0     1403
0.0     1162
7.0      389
13.0     331
1.0      312
9.0      274
12.0     273
4.0      250
8.0      217
10.0     192
14.0     189
6.0      138
11.0     109
dtype: int64
Completed iteration 15
2.0     5637
5.0     1474
3.0     1403
0.0     1162
7.0      373
13.0     331
1.0      311
9.0      275
12.0     273
4.0      263
8.0      217
10.0     193
14.0     191
6.0      138
11.0     109
dtype: int64
Completed iteration 16
2.0     5638
5.0     1474
3.0     1403
0.0     1163
7.0      357
13.0     331
1.0      310
9.0      275
4.0      274
12.0     274
8.0      220
10.0     192
14.0     192
6.0      138
11.0     109
dtype: int64
Completed iteration 17
2.0     5638
5.0     1474
3.0     1403
0.0     1163
7.0      333
13.0     331
1.0      307
4.0      292
12.0     281
9.0      275
8.0      221
14.0     193
10.0     192
6.0      138
11.0     109
dtype: int64
Completed iteration 18
2.0     5638
5.0     1474
3.0     1403
0.0     1162
13.0     331
7.0      314
1.0      307
4.0      298
12.0     295
9.0      275
8.0      222
10.0     192
14.0     192
6.0      138
11.0     109
dtype: int64
Completed iteration 19
2.0     5638
5.0     1474
3.0     1402
0.0     1162
13.0     331
4.0      316
12.0     306
1.0      303
7.0      290
9.0      273
8.0      226
14.0     192
10.0     190
6.0      138
11.0     109
dtype: int64
Completed iteration 20
2.0     5638
5.0     1474
3.0     1402
0.0     1163
4.0      335
13.0     331
12.0     306
1.0      301
9.0      271
7.0      266
8.0      235
14.0     192
10.0     189
6.0      138
11.0     109
dtype: int64
Completed iteration 21
Reached 21 iterations
Centroids:
Centroid 1: [-0.01575751 -0.00107792 -0.00644833 -0.0016176   0.03304305 -0.03241785
  0.00354679  0.06794674 -0.30804738 -0.41499087 -0.27566725  0.5901654
 -0.01460133  0.1015331   0.40388575]
Centroid 2: [ 0.00886385  0.08228796  0.02954931 -0.4157477  -0.04367853  0.15854129
  0.15034574  0.02167225 -0.01625862  0.06894494  0.02863753  0.00327308
 -0.03190351 -0.47701773  0.1620914 ]
Centroid 3: [-7.62678403e-03 -1.54268872e-02 -2.54280847e-02  1.32509405e-02
  7.92737957e-03  1.81682874e-03  5.49063727e-04 -1.15863252e-02
  2.27862552e-01  1.01275228e-01  2.34756339e-02 -3.05108637e-01
 -5.83697222e-02  3.65397960e-01  8.38321567e-01]
Centroid 4: [-2.8322859e-02  2.5651973e-02  1.7850714e-02 -2.2885436e-02
 -1.8507851e-02 -1.5549767e-02  6.9252113e-05  2.4688855e-02
 -7.8276110e-01  4.8823629e-02  2.9358399e-01 -8.3956711e-02
 -3.4371216e-02  1.9154340e-01  4.6562842e-01]
Centroid 5: [ 0.00981392 -0.01585151  0.01523842 -0.00439026 -0.16953795  0.03965104
 -0.07499819 -0.26718438  0.22991835 -0.5236182  -0.14330903 -0.16696373
 -0.03059097 -0.3106615   0.27491808]
Centroid 6: [-1.0310891e-03  3.8721005e-03 -8.4050425e-04 -3.4929840e-03
  5.0403555e-03 -4.3160198e-03  3.8393322e-04  1.8175120e-02
  2.8611487e-01  3.7119001e-01  1.1023080e-01  6.9467759e-01
 -2.4333786e-02  1.2189050e-01  4.1690114e-01]
Centroid 7: [-1.05282366e-02 -4.91335522e-04 -2.73406412e-03 -1.95959792e-03
  8.37847032e-03  4.40615648e-03  3.03311856e-03 -2.85830684e-02
  1.14058614e-01 -4.06893343e-01  8.11594009e-01 -2.40588471e-01
 -1.63481552e-02 -3.55173810e-03  1.35633782e-01]
Centroid 8: [ 0.00907082  0.03335638 -0.00318121 -0.00485475  0.05039888 -0.04499395
  0.00959666  0.2519024   0.35075095 -0.6204954  -0.24674928 -0.17008562
 -0.01686145 -0.0895317   0.23248081]
Centroid 9: [ 0.12101481 -0.14807339  0.05227765  0.09736615  0.29832503 -0.20546958
  0.13226625 -0.13662754  0.0262267  -0.09622715 -0.04560643  0.0142497
 -0.0328091  -0.4697138   0.18448973]
Centroid 10: [-0.03972928 -0.01314189 -0.01811609  0.02918911 -0.10514477  0.13265018
 -0.0182576  -0.56569684 -0.08670869  0.1961374  -0.35948935 -0.29556617
 -0.01342964  0.02563111  0.20416404]
Centroid 11: [ 0.21406254 -0.1507275   0.01228641  0.01112103  0.03932957  0.05663154
  0.04756557 -0.13320212  0.19382814  0.1752957   0.11934608 -0.449051
 -0.03571583 -0.35784355  0.28886077]
Centroid 12: [ 0.00818099  0.00378318  0.00412624 -0.00529255 -0.00905146 -0.01691307
 -0.00866849  0.01709395 -0.04475385  0.0188806  -0.17600103 -0.06962625
  0.93352765 -0.0675834   0.13664222]
Centroid 13: [-0.06219756  0.07336981  0.03117868  0.07740468 -0.15171558 -0.18411672
 -0.3705197  -0.00990007 -0.00138712  0.08833708  0.04041226 -0.02673878
 -0.03358494 -0.49717385  0.1770654 ]
Centroid 14: [-0.01365811  0.00654097 -0.01027269 -0.03150756  0.10585973 -0.09353515
  0.03386173  0.4463685   0.03849847  0.12865539 -0.48790044 -0.48548383
 -0.01284913 -0.00511853  0.23156503]
Centroid 15: [-0.11230754  0.02580272 -0.05360564  0.3702406  -0.00514883  0.31977424
  0.09025846  0.09773177 -0.01653177  0.04680838  0.02202662  0.03157699
 -0.0305083  -0.4689133   0.15042685]
```

poly (gamma=1.0 / n_features)

In [ ]:

```
n_features = le_X_train025.shape[1]
spectral_clustering(
    le_X_train025,
    cuts=23,
    fname="label_encoded_spectral_clustering",
    affinity="poly",
    gamma=1.0 / n_features,
)
```

```
eigenvalues: [9.9989295e-01 9.9988639e-01 9.9987376e-01 9.9985456e-01 9.9983513e-01
 9.9982941e-01 9.9978435e-01 9.9975431e-01 9.9957722e-01 9.9950296e-01
 9.9948639e-01 9.9938047e-01 9.9815810e-01 9.9683940e-01 9.9626154e-01
 9.9614918e-01 9.8223424e-01 9.7860557e-01 9.7008169e-01 8.7460905e-01
 4.2129523e-01 3.6216567e-16 2.4852591e-20].
Finished running k-means++
1.0     5699
22.0     826
15.0     751
4.0      692
9.0      595
8.0      521
21.0     512
0.0      367
10.0     331
2.0      287
7.0      278
5.0      247
6.0      233
17.0     196
16.0     164
13.0     152
3.0      152
12.0     101
11.0     100
20.0      93
19.0      35
18.0      15
14.0       3
dtype: int64
Completed iteration 1
1.0     5704
22.0     803
15.0     754
4.0      705
8.0      497
21.0     492
9.0      472
0.0      325
7.0      320
10.0     296
3.0      282
2.0      278
6.0      270
5.0      209
13.0     208
17.0     199
16.0     179
12.0      95
11.0      92
20.0      90
19.0      50
18.0      24
14.0       6
dtype: int64
Completed iteration 2
1.0     5704
22.0     803
15.0     753
4.0      710
8.0      488
21.0     486
9.0      480
7.0      334
0.0      318
6.0      295
10.0     291
2.0      279
17.0     227
3.0      226
5.0      207
13.0     181
16.0     177
11.0      98
12.0      94
20.0      90
18.0      52
19.0      40
14.0      17
dtype: int64
Completed iteration 3
1.0     5704
22.0     803
15.0     754
4.0      703
21.0     486
8.0      483
9.0      483
7.0      342
0.0      307
6.0      297
10.0     284
2.0      267
3.0      218
5.0      216
17.0     215
16.0     179
13.0     177
11.0     103
18.0      97
12.0      93
20.0      87
19.0      35
14.0      17
dtype: int64
Completed iteration 4
1.0     5704
22.0     802
15.0     751
4.0      702
21.0     487
9.0      485
8.0      482
7.0      345
0.0      302
6.0      296
10.0     279
2.0      261
5.0      217
3.0      216
17.0     204
13.0     176
16.0     174
18.0     124
11.0     111
12.0      93
20.0      84
19.0      37
14.0      18
dtype: int64
Completed iteration 5
1.0     5704
22.0     802
15.0     754
4.0      700
21.0     488
9.0      484
8.0      477
7.0      347
0.0      298
6.0      298
10.0     275
2.0      257
3.0      217
5.0      214
17.0     201
13.0     177
16.0     176
18.0     132
11.0     116
12.0      93
20.0      83
19.0      39
14.0      18
dtype: int64
Completed iteration 6
1.0     5704
22.0     802
15.0     755
4.0      698
21.0     488
9.0      485
8.0      473
7.0      348
6.0      300
0.0      294
10.0     270
2.0      255
3.0      217
5.0      211
17.0     200
16.0     180
13.0     178
18.0     140
11.0     119
12.0      93
20.0      83
19.0      39
14.0      18
dtype: int64
Completed iteration 7
1.0     5704
22.0     802
15.0     756
4.0      696
21.0     488
9.0      485
8.0      470
7.0      346
6.0      300
0.0      292
10.0     264
2.0      249
3.0      217
5.0      214
17.0     200
16.0     186
13.0     178
18.0     147
11.0     123
12.0      93
20.0      83
19.0      39
14.0      18
dtype: int64
Completed iteration 8
1.0     5704
22.0     802
15.0     756
4.0      694
21.0     487
9.0      485
8.0      469
7.0      344
6.0      306
0.0      287
10.0     259
2.0      247
3.0      218
5.0      210
17.0     200
16.0     191
13.0     177
18.0     159
11.0     123
12.0      93
20.0      82
19.0      39
14.0      18
dtype: int64
Completed iteration 9
1.0     5704
22.0     802
15.0     757
4.0      693
21.0     487
9.0      485
8.0      468
7.0      343
6.0      309
0.0      285
10.0     253
2.0      246
3.0      219
5.0      209
17.0     200
16.0     199
13.0     177
18.0     159
11.0     123
12.0      93
20.0      82
19.0      39
14.0      18
dtype: int64
Completed iteration 10
1.0     5704
22.0     802
```

```
15.0     760
4.0      691
21.0     487
9.0      485
8.0      467
7.0      343
6.0      312
0.0      282
2.0      245
10.0     240
3.0      223
16.0     208
5.0      207
17.0     200
13.0     177
18.0     162
11.0     123
12.0      93
20.0      82
19.0      39
14.0      18
dtype: int64
Completed iteration 11
1.0     5704
22.0     802
15.0     763
4.0      691
21.0     487
9.0      485
8.0      464
7.0      343
6.0      313
0.0      283
2.0      246
16.0     229
3.0      224
10.0     216
5.0      205
17.0     200
13.0     176
18.0     165
11.0     123
12.0      93
20.0      82
19.0      38
14.0      18
dtype: int64
Completed iteration 12
1.0     5704
22.0     802
15.0     765
4.0      692
21.0     487
9.0      485
8.0      463
7.0      344
6.0      313
0.0      284
2.0      247
16.0     243
3.0      226
5.0      205
17.0     200
10.0     197
13.0     176
18.0     163
11.0     123
12.0      94
20.0      81
19.0      38
14.0      18
dtype: int64
Completed iteration 13
1.0     5704
22.0     802
15.0     769
4.0      693
21.0     487
9.0      485
8.0      462
7.0      346
6.0      313
0.0      285
2.0      248
16.0     247
3.0      229
```

```
5.0      205
17.0     200
10.0     179
13.0     179
18.0     163
11.0     122
12.0      94
20.0      81
19.0      39
14.0      18
dtype: int64
Completed iteration 14
1.0     5704
22.0     802
15.0     770
4.0      694
21.0     488
9.0      485
8.0      462
7.0      344
6.0      313
0.0      286
16.0     248
2.0      248
3.0      229
5.0      205
17.0     200
13.0     179
10.0     175
18.0     163
11.0     122
12.0      94
20.0      81
19.0      40
14.0      18
dtype: int64
Completed iteration 15
1.0     5704
22.0     802
15.0     769
4.0      695
21.0     488
9.0      485
8.0      463
7.0      343
6.0      313
0.0      286
16.0     249
2.0      248
3.0      228
5.0      205
17.0     200
13.0     179
10.0     175
18.0     163
11.0     122
12.0      94
20.0      81
19.0      40
14.0      18
dtype: int64
Completed iteration 16
Epsilon has a maximum value of 0.008582837879657745
Centroids:
Centroid 1: [ 0.01523761 -0.00708055 -0.03181197 -0.00077339 -0.01172824 -0.00190007
 -0.02717273  0.02608092 -0.06037023 -0.00502806 -0.03021966 -0.3098362
 -0.03355773  0.270223   -0.30745488  0.02165365 -0.26904455  0.2566848
 -0.07368536  0.44931772  0.01797864 -0.14456955  0.44988593]
Centroid 2: [ 2.6877552e-02  1.5814797e-04  1.5463418e-03  1.2510738e-02
  1.3666025e-03  1.5620427e-03  5.1730359e-03  4.8847101e-03
 -1.4960954e-02  4.9390583e-03  4.6967762e-03  1.8928547e-01
  1.9005580e-02 -3.1548236e-02 -1.1015692e-02 -2.7145341e-03
  4.9161471e-02 -4.9902193e-02  2.4639109e-02 -2.6030781e-02
  2.4582652e-02 -3.3382651e-01  9.1685593e-01]
Centroid 3: [-0.00164082  0.04188208  0.01824834  0.1453729  -0.04040351  0.11521885
  0.44980615  0.35873702 -0.13306838 -0.03214712  0.00791179 -0.05981342
 -0.02009224 -0.14247419 -0.04384664 -0.00531815  0.14484416 -0.09237698
  0.13650255 -0.08514621  0.00446084  0.48634732  0.19951226]
Centroid 4: [ 0.07929678  0.05001523 -0.03020572  0.02703658 -0.05305905  0.03351728
 -0.15705295  0.11003485  0.45619     0.01227522 -0.00504095  0.03992864
  0.51102597 -0.23251434  0.06937544 -0.04473519 -0.21852905  0.13303646
  0.02199876 -0.3382692   0.003026    0.09967571  0.17045547]
Centroid 5: [-0.18775612 -0.07057977  0.03916426 -0.02860005  0.01684047  0.00368654
 -0.02867258  0.04031738  0.05237837  0.00405503  0.00184253 -0.10220215
  0.01750602 -0.23962846  0.4342988  -0.00503154  0.20645799 -0.2172162
 -0.05736521  0.53026575  0.01932638 -0.14212918  0.41003567]
```

```
Centroid 6: [-0.00289625 -0.00898197  0.02224159  0.08408635 -0.01610391  0.02993881
  0.18323855  0.08612678  0.07039014 -0.05927076  0.03549167 -0.03417838
  0.10589318  0.20286693  0.01291227  0.02801034  0.2850791  -0.25484166
  0.029241    0.03588036  0.00553918  0.7715214   0.24416095]
Centroid 7: [ 0.0459751  -0.06469513 -0.00681412 -0.06698727  0.01036438 -0.07324888
 -0.31711036 -0.16070865  0.14323276 -0.06104674  0.07226732  0.02522349
  0.10060187  0.35294428  0.08685075  0.03972663  0.2674252  -0.24345823
  0.024095    0.00655835  0.00490495  0.6623616   0.2180057 ]
Centroid 8: [ 0.25139472  0.1015422  -0.02808324  0.04759127  0.00471249  0.00886032
  0.07845733  0.06496335  0.02880364 -0.01483142 -0.02737039 -0.556199
 -0.05155862  0.08202294  0.21245083  0.03663612 -0.21733107  0.2138925
 -0.10105456  0.3942564   0.0142027  -0.11627622  0.36466652]
Centroid 9: [-0.16385253 -0.09628119 -0.02287335 -0.02652617 -0.00644269  0.01168152
 -0.06132226  0.01104578 -0.10271845  0.00626896 -0.00872235  0.14042166
  0.00889821  0.3176099  -0.6549141  -0.00510051 -0.1512562   0.1359846
 -0.01259891  0.32766935  0.01466287 -0.11455757  0.34898522]
Centroid 10: [ 0.00103456  0.01482285 -0.00521195 -0.03506567  0.01800553 -0.01536756
 -0.00931207 -0.08925553 -0.12856054  0.00387254 -0.01729611  0.04385759
 -0.15024923 -0.2098127   0.00608604 -0.0291978  -0.30744874  0.30477238
  0.02236959  0.07632872  0.00551259  0.74804324  0.24750018]
Centroid 11: [ 0.0415596  -0.01608866 -0.00218127  0.02944863 -0.05194704  0.07555271
 -0.2358912   0.3071149  -0.07728227 -0.00632395  0.04044054  0.01435003
 -0.40285173 -0.13179028 -0.06922148 -0.04720108  0.02265203 -0.34383315
 -0.28462905 -0.5705942   0.0030374  -0.05226977  0.19143729]
Centroid 12: [ 3.7086707e-02 -2.1100327e-02 -4.5956094e-03 -1.5999438e-02
 -6.8945605e-03 -3.6321977e-05 -1.7705858e-01 -1.7710961e-02
  5.6327446e-03 -2.5021214e-02  7.0416145e-02  4.9247116e-02
  8.2408385e-03  2.6627493e-01  1.9433795e-01  3.7253696e-02
  2.3838662e-01  4.2434692e-02  6.4625973e-01 -2.4855894e-01
  4.0973341e-03  4.3265726e-02  1.3466682e-01]
Centroid 13: [ 0.00205288  0.01232817 -0.11132367 -0.39978653 -0.10181296  0.00685599
  0.17790054  0.14352202  0.02101085 -0.00347722  0.03301114  0.0530831
  0.01787024  0.11309104  0.07527534  0.33095908  0.30703902  0.3894447
 -0.37729883 -0.29238668 -0.03564368 -0.00212694  0.11826725]
Centroid 14: [-0.14711106 -0.04152245  0.06702901  0.2396107   0.03320424  0.02251078
  0.05474472  0.02474095  0.00834591 -0.01095193  0.08217964  0.12913875
  0.0365658   0.29094228  0.2707045   0.02002779 -0.32839295  0.11740316
 -0.2577557  -0.2361249   0.00180471 -0.00899775  0.12793845]
Centroid 15: [-0.13280244  0.22251078  0.01719133  0.00332379  0.51831484 -0.37045977
 -0.05437904  0.1055143  -0.00440027 -0.00414475 -0.00189387 -0.00963919
  0.00557624  0.00465329  0.00088056  0.01173669  0.01337221 -0.00304427
 -0.00881852  0.00534008  0.00185249 -0.00114663  0.06564001]
Centroid 16: [ 0.27348816  0.0672841  -0.02606601  0.05982834  0.01736124  0.04817709
  0.01581168  0.07551083 -0.12732221  0.01306115  0.00512765  0.32591203
  0.08947294  0.00517468 -0.11979101 -0.01350228  0.18816186 -0.20827883
 -0.03623802  0.5298059   0.01995451 -0.14552812  0.41757822]
Centroid 17: [ 0.07692242  0.03890931 -0.01324123 -0.05392876  0.07374825 -0.08499469
  0.22139025 -0.43990612 -0.0203211  -0.01080392  0.06177941 -0.03716106
  0.11246893 -0.16929741 -0.06657172 -0.03789283  0.02399851 -0.2222696
 -0.1539808  -0.39454266  0.00310022 -0.03694496  0.1601507 ]
Centroid 18: [ 0.09199288 -0.02555297  0.00459539 -0.0120279   0.0509423  -0.03403145
 -0.0683571  -0.00641275 -0.24250337 -0.00603492  0.08925674  0.18462367
 -0.3477628  -0.16781655  0.23977628 -0.02190933 -0.23306704  0.26340416
  0.24098133 -0.47275674  0.00420689  0.14733467  0.23742984]
Centroid 19: [-0.3342844  -0.18132037  0.05455919 -0.11801379 -0.01891382 -0.05870098
 -0.19235425 -0.14467266 -0.05653753  0.00549356 -0.0348653  -0.13189821
 -0.00122016 -0.03921091 -0.07924547 -0.01820662 -0.07026712  0.09196845
 -0.02432301  0.14195673 -0.03546432 -0.00553753  0.17569572]
Centroid 20: [-0.1309279   0.26175308 -0.14618614 -0.08697402 -0.08056418  0.20842242
 -0.05059246 -0.03757947  0.01846235  0.05735186 -0.55198604  0.0829533
 -0.09997676  0.08114607  0.08073952 -0.02027686  0.054348   -0.09129482
  0.03280448 -0.20456913  0.00168658 -0.02131922  0.08999194]
Centroid 21: [-0.02415204  0.00902526  0.00772401  0.00424239 -0.05755809  0.05794561
 -0.11067443  0.16294375  0.02161828  0.01123875 -0.14930893 -0.0833398
 -0.20031954 -0.15674134 -0.29869333 -0.05189439 -0.02040306 -0.31307894
 -0.4925214   0.03124629  0.0040807   0.56059796  0.18434568]
Centroid 22: [-0.12518215 -0.03737143  0.01245897 -0.06309567 -0.03304791 -0.01807613
 -0.01087693 -0.02256487  0.08211517 -0.01906173 -0.03206518 -0.8286211
 -0.10746594  0.20075236 -0.22361043  0.00613783 -0.08056331  0.08132359
  0.07642211 -0.15247548  0.00749589 -0.10486793  0.29998624]
Centroid 23: [ 0.01481447 -0.01073235  0.00241276  0.00662385 -0.00698751  0.01356563
  0.00183832  0.00260598 -0.00638422  0.00167268  0.01917301  0.09085467
  0.00783544 -0.00821282 -0.03695349 -0.0010342   0.04005997 -0.0399611
  0.03221802 -0.04077563  0.024828   -0.33789584  0.92803246]
```

In [ ]:

```python
n_features = le_X_train025.shape[1]
spectral_clustering(
    le_X_train025,
    cuts=len(np.unique(le_y_train025)),
    fname="label_encoded_spectral_clustering",
    affinity="poly",
    gamma=1.0 / n_features,
)
```

```
eigenvalues: [9.9957722e-01 9.9950296e-01 9.9948639e-01 9.9938047e-01 9.9815810e-01
 9.9683940e-01 9.9626154e-01 9.9614918e-01 9.8223424e-01 9.7860557e-01
 9.7008169e-01 8.7460905e-01 4.2129523e-01 3.6216567e-16 2.4852591e-20].
Finished running k-means++
3.0     6536
0.0     1338
10.0    1060
1.0      684
6.0      671
13.0     609
9.0      410
11.0     246
2.0      237
12.0     221
4.0      105
5.0      104
8.0       90
7.0       35
14.0       4
dtype: int64
Completed iteration 1
3.0     6526
0.0     1258
10.0    1028
6.0      781
1.0      666
13.0     624
9.0      398
11.0     266
2.0      242
12.0     235
4.0      105
5.0       97
8.0       79
7.0       41
14.0       4
dtype: int64
Completed iteration 2
3.0     6526
0.0     1169
10.0    1044
6.0      838
1.0      661
13.0     632
9.0      390
11.0     264
12.0     247
2.0      243
4.0      103
5.0       96
8.0       76
7.0       57
14.0       4
dtype: int64
Completed iteration 3
3.0     6526
0.0     1109
10.0    1022
6.0      832
1.0      657
13.0     636
9.0      390
11.0     261
12.0     254
2.0      244
7.0      142
4.0      102
5.0       96
8.0       75
14.0       4
dtype: int64
Completed iteration 4
3.0     6526
0.0     1069
10.0     971
6.0      755
1.0      652
13.0     644
9.0      389
7.0      310
11.0     260
12.0     252
2.0      246
4.0      101
5.0       96
8.0       75
```

```
14.0       4
dtype: int64
Completed iteration 5
3.0     6526
0.0     1042
10.0     877
6.0      744
13.0     650
1.0      646
7.0      440
9.0      389
11.0     261
12.0     252
2.0      248
4.0      100
5.0       96
8.0       75
14.0       4
dtype: int64
Completed iteration 6
3.0     6526
0.0     1026
10.0     800
6.0      739
13.0     656
1.0      643
7.0      537
9.0      389
11.0     261
12.0     250
2.0      248
4.0      100
5.0       96
8.0       75
14.0       4
dtype: int64
Completed iteration 7
3.0     6526
0.0     1011
6.0      749
10.0     742
13.0     658
1.0      640
7.0      601
9.0      390
11.0     260
12.0     250
2.0      247
4.0      100
5.0       97
8.0       75
14.0       4
dtype: int64
Completed iteration 8
3.0     6526
0.0      995
6.0      773
10.0     696
13.0     659
1.0      640
7.0      639
9.0      390
11.0     260
12.0     249
2.0      247
4.0      100
5.0       97
8.0       75
14.0       4
dtype: int64
Completed iteration 9
3.0     6526
0.0      977
6.0      773
10.0     683
7.0      670
13.0     660
1.0      639
9.0      390
11.0     260
12.0     249
2.0      247
4.0      100
5.0       97
8.0       75
14.0       4
```

```
dtype: int64
Completed iteration 10
3.0     6526
0.0      969
6.0      771
7.0      692
10.0     671
13.0     661
1.0      639
9.0      390
11.0     260
12.0     248
2.0      247
4.0      100
5.0       97
8.0       75
14.0       4
dtype: int64
Completed iteration 11
3.0     6526
0.0      960
6.0      761
7.0      713
10.0     669
13.0     662
1.0      639
9.0      390
11.0     260
2.0      247
12.0     247
4.0      100
5.0       97
8.0       75
14.0       4
dtype: int64
Completed iteration 12
3.0     6526
0.0      953
6.0      746
7.0      733
10.0     671
13.0     663
1.0      639
9.0      390
11.0     260
2.0      247
12.0     246
4.0      100
5.0       97
8.0       75
14.0       4
dtype: int64
Completed iteration 13
3.0     6526
0.0      950
7.0      750
6.0      734
10.0     668
13.0     663
1.0      639
9.0      390
11.0     261
2.0      247
12.0     246
4.0      100
5.0       97
8.0       75
14.0       4
dtype: int64
Completed iteration 14
3.0     6526
0.0      949
7.0      757
6.0      731
10.0     665
13.0     663
1.0      639
9.0      390
11.0     261
2.0      247
12.0     246
4.0      100
5.0       97
8.0       75
14.0       4
dtype: int64
```

```
Completed iteration 15
Epsilon has a maximum value of 0.006696181371808052
Centroids:
Centroid 1: [ 0.04133097 -0.01581053 -0.03746513 -0.7170013  -0.07589114  0.16549145
 -0.06597362  0.02005567 -0.1677542   0.1627101  -0.01098711  0.11935657
  0.0114015  -0.11478197  0.35032633]
Centroid 2: [ 0.0856723  -0.06173782  0.05163561 -0.01338958  0.09751168  0.25236374
  0.04031971  0.03209822  0.29105917 -0.26256308  0.03481988  0.00749357
  0.00567707  0.76494044  0.25240698]
Centroid 3: [ 0.47221822  0.0101261   0.00441823  0.03254157  0.5318974  -0.23830897
  0.06209445 -0.04552643 -0.20773269  0.1209623   0.02869973 -0.35940865
  0.00313313  0.09032398  0.17610091]
Centroid 4: [-0.01386064  0.00448726  0.00650201  0.17746262  0.017649   -0.02870757
 -0.01416574 -0.00252734  0.04808839 -0.04872525  0.02558277 -0.02785017
  0.02463123 -0.3345672   0.91890925]
Centroid 5: [ 0.01789029 -0.0040377   0.03759465  0.05985704  0.01900957  0.1262739
  0.08403646  0.4110692   0.34868255  0.4381668  -0.43759835 -0.34470502
 -0.04227245 -0.00239296  0.13906938]
Centroid 6: [-0.03053574 -0.00626437 -0.00174615  0.01580081  0.02490599  0.20658444
  0.13777512  0.03154407  0.21210137  0.16897695  0.8417103  -0.14329079
  0.00437649  0.00930727  0.10328933]
Centroid 7: [-0.16084622  0.0129155   0.00066839  0.36421362  0.11912386  0.00702872
 -0.15253538 -0.01618527  0.20598193 -0.22833689 -0.03812411  0.5851817
  0.02212936 -0.16132726  0.46304008]
Centroid 8: [ 0.03750367  0.0045564  -0.00197256 -0.11305118  0.02928072 -0.24798268
  0.44558555 -0.00518415  0.21386217 -0.22562566 -0.06107885  0.55663514
  0.02022219 -0.14867045  0.42900392]
Centroid 9: [-0.2586961   0.05558088 -0.4877667   0.17565532 -0.34278342  0.01315442
  0.17152683 -0.02726514 -0.06454743  0.03252091  0.10796374 -0.376661
  0.00258589  0.03148954  0.15491198]
Centroid 10: [-0.1470122  -0.01217136  0.0597269  -0.03775625 -0.04066189 -0.17654787
 -0.06788444 -0.05364135  0.00706902 -0.3419647  -0.28376853 -0.6304169
  0.0033984  -0.05381601  0.21367157]
Centroid 11: [-0.10794248  0.00250917 -0.01476214  0.03230372  0.00132318  0.33055925
 -0.60309076  0.00219018 -0.19355205  0.17854333 -0.02953856  0.37691987
  0.01634437 -0.12894295  0.39550945]
Centroid 12: [ 0.27662557 -0.02498541  0.11607596  0.1681733  -0.21777011  0.21206383
  0.17208436 -0.00201864 -0.22253354  0.10047986 -0.18377203 -0.06833091
 -0.02235402 -0.01875212  0.1521688 ]
Centroid 13: [-0.18372981 -0.03251924  0.17239338  0.12401421 -0.26812598 -0.1473743
  0.21720251 -0.0117526  -0.07666284  0.1391989   0.30394033 -0.515295
  0.00458884  0.15154874  0.2507225 ]
Centroid 14: [-0.13772655  0.00240909 -0.04196882  0.00917581 -0.14486843 -0.218896
 -0.05001706 -0.03190373 -0.23701318  0.19839326 -0.03239331  0.06417585
  0.00542491  0.7319526   0.2435695 ]
Centroid 15: [-2.55882945e-02  9.80719686e-01  9.92303491e-02  4.13632318e-02
  6.72414061e-03  8.50395299e-03  4.92748804e-03 -4.24882455e-04
  1.08567458e-02 -1.09772775e-02  3.64925107e-03 -3.70418979e-03
  1.51258335e-03 -2.68521532e-03  5.75608350e-02]
```

poly (gamma=0.1)

In [ ]:

```python
spectral_clustering(
    le_X_train025,
    cuts=23,
    fname="label_encoded_spectral_clustering",
    affinity="poly",
    gamma=0.1,
)
```

```
eigenvalues: [9.9988770e-01 9.9985909e-01 9.9984884e-01 9.9982798e-01 9.9978435e-01
 9.9975991e-01 9.9975038e-01 9.9972260e-01 9.9954313e-01 9.9944788e-01
 9.9937046e-01 9.9839300e-01 9.9811047e-01 9.9684560e-01 9.9625939e-01
 9.9615240e-01 9.8222405e-01 9.7860873e-01 9.7007835e-01 8.7461907e-01
 4.2127913e-01 1.8779957e-16 5.0089715e-19].
Finished running k-means++
3.0     6508
2.0      634
1.0      632
21.0     610
7.0      500
10.0     494
6.0      440
13.0     328
22.0     310
4.0      288
17.0     274
5.0      249
0.0      211
9.0      165
16.0     143
11.0     108
19.0      97
20.0      93
12.0      89
8.0       78
15.0      76
18.0      13
14.0      10
dtype: int64
Completed iteration 1
3.0     6503
21.0     618
2.0      617
10.0     490
7.0      482
1.0      446
6.0      429
13.0     317
22.0     316
17.0     313
5.0      291
9.0      289
4.0      278
0.0      224
11.0     147
16.0     136
12.0      99
20.0      88
19.0      76
8.0       69
15.0      67
18.0      45
14.0      10
dtype: int64
Completed iteration 2
3.0     6503
21.0     591
2.0      519
10.0     489
7.0      458
6.0      427
1.0      402
9.0      340
17.0     325
22.0     321
13.0     306
5.0      283
4.0      254
0.0      248
18.0     184
11.0     181
16.0     131
12.0      98
20.0      86
19.0      67
8.0       65
15.0      62
14.0      10
dtype: int64
Completed iteration 3
3.0     6503
21.0     583
2.0      493
10.0     487
7.0      443
```

```
6.0      426
1.0      393
9.0      382
17.0     329
22.0     324
13.0     296
0.0      258
4.0      249
18.0     241
5.0      239
11.0     180
16.0     126
12.0     101
20.0      86
15.0      72
8.0       65
19.0      62
14.0      12
dtype: int64
Completed iteration 4
3.0     6503
21.0     611
2.0      493
10.0     487
7.0      446
6.0      423
9.0      421
1.0      395
17.0     330
22.0     327
13.0     292
0.0      262
5.0      252
4.0      246
18.0     219
16.0     128
11.0     116
12.0     103
20.0      86
15.0      75
8.0       64
19.0      57
14.0      14
dtype: int64
Completed iteration 5
3.0     6503
21.0     605
2.0      495
10.0     487
7.0      447
9.0      445
6.0      421
1.0      401
22.0     329
17.0     329
13.0     290
0.0      263
5.0      252
4.0      247
18.0     213
16.0     129
12.0     100
11.0      95
20.0      85
15.0      79
8.0       61
19.0      59
14.0      15
dtype: int64
Completed iteration 6
3.0     6503
21.0     587
2.0      499
10.0     487
9.0      466
7.0      444
6.0      422
1.0      402
17.0     329
22.0     328
13.0     287
0.0      263
5.0      248
4.0      247
18.0     212
16.0     128
```

```
11.0      92
12.0      87
20.0      84
15.0      82
19.0      79
8.0       58
14.0      16
dtype: int64
Completed iteration 7
3.0     6503
21.0     569
2.0      504
10.0     487
9.0      479
7.0      440
6.0      423
1.0      413
17.0     330
22.0     328
13.0     283
0.0      261
4.0      246
5.0      244
18.0     211
16.0     127
19.0      90
11.0      89
15.0      84
20.0      83
12.0      80
8.0       60
14.0      16
dtype: int64
Completed iteration 8
3.0     6503
21.0     555
2.0      506
9.0      490
10.0     489
7.0      439
6.0      423
1.0      417
17.0     331
22.0     328
13.0     282
0.0      261
4.0      245
5.0      240
18.0     210
16.0     127
19.0      96
11.0      90
15.0      84
20.0      82
12.0      75
8.0       61
14.0      16
dtype: int64
Completed iteration 9
3.0     6503
21.0     541
2.0      506
9.0      499
10.0     489
7.0      439
6.0      423
1.0      422
17.0     331
22.0     327
13.0     280
0.0      261
4.0      245
5.0      237
18.0     211
16.0     127
19.0     102
11.0      90
15.0      86
20.0      82
12.0      72
8.0       61
14.0      16
dtype: int64
Completed iteration 10
3.0     6503
21.0     529
```

```
9.0      510
2.0      506
10.0     489
7.0      439
1.0      423
6.0      423
17.0     331
22.0     327
13.0     280
0.0      261
4.0      245
5.0      235
18.0     211
16.0     127
19.0     102
11.0      90
15.0      88
20.0      82
12.0      72
8.0       61
14.0      16
dtype: int64
Completed iteration 11
3.0     6503
21.0     517
9.0      517
2.0      506
10.0     489
7.0      438
1.0      427
6.0      423
17.0     332
22.0     327
13.0     280
0.0      262
4.0      245
5.0      235
18.0     211
16.0     127
19.0     102
11.0      90
15.0      89
20.0      82
12.0      71
8.0       61
14.0      16
dtype: int64
Completed iteration 12
3.0     6503
9.0      524
21.0     510
2.0      506
10.0     489
7.0      438
1.0      427
6.0      423
17.0     332
22.0     327
13.0     280
0.0      262
4.0      245
5.0      235
18.0     211
16.0     127
19.0     102
15.0      90
11.0      90
20.0      82
12.0      70
8.0       61
14.0      16
dtype: int64
Completed iteration 13
3.0     6503
9.0      528
2.0      507
21.0     502
10.0     489
7.0      438
1.0      431
6.0      423
17.0     332
22.0     327
13.0     280
0.0      262
4.0      245
```

```
5.0      235
18.0     211
16.0     127
19.0     100
15.0      91
11.0      90
20.0      82
12.0      70
8.0       61
14.0      16
dtype: int64
Completed iteration 14
3.0     6503
9.0      531
2.0      507
21.0     497
10.0     489
7.0      439
1.0      432
6.0      423
17.0     332
22.0     327
13.0     280
0.0      262
4.0      245
5.0      235
18.0     211
16.0     127
19.0      98
15.0      93
11.0      90
20.0      82
12.0      70
8.0       61
14.0      16
dtype: int64
Completed iteration 15
3.0     6503
9.0      532
2.0      508
21.0     494
10.0     488
7.0      439
1.0      434
6.0      423
17.0     332
22.0     327
13.0     280
0.0      262
4.0      245
5.0      235
18.0     211
16.0     127
19.0      97
15.0      95
11.0      90
20.0      82
12.0      70
8.0       61
14.0      15
dtype: int64
Completed iteration 16
3.0     6503
9.0      533
2.0      508
21.0     492
10.0     488
7.0      438
1.0      435
6.0      423
17.0     332
22.0     327
13.0     280
0.0      262
4.0      245
5.0      235
18.0     211
16.0     127
15.0      97
19.0      95
11.0      90
20.0      82
12.0      71
8.0       61
14.0      15
dtype: int64
```

```
Completed iteration 17
3.0     6503
9.0      533
2.0      511
21.0     489
10.0     488
1.0      438
7.0      438
6.0      423
17.0     332
22.0     327
13.0     280
0.0      262
4.0      245
5.0      235
18.0     210
16.0     127
15.0     100
19.0      90
11.0      90
20.0      82
12.0      71
8.0       61
14.0      15
dtype: int64
Completed iteration 18
3.0     6503
9.0      533
2.0      512
21.0     489
10.0     488
1.0      438
7.0      438
6.0      423
17.0     332
22.0     328
13.0     278
0.0      262
4.0      245
5.0      233
18.0     210
16.0     127
15.0     103
11.0      90
19.0      87
20.0      84
12.0      71
8.0       61
14.0      15
dtype: int64
Completed iteration 19
3.0     6503
9.0      533
2.0      511
21.0     488
10.0     488
1.0      438
7.0      438
6.0      423
17.0     332
22.0     328
13.0     278
0.0      262
4.0      246
5.0      231
18.0     210
16.0     127
15.0     106
11.0      91
19.0      86
20.0      85
12.0      72
8.0       60
14.0      14
dtype: int64
Completed iteration 20
3.0     6503
9.0      533
2.0      513
10.0     488
21.0     487
1.0      438
7.0      438
6.0      423
17.0     332
22.0     328
```

```
13.0     276
0.0      262
4.0      246
5.0      229
18.0     210
16.0     127
15.0     107
11.0      94
19.0      86
20.0      86
12.0      72
8.0       59
14.0      13
dtype: int64
Completed iteration 21
Reached 21 iterations
Centroids:
Centroid 1: [-0.02862747  0.02204207  0.0058065   0.00870411  0.03791964  0.03286576
 -0.00647848 -0.0350415   0.0458893   0.02012604  0.30627874  0.03026772
  0.0285956   0.27144542  0.31097823 -0.03083819  0.2663905   0.2543286
  0.0720212  -0.4466187   0.01790138  0.2067432   0.42223996]
Centroid 2: [-0.07234709  0.02332333 -0.02668004  0.01970112  0.0341635   0.05778226
  0.0192813  -0.04319468  0.05553879 -0.01307561 -0.17383409  0.00820504
 -0.08419748 -0.11422376 -0.12318762  0.01665997 -0.2329086  -0.2527391
  0.05156342 -0.61430365  0.02283004  0.23382957  0.44985056]
Centroid 3: [-0.01211649 -0.01533038  0.03523864 -0.00397364 -0.00344976 -0.07382625
 -0.04049315 -0.10086526  0.07534169 -0.00889881 -0.05028701  0.04866587
  0.15595157 -0.21111104 -0.0123086   0.02880915  0.30726513  0.30673346
 -0.03093842 -0.05946023  0.00552175 -0.69304615  0.35300133]
Centroid 4: [-0.01442523  0.01310719 -0.0146973   0.00390116 -0.0024708   0.01023417
 -0.00934287 -0.0218252  -0.00892056 -0.01874576 -0.17661378 -0.00947673
 -0.01738654 -0.02803164  0.0138602   0.00206356 -0.04797998 -0.04872968
 -0.02547243  0.02779472  0.02460402  0.4626991   0.86027867]
Centroid 5: [-0.00833586  0.02587473  0.04394224 -0.06018051 -0.25973833 -0.32441244
 -0.10508132 -0.18617025  0.08153229 -0.08287603  0.07096051  0.05207971
 -0.27266455 -0.16691236  0.04994221  0.04139005  0.00299886 -0.22908615
  0.18510312  0.45935255  0.00293572  0.06023008  0.16230397]
Centroid 6: [ 0.02468214  0.15596476  0.14592351 -0.02914023  0.00179132  0.12739506
  0.08003553 -0.0381149   0.05642467 -0.12214956 -0.1284871   0.03462565
  0.18555875 -0.0583825  -0.1964394  -0.12943184  0.03628606  0.2944084
 -0.02723185  0.4381301  -0.00390021 -0.03892193  0.20539854]
Centroid 7: [ 0.03784885  0.08109085  0.04840948  0.02174122  0.16240367 -0.19916646
  0.06554647  0.06257677 -0.10604707 -0.01365087 -0.01041896 -0.01687737
 -0.10538904  0.3288189  -0.0721159  -0.03488326 -0.27330303 -0.24854636
 -0.02189198 -0.02131999  0.0050865  -0.6585035   0.322775  ]
Centroid 8: [ 1.4889927e-01 -3.9231721e-02  4.1572243e-02  1.0509953e-03
  6.8156868e-02  3.0440849e-03  3.1767416e-04 -5.7690717e-02
  7.3539600e-02  1.2033742e-02 -1.3589884e-01  5.1138759e-02
 -1.0548196e-02  3.2361656e-01  6.6172504e-01 -1.4632920e-02
  1.5593639e-01  1.4086083e-01  1.2163022e-02 -3.2533121e-01
  1.4590569e-02  1.6296570e-01  3.2795507e-01]
Centroid 9: [ 0.03213068 -0.04994112 -0.06495666 -0.00149242 -0.09159663 -0.08482619
 -0.01973573  0.0166288  -0.03327363 -0.02906735 -0.14264198 -0.00174003
 -0.01433829  0.16992642 -0.33818635 -0.08965469  0.55487806  0.55001664
  0.15583858 -0.12253177  0.00075806  0.03556556  0.09966391]
Centroid 10: [ 0.2020254  -0.08347873  0.03330142 -0.00186188  0.02595383  0.01583821
  0.030902    0.05380235 -0.04598412  0.02104964  0.15729657 -0.01807081
 -0.01222483 -0.2619959  -0.48652247  0.01827013 -0.19516416 -0.20444804
  0.05808144 -0.49581286  0.01791657  0.18530789  0.3579341 ]
Centroid 11: [ 1.15485802e-01 -4.01888527e-02  5.96391447e-02 -2.19013114e-02
  1.15560284e-02 -2.04844866e-02 -7.60628318e-04  5.60196489e-02
 -6.41420856e-02  5.51979244e-02  8.29855084e-01  3.18925246e-03
  1.05107926e-01  1.99792549e-01  2.26152748e-01 -1.26566263e-02
  8.08383822e-02  8.18111449e-02 -7.67950043e-02  1.53337553e-01
  7.53432326e-03  1.47718713e-01  2.83219904e-01]
Centroid 12: [-0.21311934  0.00945559 -0.10098536 -0.03373767 -0.3305141  -0.23393838
  0.02062588  0.31114408 -0.38664758  0.05479418 -0.16928798 -0.04906867
  0.4289068   0.04473864  0.01828419 -0.00088002 -0.02935699 -0.04437856
  0.01621308 -0.14734398  0.00686758  0.06870469  0.14787911]
Centroid 13: [-1.51186988e-01 -1.96724325e-01  1.33671477e-01  6.34424835e-02
 -5.07704281e-05 -1.54100344e-01 -2.37336800e-01 -2.41116017e-01
  2.21817017e-01  1.83143571e-01 -1.32403627e-01 -7.00410381e-02
  3.27007025e-01  2.89828843e-03 -1.63283020e-01  2.64898539e-02
  8.70821103e-02  6.48505986e-02 -1.08514875e-01  3.32436204e-01
  2.44510826e-03 -2.13235822e-02  1.47354111e-01]
Centroid 14: [ 0.04095628 -0.03730819 -0.13379651  0.01990865  0.20005643  0.18044715
  0.10889898  0.0135969   0.02483642 -0.0372251  -0.04139877  0.01301122
  0.25157332  0.0423601  -0.0435071   0.0332027   0.07929935 -0.22856036
  0.28716287  0.5075598   0.00276361  0.07041893  0.16690114]
Centroid 15: [ 0.00340431 -0.02000862  0.04786325 -0.40397972  0.10818809  0.06743582
 -0.46869105  0.13481551  0.03866618 -0.23594809  0.02944787 -0.08741547
  0.01237688  0.00391088  0.00934891  0.00617462  0.00153358  0.00348143
 -0.0129743   0.01473333  0.00210681  0.02820421  0.07321687]
Centroid 16: [ 0.5474636  -0.11918685  0.22834851 -0.00981501  0.2302645  -0.19203547
 -0.01522856  0.0135472  -0.0204547   0.06090862  0.25060728  0.00984963
  0.04567898  0.01038284  0.13013914 -0.00111293  0.11331572  0.09836315
```

```
  0.03152237 -0.2478989   0.01043729  0.07339647  0.2510459 ]
Centroid 17: [ 0.00887118  0.06029915  0.02322992  0.00373255  0.1565799  -0.07118604
  0.05990182  0.01326991 -0.01287599 -0.05298926 -0.04879545  0.00965132
 -0.00520709  0.2607905  -0.19415721 -0.03056634 -0.23779866  0.03711891
 -0.6346428   0.2486496   0.00408296 -0.02783665  0.14100395]
Centroid 18: [-0.21021368  0.07480474 -0.04786731  0.00724342 -0.04364685  0.0948172
 -0.00286482  0.01634423 -0.01314585  0.01614226  0.5723626  -0.00769923
  0.04383013  0.07967858 -0.21377476 -0.03052329  0.21612346  0.21289621
  0.10088239 -0.4029955   0.01456456  0.17137723  0.35177058]
Centroid 19: [-0.12810539 -0.00864645 -0.02435574  0.03707094  0.15626672  0.03399685
  0.07767035  0.33442104 -0.29499298  0.1337923  -0.05717887 -0.07048073
 -0.5257223  -0.23391923 -0.07893736  0.04791905  0.2301791   0.15532745
 -0.03555211  0.3324579   0.00305663 -0.08499432  0.18631206]
Centroid 20: [ 4.2211529e-02  2.0663671e-02 -1.6210979e-02  7.7414185e-02
  3.5578404e-02 -5.8730576e-02  1.1772513e-02  1.2537345e-02
  3.5824399e-02  3.1404287e-02 -4.6751134e-02 -4.0235733e-05
  2.1328652e-02 -8.9067906e-02  4.8578274e-02  6.0505878e-02
 -6.8531111e-02  1.0870738e-01  6.2435266e-02  3.6171496e-02
 -9.9662073e-02 -3.5112877e-03  5.8915738e-02]
Centroid 21: [-0.01691985 -0.04183232 -0.00377482  0.03988554  0.14829668  0.1292393
 -0.00254284  0.04258452  0.02045997  0.13593283  0.072414   -0.0266442
  0.20085457 -0.14126988  0.28702107  0.04149069  0.02767691 -0.30751866
  0.49167034 -0.02326182  0.00409062 -0.5225921   0.26354533]
Centroid 22: [-0.30366224  0.10934854 -0.08609906  0.03065802 -0.00137049  0.09929734
 -0.00433087 -0.10318568  0.11360881 -0.04221817 -0.37566632  0.02345961
 -0.10408543  0.0709538   0.23947075  0.00640447 -0.15253222 -0.17212126
  0.02870053 -0.47533002  0.01815882  0.18628466  0.35848   ]
Centroid 23: [-0.0111879  -0.07381573 -0.15776408  0.0279993  -0.3106282   0.42666352
  0.05357711 -0.02349454  0.07324141 -0.05374787  0.06152416 -0.00191756
 -0.01353129 -0.063497    0.03590596 -0.00380728 -0.18166299 -0.13713892
 -0.10184087  0.04802769  0.00475543 -0.53418076  0.29190123]
```

In [ ]:

```
spectral_clustering(
    le_X_train025,
    cuts=len(np.unique(le_y_train025)),
    fname="label_encoded_spectral_clustering",
    affinity="poly",
    gamma=0.1,
)
```

```
eigenvalues: [9.9954313e-01 9.9944788e-01 9.9937046e-01 9.9839300e-01 9.9811047e-01
 9.9684560e-01 9.9625939e-01 9.9615240e-01 9.8222405e-01 9.7860873e-01
 9.7007835e-01 8.7461907e-01 4.2127913e-01 1.8779957e-16 5.0089715e-19].
Finished running k-means++
4.0     6539
2.0      960
7.0      741
0.0      646
13.0     623
3.0      544
5.0      519
6.0      453
8.0      365
1.0      312
12.0     274
11.0     206
9.0       99
10.0      50
14.0      19
dtype: int64
Completed iteration 1
4.0     6521
2.0      872
7.0      679
13.0     651
0.0      590
6.0      560
5.0      497
11.0     463
8.0      341
1.0      305
12.0     304
3.0      260
14.0     117
9.0      102
10.0      88
dtype: int64
Completed iteration 2
4.0     6522
2.0      831
13.0     684
7.0      672
6.0      595
0.0      562
11.0     515
5.0      495
8.0      327
3.0      282
1.0      273
12.0     244
10.0     140
14.0     105
9.0      103
dtype: int64
Completed iteration 3
4.0     6522
2.0      798
13.0     706
7.0      675
6.0      609
0.0      550
11.0     546
5.0      494
8.0      292
3.0      262
12.0     245
1.0      233
10.0     205
14.0     112
9.0      101
dtype: int64
Completed iteration 4
4.0     6522
2.0      779
13.0     716
7.0      673
6.0      618
11.0     552
0.0      539
5.0      494
3.0      259
8.0      256
10.0     246
12.0     243
1.0      213
14.0     140
```

```
9.0      100
dtype: int64
Completed iteration 5
4.0     6522
2.0      768
13.0     723
7.0      656
6.0      619
11.0     552
0.0      532
5.0      496
12.0     255
3.0      253
8.0      253
10.0     243
1.0      210
14.0     168
9.0      100
dtype: int64
Completed iteration 6
4.0     6522
2.0      757
13.0     727
7.0      646
6.0      618
11.0     552
0.0      528
5.0      497
12.0     262
3.0      252
8.0      251
10.0     243
1.0      209
14.0     186
9.0      100
dtype: int64
Completed iteration 7
4.0     6523
2.0      755
13.0     727
7.0      650
6.0      615
11.0     552
0.0      527
5.0      497
12.0     268
8.0      252
3.0      250
10.0     235
1.0      209
14.0     190
9.0      100
dtype: int64
Completed iteration 8
4.0     6523
2.0      756
13.0     726
7.0      652
6.0      614
11.0     552
0.0      527
5.0      498
12.0     267
8.0      252
3.0      249
10.0     235
1.0      209
14.0     190
9.0      100
dtype: int64
Completed iteration 9
4.0     6523
2.0      756
13.0     725
7.0      652
6.0      614
11.0     553
0.0      527
5.0      499
12.0     267
8.0      252
3.0      248
10.0     235
1.0      209
14.0     190
9.0      100
```

```
dtype: int64
Completed iteration 10
Epsilon has a maximum value of 0.006528232712298632
Centroids:
Centroid 1: [ 0.00124901  0.02353882  0.54303265  0.00215698  0.03955526  0.12530647
 -0.08021356 -0.03264853  0.25763103  0.25048688  0.10053911 -0.4317955
  0.01598541  0.18768984  0.3857419 ]
Centroid 2: [-0.3451858   0.1552379  -0.0549162  -0.08772843 -0.57953054 -0.2831633
 -0.06534661  0.05144505  0.24216242  0.18408763 -0.07156145  0.33745328
  0.0033532  -0.09933509  0.20024493]
Centroid 3: [-0.02581418  0.01116294  0.10053862 -0.0165043  -0.03109123 -0.25021896
 -0.43809506  0.01932278 -0.2177647  -0.23024863  0.06023981 -0.550563
  0.0199753   0.20579955  0.396926  ]
Centroid 4: [ 0.17971376 -0.11965767 -0.15015551  0.05008253  0.34877872 -0.22776186
 -0.18917915  0.03072848  0.21674068  0.26112628 -0.26961386  0.44168085
  0.00429616 -0.10231027  0.24744712]
Centroid 5: [-0.00899942 -0.01937072 -0.17677274 -0.00966443 -0.01739684 -0.0280995
  0.01386618  0.0021067  -0.04803387 -0.04878531 -0.02549634  0.0278194
  0.02463073  0.46318874  0.86120945]
Centroid 6: [-0.06246013  0.05662791  0.83607596  0.00563717  0.10631128  0.203408
  0.22651455 -0.01249074  0.08470446  0.08324327 -0.07451893  0.15525311
  0.0075317   0.14441721  0.28400782]
Centroid 7: [ 0.07366277  0.00758454 -0.06563333  0.04765576  0.00156069  0.33874196
  0.6255097  -0.01957534  0.18728943  0.17256904  0.02475529 -0.3612257
  0.01581372  0.17827128  0.36013424]
Centroid 8: [-0.04647108 -0.02095197  0.02594543 -0.01587232 -0.10278434  0.22457816
 -0.02110742 -0.02717206 -0.27830374 -0.25708127 -0.0187922  -0.029749
  0.00569687 -0.74072164  0.36191013]
Centroid 9: [ 0.0896027   0.01337796  0.0148291   0.00203892  0.37442786 -0.16212457
  0.14351363  0.0475908  -0.01975247 -0.37786177  0.36810124  0.47641897
  0.0035278  -0.05677933  0.21565472]
Centroid 10: [-0.0075561  -0.03688001 -0.05814638 -0.00989774 -0.01909145  0.12708327
 -0.09676255 -0.40865788 -0.34887686  0.4386321   0.43797368  0.34522352
 -0.04229356  0.02239504  0.13747588]
Centroid 11: [ 0.02895253 -0.10088176  0.07208715  0.05784438 -0.35257134 -0.19764426
  0.03667921  0.05573001  0.0248562  -0.28549546  0.235206    0.65459925
  0.00350986  0.09710566  0.20892127]
Centroid 12: [ 0.08741812 -0.00323286 -0.02758571  0.04396934  0.1510834  -0.2199298
  0.01544501  0.02872865  0.28249127  0.2757661  -0.01646408 -0.07298139
  0.005686   -0.7247909   0.36323637]
Centroid 13: [-0.18900874  0.05936766 -0.17370565 -0.03312683  0.2125689   0.229542
 -0.1876813   0.01436323  0.20084958  0.06716608  0.17865746  0.12128574
 -0.02205048  0.0404955   0.14532654]
Centroid 14: [ 0.10641414 -0.03233918 -0.3678087   0.02512393 -0.1135634   0.01155107
  0.15825576  0.01191335 -0.20345698 -0.22572443  0.03775376 -0.5782156
  0.02188617  0.22374596  0.43023428]
Centroid 15: [ 0.0102747  -0.09620944 -0.044553    0.01143827  0.03397402  0.20731531
 -0.20015617 -0.0264176  -0.27534327 -0.04855714 -0.5659958   0.35924992
  0.00473145 -0.08869596  0.2054358 ]
```

poly (gamma=0.15)

In [ ]:

```
spectral_clustering(
    le_X_train025,
    cuts=23,
    fname="label_encoded_spectral_clustering",
    affinity="poly",
    gamma=0.15,
)
```

```
WARNING:jax._src.xla_bridge:No GPU/TPU found, falling back to CPU. (Set TF_CPP_MIN_LOG_LEVEL=0 and rerun for more info.)
```

```
eigenvalues: [9.9994981e-01 9.9994802e-01 9.9992979e-01 9.9984801e-01 9.9983108e-01
 9.9981737e-01 9.9977839e-01 9.9976015e-01 9.9957794e-01 9.9942619e-01
 9.9812502e-01 9.9682689e-01 9.9625343e-01 9.9596763e-01 9.8182416e-01
 9.7822905e-01 9.7001499e-01 8.7461996e-01 4.2127788e-01 7.4355703e-14
 5.6841887e-14 1.4760132e-15 8.1958574e-20].
Finished running k-means++
1.0     6615
2.0      886
8.0      556
5.0      495
4.0      489
3.0      442
22.0     334
0.0      322
12.0     311
15.0     302
16.0     286
20.0     256
21.0     255
6.0      207
9.0      166
7.0      139
19.0      98
10.0      85
11.0      39
17.0      30
13.0      25
18.0       9
14.0       3
dtype: int64
Completed iteration 1
1.0     6518
2.0      783
12.0     576
8.0      542
5.0      486
3.0      467
4.0      441
22.0     341
15.0     341
16.0     321
0.0      283
6.0      193
20.0     179
21.0     153
19.0     142
7.0      140
9.0      134
11.0     110
10.0      84
13.0      64
17.0      30
18.0      19
14.0       3
dtype: int64
Completed iteration 2
1.0     6518
2.0      726
12.0     648
8.0      536
5.0      485
3.0      441
4.0      424
15.0     357
22.0     356
16.0     337
0.0      279
6.0      189
20.0     163
7.0      137
9.0      134
21.0     131
19.0     128
11.0     124
10.0      84
13.0      72
18.0      49
17.0      29
14.0       3
dtype: int64
Completed iteration 3
1.0     6518
2.0      693
12.0     680
8.0      523
5.0      486
3.0      430
4.0      417
15.0     364
22.0     361
16.0     350
0.0      270
6.0      193
20.0     156
7.0      135
9.0      133
21.0     133
11.0     128
19.0     121
10.0      84
18.0      74
13.0      69
17.0      29
14.0       3
dtype: int64
Completed iteration 4
1.0     6518
12.0     687
2.0      685
8.0      516
5.0      486
3.0      432
4.0      415
15.0     370
22.0     359
16.0     358
0.0      265
6.0      196
20.0     155
21.0     136
7.0      135
9.0      133
11.0     124
19.0     118
10.0      83
18.0      75
13.0      72
17.0      29
14.0       3
dtype: int64
Completed iteration 5
1.0     6518
12.0     692
2.0      680
8.0      515
5.0      486
3.0      430
4.0      414
15.0     373
16.0     364
22.0     355
0.0      262
6.0      196
20.0     156
7.0      139
21.0     137
9.0      133
11.0     121
19.0     118
10.0      83
13.0      74
18.0      72
17.0      29
14.0       3
dtype: int64
Completed iteration 6
1.0     6518
12.0     696
2.0      677
8.0      515
5.0      486
3.0      427
4.0      415
15.0     373
16.0     370
22.0     354
0.0      257
6.0      198
20.0     156
7.0      140
21.0     139
9.0      133
11.0     120
19.0     116
10.0      83
13.0      74
18.0      71
17.0      29
14.0       3
dtype: int64
Completed iteration 7
1.0     6518
12.0     697
2.0      676
8.0      515
5.0      486
3.0      425
4.0      415
15.0     373
16.0     371
22.0     352
0.0      258
6.0      199
20.0     155
7.0      142
21.0     141
9.0      133
11.0     120
19.0     115
10.0      83
13.0      75
18.0      69
17.0      29
14.0       3
dtype: int64
Completed iteration 8
1.0     6518
12.0     697
2.0      675
8.0      515
5.0      486
3.0      426
4.0      415
15.0     373
16.0     371
22.0     352
0.0      258
6.0      200
20.0     156
7.0      143
21.0     141
9.0      133
11.0     118
19.0     114
10.0      83
13.0      75
18.0      69
17.0      29
14.0       3
dtype: int64
Completed iteration 9
1.0     6518
12.0     697
2.0      675
8.0      516
5.0      486
3.0      426
4.0      415
15.0     374
16.0     371
22.0     352
0.0      258
6.0      200
20.0     155
7.0      143
21.0     141
9.0      133
11.0     118
19.0     113
10.0      83
13.0      75
18.0      69
17.0      29
14.0       3
dtype: int64
Completed iteration 10
1.0     6518
12.0     697
2.0      675
8.0      516
5.0      486
3.0      426
4.0      415
15.0     374
16.0     371
22.0     354
0.0      258
6.0      204
20.0     154
7.0      143
21.0     141
9.0      133
11.0     115
19.0     111
10.0      83
13.0      75
18.0      69
17.0      29
14.0       3
dtype: int64
Completed iteration 11
1.0     6518
12.0     697
2.0      675
8.0      516
5.0      486
3.0      426
4.0      415
15.0     374
16.0     371
22.0     355
0.0      258
6.0      206
20.0     151
7.0      143
21.0     141
9.0      133
19.0     112
11.0     112
10.0      83
13.0      77
18.0      69
17.0      29
14.0       3
dtype: int64
Completed iteration 12
1.0     6518
12.0     697
2.0      675
8.0      516
5.0      486
3.0      426
4.0      415
15.0     374
16.0     371
22.0     357
0.0      258
6.0      206
20.0     150
7.0      143
21.0     141
9.0      133
19.0     116
11.0     106
10.0      83
13.0      78
18.0      69
17.0      29
14.0       3
dtype: int64
Completed iteration 13
1.0     6518
12.0     697
2.0      675
8.0      516
5.0      486
3.0      426
4.0      416
15.0     372
16.0     371
22.0     353
0.0      258
6.0      206
20.0     148
7.0      143
21.0     141
9.0      133
19.0     133
11.0      93
10.0      83
13.0      81
18.0      69
17.0      29
14.0       3
dtype: int64
Completed iteration 14
1.0     6518
12.0     697
2.0      675
8.0      516
5.0      486
3.0      426
4.0      415
16.0     371
15.0     371
22.0     348
0.0      258
6.0      206
20.0     147
7.0      142
21.0     141
19.0     139
9.0      133
11.0      92
13.0      85
10.0      83
18.0      69
17.0      29
14.0       3
dtype: int64
Completed iteration 15
1.0     6518
12.0     697
2.0      675
8.0      516
5.0      486
3.0      426
4.0      415
16.0     371
15.0     368
22.0     347
0.0      258
6.0      205
20.0     151
7.0      141
21.0     141
19.0     135
9.0      133
13.0      92
11.0      91
10.0      83
18.0      69
17.0      29
14.0       3
dtype: int64
Completed iteration 16
1.0     6518
12.0     697
2.0      675
8.0      516
5.0      486
3.0      426
4.0      413
16.0     371
15.0     366
22.0     347
0.0      258
6.0      205
20.0     157
21.0     141
7.0      140
9.0      133
19.0     128
13.0      98
11.0      91
10.0      83
18.0      69
17.0      29
14.0       3
dtype: int64
Completed iteration 17
1.0     6518
12.0     697
2.0      675
8.0      515
5.0      486
3.0      426
4.0      410
16.0     371
15.0     363
22.0     345
0.0      258
6.0      206
20.0     160
21.0     141
7.0      135
9.0      133
19.0     121
13.0     112
11.0      94
10.0      83
18.0      69
17.0      29
14.0       3
dtype: int64
Completed iteration 18
1.0     6519
12.0     697
2.0      675
8.0      515
5.0      486
3.0      427
4.0      408
16.0     371
15.0     355
22.0     345
0.0      258
6.0      206
20.0     163
21.0     141
7.0      134
9.0      133
19.0     118
13.0     117
11.0      97
10.0      83
18.0      70
17.0      29
14.0       3
dtype: int64
Completed iteration 19
1.0     6519
12.0     697
2.0      675
8.0      513
5.0      486
3.0      427
4.0      408
16.0     372
15.0     350
22.0     346
0.0      258
6.0      204
20.0     166
21.0     141
7.0      136
9.0      134
19.0     117
13.0     116
11.0      99
10.0      83
18.0      71
17.0      29
14.0       3
dtype: int64
Completed iteration 20
1.0     6519
12.0     697
2.0      675
8.0      513
5.0      486
3.0      427
4.0      408
16.0     372
15.0     347
22.0     346
0.0      258
6.0      205
20.0     166
21.0     141
7.0      138
9.0      135
19.0     118
13.0     112
11.0      99
10.0      83
18.0      73
17.0      29
14.0       3
dtype: int64
Completed iteration 21
Reached 21 iterations
Centroids:
Centroid 1: [ 0.01795617 -0.00419744 -0.02316684  0.01757244 -0.01970202 -0.00448749
 -0.05546277  0.01762426  0.05435304 -0.31416786 -0.02722855  0.2571069
  0.28913972  0.04678697  0.27568734  0.20977323  0.07082978  0.45055276
  0.0180858   0.00805133  0.00335    -0.01699828  0.47195673]
Centroid 2: [ 1.6139619e-02  1.2703321e-02 -2.4205483e-02  3.0154339e-03
  2.1793935e-02  8.6639257e-04  4.6384293e-03  8.1821019e-03
  1.6873045e-02  1.7786440e-01  1.7704688e-02 -2.9137284e-02
  1.4450148e-02 -1.4785549e-04 -5.3292539e-02 -4.2759344e-02
 -2.5612209e-02 -2.7757021e-02  2.4591517e-02  2.3734443e-02
 -1.9249395e-05 -1.7293061e-05  9.7604471e-01]
Centroid 3: [ 5.5849407e-02  6.6169365e-03 -2.8248069e-01  1.6129746e-01
  2.3017617e-01 -1.5633975e-03 -1.7738143e-02  6.6498466e-02
  1.3197225e-01  3.0296719e-01  9.5198825e-02  1.5935154e-03
  1.2964426e-01  2.8433144e-04 -1.9895437e-01 -1.7804883e-01
  3.2082066e-02  4.9695769e-01  1.8744396e-02  8.9846225e-03
  1.0635618e-03 -5.4243458e-03  4.1437137e-01]
Centroid 4: [-1.51552930e-01  9.79105171e-05  1.81685254e-01 -1.15477026e-01
 -2.00274408e-01  5.54301601e-04 -7.85237998e-02 -1.07502844e-02
  9.84424353e-02  1.25378504e-01  8.90241470e-03  3.06634396e-01
  6.16066337e-01  5.93769588e-02  1.61720335e-01  1.18531473e-01
  1.18073635e-02  3.04562032e-01  1.36803193e-02  6.18637633e-03
  2.12048437e-03 -1.07668824e-02  3.43621492e-01]
Centroid 5: [ 0.07813489 -0.00478222  0.01656819  0.06256688 -0.00718803  0.04306534
 -0.17547277 -0.1853953  -0.13999869  0.02210085  0.10451148  0.3286482
 -0.07530762  0.01269447 -0.29365522 -0.21709318 -0.01852991  0.02283324
  0.00503165 -0.1415725   0.13814525 -0.6988135  -0.02451393]
Centroid 6: [-0.08831729  0.00536354  0.06166657 -0.03014964 -0.14822128 -0.00380418
 -0.01432435 -0.02990657 -0.09208677 -0.8240052  -0.10998429  0.20513192
  0.22002152  0.02694952  0.08544038  0.07462814 -0.07771022 -0.14853555
  0.00752098  0.00681536  0.00091593 -0.00466802  0.3178458 ]
Centroid 7: [-0.08992285  0.00179277  0.06536358  0.01114417  0.11039352 -0.00516503
 -0.17959154  0.10027127 -0.49619463  0.04841511  0.5059667  -0.24464588
 -0.06333689 -0.03916889  0.2328208   0.13527603 -0.05053146 -0.31052253
  0.00298753 -0.02924042  0.03152059 -0.15944505  0.11690465]
Centroid 8: [-0.01020239  0.00416225  0.00158687  0.07327972 -0.0024908   0.00598666
 -0.23215747 -0.09201579 -0.00135637  0.07413501 -0.0103207   0.2947427
 -0.22052027 -0.01178332 -0.24172524  0.03322852 -0.565025   -0.28170246
  0.00388718 -0.01429522  0.01698746 -0.08601566  0.11744247]
Centroid 9: [ 0.05773617  0.00431035 -0.05875878  0.06261122  0.0110647   0.00350282
  0.01558632 -0.08474794  0.13588184  0.04724295 -0.15834238 -0.2115059
 -0.01229129 -0.01888166  0.33321932  0.26911542 -0.03148371  0.04900229
  0.00546871 -0.14840034  0.14518583 -0.7344273  -0.01014694]
Centroid 10: [-0.01432809 -0.00099776 -0.00725499  0.23280539 -0.15129362  0.00769665
  0.14663352  0.15618508 -0.04040098  0.11843607  0.02251958  0.13627538
 -0.20379862  0.2154151  -0.01369276  0.4222759   0.32221887 -0.18108694
 -0.02724574 -0.00396777  0.00611135 -0.03058176  0.10311875]
Centroid 11: [-0.45841682  0.03118671  0.03655873  0.03713652  0.16696241 -0.00610604
  0.2490378  -0.17850435 -0.4904146   0.15356702 -0.3961636   0.02795212
  0.01864218  0.00367082 -0.03598121 -0.03089768  0.01093971  0.1553471
  0.00621319  0.00295857  0.00059999 -0.00305087  0.14693584]
Centroid 12: [ 0.3197242  -0.00227502  0.01704012  0.07248565 -0.00529549  0.00396386
  0.48175013 -0.39515182 -0.0581116  -0.06956216  0.20313631 -0.16557403
  0.06025447 -0.01808024 -0.08007427 -0.20667925  0.08627465 -0.4209337
  0.00221177  0.00248056  0.00101476 -0.0051537   0.14509763]
Centroid 13: [ 0.09380807 -0.00717061  0.19532044 -0.12664494 -0.16937506  0.0028811
 -0.03908519  0.0297963  -0.04861939 -0.09004114  0.0189207  -0.2263757
 -0.394835   -0.04563444 -0.21472381 -0.18450233  0.0537095   0.5067408
  0.01852494  0.00886156  0.00122586 -0.00625004  0.41614422]
Centroid 14: [-0.04946671 -0.01066659 -0.01731632 -0.16133238  0.06395601  0.02083562
  0.25677142  0.35852143  0.10541601 -0.01256006 -0.08479978 -0.12824656
 -0.03381398 -0.0210605  -0.15091942 -0.00053848 -0.27715227 -0.26614153
 -0.05272682 -0.02545791  0.02735924 -0.13837059  0.10174731]
Centroid 15: [-0.01498254  0.04206039 -0.19548441 -0.00446457  0.04225015 -0.87867576
  0.04985236  0.07813766  0.03280457  0.03955862  0.00925555  0.002051
  0.00278093  0.00778454 -0.01892358 -0.01436892 -0.00656384 -0.0077108
  0.00358627 -0.00121632  0.0044297  -0.02244625  0.13574605]
Centroid 16: [-0.13829824  0.00723268 -0.00723768 -0.11507901  0.0473589   0.03653432
  0.19429068  0.33734813  0.04936532 -0.07853901 -0.00287282 -0.05206871
  0.10523713  0.00719653 -0.16566749 -0.17726475  0.06762147  0.02651416
  0.00472029 -0.13223466  0.12908435 -0.6529714  -0.02085232]
Centroid 17: [ 0.08046992  0.0040799  -0.3903901   0.15777394  0.13907623 -0.00193271
  0.00665693  0.037632   -0.03155166 -0.47210476 -0.03626548  0.05085752
 -0.16545337  0.00684189  0.188326    0.14586319  0.08023202  0.3354723
  0.01217599  0.0054029   0.00242708 -0.01230984  0.32419285]
Centroid 18: [ 0.07066332 -0.00671036 -0.0866902   0.07035144 -0.10799088 -0.00283483
  0.09926221 -0.22236495  0.6021356  -0.09449252  0.48818046 -0.06335002
 -0.03439895 -0.00955205 -0.05883348 -0.05651413  0.02615196  0.23580882
  0.00866079  0.00410722  0.00065994 -0.00336217  0.19674018]
Centroid 19: [ 0.1286513  -0.01859019  0.4751646  -0.22710228 -0.32135195  0.01484451
 -0.07227848 -0.17475788  0.03760097 -0.05564624 -0.08432724  0.02980241
  0.02700323  0.01747671  0.29696602  0.2246812   0.03605372  0.0453864
  0.00321596 -0.03595889  0.03710454 -0.18769906  0.07769745]
Centroid 20: [ 1.14907756e-01 -9.06812772e-03 -1.00547545e-01 -3.75441104e-01
  4.15448174e-02  2.74771405e-03  3.88898030e-02  6.75473884e-02
 -7.46898353e-02  8.67658630e-02 -4.26702239e-02  3.35798293e-01
 -2.12180391e-01 -4.88243401e-02  2.40054280e-01 -6.46089241e-02
  2.84704924e-01 -3.33398610e-01 -4.07734769e-05 -6.90753805e-03
  1.00222863e-02 -5.04906066e-02  1.29491225e-01]
Centroid 21: [-0.388894    0.01337892  0.00698304  0.02928255 -0.02782239 -0.00496369
  0.04399245 -0.25225452  0.23352368 -0.04673731  0.23868217 -0.14449002
  0.04206128 -0.02676392  0.0389251  -0.21699908  0.23776127 -0.47091088
  0.00265771 -0.00267753  0.00657392 -0.03326987  0.1662506 ]
Centroid 22: [ 0.3106803  -0.00174171  0.60421425 -0.05202698  0.28029558 -0.00098865
  0.12618151  0.1502998   0.07491524  0.07866518  0.0084109   0.12164126
  0.10561336  0.01383041  0.02089686  0.00968035  0.02895961  0.24605858
  0.01011717  0.00490766  0.00116845 -0.0059391   0.2510419 ]
Centroid 23: [ 0.09370705 -0.0011774  -0.04173628  0.05657651  0.05752667 -0.00738452
 -0.18186426  0.10528321  0.15479103  0.10230602 -0.3832096  -0.15076265
 -0.0796804  -0.03409109  0.08599363 -0.0613615   0.01752001 -0.5311917
  0.00339593 -0.01054748  0.01492342 -0.07550935  0.18940288]
```

In [ ]:

```
spectral_clustering(
    le_X_train025,
    cuts=len(np.unique(le_y_train025)),
    fname="label_encoded_spectral_clustering",
    affinity="poly",
    gamma=0.15,
)
```

```
eigenvalues: [9.9957794e-01 9.9942619e-01 9.9812502e-01 9.9682689e-01 9.9625343e-01
 9.9596763e-01 9.8182416e-01 9.7822905e-01 9.7001499e-01 8.7461996e-01
 4.2127788e-01 7.4355703e-14 5.6841887e-14 1.4760132e-15 8.1958574e-20].
Finished running k-means++
1.0     6533
2.0      917
4.0      673
0.0      598
14.0     582
8.0      564
11.0     543
10.0     507
13.0     395
9.0      274
7.0      255
12.0     247
3.0      151
6.0      107
5.0        4
dtype: int64
Completed iteration 1
1.0     6533
2.0      805
4.0      640
11.0     627
14.0     608
8.0      606
0.0      572
10.0     501
13.0     378
9.0      268
12.0     256
7.0      227
3.0      218
6.0      102
5.0        9
dtype: int64
Completed iteration 2
1.0     6533
2.0      772
11.0     663
4.0      631
8.0      619
14.0     616
0.0      557
10.0     501
13.0     380
9.0      260
12.0     256
3.0      231
7.0      220
6.0       98
5.0       13
dtype: int64
Completed iteration 3
1.0     6533
2.0      761
11.0     685
4.0      625
14.0     622
8.0      616
0.0      549
10.0     502
13.0     394
9.0      254
12.0     254
3.0      239
7.0      205
6.0       93
5.0       18
dtype: int64
Completed iteration 4
1.0     6533
2.0      752
11.0     702
14.0     626
4.0      622
8.0      617
0.0      541
10.0     501
13.0     399
12.0     253
9.0      250
3.0      240
7.0      204
6.0       91
```

```
5.0      19
dtype: int64
Completed iteration 5
1.0     6533
2.0      740
11.0     720
14.0     627
4.0      622
8.0      615
0.0      538
10.0     501
13.0     400
12.0     252
9.0      248
3.0      241
7.0      204
6.0       90
5.0       19
dtype: int64
Completed iteration 6
1.0     6533
11.0     734
2.0      730
14.0     628
4.0      622
8.0      612
0.0      537
10.0     501
13.0     400
12.0     251
9.0      248
3.0      241
7.0      204
6.0       89
5.0       20
dtype: int64
Completed iteration 7
1.0     6533
11.0     741
2.0      727
14.0     628
4.0      622
8.0      609
0.0      536
10.0     501
13.0     400
12.0     251
9.0      248
3.0      241
7.0      204
6.0       89
5.0       20
dtype: int64
Completed iteration 8
Epsilon has a maximum value of 0.00680013420060277
Centroids:
Centroid 1: [-4.1026605e-04 -5.4468358e-01 -4.0607430e-02  1.3497582e-01
 -7.3076740e-02  2.3023374e-02  2.8761318e-01  2.2191089e-01
  1.0127597e-01  4.3676701e-01  1.6209442e-02  7.1421359e-03
  3.3443028e-03 -1.6961534e-02  4.3427065e-01]
Centroid 2: [ 1.6832262e-02  1.7817886e-01  1.7742846e-02 -2.9195603e-02
  1.4466196e-02 -1.6978622e-04 -5.3412329e-02 -4.2864632e-02
 -2.5670281e-02 -2.7819106e-02  2.4649631e-02  2.3790516e-02
 -1.9335661e-05 -1.7346591e-05  9.7834641e-01]
Centroid 3: [ 1.6663292e-01  3.6095482e-01  1.1925103e-01  4.9002306e-03
  1.4934412e-01 -2.4629681e-04 -2.3120016e-01 -2.0679526e-01
  3.8093880e-02  5.8772671e-01  2.2210598e-02  1.0636483e-02
  1.2892886e-03 -6.5745311e-03  4.9182409e-01]
Centroid 4: [-0.3071122   0.19844346 -0.2351555   0.22980951 -0.18814705 -0.01143419
  0.24412665  0.04178289  0.1962734  -0.1008743  -0.00340847 -0.00327477
  0.00693799 -0.03499766  0.15294077]
Centroid 5: [ 0.14353013  0.00229967 -0.14072739 -0.21242991  0.05301405 -0.01358767
  0.26392284  0.17880535  0.03530053  0.07537534  0.00546857 -0.15329601
  0.1496968  -0.7572448  -0.02209451]
Centroid 6: [ 0.00231095 -0.01552892 -0.00810563 -0.03288363  0.06555921 -0.4049232
 -0.40989742  0.4878347   0.24933645 -0.10871828 -0.3577054  -0.00236639
  0.00313849 -0.01523667  0.05359956]
Centroid 7: [-0.03095257  0.07519738  0.02155406  0.17445076 -0.16362724  0.44359705
 -0.2612186   0.4455376   0.4695198  -0.37309292 -0.02508467 -0.00654425
  0.00942866 -0.04717205  0.14187765]
Centroid 8: [ 0.03339958  0.06531835 -0.04952646  0.22644456 -0.22185552 -0.01312917
 -0.28768298 -0.02922022 -0.53919315 -0.38841587  0.00464495 -0.02830126
  0.03142092 -0.1590395   0.14730237]
Centroid 9: [ 0.11349276  0.08015808  0.00546193  0.34626654  0.6274439   0.06463943
  0.2003533   0.14851716  0.024549    0.3642895   0.01596426  0.00720654
  0.00257029 -0.01304847  0.4044823 ]
Centroid 10: [-0.4757729   0.03954284  0.5278416  -0.24635226 -0.05195914 -0.0398689
  0.21622142  0.10042706 -0.03397052 -0.36088327  0.00315044 -0.02456839
  0.02738407 -0.13852508  0.13597976]
Centroid 11: [-0.09222962 -0.8360146  -0.10499968  0.21128614  0.22003907  0.02642465
  0.09104713  0.07392298 -0.07294264 -0.15689982  0.00754472  0.00681364
  0.00096989 -0.00493848  0.31989056]
Centroid 12: [-0.0422189  -0.1082226   0.02926494 -0.2587466  -0.44169924 -0.05100907
 -0.24208064 -0.20825091  0.06001777  0.5565238   0.02019617  0.00966054
  0.00129965 -0.00662731  0.4521207 ]
Centroid 13: [ 0.25977972  0.15062155 -0.3480261  -0.233816   -0.18711464 -0.03718461
  0.24872956  0.2502738  -0.27053955 -0.44461465  0.0043526  -0.03962949
  0.04292266 -0.21713346  0.16835126]
Centroid 14: [ 1.4291790e-01 -3.9681908e-02 -5.1039249e-02 -1.7787887e-01
  7.7599235e-02 -3.3033088e-02 -4.4413403e-02 -3.4687862e-01
  2.8214192e-01 -6.3022256e-01  3.4395836e-03 -1.6602097e-04
  5.4053096e-03 -2.7367651e-02  2.1902807e-01]
Centroid 15: [-0.08672481 -0.01486818  0.09955537  0.24115989 -0.03185505  0.01368773
 -0.3115832  -0.2298923  -0.02351366  0.02753295  0.00570571 -0.1604632
  0.15658198 -0.79207337 -0.02768399]
```

rbf (gamma=1.0)

```python
spectral_clustering(
    le_X_train025,
    cuts=23,
    fname="label_encoded_spectral_clustering",
    affinity="rbf",
    gamma=1.0,
)
```

```
eigenvalues: [2.3329157e-18 2.2065703e-18 2.0632335e-18 1.7459047e-18 1.6057179e-18
 7.8783308e-19 7.0039321e-19 4.6904418e-19 4.2392001e-19 2.8425227e-19
 2.0007891e-19 1.3124208e-19 7.2209598e-20 6.9068030e-20 2.1548276e-20
 2.8687060e-21 9.1183435e-22 3.7461878e-23 2.4632515e-23 6.9405777e-27
 3.5174635e-30 5.0740151e-35 0.0000000e+00].
Finished running k-means++
0.0     3500
2.0     3096
22.0     614
1.0      467
18.0     463
9.0      440
3.0      357
19.0     322
4.0      288
20.0     285
17.0     280
16.0     271
6.0      239
15.0     228
21.0     222
8.0      196
10.0     193
11.0     186
7.0      177
12.0     168
5.0      128
14.0     118
13.0     112
dtype: int64
Completed iteration 1
0.0     3411
2.0     3012
1.0      528
22.0     491
9.0      413
18.0     381
17.0     343
16.0     332
3.0      330
15.0     294
4.0      273
19.0     270
7.0      269
20.0     246
12.0     226
10.0     223
11.0     221
6.0      217
21.0     213
8.0      203
5.0      163
13.0     157
14.0     134
dtype: int64
Completed iteration 2
0.0     3409
2.0     3010
1.0      531
22.0     409
9.0      390
18.0     356
16.0     332
17.0     317
3.0      312
15.0     305
7.0      297
4.0      271
12.0     259
19.0     254
10.0     241
20.0     238
11.0     236
21.0     230
6.0      229
5.0      206
8.0      194
13.0     167
14.0     157
dtype: int64
Completed iteration 3
0.0     3410
2.0     3010
1.0      512
9.0      391
22.0     388
18.0     355
16.0     331
17.0     324
15.0     315
3.0      304
7.0      292
4.0      264
12.0     264
19.0     256
21.0     242
20.0     242
10.0     234
6.0      233
11.0     228
5.0      225
8.0      189
13.0     174
14.0     167
dtype: int64
Completed iteration 4
0.0     3410
2.0     3010
1.0      495
22.0     385
9.0      382
18.0     346
17.0     338
15.0     323
16.0     320
3.0      303
7.0      285
12.0     262
19.0     256
4.0      255
21.0     252
20.0     243
6.0      241
10.0     238
5.0      236
11.0     229
8.0      190
13.0     176
14.0     175
dtype: int64
Completed iteration 5
0.0     3411
2.0     3010
1.0      487
22.0     389
9.0      384
17.0     344
15.0     334
18.0     332
16.0     321
3.0      300
7.0      286
19.0     266
21.0     257
4.0      250
12.0     249
6.0      241
20.0     241
11.0     234
10.0     234
5.0      231
8.0      188
13.0     182
14.0     179
dtype: int64
Completed iteration 6
0.0     3411
2.0     3010
1.0      481
22.0     401
9.0      383
17.0     346
15.0     338
18.0     331
16.0     322
3.0      299
19.0     270
21.0     268
7.0      266
4.0      245
12.0     245
6.0      244
20.0     236
11.0     235
10.0     234
5.0      223
8.0      190
13.0     188
14.0     184
dtype: int64
Completed iteration 7
0.0     3411
2.0     3010
1.0      472
22.0     415
9.0      387
17.0     359
15.0     334
18.0     325
16.0     323
3.0      296
19.0     278
21.0     266
7.0      254
6.0      247
11.0     242
10.0     239
4.0      238
20.0     237
12.0     232
5.0      219
13.0     197
8.0      191
14.0     178
dtype: int64
Completed iteration 8
0.0     3412
2.0     3010
1.0      459
22.0     424
9.0      385
17.0     363
15.0     334
18.0     322
16.0     320
3.0      295
19.0     288
21.0     267
7.0      246
10.0     246
6.0      244
11.0     241
20.0     240
4.0      231
12.0     230
5.0      220
13.0     205
8.0      189
14.0     179
dtype: int64
Completed iteration 9
0.0     3412
2.0     3010
1.0      459
22.0     436
9.0      382
17.0     366
15.0     327
18.0     322
16.0     320
3.0      303
19.0     288
21.0     265
10.0     249
20.0     245
7.0      242
11.0     241
6.0      239
4.0      229
12.0     229
5.0      214
13.0     202
8.0      192
14.0     178
dtype: int64
Completed iteration 10
0.0     3412
2.0     3010
1.0      451
22.0     444
9.0      380
17.0     371
15.0     328
16.0     323
18.0     316
3.0      303
19.0     296
21.0     263
10.0     245
20.0     245
6.0      238
11.0     237
7.0      237
12.0     231
4.0      228
5.0      217
13.0     206
8.0      191
14.0     178
dtype: int64
Completed iteration 11
0.0     3412
2.0     3010
1.0      446
22.0     443
9.0      380
17.0     373
15.0     326
16.0     326
18.0     311
3.0      303
19.0     301
21.0     259
7.0      242
10.0     242
20.0     240
11.0     239
6.0      239
12.0     233
4.0      232
5.0      217
13.0     206
8.0      193
14.0     177
dtype: int64
Completed iteration 12
0.0     3412
2.0     3010
1.0      449
22.0     448
9.0      372
17.0     370
15.0     329
16.0     327
18.0     310
19.0     305
3.0      299
21.0     259
10.0     240
20.0     240
6.0      239
7.0      239
11.0     236
4.0      231
12.0     231
5.0      216
13.0     216
8.0      194
14.0     178
dtype: int64
Completed iteration 13
0.0     3412
2.0     3010
22.0     457
1.0      445
17.0     369
9.0      365
16.0     331
15.0     329
19.0     307
18.0     306
3.0      297
21.0     253
10.0     242
6.0      241
11.0     240
7.0      239
20.0     237
12.0     230
4.0      226
13.0     225
5.0      215
8.0      197
14.0     177
dtype: int64
Completed iteration 14
0.0     3411
2.0     3010
22.0     458
1.0      441
17.0     365
9.0      363
16.0     332
15.0     327
19.0     314
18.0     303
3.0      295
21.0     254
10.0     244
6.0      243
11.0     239
7.0      237
20.0     237
13.0     232
12.0     227
4.0      223
5.0      216
8.0      202
14.0     177
dtype: int64
Completed iteration 15
0.0     3411
2.0     3010
22.0     458
1.0      443
17.0     364
9.0      360
16.0     335
15.0     323
19.0     315
18.0     300
3.0      296
21.0     256
10.0     244
6.0      243
11.0     239
7.0      238
13.0     235
20.0     232
12.0     226
4.0      221
5.0      220
8.0      204
14.0     177
dtype: int64
Completed iteration 16
0.0     3411
2.0     3010
22.0     454
1.0      440
17.0     364
9.0      360
16.0     331
15.0     322
19.0     316
3.0      301
18.0     300
21.0     258
6.0      244
10.0     243
13.0     239
7.0      239
11.0     238
20.0     232
5.0      224
12.0     221
4.0      220
8.0      208
14.0     175
dtype: int64
Completed iteration 17
0.0     3411
2.0     3010
22.0     451
1.0      442
17.0     361
9.0      360
16.0     333
15.0     323
19.0     317
3.0      301
18.0     297
21.0     262
6.0      246
10.0     243
13.0     240
11.0     237
7.0      236
20.0     228
5.0      225
12.0     222
4.0      220
8.0      212
14.0     173
dtype: int64
Completed iteration 18
0.0     3411
2.0     3010
22.0     445
1.0      439
9.0      362
17.0     359
16.0     331
15.0     322
19.0     322
3.0      300
18.0     297
21.0     262
6.0      247
13.0     243
10.0     242
11.0     240
7.0      232
20.0     226
5.0      225
12.0     223
8.0      220
4.0      217
14.0     175
dtype: int64
Completed iteration 19
0.0     3412
2.0     3010
1.0      435
22.0     435
9.0      366
17.0     358
16.0     328
15.0     324
19.0     321
3.0      300
18.0     297
21.0     262
13.0     247
6.0      246
11.0     243
10.0     242
7.0      231
5.0      228
12.0     224
8.0      223
20.0     222
4.0      219
14.0     177
dtype: int64
Completed iteration 20
0.0     3412
2.0     3010
22.0     433
1.0      431
9.0      364
17.0     356
16.0     329
19.0     326
15.0     323
3.0      300
18.0     299
21.0     263
13.0     247
6.0      246
11.0     243
10.0     241
7.0      230
8.0      227
5.0      227
12.0     225
20.0     219
4.0      218
14.0     181
dtype: int64
Completed iteration 21
Reached 21 iterations
Centroids:
Centroid 1: [-4.92710024e-06 -3.30673560e-04  1.11253976e-04 -3.94254093e-05
  2.24213611e-04 -1.91063751e-04  1.93344502e-04  1.07691667e-04
 -3.23629327e-04 -2.84290527e-05 -9.24742296e-02  3.93204846e-06
 -1.23537291e-04  8.99756849e-01 -4.19481099e-01  1.27449253e-04
 -1.03681360e-03 -1.06724634e-04  8.05812160e-05  2.58657819e-04
  1.08652814e-04 -1.11625204e-05 -3.15138022e-05]
Centroid 2: [-1.6009067e-03 -1.4914760e-03 -1.8583190e-04 -1.1256082e-01
 -7.8223795e-03  9.1222944e-03 -1.6227741e-03  2.6063977e-02
 -4.4950773e-03 -1.4304890e-01  1.4853972e-01  5.8896327e-03
 -1.9314146e-02 -3.2251373e-01 -5.5553329e-01  3.3397105e-02
 -4.3089013e-03  9.2052585e-03  4.6861937e-04  1.6104319e-03
 -6.1694860e-02 -2.2639424e-02  2.2160064e-03]
Centroid 3: [-1.51065047e-04  5.00996684e-05  3.59938422e-04  1.53670975e-04
 -2.63058464e-04  6.86270287e-05 -1.65851598e-04  2.75120779e-04
  6.23901084e-04 -2.37611021e-04  1.11511856e-01 -1.61946940e-04
 -1.00683807e-04 -9.05034065e-01  3.91512901e-01  1.01626516e-04
 -2.52554280e-04  1.52899611e-05  3.04346846e-04 -1.49494808e-04
  9.60910111e-04  1.11606889e-04  6.71232119e-05]
Centroid 4: [ 0.0364306   0.00915612  0.00399699  0.03896888  0.02809324  0.03313
 -0.00079301  0.00403828  0.01127437 -0.08787534 -0.0235747  -0.00254835
 -0.01103767  0.08934496  0.12375119 -0.01271716 -0.00056588  0.00530106
 -0.01300633  0.0156068   0.49186406  0.17012915  0.0136897 ]
Centroid 5: [-1.4757463e-01 -3.3023272e-02 -1.0822596e-02  7.4271217e-02
 -7.0298024e-02  5.1970512e-02 -1.1349641e-02 -3.0003343e-02
  1.4336806e-02 -1.0191370e-01 -9.3626864e-02 -2.7772374e-03
 -2.4147956e-01 -5.7436097e-02 -1.2568915e-01 -6.9734842e-02
 -2.8303561e-03  3.8713440e-03  1.6527057e-03 -2.9557696e-04
 -3.4321979e-01 -1.0687623e-01 -6.8201232e-03]
Centroid 6: [-6.3650131e-02 -4.2809058e-02 -1.4499441e-02  5.8813659e-03
 -2.3910606e-02 -5.0779782e-02 -3.7084535e-02 -3.3589272e-04
 -4.5440730e-02  3.4481886e-01 -1.6460285e-01  1.2996710e-02
  2.8624875e-02  1.4667985e-02 -3.1506237e-02  4.3261625e-02
 -1.3213872e-02  2.2869429e-02 -9.9180052e-03 -2.4092250e-02
  2.5950193e-01  7.6048836e-02 -6.0011383e-02]
Centroid 7: [ 0.01873127  0.02205092 -0.0008616   0.56951016  0.02862727 -0.0305386
  0.00136902  0.01893026  0.01108425  0.02176573  0.02864838  0.00427183
 -0.02651415  0.05789866  0.07607041  0.00182456 -0.0022778   0.00141449
  0.01234166 -0.01068115  0.0086207  -0.00064984  0.00866148]
Centroid 8: [-0.0165033  -0.00715241 -0.00598602  0.04510175 -0.5092454   0.0571637
 -0.03536077 -0.00292327  0.00512888  0.03545818  0.02184104 -0.00318835
 -0.03028777  0.01045901  0.05700839  0.01120142 -0.00435986  0.00084244
  0.00566263 -0.00646426  0.04311408  0.01704983 -0.00229268]
Centroid 9: [-0.02843961 -0.01225225  0.0045837  -0.583993    0.00346888 -0.00979746
 -0.00596609 -0.01771572  0.00094741 -0.05116143 -0.00550881 -0.01551284
  0.1094936  -0.03506993 -0.06941648  0.02568434  0.00495091 -0.00375233
 -0.00456785 -0.00468601  0.01000928  0.01120415 -0.04392275]
Centroid 10: [-2.07774397e-02 -1.31638404e-02  1.48180436e-04 -1.09775178e-01
 -7.35670254e-02  2.42653210e-02 -1.06675858e-02  4.66943532e-03
 -8.44398804e-04 -3.58772367e-01 -2.41535082e-02 -4.92729666e-03
  1.35404826e-03  2.19500452e-01  4.30049390e-01 -1.08357240e-02
 -4.65855189e-03  2.97826040e-03 -1.01364786e-02 -1.65684149e-02
 -4.19363305e-02 -1.60521492e-02  1.55555075e-02]
Centroid 11: [ 0.05815556  0.00456709  0.01224432  0.01626287  0.18649717  0.34058768
  0.00402303 -0.02291062  0.00577001  0.23639278  0.08530065 -0.013905
 -0.01779779 -0.06174031 -0.06685768  0.0138535   0.01589761  0.01054007
 -0.002692    0.02167202  0.06661311 -0.0239118   0.05360452]
Centroid 12: [-0.10193029  0.02952764 -0.00074151 -0.11720101  0.0459828  -0.11298426
 -0.00586847  0.02102821 -0.01556065  0.08120444  0.28424004  0.00179168
  0.04503046 -0.05682016 -0.13041067  0.04279685 -0.00910749 -0.00295871
  0.00636682  0.01308222 -0.3265751  -0.11169145  0.05207752]
Centroid 13: [-0.17078918  0.02114604  0.00331406  0.0834627   0.3912597  -0.06769994
  0.03891176  0.01585971 -0.01241983 -0.18903174 -0.01398836 -0.00634866
 -0.00908008  0.09629626  0.179697   -0.0553642   0.01362866 -0.00516649
 -0.005874   -0.02214753  0.06987169  0.02193632 -0.02536526]
Centroid 14: [ 0.0369265   0.07715413  0.02073149 -0.3279829  -0.08433156 -0.04966683
 -0.00516772  0.01868549 -0.0092465   0.20387152 -0.00898173 -0.02174555
 -0.11738817  0.15417975  0.29940557  0.00636848  0.01632454 -0.00516569
  0.00198794  0.00510359  0.04956665  0.0127923   0.01247633]
Centroid 15: [ 0.04289739 -0.16973634  0.00885544  0.09414171  0.01944782 -0.03077786
```

```
 0.03627064  0.02894213  0.04189933  0.04857159  0.0309411  -0.006317
 0.43492556  0.03298746 -0.03282183  0.0095029  -0.0225647   0.00694406
-0.01400352  0.00910108 -0.01447232 -0.02092049  0.00722329]
Centroid 16: [ 0.04351544 -0.0123076  -0.00243254  0.15676239 -0.03417041 -0.09064642
 0.01440514 -0.0154094   0.02323112 -0.53415203  0.0256523   0.0127939
-0.02488508 -0.06541897 -0.09126901 -0.00536659 -0.0084556   0.01683784
 0.01061151 -0.0039999   0.01183789  0.0223662   0.00693448]
Centroid 17: [-0.08751522 -0.00208295  0.00072207  0.07933654  0.09010186 -0.02273706
-0.00387151 -0.00118791 -0.01678696  0.37000167 -0.03813159  0.00291061
-0.00454851  0.16187148  0.29750437  0.01250323 -0.00175967 -0.02538214
-0.0094102  -0.00669031 -0.25266284 -0.09306212 -0.01081592]
Centroid 18: [ 5.0222543e-03  6.0142735e-03  7.1250950e-03  2.8263873e-01
 2.8032476e-02  1.9846814e-02  4.8478250e-03 -5.8260038e-03
 2.1775559e-02  1.8065570e-01  3.0497449e-02  2.3301439e-04
-3.4216829e-02 -2.3682590e-01 -4.6407360e-01 -1.5006435e-02
-4.8782858e-03 -1.0389675e-02  1.4380057e-02  1.3560919e-02
-1.3923929e-02 -2.1495891e-03 -1.2269935e-02]
Centroid 19: [-0.02515576 -0.00356642  0.02355399 -0.15237422  0.00453238 -0.02918774
 0.01800668 -0.01583632  0.00674203  0.5601676  -0.01996216  0.00405402
 0.02614007 -0.10831039 -0.22786652 -0.01508849  0.01932721  0.00475982
 0.01217884  0.00345516 -0.08380385 -0.01313325  0.00592866]
Centroid 20: [ 0.05405803  0.01554472  0.00280374 -0.08096536  0.00283308 -0.15467902
 0.0054556   0.00700071  0.01238163 -0.03672689  0.07414581 -0.00879304
-0.04701433 -0.18147822 -0.33369985 -0.03221334  0.01136812  0.01580963
 0.00237847  0.02611374  0.3315004   0.10781262 -0.00798637]
Centroid 21: [ 1.0216701e-02  4.8839883e-03  4.2396127e-03 -2.0958997e-01
-4.6795622e-02  2.1324027e-01 -9.5036374e-03  4.1095123e-02
-3.5181220e-04 -4.2266050e-01  1.3897262e-04  1.9585144e-02
 4.8696525e-02 -7.2150931e-02 -1.7851599e-01 -3.7606996e-03
-3.4242284e-03  1.5234304e-02 -8.1529543e-03 -1.9458167e-02
 4.3098342e-02 -1.3939762e-02 -2.1404406e-02]
Centroid 22: [ 2.7561629e-01 -4.1064615e-03 -1.6665107e-02 -1.4778085e-02
 8.4733568e-02 -3.8631104e-02  3.3767631e-03  6.8779700e-05
-1.0737509e-02 -1.5807901e-01 -9.9577099e-02  2.6600624e-02
 4.2421129e-02  2.1966804e-02  7.8798771e-02  3.5656001e-02
 3.6315888e-03 -2.5634344e-03 -1.2104007e-02  2.9808169e-02
-3.1500641e-01 -7.5362541e-02 -1.3709185e-02]
Centroid 23: [ 0.01831363  0.00289137  0.00688472  0.11533575 -0.00159056  0.01417414
-0.01575541  0.00273856  0.00704801  0.07630728 -0.13671891 -0.00642908
 0.00080484  0.30569908  0.5796979  -0.00246067 -0.00402296 -0.00565842
 0.00738904  0.00125504  0.0344869   0.01668914 -0.00136668]
```

In [ ]:
```
spectral_clustering(
    le_X_train025,
    cuts=len(np.unique(le_y_train025)),
    fname="label_encoded_spectral_clustering",
    affinity="rbf",
    gamma=1.0,
)
```

```
eigenvalues: [4.2392001e-19 2.8425227e-19 2.0007891e-19 1.3124208e-19 7.2209598e-20
 6.9068030e-20 2.1548276e-20 2.8687060e-21 9.1183435e-22 3.7461878e-23
 2.4632515e-23 6.9405777e-27 3.5174635e-30 5.0740151e-35 0.0000000e+00].
Finished running k-means++
0.0     3629
1.0     3121
3.0      690
2.0      636
9.0      597
10.0     487
6.0      485
4.0      469
14.0     440
7.0      429
8.0      321
5.0      309
13.0     297
12.0     252
11.0     188
dtype: int64
Completed iteration 1
0.0     3452
1.0     3029
3.0      632
9.0      622
2.0      618
4.0      514
14.0     472
13.0     446
10.0     439
7.0      423
8.0      403
6.0      362
5.0      356
12.0     317
11.0     265
dtype: int64
Completed iteration 2
0.0     3452
1.0     3032
9.0      621
2.0      576
3.0      558
4.0      496
10.0     479
13.0     461
14.0     452
8.0      443
7.0      432
5.0      386
12.0     348
6.0      307
11.0     307
dtype: int64
Completed iteration 3
0.0     3449
1.0     3032
9.0      618
2.0      535
10.0     528
3.0      519
4.0      490
7.0      467
13.0     454
8.0      453
14.0     424
5.0      403
12.0     362
11.0     333
6.0      283
dtype: int64
Completed iteration 4
0.0     3451
1.0     3033
9.0      623
10.0     556
2.0      513
3.0      501
7.0      483
4.0      476
13.0     448
8.0      436
5.0      417
14.0     388
11.0     387
12.0     365
```

```
6.0      273
dtype: int64
Completed iteration 5
0.0     3448
1.0     3035
9.0      635
10.0     564
2.0      507
3.0      489
7.0      489
4.0      457
8.0      442
13.0     442
5.0      426
11.0     422
12.0     373
14.0     356
6.0      265
dtype: int64
Completed iteration 6
0.0     3446
1.0     3038
9.0      638
10.0     574
7.0      504
2.0      497
3.0      491
4.0      451
8.0      444
11.0     440
5.0      433
13.0     431
12.0     374
14.0     331
6.0      258
dtype: int64
Completed iteration 7
0.0     3447
1.0     3039
9.0      644
10.0     585
7.0      514
2.0      502
3.0      485
11.0     453
8.0      447
4.0      436
13.0     425
5.0      418
12.0     391
14.0     304
6.0      260
dtype: int64
Completed iteration 8
0.0     3447
1.0     3040
9.0      636
10.0     590
7.0      527
2.0      502
3.0      483
11.0     462
8.0      450
4.0      430
5.0      427
13.0     416
12.0     398
14.0     285
6.0      257
dtype: int64
Completed iteration 9
0.0     3443
1.0     3039
9.0      633
10.0     593
7.0      533
2.0      507
3.0      477
11.0     477
8.0      466
5.0      426
4.0      419
13.0     410
12.0     404
14.0     267
6.0      256
```

```
dtype: int64
Completed iteration 10
0.0     3444
1.0     3040
9.0      618
10.0     590
7.0      543
2.0      519
11.0     485
3.0      483
8.0      466
5.0      425
4.0      417
13.0     403
12.0     402
14.0     258
6.0      257
dtype: int64
Completed iteration 11
0.0     3443
1.0     3039
9.0      610
10.0     583
7.0      551
2.0      530
3.0      485
11.0     484
8.0      470
5.0      420
4.0      411
12.0     408
13.0     404
6.0      258
14.0     254
dtype: int64
Completed iteration 12
0.0     3442
1.0     3038
9.0      606
10.0     577
7.0      556
2.0      533
11.0     491
3.0      490
8.0      472
5.0      412
4.0      409
12.0     407
13.0     407
6.0      261
14.0     249
dtype: int64
Completed iteration 13
0.0     3442
1.0     3037
9.0      606
10.0     579
7.0      560
2.0      529
3.0      491
11.0     488
8.0      482
4.0      408
5.0      407
13.0     407
12.0     404
6.0      263
14.0     247
dtype: int64
Completed iteration 14
0.0     3443
1.0     3038
9.0      604
10.0     577
7.0      561
2.0      530
3.0      493
11.0     489
8.0      482
4.0      409
12.0     405
13.0     405
5.0      402
6.0      264
14.0     248
dtype: int64
```

```
Completed iteration 15
0.0     3443
1.0     3038
9.0      603
10.0     576
7.0      563
2.0      530
3.0      496
11.0     490
8.0      476
5.0      408
4.0      407
13.0     406
12.0     403
6.0      264
14.0     247
dtype: int64
Completed iteration 16
0.0     3443
1.0     3038
9.0      604
10.0     572
7.0      560
2.0      531
3.0      500
11.0     495
8.0      475
4.0      408
13.0     406
5.0      405
12.0     400
6.0      265
14.0     248
dtype: int64
Completed iteration 17
0.0     3443
1.0     3038
9.0      602
10.0     570
7.0      558
2.0      532
3.0      501
11.0     501
8.0      478
13.0     410
4.0      409
12.0     399
5.0      394
6.0      266
14.0     249
dtype: int64
Completed iteration 18
0.0     3444
1.0     3038
9.0      599
10.0     574
7.0      561
2.0      537
3.0      504
11.0     504
8.0      473
4.0      411
13.0     410
12.0     398
5.0      385
6.0      265
14.0     247
dtype: int64
Completed iteration 19
0.0     3444
1.0     3036
9.0      599
10.0     574
7.0      563
2.0      543
3.0      504
11.0     504
8.0      475
13.0     412
4.0      409
12.0     400
5.0      379
6.0      265
14.0     243
dtype: int64
Completed iteration 20
```

```
0.0     3444
1.0     3036
9.0      600
10.0     572
7.0      562
2.0      554
11.0     505
3.0      503
8.0      468
4.0      414
13.0     410
12.0     397
5.0      376
6.0      266
14.0     243
dtype: int64
Completed iteration 21
Reached 21 iterations
Centroids:
Centroid 1: [-3.7016923e-04  4.0426903e-04 -9.2359491e-02 -3.6961347e-04
  1.6817861e-04  8.9700776e-01 -4.1800332e-01  4.0627140e-04
 -9.8938972e-04 -3.3165902e-04  2.5552299e-04 -3.7672883e-04
  6.6697929e-04  1.3142027e-04  2.9733079e-04]
Centroid 2: [ 1.02270674e-03 -1.75837282e-04  1.11355335e-01 -8.57318402e-04
  4.47425176e-04 -9.03408766e-01  3.90476316e-01  2.85859220e-04
 -6.16745849e-04 -9.43686027e-05 -5.00395472e-05 -1.68617888e-04
  1.05983589e-03 -4.85215452e-04 -1.09927307e-04]
Centroid 3: [-0.01462453 -0.3078617  -0.11309037 -0.006047   -0.0007935   0.26821008
  0.55061567 -0.00876908  0.00102456  0.00323354 -0.00780018 -0.009138
 -0.07395282 -0.00916886  0.00252287]
Centroid 4: [ 0.0219333   0.04694246  0.04354127 -0.0089482  -0.00176659 -0.18972136
 -0.32897142 -0.0459796   0.00291415  0.02166219  0.00082331  0.02397308
  0.46811974  0.13698663  0.02883973]
Centroid 5: [ 0.03164912 -0.6266249   0.11296966  0.0131378  -0.07223572  0.05496928
  0.02741429  0.00331547  0.00827263  0.01169644  0.00216602 -0.02402542
  0.1034913   0.03614638  0.04806864]
Centroid 6: [ 0.02791788 -0.17936999  0.33686984  0.01751889  0.02838587 -0.00403778
  0.05072075  0.02196701 -0.00675839 -0.00343026 -0.00243035  0.03789906
 -0.2882265  -0.11559016  0.01451772]
Centroid 7: [ 7.5801611e-03 -4.8114729e-05  5.8665453e-03  6.5668654e-03
  6.8507051e-01  3.3930693e-02 -5.7871994e-02  3.0499892e-02
 -7.0769982e-03 -2.8347704e-03 -1.3776873e-02  1.5773943e-02
 -1.5814785e-02  1.8320291e-03  4.0112335e-02]
Centroid 8: [ 0.00246705  0.37596315  0.0510172  -0.00226971 -0.00677758 -0.23559128
 -0.5012152   0.01087719  0.01083489  0.00589293  0.00607639  0.02125689
 -0.12900232 -0.02906559  0.00226919]
Centroid 9: [-0.00434238 -0.00117247 -0.0568342  -0.02164697  0.00610251  0.14209719
  0.30626747  0.00141268 -0.0076748   0.01088697 -0.00687735 -0.00947271
  0.47774717  0.15465859 -0.00490341]
Centroid 10: [ 4.2134980e-03 -2.1290894e-01  1.7837712e-01  1.1279959e-02
 -2.3438297e-02 -3.2126921e-01 -5.9928775e-01  3.1294391e-02
 -2.1749916e-03  5.2467138e-03  1.8600456e-03  1.2355496e-02
 -6.8762757e-02 -2.2514023e-02 -4.2925338e-04]
Centroid 11: [-0.00403284  0.26482353 -0.08374529 -0.0028433  -0.01543281  0.31033447
  0.5771008   0.0078685  -0.00598416 -0.01525633  0.00592188 -0.00591297
 -0.05192399 -0.01459106 -0.00900591]
Centroid 12: [ 0.00639713  0.6528622   0.00520035  0.00498668  0.02472734  0.01640982
  0.06179842  0.00984982  0.00807543 -0.00955643  0.00668865  0.00079066
  0.03272068  0.00467986  0.00549816]
Centroid 13: [-0.02885124 -0.4008683  -0.2816366   0.01031901  0.04458577 -0.15389115
 -0.18484086 -0.03639832 -0.00610151  0.01279392 -0.00360717 -0.0293311
 -0.00313566 -0.00122202 -0.10837495]
Centroid 14: [-2.6496561e-02  1.5128565e-01 -1.3613702e-01  2.6185128e-03
  1.1444656e-02  7.2775237e-02  3.6705215e-02 -1.5482814e-02
  2.2816658e-03  7.7011804e-03 -7.1438272e-03 -1.2832258e-03
 -5.3318483e-01 -1.8636952e-01 -4.5770494e-04]
Centroid 15: [ 0.03167386  0.01535009  0.03196207 -0.02149904 -0.6855934  -0.01317683
 -0.05233655 -0.00124915 -0.00566623 -0.0249123   0.00779222 -0.00673672
  0.03141048  0.02776125 -0.05023222]
```

sigmoid (gamma=1.0)

In [ ]:
```
spectral_clustering(
    le_X_train025,
    cuts=23,
    fname="label_encoded_spectral_clustering",
    affinity="sigmoid",
    gamma=1.0,
)
```

```
eigenvalues: [9.9998307e-01 9.9998295e-01 9.9998224e-01 9.9998140e-01 9.9998116e-01
 9.9998021e-01 9.9997973e-01 9.9997580e-01 9.9997330e-01 9.9996972e-01
 9.9996853e-01 9.9996841e-01 9.9996662e-01 9.9996483e-01 9.9995112e-01
 9.9994552e-01 9.9993980e-01 9.9992824e-01 9.9991274e-01 9.9991250e-01
 9.9990833e-01 9.9983191e-01 3.5868186e-09].
Finished running k-means++
15.0    5203
0.0     1756
13.0    1010
16.0     743
1.0      645
12.0     546
8.0      486
7.0      408
3.0      282
10.0     227
9.0      190
2.0      135
4.0      124
20.0      95
22.0      83
5.0       81
17.0      74
6.0       68
18.0      63
11.0      59
21.0      48
19.0      22
14.0       2
dtype: int64
Completed iteration 1
15.0    4824
0.0     1317
13.0    1057
12.0     629
16.0     626
1.0      622
8.0      548
7.0      421
10.0     351
3.0      283
9.0      241
2.0      193
17.0     180
4.0      176
18.0     157
5.0      146
6.0      135
11.0     110
22.0     102
20.0      94
21.0      78
19.0      58
14.0       2
dtype: int64
Completed iteration 2
15.0    4401
0.0     1229
13.0    1167
12.0     695
1.0      593
8.0      571
16.0     544
10.0     487
7.0      460
3.0      341
9.0      219
2.0      215
18.0     203
17.0     185
4.0      184
6.0      155
5.0      149
11.0     127
22.0     121
21.0     109
19.0      97
20.0      96
14.0       2
dtype: int64
Completed iteration 3
15.0    4108
13.0    1322
0.0     1202
12.0     697
8.0      615
```

```
1.0      580
16.0     488
7.0      483
10.0     452
3.0      446
2.0      257
18.0     228
9.0      207
4.0      193
17.0     180
6.0      154
5.0      139
11.0     135
21.0     128
22.0     128
19.0     110
20.0      96
14.0       2
dtype: int64
Completed iteration 4
15.0    3874
13.0    1433
0.0     1175
12.0     702
8.0      635
3.0      594
1.0      565
7.0      493
16.0     455
10.0     423
2.0      284
18.0     245
9.0      219
4.0      184
17.0     175
6.0      144
5.0      138
11.0     131
21.0     129
22.0     129
19.0     125
20.0      96
14.0       2
dtype: int64
Completed iteration 5
15.0    3712
13.0    1523
0.0     1172
3.0      717
12.0     701
8.0      656
1.0      542
7.0      501
16.0     410
10.0     392
2.0      307
18.0     252
9.0      228
4.0      179
17.0     169
5.0      147
6.0      136
22.0     135
19.0     126
11.0     125
21.0     123
20.0      95
14.0       2
dtype: int64
Completed iteration 6
15.0    3641
13.0    1590
0.0     1185
3.0      762
12.0     689
8.0      658
1.0      532
7.0      502
10.0     389
16.0     374
2.0      317
18.0     254
9.0      236
4.0      183
17.0     164
5.0      150
```

```
22.0     137
6.0      129
21.0     126
19.0     118
11.0     118
20.0      94
14.0       2
dtype: int64
Completed iteration 7
15.0    3571
13.0    1674
0.0     1206
3.0      776
12.0     684
8.0      652
1.0      533
7.0      503
10.0     392
16.0     337
2.0      326
18.0     253
9.0      235
4.0      182
17.0     159
5.0      152
22.0     135
21.0     127
6.0      126
11.0     117
19.0     115
20.0      93
14.0       2
dtype: int64
Completed iteration 8
15.0    3526
13.0    1752
0.0     1205
3.0      777
12.0     675
8.0      642
1.0      538
7.0      508
10.0     397
2.0      332
16.0     312
18.0     253
9.0      237
4.0      179
5.0      157
17.0     149
22.0     132
6.0      126
21.0     125
11.0     119
19.0     114
20.0      93
14.0       2
dtype: int64
Completed iteration 9
15.0    3482
13.0    1822
0.0     1206
3.0      777
12.0     663
8.0      634
1.0      538
7.0      513
10.0     394
2.0      343
16.0     287
18.0     260
9.0      235
4.0      175
5.0      164
17.0     156
22.0     129
6.0      125
21.0     120
11.0     119
19.0     112
20.0      94
14.0       2
dtype: int64
Completed iteration 10
15.0    3427
13.0    1897
```

```
0.0     1204
3.0      769
12.0     667
8.0      623
1.0      535
7.0      516
10.0     387
2.0      345
16.0     269
18.0     258
9.0      231
5.0      186
4.0      174
17.0     155
22.0     128
6.0      126
21.0     120
19.0     118
11.0     118
20.0      95
14.0       2
dtype: int64
Completed iteration 11
15.0    3378
13.0    1960
0.0     1196
3.0      762
12.0     676
8.0      614
1.0      531
7.0      522
10.0     378
2.0      346
16.0     269
18.0     245
9.0      234
5.0      214
4.0      174
17.0     152
22.0     130
6.0      125
11.0     119
19.0     118
21.0     110
20.0      95
14.0       2
dtype: int64
Completed iteration 12
15.0    3342
13.0    2010
0.0     1198
3.0      754
12.0     683
8.0      605
1.0      535
7.0      520
10.0     373
2.0      343
16.0     253
18.0     246
5.0      238
9.0      235
4.0      176
17.0     150
22.0     128
6.0      126
19.0     120
11.0     120
21.0      98
20.0      95
14.0       2
dtype: int64
Completed iteration 13
15.0    3288
13.0    2072
0.0     1199
3.0      753
12.0     683
8.0      597
1.0      539
7.0      521
10.0     374
2.0      343
5.0      251
16.0     247
18.0     241
```

```
9.0      234
4.0      178
17.0     150
22.0     130
6.0      126
19.0     120
11.0     120
20.0      95
21.0      87
14.0       2
dtype: int64
Completed iteration 14
15.0    3240
13.0    2130
0.0     1204
3.0      755
12.0     683
8.0      591
1.0      540
7.0      521
10.0     376
2.0      343
5.0      252
18.0     242
16.0     232
9.0      232
4.0      181
17.0     150
22.0     127
6.0      126
19.0     122
11.0     122
20.0      95
21.0      84
14.0       2
dtype: int64
Completed iteration 15
15.0    3184
13.0    2198
0.0     1198
3.0      754
12.0     689
8.0      587
1.0      539
7.0      523
10.0     378
2.0      346
5.0      254
18.0     243
9.0      231
16.0     223
4.0      180
17.0     148
22.0     127
6.0      125
11.0     122
19.0     121
20.0      95
21.0      83
14.0       2
dtype: int64
Completed iteration 16
15.0    3109
13.0    2277
0.0     1189
3.0      760
12.0     693
8.0      581
1.0      537
7.0      526
10.0     377
2.0      346
5.0      261
18.0     241
9.0      231
16.0     218
4.0      182
17.0     147
22.0     127
6.0      125
11.0     123
19.0     121
20.0      95
21.0      82
14.0       2
dtype: int64
```

```
Completed iteration 17
15.0    3035
13.0    2357
0.0     1185
3.0      758
12.0     698
8.0      574
1.0      536
7.0      530
10.0     376
2.0      346
5.0      264
18.0     239
9.0      231
16.0     215
4.0      182
17.0     149
22.0     126
6.0      126
19.0     122
11.0     122
20.0      95
21.0      82
14.0       2
dtype: int64
Completed iteration 18
15.0    2967
13.0    2426
0.0     1182
3.0      759
12.0     699
8.0      568
1.0      537
7.0      532
10.0     376
2.0      346
5.0      268
18.0     241
9.0      229
16.0     211
4.0      182
17.0     150
6.0      126
11.0     125
22.0     125
19.0     122
20.0      95
21.0      82
14.0       2
dtype: int64
Completed iteration 19
15.0    2908
13.0    2484
0.0     1179
3.0      759
12.0     701
8.0      563
1.0      540
7.0      534
10.0     377
2.0      347
5.0      270
18.0     241
9.0      228
16.0     210
4.0      182
17.0     151
11.0     126
6.0      125
22.0     124
19.0     123
20.0      95
21.0      81
14.0       2
dtype: int64
Completed iteration 20
15.0    2855
13.0    2538
0.0     1176
3.0      759
12.0     700
8.0      560
1.0      543
7.0      538
10.0     376
2.0      347
```

```
5.0      271
18.0     238
9.0      228
16.0     213
4.0      183
17.0     151
11.0     126
6.0      125
22.0     124
19.0     122
20.0      95
21.0      80
14.0       2
dtype: int64
Completed iteration 21
Reached 21 iterations
Centroids:
Centroid 1: [-0.00866251 -0.02451079 -0.27336344 -0.01762087 -0.02604278  0.04194725
  0.03279433  0.00510852  0.01024331  0.12988734  0.00563654  0.01107448
  0.00360076 -0.01546653 -0.04064959  0.02700802  0.04018614 -0.0088744
 -0.00556757  0.00871566 -0.05215811 -0.0470721  -0.8698591 ]
Centroid 2: [-2.4515012e-02 -2.3157675e-02 -2.9244500e-01 -3.3369072e-02
 -4.9820496e-03 -4.2308483e-02 -3.1477656e-02  1.7320564e-02
  5.8751609e-02 -3.2800165e-01  2.7534166e-02  1.5851706e-02
 -6.2330082e-02 -5.8092026e-04 -1.5986998e-02 -1.4005965e-01
  1.6321145e-02  1.1716002e-02  7.2753853e-03  6.0680844e-03
 -3.5329852e-02 -1.2578539e-02 -7.1136159e-01]
Centroid 3: [ 0.03075865 -0.04353406  0.16289921 -0.01649646 -0.06575429 -0.04773531
  0.01054614  0.00631004 -0.0193712  -0.13192758 -0.02270605 -0.02242431
  0.44766495  0.02128591  0.03037527 -0.02524713  0.02524016 -0.02372778
  0.04462058  0.02131566 -0.04803638  0.01251325 -0.5242005 ]
Centroid 4: [ 0.02999168  0.03012635  0.01640646 -0.00275697 -0.01590852 -0.14943835
  0.0160133  -0.01530223 -0.08069733  0.2111428  -0.01999831 -0.00961774
  0.03883627  0.00843313  0.01850717 -0.03097207 -0.00579489  0.01080232
  0.00390126  0.00227255  0.00616237  0.07059723 -0.88807213]
Centroid 5: [ 0.03876614 -0.01390761 -0.25976825 -0.03540338 -0.04613655  0.07055662
  0.08553204  0.00708824  0.41564703  0.06987759  0.00888684 -0.0180813
  0.06555118 -0.05073521 -0.05450209  0.02874826  0.01134103  0.02392809
 -0.02953553 -0.00636432 -0.06595874 -0.04988277 -0.6092757 ]
Centroid 6: [ 0.07713991  0.06244513  0.09125289 -0.02867403 -0.1104272   0.03505493
  0.16900676 -0.06117163 -0.05936734  0.35252887 -0.12624922  0.00182173
 -0.07053928 -0.02829512 -0.01809405  0.14827777  0.02478831 -0.02894637
 -0.01226144  0.03063164 -0.04624357  0.144311   -0.5220118 ]
Centroid 7: [-0.54229665  0.01189278  0.02988039  0.04024782 -0.03178921  0.02094614
  0.01081133 -0.01630297 -0.01844654  0.0250039  -0.01335966  0.00149797
 -0.00594929  0.00174517 -0.01905633  0.02818847 -0.00235735 -0.03207182
  0.01379404  0.02085563 -0.01142419  0.03465018 -0.39006922]
Centroid 8: [ 1.94972120e-02  7.18261988e-04  9.04252157e-02  1.87828820e-02
  1.69211552e-02 -1.34927168e-01 -1.00355655e-01 -1.48843853e-02
  2.52089873e-02 -6.78890944e-02  6.26226654e-03 -2.74839588e-02
  6.09226152e-03 -4.61898977e-03  2.09603868e-02 -1.32534832e-01
 -4.68868427e-02  2.90067904e-02 -2.33283807e-02 -3.37517522e-02
  2.13263873e-02 -2.67776281e-01 -7.93817163e-01]
Centroid 9: [-0.00639843  0.02544755 -0.09720858  0.0036616   0.02319673 -0.15278384
  0.04403569 -0.00688843 -0.01440341 -0.12264073 -0.02673159  0.00973948
 -0.4644407  -0.01278778 -0.01423999 -0.0992319  -0.00149853 -0.00635152
 -0.02959498  0.01505647 -0.00785636 -0.09988782 -0.62018734]
Centroid 10: [ 0.02696916  0.01968821 -0.00672213 -0.06936759 -0.09384966  0.01881122
 -0.5162041  -0.0689842  -0.02152891  0.03128746 -0.05107652  0.01171988
 -0.02498415 -0.02087517  0.01907565  0.03312364  0.01295372 -0.0090099
 -0.02252363  0.02562072 -0.04686302  0.03018708 -0.40183485]
Centroid 11: [ 0.01513137  0.06273739  0.11646114 -0.01473906 -0.01128238 -0.01645059
  0.3955395   0.00271367 -0.02024044  0.0840394   0.02559865 -0.04349876
  0.02216916 -0.02728884 -0.00333446 -0.0408163  -0.03523336 -0.01056745
  0.00867252 -0.00268231  0.0401722  -0.02081449 -0.7150292 ]
Centroid 12: [ 0.05192081 -0.00156457  0.03556899 -0.15874448  0.35011214  0.0080593
  0.03756101  0.00308351 -0.00243546 -0.0257857  -0.04656221  0.00728024
  0.00721505 -0.0054423  -0.01374375  0.01020278  0.05706457 -0.04555211
 -0.01555122 -0.0017044   0.01036123  0.02197786 -0.2669026 ]
Centroid 13: [ 3.2398091e-03  6.3039281e-04  7.2461836e-02 -3.6308698e-03
 -2.1750284e-03 -4.2680491e-02 -2.1769287e-02  6.5564755e-03
  1.6319880e-02 -3.7090337e-01  3.5382126e-02 -1.0991894e-02
 -1.1646473e-01 -2.2740241e-03  2.4837188e-02 -1.5560293e-01
 -2.2084476e-02  1.6660400e-02  2.9160688e-02  1.0655304e-02
  4.6458724e-03  3.9923012e-02 -7.3089868e-01]
Centroid 14: [-5.4343510e-03  5.0831013e-03  7.8763463e-02  8.5205119e-03
  2.8353292e-02  3.0227691e-02 -3.4403801e-02  4.2490014e-03
 -1.5256933e-02 -5.7690162e-02 -1.4095538e-02  1.4924492e-02
  5.1979419e-02  2.1811424e-02  2.3302678e-02  2.7965374e-02
 -2.2952675e-03 -1.0994846e-04  1.1849509e-02 -5.9090387e-03
  1.3895801e-02 -2.7464947e-03 -9.6162933e-01]
Centroid 15: [ 7.9160812e-04  2.3199189e-03 -1.5786529e-05 -2.4413534e-03
 -1.0988056e-03  4.0509505e-03  3.6293813e-03 -1.3549716e-03
 -6.6573527e-03 -4.1992370e-02  1.6523942e-03 -6.5495307e-04
 -3.8907449e-03  2.0970083e-03  2.0794854e-03 -3.6711636e-01
  1.1728306e-03  5.7540281e-05  5.6967330e-03  2.2861841e-03
```

```
 -3.9486669e-04  9.1785169e-01 -2.4847420e-02]
Centroid 16: [-8.6833863e-03 -8.1803249e-03  1.2133053e-01  1.3187267e-02
  1.3311594e-02  6.0588136e-02 -2.1144025e-04  8.3814822e-03
 -1.6102033e-02  9.2431426e-02  1.3189525e-03  1.0641050e-02
  8.9485057e-02  9.7048394e-03  3.9594597e-03  2.5515167e-02
  6.4657093e-03 -4.1748318e-03  2.2545686e-02  4.7748853e-03
  9.4668195e-03 -4.1465897e-02 -9.5082760e-01]
Centroid 17: [ 0.02167456  0.01292513 -0.42160243 -0.06585103 -0.07073228  0.08064404
  0.18133996 -0.02151696 -0.0411188   0.21613288 -0.06228745  0.02284658
 -0.08410487 -0.01751712 -0.06222492  0.10709952  0.08010734 -0.03749737
 -0.0186875   0.02732783 -0.08097916  0.09606536 -0.5211101 ]
Centroid 18: [ 0.043229    0.24634516  0.00221283 -0.00843717 -0.15058793  0.01121471
  0.12652671 -0.00943899  0.05083193 -0.08872578 -0.04578258 -0.03541276
  0.03616194 -0.00465589  0.01886608  0.00316547 -0.07803995 -0.00931957
 -0.01450326  0.04139913  0.2703225   0.01678293 -0.36508358]
Centroid 19: [ 0.0252449   0.00915261 -0.05285556  0.00916413 -0.03546337  0.5185297
  0.03333795 -0.01613528  0.03244846  0.10461073  0.01833037 -0.00799248
 -0.03968212  0.00399806 -0.00824651  0.03940937  0.01413284 -0.00620592
 -0.00484106  0.02473683  0.00241387  0.01922228 -0.49448937]
Centroid 20: [ 0.037623   -0.2598211  -0.00235097 -0.04689475 -0.03882731  0.01477917
 -0.03740988 -0.02238451 -0.01359373  0.03209564  0.1649099   0.01247499
 -0.016802    0.04375789 -0.02412153  0.02076728  0.1742338  -0.01120588
  0.05162063 -0.02302334 -0.24643682  0.02592435 -0.3475854 ]
Centroid 21: [ 1.1643381e-02 -1.4756655e-02  7.0634469e-02 -7.0018098e-03
 -1.6720934e-02 -7.2631818e-01 -1.7140621e-02  6.0840932e-05
  6.9052212e-02  3.7237190e-02 -1.3864423e-02 -2.0039210e-02
 -1.0909396e-01 -2.2115773e-02 -2.4183199e-02  4.8073824e-03
 -9.8458175e-03  9.1607561e-03  2.5899002e-05 -3.1969419e-03
 -1.3870297e-02 -1.8193262e-02 -2.3871358e-01]
Centroid 22: [ 0.00410163  0.01947788 -0.15745938 -0.04141976 -0.03143437  0.05649493
 -0.07691616 -0.04482401 -0.5809711   0.03496438 -0.03371925 -0.00307214
 -0.06533307  0.0136943   0.01782743  0.02815715 -0.01347525 -0.00810187
 -0.02940425  0.00496264  0.03870443  0.02315379 -0.34387118]
Centroid 23: [ 0.28213492  0.05730062  0.10912652  0.36600655 -0.01130661  0.04474311
 -0.06091224 -0.03805846 -0.01816742  0.03223439  0.01470753 -0.00517293
 -0.0186147   0.06488201 -0.01182669  0.02812014 -0.01938904 -0.01400087
 -0.01691095  0.01311935 -0.03022088  0.03211042 -0.3390779 ]
```

In [ ]:

```python
spectral_clustering(
    le_X_train025,
    cuts=len(np.unique(le_y_train025)),
    fname="label_encoded_spectral_clustering",
    affinity="sigmoid",
    gamma=1.0,
)
```

```
eigenvalues: [9.9997330e-01 9.9996972e-01 9.9996853e-01 9.9996841e-01 9.9996662e-01
 9.9996483e-01 9.9995112e-01 9.9994552e-01 9.9993980e-01 9.9992824e-01
 9.9991274e-01 9.9991250e-01 9.9990833e-01 9.9983191e-01 3.5868186e-09].
Finished running k-means++
13.0    4902
0.0     2559
3.0     1211
12.0    1108
10.0     710
11.0     488
7.0      280
2.0      260
5.0      227
9.0      209
4.0      167
8.0       83
1.0       79
6.0       65
14.0       2
dtype: int64
Completed iteration 1
13.0    4938
0.0     2232
12.0    1208
3.0     1020
10.0     607
11.0     482
7.0      340
5.0      339
2.0      331
4.0      265
9.0      197
1.0      141
8.0      141
6.0      107
14.0       2
dtype: int64
Completed iteration 2
13.0    5013
0.0     1951
12.0    1148
3.0     1002
10.0     599
7.0      525
11.0     426
5.0      353
2.0      335
4.0      306
9.0      202
8.0      171
1.0      169
6.0      148
14.0       2
dtype: int64
Completed iteration 3
13.0    4902
0.0     1917
12.0    1080
3.0      987
7.0      696
10.0     602
11.0     376
5.0      359
2.0      339
4.0      329
9.0      212
8.0      190
1.0      186
6.0      173
14.0       2
dtype: int64
Completed iteration 4
13.0    4738
0.0     2073
12.0    1035
3.0      908
7.0      759
10.0     589
5.0      365
2.0      354
4.0      349
11.0     345
9.0      220
8.0      213
1.0      206
6.0      194
```

```
14.0       2
dtype: int64
Completed iteration 5
13.0    4633
0.0     2154
12.0    1020
3.0      883
7.0      760
10.0     573
5.0      364
4.0      362
2.0      356
11.0     331
8.0      256
9.0      234
6.0      212
1.0      210
14.0       2
dtype: int64
Completed iteration 6
13.0    4578
0.0     2148
12.0    1010
3.0      922
7.0      750
10.0     548
4.0      374
2.0      368
5.0      368
11.0     326
8.0      276
9.0      242
6.0      227
1.0      211
14.0       2
dtype: int64
Completed iteration 7
13.0    4540
0.0     2110
12.0    1006
3.0      983
7.0      727
10.0     525
2.0      385
4.0      374
5.0      362
11.0     325
8.0      303
9.0      247
6.0      242
1.0      219
14.0       2
dtype: int64
Completed iteration 8
13.0    4529
0.0     1982
3.0     1128
12.0    1001
7.0      717
10.0     502
2.0      384
4.0      371
5.0      356
11.0     333
8.0      310
9.0      253
6.0      251
1.0      231
14.0       2
dtype: int64
Completed iteration 9
13.0    4481
0.0     1836
3.0     1322
12.0     998
7.0      701
10.0     487
2.0      393
4.0      374
5.0      350
11.0     336
8.0      319
6.0      260
9.0      255
1.0      236
14.0       2
```

```
dtype: int64
Completed iteration 10
13.0    4437
0.0     1767
3.0     1448
12.0     995
7.0      681
10.0     463
2.0      403
4.0      374
11.0     357
5.0      347
8.0      320
9.0      260
6.0      258
1.0      238
14.0       2
dtype: int64
Completed iteration 11
13.0    4415
0.0     1752
3.0     1502
12.0     991
7.0      655
10.0     451
2.0      419
4.0      372
11.0     370
5.0      347
8.0      320
9.0      265
6.0      254
1.0      235
14.0       2
dtype: int64
Completed iteration 12
13.0    4399
0.0     1772
3.0     1498
12.0     985
7.0      645
10.0     445
2.0      428
11.0     375
4.0      370
5.0      350
8.0      322
9.0      269
6.0      251
1.0      239
14.0       2
dtype: int64
Completed iteration 13
13.0    4392
0.0     1797
3.0     1481
12.0     977
7.0      638
10.0     443
2.0      434
11.0     375
4.0      372
5.0      351
8.0      322
9.0      275
6.0      253
1.0      238
14.0       2
dtype: int64
Completed iteration 14
13.0    4386
0.0     1821
3.0     1466
12.0     972
7.0      637
10.0     444
2.0      436
4.0      371
11.0     371
5.0      351
8.0      321
9.0      281
6.0      252
1.0      239
14.0       2
dtype: int64
```

```
Completed iteration 15
13.0    4387
0.0     1827
3.0     1461
12.0     970
7.0      637
10.0     442
2.0      436
4.0      371
11.0     370
5.0      350
8.0      323
9.0      284
6.0      251
1.0      239
14.0       2
dtype: int64
Completed iteration 16
Epsilon has a maximum value of 0.00852470938116312
Centroids:
Centroid 1: [ 0.01945323  0.14447753  0.01965215 -0.00377686  0.08030927 -0.01606437
 -0.02341309 -0.0088664   0.01038201  0.00392016  0.01219641  0.00364531
 -0.00640873 -0.12641023 -0.9422967 ]
Centroid 2: [-0.01708128  0.08554678  0.3037909   0.05677773 -0.02334643  0.17494424
 -0.03411942  0.04475827  0.15166971 -0.03414135  0.03236789 -0.01271197
 -0.19084334  0.04031102 -0.42340645]
Centroid 3: [-1.01516791e-01  3.87182087e-01 -1.88054010e-01 -1.47419414e-04
  3.25215831e-02 -4.13343497e-02 -4.94280830e-02  1.70107514e-01
  6.48309439e-02 -5.61135784e-02 -2.48095859e-02  3.02870683e-02
 -1.14797354e-01  1.78538501e-01 -6.11164927e-01]
Centroid 4: [-0.06641286  0.23034564 -0.00451896  0.00268242  0.03233751  0.00279852
 -0.0093655   0.02275498  0.02292868 -0.0020003   0.00607357  0.01451095
 -0.02451501  0.06532802 -0.91274405]
Centroid 5: [ 0.04929734 -0.46568957  0.00692579  0.0145882  -0.38581976 -0.02778297
 -0.01358525 -0.12544282  0.02027011 -0.00913433  0.01226807  0.02717857
 -0.00546685  0.0237301  -0.6292285 ]
Centroid 6: [-0.06980243 -0.02468231 -0.00177373 -0.0448995   0.5339325   0.06209921
  0.04721852 -0.02414148  0.0120466  -0.02382365  0.03881252  0.02594368
 -0.03901901  0.00501545 -0.594194  ]
Centroid 7: [-0.23868375  0.03587369 -0.15328291 -0.03984706 -0.05903682 -0.04372717
  0.03212363  0.04321922 -0.11120197  0.02142523 -0.00571279  0.05050049
  0.25406858  0.03940891 -0.36869952]
Centroid 8: [ 0.04286189 -0.10991481  0.00457529 -0.03041211  0.00672986 -0.01289914
  0.01108698 -0.1500361  -0.05131786  0.02834456 -0.03867104 -0.03794768
  0.02856995 -0.2952946  -0.84520125]
Centroid 9: [ 0.44933033  0.10427824 -0.01288331 -0.04332958  0.0707294  -0.08369451
 -0.05767941  0.05719995  0.00275147  0.01763508 -0.02066133  0.00302831
 -0.06345078 -0.00775915 -0.65937424]
Centroid 10: [ 0.07776884 -0.53089505 -0.0256555   0.03277994  0.20173325 -0.02216693
 -0.00156283 -0.06894284  0.01346978 -0.06525566  0.02842072  0.01723976
 -0.02016856  0.03738019 -0.5913704 ]
Centroid 11: [-1.6667116e-02 -1.0643810e-01 -1.6215565e-02  2.3320458e-04
 -4.7525337e-01 -1.6104717e-02  3.9751749e-03 -1.3881165e-01
 -3.5949502e-02  7.5464901e-03 -5.5997770e-02 -1.4631918e-03
  2.5170207e-02 -2.1765457e-01 -6.9973797e-01]
Centroid 12: [-0.05193531  0.15172648 -0.09221786  0.02785723 -0.48921397 -0.01926696
 -0.02612835  0.07324933  0.06489651 -0.03970679 -0.00758852  0.04957802
 -0.07236055  0.09598146 -0.6366299 ]
Centroid 13: [ 0.02503186 -0.31096512  0.05120171 -0.01127991 -0.0695163   0.009582
  0.02419125 -0.16860324 -0.01164422  0.02758047  0.03186585  0.00816043
 -0.00384961  0.06120215 -0.8486463 ]
Centroid 14: [-0.02369893 -0.01186094 -0.0136357   0.01540716  0.0613142   0.01937821
  0.01827109  0.03651153  0.00100504 -0.00524163  0.01363753 -0.0023432
  0.01288014 -0.00323291 -0.9773422 ]
Centroid 15: [-6.6585722e-03 -4.1998837e-02  1.6526437e-03 -6.5499800e-04
 -3.8913905e-03  2.0974381e-03  2.0798924e-03 -3.6715803e-01
  1.1731395e-03  5.7500089e-05  5.6978199e-03  2.2866465e-03
 -3.9504259e-04  9.1792858e-01 -2.4850771e-02]
```

one-hot encoded run

additive chi2

In [ ]:

```python
spectral_clustering(
    oe_X_train025,
    cuts=23,
    fname="one-hot_encoded_spectral_clustering",
    affinity="additive_chi2",
)
```

```
eigenvalues: [9.9994206e-01 9.9993849e-01 9.9993706e-01 9.9993253e-01 9.9992669e-01
 9.9992490e-01 9.9991310e-01 9.9991131e-01 9.9990904e-01 9.9990523e-01
 9.9989450e-01 9.9988222e-01 9.9986792e-01 9.9985254e-01 9.9984121e-01
 9.9983311e-01 9.9983084e-01 9.9981248e-01 9.9977577e-01 9.9968719e-01
 9.9947876e-01 9.9825495e-01 2.1680598e-12].
Finished running k-means++
8.0     6303
1.0      894
17.0     608
2.0      462
19.0     395
4.0      364
22.0     357
16.0     307
3.0      304
7.0      276
11.0     252
21.0     227
10.0     219
9.0      211
5.0      211
0.0      191
6.0      185
12.0     184
13.0     152
15.0     139
20.0      92
18.0      10
14.0       7
dtype: int64
Completed iteration 1
8.0     5834
1.0      769
17.0     621
2.0      489
22.0     468
19.0     416
4.0      412
3.0      391
7.0      335
0.0      281
15.0     263
16.0     248
11.0     240
21.0     235
6.0      217
12.0     216
10.0     202
9.0      194
5.0      187
13.0     186
20.0     113
18.0      21
14.0      12
dtype: int64
Completed iteration 2
8.0     5752
1.0      679
17.0     611
22.0     521
2.0      499
4.0      442
19.0     415
3.0      414
7.0      332
0.0      309
21.0     256
11.0     245
15.0     240
10.0     226
6.0      214
13.0     213
16.0     209
5.0      192
12.0     185
9.0      176
20.0     130
18.0      56
14.0      34
dtype: int64
Completed iteration 3
8.0     5723
1.0      618
17.0     591
22.0     552
2.0      511
```

```
4.0      422
19.0     413
3.0      383
7.0      327
0.0      318
21.0     264
11.0     253
15.0     233
13.0     229
6.0      225
10.0     221
5.0      209
16.0     201
9.0      180
12.0     168
20.0     139
18.0      99
14.0      71
dtype: int64
Completed iteration 4
8.0     5709
1.0      594
17.0     579
22.0     557
2.0      515
19.0     412
4.0      394
3.0      349
7.0      335
0.0      317
21.0     258
11.0     249
13.0     239
15.0     238
5.0      238
6.0      236
10.0     226
16.0     207
9.0      185
12.0     165
20.0     141
18.0     111
14.0      96
dtype: int64
Completed iteration 5
8.0     5708
1.0      582
17.0     570
22.0     556
2.0      514
19.0     415
4.0      368
7.0      341
3.0      322
0.0      313
5.0      263
21.0     254
6.0      252
13.0     247
11.0     244
15.0     237
10.0     230
16.0     208
9.0      187
12.0     163
20.0     145
18.0     117
14.0     114
dtype: int64
Completed iteration 6
8.0     5707
1.0      578
17.0     556
22.0     554
2.0      512
19.0     415
7.0      348
4.0      347
0.0      314
3.0      298
5.0      286
6.0      262
13.0     254
21.0     244
11.0     242
10.0     233
```

```
15.0     231
16.0     210
9.0      182
12.0     157
20.0     156
14.0     134
18.0     130
dtype: int64
Completed iteration 7
8.0     5708
1.0      577
22.0     548
17.0     536
2.0      512
19.0     415
7.0      355
4.0      323
0.0      317
5.0      312
3.0      274
6.0      263
13.0     258
11.0     245
21.0     239
10.0     231
15.0     228
16.0     211
9.0      184
14.0     177
20.0     162
12.0     143
18.0     132
dtype: int64
Completed iteration 8
8.0     5710
1.0      575
22.0     536
17.0     527
2.0      509
19.0     415
7.0      359
5.0      335
0.0      326
4.0      302
6.0      279
13.0     256
3.0      249
11.0     245
10.0     233
21.0     233
15.0     230
16.0     213
14.0     196
9.0      186
20.0     164
12.0     139
18.0     133
dtype: int64
Completed iteration 9
8.0     5712
1.0      573
17.0     515
22.0     514
2.0      509
19.0     416
5.0      362
7.0      361
0.0      328
6.0      301
4.0      283
13.0     252
11.0     243
10.0     235
15.0     231
3.0      231
21.0     227
16.0     216
14.0     212
9.0      186
20.0     171
12.0     138
18.0     134
dtype: int64
Completed iteration 10
8.0     5710
1.0      571
```

```
2.0      509
22.0     499
17.0     495
19.0     417
5.0      384
7.0      368
0.0      329
6.0      327
4.0      266
13.0     251
11.0     245
10.0     238
15.0     235
14.0     229
21.0     227
16.0     217
3.0      203
9.0      183
20.0     172
12.0     144
18.0     131
dtype: int64
Completed iteration 11
8.0     5712
1.0      569
2.0      511
22.0     463
17.0     458
19.0     416
5.0      390
7.0      370
6.0      349
0.0      329
14.0     261
13.0     252
4.0      250
11.0     246
10.0     238
15.0     236
21.0     226
16.0     219
3.0      197
9.0      182
20.0     174
12.0     168
18.0     134
dtype: int64
Completed iteration 12
8.0     5716
1.0      567
2.0      498
22.0     427
19.0     416
17.0     400
5.0      396
6.0      370
7.0      370
0.0      329
14.0     297
13.0     256
11.0     248
10.0     235
15.0     235
4.0      232
21.0     226
12.0     225
16.0     220
3.0      192
9.0      181
20.0     176
18.0     138
dtype: int64
Completed iteration 13
8.0     5714
1.0      567
2.0      484
19.0     418
17.0     400
5.0      398
22.0     397
6.0      386
7.0      369
0.0      326
14.0     312
13.0     261
11.0     249
```

```
15.0     235
12.0     234
10.0     231
16.0     230
21.0     226
4.0      217
3.0      197
9.0      185
20.0     177
18.0     137
dtype: int64
Completed iteration 14
8.0     5715
1.0      568
2.0      476
19.0     417
17.0     406
5.0      403
6.0      390
22.0     381
7.0      369
14.0     327
0.0      322
13.0     260
11.0     250
16.0     248
15.0     238
10.0     228
21.0     225
12.0     221
4.0      209
3.0      201
9.0      186
20.0     177
18.0     133
dtype: int64
Completed iteration 15
8.0     5711
1.0      567
2.0      477
19.0     417
17.0     410
5.0      407
6.0      393
22.0     375
7.0      368
14.0     332
0.0      317
13.0     260
16.0     256
11.0     251
15.0     235
10.0     228
21.0     226
12.0     214
4.0      206
3.0      203
9.0      187
20.0     177
18.0     133
dtype: int64
Completed iteration 16
8.0     5711
1.0      566
2.0      477
19.0     418
17.0     411
5.0      407
6.0      395
22.0     374
7.0      369
14.0     333
0.0      318
13.0     258
16.0     257
11.0     251
15.0     234
10.0     227
21.0     226
12.0     211
3.0      205
4.0      203
9.0      188
20.0     178
18.0     133
dtype: int64
```

```
Completed iteration 17
8.0     5710
1.0      566
2.0      479
19.0     418
17.0     411
5.0      410
6.0      394
22.0     371
7.0      369
14.0     335
0.0      314
16.0     263
13.0     260
11.0     252
15.0     234
10.0     227
21.0     225
3.0      206
12.0     205
4.0      202
9.0      188
20.0     178
18.0     133
dtype: int64
Completed iteration 18
8.0     5708
1.0      566
2.0      480
19.0     418
17.0     412
5.0      411
6.0      393
22.0     370
7.0      368
14.0     338
0.0      312
16.0     266
13.0     263
11.0     253
15.0     234
10.0     226
21.0     226
3.0      207
12.0     202
4.0      199
9.0      188
20.0     178
18.0     132
dtype: int64
Completed iteration 19
8.0     5709
1.0      566
2.0      480
19.0     418
5.0      413
17.0     412
6.0      390
22.0     370
7.0      368
14.0     338
0.0      309
13.0     266
16.0     266
11.0     253
15.0     235
21.0     226
10.0     225
3.0      210
12.0     201
4.0      198
9.0      188
20.0     178
18.0     131
dtype: int64
Completed iteration 20
8.0     5708
1.0      566
2.0      479
19.0     418
5.0      414
17.0     410
6.0      389
22.0     370
7.0      368
14.0     338
```

```
0.0      307
13.0     274
16.0     266
11.0     253
15.0     235
21.0     226
10.0     223
3.0      212
12.0     201
4.0      197
9.0      188
20.0     177
18.0     131
dtype: int64
Completed iteration 21
Reached 21 iterations
Centroids:
Centroid 1: [ 0.24267724 -0.13824661  0.09756847 -0.08098166 -0.07791812  0.08978593
  0.03686304 -0.04874145 -0.06347603  0.01261237 -0.01696619 -0.02007162
  0.14473644  0.04959242  0.05745982 -0.06304035  0.11467402  0.14542902
 -0.06150552 -0.06613248 -0.15167105 -0.03041694  0.69686335]
Centroid 2: [-0.1858282   0.16328031 -0.02272305 -0.04771477  0.12334422 -0.37079757
  0.18262656 -0.05225949 -0.05128085 -0.05037179 -0.0154154   0.25640506
 -0.10378523 -0.18392524  0.0634215  -0.10846432 -0.07615902 -0.0245099
 -0.13685402 -0.26827255  0.3705501  -0.09472573  0.4635503 ]
Centroid 3: [ 0.04452232  0.14635126  0.25472462 -0.00254571  0.057929   -0.15543367
  0.0385978   0.06414147 -0.18977919  0.05576608  0.17771226 -0.00665542
  0.01881602 -0.18569499 -0.02172818  0.06190461 -0.1060658   0.07594681
 -0.09780572 -0.10390148 -0.04491403  0.00565689  0.6735289 ]
Centroid 4: [-0.05222487  0.07758626  0.21423098 -0.01296922 -0.15954812  0.01272495
 -0.04217317 -0.09373969  0.230222   -0.07301573 -0.2263713   0.10604155
  0.02222758 -0.05417424 -0.01684171 -0.02264854 -0.02518094 -0.03251761
 -0.01891595 -0.02910074 -0.14743654 -0.00364373  0.68496734]
Centroid 5: [-0.08296812 -0.32454446 -0.10429601  0.03982227  0.06087263 -0.04739852
 -0.05551223 -0.14977928 -0.09148562 -0.01912963 -0.12076304  0.15599132
  0.0319926  -0.20646851 -0.30277798 -0.14574152  0.30575028  0.00256778
 -0.05008047 -0.07241733  0.05970961 -0.01394716  0.34181604]
Centroid 6: [ 0.08605596 -0.09156269  0.3211291  -0.13341436 -0.11780358  0.02067127
 -0.20007789 -0.11985602 -0.06354669 -0.07909532  0.04839959 -0.14514992
 -0.02610602 -0.04619528 -0.04470189  0.01463833  0.00947485  0.02475934
  0.06514561 -0.06493608 -0.09800708  0.02583985  0.6781443 ]
Centroid 7: [ 0.09522706  0.04070899  0.01742621  0.19573164  0.00211581  0.09600951
  0.0728901   0.03555746 -0.03119609 -0.00900759 -0.00336214  0.143316
  0.14307953 -0.11644429 -0.20098343  0.05816126  0.20545134  0.01608779
  0.00169571  0.29394552 -0.24661416 -0.02918215  0.45007423]
Centroid 8: [ 0.03026478  0.01004246  0.01482916  0.10227904 -0.01555436  0.04568876
  0.08404397  0.0458249   0.00950027  0.05045681  0.05461545 -0.04454067
 -0.09557013  0.21810701  0.32718825  0.21799171 -0.3280837  -0.00588419
  0.00431963  0.20808093 -0.17247064 -0.21703053  0.31195346]
Centroid 9: [ 0.02649581  0.01408114  0.01169332  0.0117351  -0.02023936  0.07758554
  0.00365105  0.03058048  0.01665473  0.01256082  0.04084055 -0.04067089
  0.03482842  0.01654156 -0.00199094  0.04538669  0.00379778 -0.01154712
  0.01982235  0.07352494 -0.11958738  0.0532168   0.9710008 ]
Centroid 10: [ 0.11489274  0.23915026  0.02098734 -0.01958531 -0.00709534  0.08809253
 -0.0245065   0.06637094 -0.00676699 -0.08256688  0.07790293  0.01813041
  0.31951964 -0.21612908 -0.4152869  -0.13007227  0.39039984 -0.00125298
 -0.01249377  0.08342879 -0.01592201  0.21494542  0.24501726]
Centroid 11: [ 1.82641730e-01 -1.51931003e-01 -1.34346947e-01 -8.69462043e-02
  1.28141284e-01  7.47025013e-02  2.24137702e-03  1.15792910e-02
  1.64107438e-02  8.27162564e-02  1.25690088e-01 -1.00984558e-01
  9.90962386e-02 -1.10526811e-02 -4.65300269e-02 -1.62654575e-02
  3.10170744e-02  1.16339885e-01 -4.13263813e-02  3.40753086e-02
  8.18826407e-02 -3.61222686e-04  6.82730734e-01]
Centroid 12: [-0.06437161  0.0532319   0.04672088 -0.03903933 -0.04907344  0.00277983
  0.03994046  0.10515103  0.09097631  0.08493926  0.03481897 -0.12497643
 -0.20270808  0.24299394  0.31180453  0.06403863 -0.31113693  0.01854457
  0.05183704 -0.04645019  0.05890809  0.43326393  0.28545702]
Centroid 13: [ 0.03650099 -0.08464353  0.0251156   0.01981754 -0.0775684   0.18601763
  0.05497431 -0.08351307  0.00237084  0.0073702  -0.15994887  0.11373623
 -0.02109562  0.48125827  0.03518689 -0.3330412   0.28285354  0.09263035
  0.12652688 -0.00299833  0.19806105 -0.08786359  0.3032451 ]
Centroid 14: [ 0.14420974 -0.06542236 -0.02258438  0.00482593 -0.09982789  0.21931705
 -0.13220702 -0.07675973  0.07420172  0.04156683  0.11935569 -0.10715985
  0.06290189 -0.15847343 -0.00524535  0.06731338 -0.06952047  0.06616908
 -0.06117936 -0.13450906 -0.07465167 -0.02610576  0.69334704]
Centroid 15: [-3.06285709e-01  1.09073468e-01  8.81990269e-02 -2.34765490e-03
  1.57494694e-01 -2.02161103e-01  8.46334398e-02 -5.42771555e-02
  2.89439186e-02 -2.11339691e-04 -1.08479254e-01  9.49060097e-02
  6.47743046e-02 -6.68257941e-04 -7.58969858e-02  1.63880959e-02
 -4.73976545e-02 -2.23407596e-02  2.55341339e-03  1.06659271e-01
  2.41963882e-02 -1.99307036e-02  6.15693688e-01]
Centroid 16: [-0.03766763  0.19007488  0.02452561 -0.27355275 -0.01924387  0.0133708
 -0.16711658  0.0417469   0.0893781  -0.02943783 -0.02407044 -0.17870592
  0.02002017 -0.10748006 -0.08703322 -0.1249266   0.08740348 -0.03233992
  0.06198743 -0.2603174   0.25614125  0.0098877   0.4079191 ]
Centroid 17: [-1.12059399e-01 -2.70942673e-02 -6.29904540e-03 -8.91366005e-02
```

```
  3.98703106e-02 -7.97252357e-02 -2.26698846e-01 -1.51281536e-01
 -2.32789185e-04  1.90924138e-01 -5.26654720e-02 -2.41160750e-01
  2.14479379e-02 -2.40221098e-02  2.17273876e-01 -1.18845016e-01
  1.87050998e-01  4.12053496e-01  5.13457917e-02  2.54921049e-01
 -1.22564360e-02 -1.05463803e-01  2.52690554e-01]
Centroid 18: [-0.12165889 -0.05280581 -0.24108048  0.10707944 -0.00753121  0.20431751
  0.04924542  0.01285955  0.24161169 -0.01474719 -0.2801039   0.12862828
 -0.02839787  0.16872393 -0.04919307 -0.11644427  0.04660827 -0.13762978
  0.03599096  0.08650925  0.06512889  0.00286423  0.62241626]
Centroid 19: [-7.9834843e-03 -2.1614513e-01 -1.0859443e-01  9.9583015e-02
  7.0103750e-02 -1.4497454e-01  6.5234664e-05 -2.0609763e-01
 -1.5343887e-01  7.7108210e-03 -9.8900571e-02  1.2050781e-01
 -1.7502633e-01  7.7196015e-03  4.8188329e-02 -3.5782617e-02
 -6.1894424e-02 -2.6967593e-02 -4.2668104e-02 -9.2788950e-02
  8.9392960e-02  1.1358786e-01  1.5119703e-01]
Centroid 20: [ 0.15599354 -0.24158983 -0.06574729  0.20849928  0.03440172 -0.07633683
 -0.00674113  0.12106732 -0.11772721 -0.16413149 -0.04025167  0.10801417
 -0.09616296 -0.11451677 -0.28278568  0.10376707 -0.2364141  -0.34696826
 -0.07541053 -0.31258777  0.29930153 -0.04581226  0.4162999 ]
Centroid 21: [ 0.12546284  0.4226697   0.0988082  -0.02964485 -0.05964324  0.17412798
  0.06669726  0.15934792  0.10620742  0.00627513  0.1509325  -0.13030379
  0.15677825  0.04854398 -0.06180272  0.00223252  0.00412527 -0.02976882
  0.0206635   0.10744859 -0.05446579  0.02090404  0.38301587]
Centroid 22: [-0.1209778  -0.16813405 -0.05541352 -0.12151144  0.05558487 -0.14805795
 -0.09855732 -0.02547016  0.01136658 -0.01087718 -0.05039747 -0.08597099
 -0.19653821  0.06049907  0.23354802  0.02198294 -0.254073   -0.01927074
  0.0140732  -0.24116088  0.28300473 -0.1605246   0.4430758 ]
Centroid 23: [-2.6856562e-02  3.1233868e-02 -3.0734015e-01  3.2567114e-02
  2.0601240e-01 -7.4614510e-02  1.1768802e-01  1.4614251e-01
  1.8272411e-02  1.4565316e-01 -3.7061661e-02 -1.4050332e-02
 -5.6251712e-02 -4.6189831e-04 -7.2639272e-02 -4.6753408e-03
 -4.3255858e-02 -1.7848101e-02 -5.7459120e-02  1.0529578e-01
  2.1651416e-01  1.8551460e-02  6.8806905e-01]
```

In [ ]:

```
spectral_clustering(
    oe_X_train025,
    cuts=len(np.unique(le_y_train025)),
    fname="one-hot_encoded_spectral_clustering",
    affinity="additive_chi2",
)
```

```
eigenvalues: [9.9990904e-01 9.9990523e-01 9.9989450e-01 9.9988222e-01 9.9986792e-01
 9.9985254e-01 9.9984121e-01 9.9983311e-01 9.9983084e-01 9.9981248e-01
 9.9977577e-01 9.9968719e-01 9.9947876e-01 9.9825495e-01 2.1680598e-12].
Finished running k-means++
8.0     5558
2.0     2056
13.0     785
12.0     663
0.0      654
9.0      428
14.0     391
11.0     351
4.0      311
6.0      298
7.0      252
5.0      239
1.0      164
3.0      105
10.0      95
dtype: int64
Completed iteration 1
8.0     5890
2.0     1152
12.0     729
14.0     699
9.0      626
0.0      607
6.0      464
11.0     418
13.0     340
1.0      335
4.0      310
5.0      233
7.0      231
3.0      188
10.0     128
dtype: int64
Completed iteration 2
8.0     6030
2.0      859
12.0     757
14.0     733
0.0      703
9.0      664
6.0      463
11.0     447
1.0      409
4.0      297
3.0      245
5.0      235
7.0      229
10.0     148
13.0     131
dtype: int64
Completed iteration 3
8.0     6067
2.0      765
12.0     743
14.0     743
0.0      685
9.0      666
6.0      506
11.0     483
1.0      427
4.0      283
3.0      262
7.0      233
5.0      231
10.0     156
13.0     100
dtype: int64
Completed iteration 4
8.0     6071
14.0     726
12.0     721
2.0      697
9.0      650
0.0      642
6.0      585
11.0     504
1.0      424
4.0      265
3.0      263
7.0      239
5.0      222
13.0     179
```

```
10.0     162
dtype: int64
Completed iteration 5
8.0      6051
14.0      701
12.0      699
6.0       668
2.0       659
0.0       621
9.0       619
11.0      502
1.0       428
13.0      267
3.0       259
4.0       253
7.0       237
5.0       219
10.0      167
dtype: int64
Completed iteration 6
8.0      6043
6.0       739
12.0      675
14.0      674
2.0       636
0.0       607
9.0       595
11.0      498
1.0       434
13.0      316
3.0       261
4.0       251
7.0       234
5.0       220
10.0      167
dtype: int64
Completed iteration 7
8.0      6028
6.0       787
14.0      661
12.0      659
2.0       632
0.0       603
9.0       582
11.0      487
1.0       437
13.0      335
3.0       262
4.0       256
7.0       234
5.0       218
10.0      169
dtype: int64
Completed iteration 8
8.0      6019
6.0       829
12.0      653
14.0      649
2.0       626
0.0       584
9.0       576
11.0      482
1.0       439
13.0      347
3.0       271
4.0       257
7.0       235
5.0       215
10.0      168
dtype: int64
Completed iteration 9
8.0      6007
6.0       858
12.0      645
14.0      640
2.0       621
0.0       584
9.0       574
11.0      480
1.0       441
13.0      354
3.0       273
4.0       257
7.0       237
5.0       209
10.0      170
```

```
dtype: int64
Completed iteration 10
8.0      6007
6.0       880
12.0      641
14.0      637
2.0       618
0.0       572
9.0       572
11.0      476
1.0       441
13.0      352
3.0       276
4.0       261
7.0       238
5.0       208
10.0      171
dtype: int64
Completed iteration 11
8.0      6005
6.0       896
12.0      639
14.0      636
2.0       617
9.0       570
0.0       562
11.0      474
1.0       441
13.0      353
3.0       276
4.0       262
7.0       240
5.0       208
10.0      171
dtype: int64
Completed iteration 12
8.0      6004
6.0       897
12.0      639
14.0      634
2.0       622
9.0       567
0.0       561
11.0      471
1.0       441
13.0      353
3.0       277
4.0       262
7.0       241
5.0       208
10.0      173
dtype: int64
Completed iteration 13
8.0      5995
6.0       906
14.0      638
12.0      636
2.0       622
0.0       567
9.0       566
11.0      469
1.0       441
13.0      345
3.0       281
4.0       261
7.0       241
5.0       208
10.0      174
dtype: int64
Completed iteration 14
8.0      5994
6.0       910
12.0      637
14.0      636
2.0       625
9.0       565
0.0       562
11.0      467
1.0       441
13.0      342
3.0       283
4.0       263
7.0       241
5.0       208
10.0      176
dtype: int64
```

```
Completed iteration 15
8.0      5996
6.0       916
12.0      639
14.0      637
2.0       623
9.0       565
0.0       555
11.0      466
1.0       441
13.0      339
3.0       284
4.0       263
7.0       241
5.0       209
10.0      176
dtype: int64
Completed iteration 16
8.0      5993
6.0       919
12.0      640
14.0      637
2.0       623
9.0       565
0.0       557
11.0      465
1.0       441
13.0      339
3.0       284
4.0       263
7.0       241
5.0       209
10.0      174
dtype: int64
Completed iteration 17
Epsilon has a maximum value of 0.006875512655824423
Centroids:
Centroid 1: [-0.06220567 -0.03128384 -0.05532508  0.00178634  0.16879714  0.01699469
  0.07489372 -0.03757859  0.07681162  0.14106357 -0.05689994 -0.07985076
 -0.18020265 -0.04310692  0.7834882 ]
Centroid 2: [-0.14992236 -0.18918924 -0.04829156  0.1236979  -0.104275   -0.12193202
 -0.30845785  0.12040813 -0.26660934 -0.39054585 -0.086231   -0.34643602
  0.3346098  -0.05386055  0.46630615]
Centroid 3: [ 0.03243937  0.12823407 -0.01516835 -0.03067741 -0.03799861  0.01536544
 -0.09758815 -0.00173745 -0.06830925 -0.01006547 -0.0317318   0.10248762
  0.22548562  0.02718314  0.8190593 ]
Centroid 4: [-0.01672763 -0.03796703 -0.09483787  0.07266875  0.09157248 -0.22071889
 -0.3373487  -0.18525283  0.30725446 -0.02696287 -0.00076093 -0.17816971
  0.21083117 -0.14358391  0.42034578]
Centroid 5: [-0.00560709 -0.07071371  0.05717726  0.04349514  0.21037963 -0.20876528
 -0.35916454 -0.13821061  0.3585822   0.01769604 -0.02043139  0.05256172
 -0.01706525  0.43431908  0.27404606]
Centroid 6: [ 0.01616256  0.212918   -0.04026171 -0.2527842   0.03927467 -0.09966124
  0.2976917  -0.12968814  0.21359156  0.5551312   0.03701527  0.2957576
 -0.03461581 -0.12156373  0.29896995]
Centroid 7: [-0.11062643  0.03930549  0.19593753 -0.10073278  0.01831567 -0.21719494
 -0.05091859  0.06542453 -0.08874426  0.08862306 -0.07814492 -0.13531613
 -0.04261798  0.01403823  0.78655076]
Centroid 8: [-0.01629567  0.01803211 -0.18429017  0.08201854 -0.03323665  0.5243457
  0.06618229 -0.36864945  0.32933637  0.14467314  0.1483407   0.04174339
  0.2175304  -0.10399178  0.34424737]
Centroid 9: [ 0.01738425  0.01021718  0.0390149  -0.04373004  0.03250917  0.01724128
 -0.00284624  0.04455189  0.003083   -0.01314021  0.02208718  0.07187262
 -0.12065557  0.05193633  0.97442347]
Centroid 10: [ 0.02377047  0.07322925  0.04246423 -0.06722952 -0.1543821   0.26413667
  0.3830977   0.19454424 -0.37859884 -0.00157692  0.01407102  0.1390786
 -0.11777834 -0.02370501  0.331415  ]
Centroid 11: [ 1.94129065e-01  1.06952302e-01  1.79903224e-01 -3.05772722e-01
  1.33211717e-01  4.78834175e-02 -3.20759155e-02  1.07636452e-01
  7.12408946e-05  6.06368249e-03  5.66965751e-02  2.32681409e-01
 -9.50470269e-02 -1.06297985e-01  4.11380291e-01]
Centroid 12: [-0.04944424 -0.00708513  0.01208038  0.13558073  0.20915164 -0.13497628
 -0.23788229  0.05228581  0.25050497  0.02717298  0.00536378  0.31401
 -0.2633244  -0.03175762  0.5320185 ]
Centroid 13: [ 0.25757605 -0.03476954 -0.32453126  0.1718813  -0.00992453  0.14388737
 -0.06112954 -0.11264855  0.02601364 -0.13951898  0.02436013  0.09179515
  0.02306692 -0.00285006  0.73229074]
Centroid 14: [ 0.07117458  0.01087715 -0.0216037  -0.19808933 -0.18975915  0.0677079
  0.19768058 -0.03000386 -0.22805417 -0.02836142  0.05211345 -0.297122
  0.2991693   0.02952801  0.47853848]
Centroid 15: [-0.06953982 -0.06136304 -0.03577795  0.30044338 -0.15350659 -0.21585043
  0.08797627 -0.13654523 -0.09011857 -0.01779773 -0.16012996 -0.32908857
  0.44547266 -0.11416594  0.54202056]
```

chi2 (gamma=1.0)

In [ ]:

```
spectral_clustering(
    oe_X_train025,
    cuts=23,
    fname="one-hot_encoded_spectral_clustering",
    affinity="chi2",
    gamma=1.0,
)
```

```
eigenvalues: [4.2849140e-19 2.1978150e-19 1.3190085e-19 1.2006251e-19 1.1135112e-19
 7.6815985e-20 2.8767852e-20 1.8580284e-20 3.8743233e-21 1.2061609e-21
 6.5826805e-22 3.1409243e-22 9.0774635e-23 6.4550626e-23 2.3096634e-23
 1.9380088e-26 4.0186283e-28 2.2241039e-29 4.3910724e-33 1.0208590e-38
 1.4979881e-41 1.7376101e-43 0.0000000e+00].
Finished running k-means++
0.0      5335
1.0      1400
3.0       871
13.0      551
15.0      540
10.0      441
12.0      409
20.0      269
6.0       245
2.0       224
5.0       222
14.0      217
9.0       211
18.0      181
21.0      176
16.0      146
22.0      145
19.0      139
17.0      135
8.0       133
11.0      133
7.0       121
4.0       106
dtype: int64
Completed iteration 1
0.0      5233
1.0      1346
3.0       797
13.0      574
15.0      438
12.0      417
10.0      398
6.0       257
2.0       250
20.0      246
14.0      241
9.0       238
16.0      216
5.0       208
22.0      207
11.0      205
21.0      188
18.0      172
17.0      168
8.0       151
7.0       149
19.0      136
4.0       115
dtype: int64
Completed iteration 2
0.0      5234
1.0      1344
3.0       769
13.0      576
15.0      426
12.0      412
10.0      390
6.0       270
2.0       259
14.0      234
9.0       228
16.0      226
11.0      215
22.0      215
20.0      214
5.0       209
17.0      194
21.0      186
7.0       170
18.0      169
8.0       153
4.0       130
19.0      127
dtype: int64
Completed iteration 3
0.0      5233
1.0      1346
3.0       749
13.0      585
15.0      408
```

```
12.0      406
10.0      385
6.0       281
2.0       252
14.0      242
16.0      233
9.0       226
11.0      218
5.0       214
22.0      214
17.0      203
20.0      202
21.0      185
7.0       182
18.0      171
8.0       148
4.0       146
19.0      121
dtype: int64
Completed iteration 4
0.0      5233
1.0      1345
3.0       736
13.0      592
15.0      401
12.0      396
10.0      383
6.0       287
2.0       258
14.0      250
16.0      238
9.0       227
11.0      221
5.0       218
22.0      208
7.0       196
17.0      196
20.0      190
21.0      186
18.0      180
8.0       147
4.0       142
19.0      120
dtype: int64
Completed iteration 5
0.0      5233
1.0      1345
3.0       721
13.0      597
15.0      390
12.0      384
10.0      380
6.0       289
2.0       265
14.0      255
16.0      232
5.0       232
9.0       229
11.0      226
7.0       221
22.0      197
21.0      193
20.0      187
18.0      185
17.0      177
8.0       152
4.0       141
19.0      119
dtype: int64
Completed iteration 6
0.0      5233
1.0      1344
3.0       711
13.0      601
15.0      382
12.0      377
10.0      375
6.0       294
14.0      267
2.0       262
5.0       243
11.0      231
7.0       231
9.0       229
16.0      224
21.0      199
```

```
22.0      198
18.0      187
20.0      186
17.0      164
8.0       155
4.0       138
19.0      119
dtype: int64
Completed iteration 7
0.0      5233
1.0      1344
3.0       700
13.0      596
15.0      381
10.0      373
12.0      369
6.0       295
2.0       265
14.0      265
5.0       249
7.0       243
9.0       236
11.0      226
16.0      222
22.0      204
21.0      195
18.0      193
20.0      186
17.0      163
8.0       154
4.0       136
19.0      122
dtype: int64
Completed iteration 8
0.0      5233
1.0      1344
3.0       698
13.0      596
15.0      384
10.0      373
12.0      367
6.0       294
14.0      271
2.0       265
5.0       254
9.0       239
7.0       234
11.0      222
16.0      213
22.0      207
21.0      198
18.0      194
20.0      186
17.0      164
8.0       154
4.0       135
19.0      125
dtype: int64
Completed iteration 9
0.0      5233
1.0      1344
3.0       697
13.0      598
15.0      386
10.0      373
12.0      363
6.0       296
14.0      272
2.0       264
5.0       261
9.0       240
7.0       227
11.0      221
16.0      211
22.0      205
21.0      200
18.0      199
20.0      179
17.0      166
8.0       156
4.0       134
19.0      125
dtype: int64
Completed iteration 10
0.0      5233
1.0      1344
```

```
3.0       696
13.0      602
15.0      387
10.0      374
12.0      361
6.0       292
14.0      276
2.0       262
5.0       262
9.0       238
7.0       222
11.0      219
16.0      214
18.0      207
22.0      205
21.0      196
20.0      181
17.0      163
8.0       159
4.0       134
19.0      123
dtype: int64
Completed iteration 11
0.0      5233
1.0      1344
3.0       696
13.0      603
15.0      391
10.0      374
12.0      358
6.0       290
14.0      272
5.0       263
2.0       260
9.0       237
11.0      221
7.0       219
16.0      214
18.0      209
22.0      207
21.0      194
20.0      185
17.0      164
8.0       158
4.0       134
19.0      124
dtype: int64
Completed iteration 12
0.0      5233
1.0      1344
3.0       693
13.0      603
15.0      392
10.0      372
12.0      355
6.0       285
14.0      269
5.0       267
2.0       261
9.0       236
16.0      221
11.0      219
7.0       216
18.0      216
22.0      207
21.0      192
20.0      184
17.0      169
8.0       158
4.0       133
19.0      125
dtype: int64
Completed iteration 13
0.0      5233
1.0      1345
3.0       688
13.0      604
15.0      394
10.0      374
12.0      355
6.0       282
5.0       275
14.0      270
2.0       259
9.0       234
18.0      219
```

```
11.0      219
7.0       217
16.0      216
22.0      206
21.0      190
20.0      187
17.0      165
8.0       159
4.0       132
19.0      127
dtype: int64
Completed iteration 14
0.0      5233
1.0      1345
3.0       687
13.0      605
15.0      393
10.0      374
12.0      356
6.0       282
5.0       277
14.0      272
2.0       256
9.0       235
18.0      217
7.0       217
16.0      217
11.0      215
22.0      206
20.0      195
21.0      191
17.0      164
8.0       158
4.0       131
19.0      124
dtype: int64
Completed iteration 15
0.0      5233
1.0      1345
3.0       687
13.0      605
15.0      393
10.0      375
12.0      356
6.0       281
5.0       278
14.0      269
2.0       255
9.0       235
18.0      225
11.0      217
7.0       215
16.0      213
22.0      207
20.0      192
21.0      192
17.0      166
8.0       157
4.0       128
19.0      126
dtype: int64
Completed iteration 16
0.0      5233
1.0      1345
3.0       687
13.0      607
15.0      392
10.0      375
12.0      355
5.0       281
6.0       278
14.0      269
2.0       255
9.0       237
18.0      225
11.0      216
7.0       215
16.0      214
22.0      209
20.0      191
21.0      189
17.0      165
8.0       157
4.0       129
19.0      126
dtype: int64
```

```
Completed iteration 17
0.0     5233
1.0     1345
3.0      687
13.0     607
15.0     393
10.0     375
12.0     355
5.0      284
6.0      279
14.0     267
2.0      254
9.0      240
18.0     220
16.0     217
11.0     217
7.0      215
22.0     209
20.0     191
21.0     188
17.0     166
8.0      153
4.0      128
19.0     127
dtype: int64
Completed iteration 18
0.0     5232
1.0     1346
3.0      686
13.0     608
15.0     395
10.0     375
12.0     357
5.0      286
6.0      278
14.0     267
2.0      253
9.0      238
11.0     220
18.0     219
16.0     215
7.0      214
22.0     211
20.0     190
21.0     185
17.0     164
8.0      153
4.0      129
19.0     129
dtype: int64
Completed iteration 19
0.0     5232
1.0     1346
3.0      685
13.0     611
15.0     395
10.0     375
12.0     357
5.0      289
6.0      277
14.0     265
2.0      251
9.0      241
18.0     222
16.0     217
11.0     216
7.0      214
22.0     211
20.0     188
21.0     183
17.0     164
8.0      152
19.0     130
4.0      129
dtype: int64
Completed iteration 20
0.0     5232
1.0     1345
3.0      685
13.0     611
15.0     393
10.0     375
12.0     357
5.0      294
6.0      280
14.0     263
```

```
2.0      251
9.0      237
18.0     221
16.0     219
11.0     219
7.0      212
22.0     211
21.0     186
20.0     183
17.0     163
8.0      153
19.0     131
4.0      129
dtype: int64
Completed iteration 21
Reached 21 iterations
Centroids:
Centroid 1: [ 6.3199266e-05 -5.8559156e-03 -1.5853833e-05 -2.7453783e-05
  9.0967318e-05  1.3360729e-04 -5.4774384e-05  2.3954854e-04
 -5.7672631e-05  9.9370676e-01 -8.6175096e-05  3.7072488e-04
 -4.3806496e-05 -8.8148663e-05  8.0985365e-06  4.7656860e-05
  5.5221288e-05  2.5358906e-06 -1.4258657e-05  2.3690430e-02
  1.6673982e-04  4.5362201e-05 -4.8835322e-05]
Centroid 2: [-3.3042280e-04  3.0693911e-02 -6.2194676e-04  4.2985810e-04
  1.9348376e-04  5.8304903e-04  5.5911718e-04  2.5334884e-04
 -1.0067743e-04 -9.7866964e-01 -1.2802008e-04 -2.8094827e-04
  1.6048594e-04 -9.0433219e-05 -3.0781611e-04 -4.9164682e-05
  9.4464696e-05 -5.6971743e-04 -4.0357365e-05 -3.4633644e-02
 -8.2208408e-04  1.9645004e-04  2.5593428e-07]
Centroid 3: [-0.01321212 -0.02518395 -0.00575104  0.00322744 -0.01067055 -0.5528677
 -0.01392418 -0.01187083 -0.12250786  0.00500732  0.00372739 -0.06089681
  0.00081765  0.00731046  0.0152635   0.00231235  0.02470171  0.00999752
  0.00814279 -0.04003864 -0.00549539  0.00236948 -0.00073622]
Centroid 4: [-0.83357024 -0.01659639 -0.03150583 -0.0066744  -0.00147275  0.03093407
 -0.04457255 -0.04817184  0.00797275  0.04650148  0.01390211 -0.00379146
 -0.00610478  0.00628594 -0.01198125  0.00508963  0.18185161  0.04032913
  0.04286068 -0.0890049  -0.00450818 -0.0030998  -0.01779785]
Centroid 5: [-0.01722172  0.00159859  0.02048071 -0.01808152  0.02655248  0.00412149
 -0.03663777 -0.04439125  0.00462336  0.01455274  0.01904245  0.00454092
  0.1118219  -0.5712646   0.00304796  0.03217117  0.0764229   0.0157975
  0.01600232 -0.00356804  0.1081745  -0.0024967   0.01232348]
Centroid 6: [ 8.4173563e-04  7.3396461e-03  5.6456486e-03 -9.8647084e-04
  4.2193990e-02  5.7213426e-01  7.6394957e-03 -2.1948930e-02
 -4.5069061e-02  2.6001842e-04 -1.4431542e-02 -5.6925539e-02
 -5.0416086e-03 -1.3847854e-02  1.0693874e-02 -3.4210966e-03
  9.1391597e-03 -2.8846994e-02  5.3571425e-03 -2.6256632e-02
  7.3424010e-03  2.4475355e-03 -3.3245829e-03]
Centroid 7: [ 0.01815344 -0.5936639   0.02159363 -0.01203974  0.03085548  0.00397178
 -0.00614179 -0.01784894  0.00880265 -0.00159566 -0.00181663 -0.02542289
  0.01306486  0.00933448 -0.0136395   0.01422676  0.00134509 -0.00815547
  0.00202132  0.00557906 -0.0066845   0.00234337  0.00805903]
Centroid 8: [-8.0359839e-02 -6.9712408e-02 -9.7181156e-02 -6.7563574e-03
 -3.1212568e-02  1.0169444e-01 -1.3785666e-01 -1.3542409e-01
  7.2580134e-03  1.2920459e-01  1.8104207e-02  2.0532643e-02
 -4.9843597e-03  1.3053912e-02 -3.7985910e-02 -4.0913810e-04
  4.9329084e-01  1.3154270e-01  1.1382629e-01 -2.9243380e-01
 -1.0525386e-02  6.7916848e-03 -3.6955178e-02]
Centroid 9: [ 0.01762038 -0.06691072  0.01509578 -0.00118333  0.04475541 -0.10791888
 -0.03464841  0.03849801 -0.16229276  0.03507648  0.06213317  0.43353042
  0.0018619   0.00309035 -0.03678531 -0.02742205 -0.00186942 -0.050225
  0.00645554 -0.0674786  -0.01081811  0.00980088 -0.00882297]
Centroid 10: [ 0.01563335 -0.05863761  0.02285711 -0.01268458 -0.04511831  0.04280428
 -0.00094118  0.57990754  0.01256764  0.01453267  0.00798568 -0.01665683
  0.01382296 -0.02579233  0.00435512  0.02826064 -0.02818434 -0.0073976
  0.00140513 -0.00974941  0.01355452 -0.00290473  0.01725389]
Centroid 11: [-1.6770564e-01 -1.5404003e-02 -4.0048748e-02  6.2577741e-04
 -4.8919064e-03  2.9807271e-02 -4.0621664e-02 -5.6882538e-02
  1.1502071e-02  5.1714171e-02  2.3699317e-02  1.2705715e-03
 -1.4652163e-02  3.0647941e-02 -1.0998239e-02  7.4204516e-01
  1.8267298e-01  4.1489597e-02  4.2252351e-02 -8.5250251e-02
  5.0696274e-03 -2.3265914e-03 -2.0967331e-02]
Centroid 12: [-2.15685852e-02  5.14316618e-01 -1.17045857e-01  7.97226354e-02
  7.72217363e-02  6.88626915e-02  1.63884088e-02  1.23783998e-01
  3.47127847e-04 -3.67296091e-03  2.71437282e-04 -5.15984278e-03
  1.31897265e-02  3.06011662e-02 -2.34854948e-02  3.25433090e-02
 -6.64353793e-05 -1.14709595e-02  3.95809440e-03 -8.36700648e-02
 -1.30981049e-02  3.49343783e-04 -4.03398201e-02]
Centroid 13: [-2.9601088e-01 -2.8062539e-02 -3.6871258e-02 -3.0348923e-03
 -1.0352329e-02  3.1491634e-02 -4.3078069e-02 -4.9805302e-02
  1.0148970e-02  5.3902745e-02  1.7971914e-02  1.3094403e-02
 -2.3717855e-03  7.2989739e-03 -1.1227776e-02 -7.0653361e-01
  1.8653637e-01  4.3340590e-02  4.5736399e-02 -9.8484926e-02
  2.6770974e-02 -6.9721712e-04 -1.7087739e-02]
Centroid 14: [ 7.8262067e-01 -1.5937967e-02 -3.4569509e-02 -5.0490028e-03
 -8.8867190e-04  2.9439293e-02 -4.7406588e-02 -4.6389170e-02
  6.8553686e-03  5.2485496e-02  1.2649149e-02  1.0380625e-02
```

```
 -4.8278435e-03  5.8240555e-03 -1.3245841e-02  2.3825228e-01
  1.8155542e-01  3.8523775e-02  4.1909248e-02 -8.6613841e-02
  2.7095541e-04 -1.1398721e-03 -1.2978865e-02]
Centroid 15: [-0.0195194  -0.03210707 -0.05482349  0.02286405 -0.5165933   0.08177797
 -0.02332299 -0.00702394  0.01802692  0.05584709  0.01856342  0.01738245
 -0.00632351 -0.02276357 -0.00739652  0.00893109 -0.01170137 -0.03771949
  0.00328052  0.01592853 -0.00952167 -0.01160775  0.00124582]
Centroid 16: [ 0.6366779  -0.01591936 -0.04588603 -0.00086437 -0.01436696  0.01812726
 -0.04380732 -0.05122356  0.00763413  0.04730223  0.01903083 -0.00241792
 -0.02655883  0.01558628 -0.0160996  -0.45428848  0.19375917  0.04125744
  0.04288365 -0.09407748 -0.00518434  0.00151605 -0.02381307]
Centroid 17: [-0.02651731 -0.03650391 -0.02063224  0.01027976  0.0247544   0.01169479
 -0.01573747 -0.5704608   0.0055748  -0.01996347 -0.01017009 -0.02440186
  0.00376844  0.00655663 -0.00359989 -0.00468319  0.00117425 -0.01062851
 -0.00144161  0.00389776  0.02160772 -0.00637258 -0.0412844 ]
Centroid 18: [-0.01351415 -0.0085738   0.00117627 -0.01355571 -0.0283073  -0.00110009
 -0.00816279 -0.02339662  0.0189635   0.02857544  0.01585144 -0.02215269
  0.52922106  0.23737249 -0.01976032 -0.01274346  0.06961171  0.01677627
  0.01817541 -0.04845143 -0.02826451 -0.00968194 -0.02777364]
Centroid 19: [ 3.8310036e-03  2.1587435e-02 -1.7633114e-02  4.4191717e-03
  4.5778891e-01  3.1952024e-02 -2.2909483e-01  2.2178993e-02
 -2.7801182e-02  3.1425286e-02 -3.4666505e-02 -4.6026513e-02
  1.4650760e-02  1.2803684e-03  5.9919812e-02  1.6377734e-02
  1.5623612e-02 -5.3945067e-03  8.8030873e-03 -2.6961438e-02
  8.7619619e-03  2.8429390e-04  2.2805312e-03]
Centroid 20: [-0.07065143 -0.02336239 -0.02141078  0.0042968  -0.00817596 -0.00378537
 -0.01694754 -0.02710341 -0.00914866  0.00878978  0.00075887  0.00418246
 -0.54181194  0.14321508  0.00719868 -0.01395401  0.0698345   0.00504603
  0.016614   -0.02444724 -0.0374792   0.00988807 -0.0174609 ]
Centroid 21: [ 0.03265808  0.4369652   0.24060029 -0.16423576 -0.11585233 -0.05215774
 -0.01544527 -0.01677183  0.01500805 -0.01046996 -0.0163368  -0.00144338
 -0.02812443 -0.02229066  0.00920834 -0.00860585 -0.01709142 -0.01445161
 -0.0013414   0.0037359   0.03290635  0.00246364  0.01732199]
Centroid 22: [-0.00234643  0.01653184  0.00964678  0.00422434  0.19266243 -0.32905135
  0.06954565 -0.01174041  0.38509372  0.01393553 -0.02950821  0.00534074
 -0.01499479  0.0057312   0.00866165  0.00075156 -0.01502127 -0.06176702
  0.0054322   0.02387475  0.02954803 -0.00146903 -0.01163952]
Centroid 23: [ 0.00283311 -0.00397213 -0.03178142  0.03592297 -0.04340752 -0.01688237
  0.34945783 -0.00773588 -0.04726804 -0.0304797  -0.01658762 -0.0286772
 -0.00291883 -0.00738049 -0.03328218 -0.01187336 -0.03996362 -0.0530999
 -0.00071773  0.19311437 -0.03038838 -0.00253195 -0.00743132]
```

In [ ]:

```
spectral_clustering(
    oe_X_train025,
    cuts=len(np.unique(le_y_train025)),
    fname="one-hot_encoded_spectral_clustering",
    affinity="chi2",
    gamma=1.0,
)
```

```
eigenvalues: [3.8743233e-21 1.2061609e-21 6.5826805e-22 3.1409243e-22 9.0774635e-23
 6.4550626e-23 2.3096634e-23 1.9380088e-26 4.0186283e-28 2.2241039e-29
 4.3910724e-33 1.0208590e-38 1.4979881e-41 1.7376101e-43 0.0000000e+00].
Finished running k-means++
0.0     5498
4.0     1572
12.0    1131
1.0      827
13.0     619
5.0      339
3.0      334
7.0      326
2.0      320
9.0      311
14.0     278
6.0      260
8.0      208
11.0     171
10.0     156
dtype: int64
Completed iteration 1
0.0     5318
4.0     1438
12.0     926
1.0      769
13.0     608
2.0      422
5.0      420
7.0      357
8.0      347
9.0      347
14.0     339
3.0      321
6.0      298
11.0     231
10.0     209
dtype: int64
Completed iteration 2
0.0     5307
4.0     1426
12.0     852
1.0      717
13.0     567
2.0      469
8.0      399
5.0      383
3.0      377
14.0     363
9.0      345
7.0      344
6.0      294
11.0     284
10.0     223
dtype: int64
Completed iteration 3
0.0     5308
4.0     1426
12.0     825
1.0      688
13.0     549
2.0      488
3.0      429
8.0      415
14.0     367
5.0      356
9.0      338
7.0      324
11.0     302
6.0      292
10.0     243
dtype: int64
Completed iteration 4
0.0     5309
4.0     1430
12.0     816
1.0      686
13.0     535
2.0      485
3.0      458
8.0      413
14.0     357
5.0      351
9.0      334
7.0      313
11.0     308
6.0      294
```

```
10.0     261
dtype: int64
Completed iteration 5
0.0     5313
4.0     1429
12.0     791
1.0      683
13.0     543
3.0      479
2.0      462
8.0      405
14.0     361
5.0      348
9.0      332
11.0     319
7.0      308
6.0      290
10.0     287
dtype: int64
Completed iteration 6
0.0     5313
4.0     1429
12.0     799
1.0      681
13.0     530
3.0      493
2.0      459
8.0      408
14.0     364
5.0      341
9.0      329
11.0     315
7.0      306
10.0     298
6.0      285
dtype: int64
Completed iteration 7
0.0     5313
4.0     1430
12.0     797
1.0      683
13.0     534
3.0      498
2.0      443
8.0      408
14.0     371
5.0      340
9.0      328
11.0     309
7.0      307
10.0     301
6.0      288
dtype: int64
Completed iteration 8
0.0     5312
4.0     1429
12.0     794
1.0      682
13.0     537
3.0      502
2.0      432
8.0      406
14.0     367
5.0      344
9.0      330
7.0      317
10.0     311
11.0     296
6.0      291
dtype: int64
Completed iteration 9
0.0     5311
4.0     1428
12.0     793
1.0      687
13.0     541
3.0      506
2.0      427
8.0      404
14.0     360
5.0      349
9.0      330
7.0      325
10.0     306
6.0      293
11.0     290
```

```
dtype: int64
Completed iteration 10
0.0     5310
4.0     1426
12.0     791
1.0      688
13.0     541
3.0      513
2.0      423
8.0      400
5.0      354
14.0     350
7.0      334
9.0      327
10.0     298
11.0     298
6.0      297
dtype: int64
Completed iteration 11
0.0     5308
4.0     1421
12.0     782
1.0      692
13.0     546
3.0      512
2.0      422
8.0      398
5.0      356
14.0     356
7.0      341
9.0      326
11.0     307
6.0      296
10.0     287
dtype: int64
Completed iteration 12
0.0     5307
4.0     1420
12.0     783
1.0      692
13.0     548
3.0      515
2.0      423
8.0      393
5.0      363
14.0     348
7.0      343
9.0      324
11.0     307
6.0      297
10.0     287
dtype: int64
Completed iteration 13
0.0     5309
4.0     1421
12.0     779
1.0      692
13.0     550
3.0      514
2.0      426
8.0      390
5.0      360
7.0      346
14.0     338
9.0      324
11.0     314
6.0      301
10.0     286
dtype: int64
Completed iteration 14
0.0     5309
4.0     1422
12.0     778
1.0      693
13.0     550
3.0      515
2.0      423
8.0      389
5.0      362
7.0      349
14.0     330
9.0      324
11.0     318
6.0      304
10.0     284
dtype: int64
```

```
Completed iteration 15
0.0     5307
4.0     1422
12.0     778
1.0      695
13.0     553
3.0      518
2.0      418
8.0      385
5.0      362
7.0      351
14.0     327
9.0      325
11.0     323
6.0      302
10.0     284
dtype: int64
Completed iteration 16
0.0     5306
4.0     1421
12.0     779
1.0      695
13.0     557
3.0      517
2.0      418
8.0      386
5.0      353
7.0      352
9.0      329
11.0     323
14.0     323
6.0      302
10.0     289
dtype: int64
Completed iteration 17
0.0     5306
4.0     1421
12.0     778
1.0      693
13.0     560
3.0      517
2.0      418
8.0      386
7.0      353
5.0      345
9.0      330
11.0     328
14.0     320
6.0      304
10.0     291
dtype: int64
Completed iteration 18
0.0     5306
4.0     1421
12.0     778
1.0      693
13.0     561
3.0      517
2.0      420
8.0      383
7.0      354
5.0      341
9.0      332
11.0     329
14.0     319
6.0      305
10.0     291
dtype: int64
Completed iteration 19
Epsilon has a maximum value of 0.009705143980681896
Centroids:
Centroid 1: [-3.33222051e-05  9.89467144e-01 -3.61122802e-04  9.72376554e-04
 -1.09372915e-04 -1.74649002e-04  1.75886782e-06 -5.49026183e-04
  2.92645826e-04 -1.76048619e-04 -9.06091227e-05  2.30483040e-02
  4.57187620e-04 -1.13018550e-05 -4.55651782e-04]
Centroid 2: [-1.6474614e-02  6.0024895e-02  1.9239308e-02  5.0026467e-03
 -1.3152301e-02 -2.7796328e-03 -1.4810729e-02 -8.2915133e-01
  1.9095592e-01  4.2331360e-02  4.8404489e-02 -9.7631812e-02
 -2.6559450e-03  1.5269821e-04 -1.9543540e-02]
Centroid 3: [ 0.57460177  0.03347578 -0.00509146  0.02535396 -0.01326871 -0.04247858
  0.00057978  0.00933573  0.02264949 -0.05203916  0.00804977 -0.07447818
 -0.01310874 -0.00446656 -0.03461188]
Centroid 4: [ 6.28050119e-02  1.27813458e-01  4.66589481e-02  1.45848850e-02
  7.14690331e-03  2.50777882e-02 -2.89915800e-02 -4.01559681e-01
  5.61441183e-01  1.40633419e-01  1.23025514e-01 -2.86616772e-01
 -2.07987567e-03  3.13058146e-04 -4.56536710e-02]
```

```
Centroid 5: [-2.9901773e-04 -9.6376073e-01 -2.2616613e-04 -1.2808143e-03
  1.8189484e-04  2.4176888e-04 -2.4873535e-03 -1.3087769e-03
 -7.1099238e-04 -2.1344759e-03  4.1528459e-04 -3.8602117e-02
 -1.7941305e-03  8.9410954e-04  1.9392098e-03]
Centroid 6: [ 0.01898941  0.00454966 -0.01761514 -0.51081437  0.00643055 -0.01321931
  0.080994    0.01138106 -0.04918917 -0.10945731  0.00567327 -0.09285351
  0.01520558 -0.00210078  0.01902769]
Centroid 7: [-0.01826219  0.01744837  0.01590544  0.02350973 -0.02777881 -0.12244397
 -0.03046876 -0.03060252  0.00864128 -0.01699785  0.00901316 -0.02496866
  0.5439035  -0.00188014 -0.0733874 ]
Centroid 8: [-0.00563521  0.05045298  0.01244214  0.00245468  0.5172873  -0.20450982
 -0.05825358  0.01255015  0.023909   -0.00284389  0.01315866 -0.04012499
 -0.09901769 -0.00105846  0.01627392]
Centroid 9: [-0.5755265   0.02658522 -0.0387213  -0.08510811 -0.00273874 -0.04290657
 -0.01011967  0.02202126  0.07823411  0.01459132  0.02285223 -0.08579198
 -0.02475905 -0.00640761 -0.02991094]
Centroid 10: [-0.12439175  0.01841875  0.06038285  0.53894573 -0.01078576 -0.00562466
  0.01352437  0.01015799 -0.01169333 -0.08600269  0.01473085 -0.07475899
 -0.01625251  0.0065377  -0.00784028]
Centroid 11: [ 0.02837161  0.01032772  0.00896073 -0.00686658  0.08335044  0.55376947
 -0.00115077  0.00984741  0.04326078 -0.01978023  0.01419795 -0.04968987
 -0.09024977  0.00650131 -0.0317117 ]
Centroid 12: [-0.00563286  0.01886283 -0.01063215  0.01472742 -0.5043719  -0.07556095
  0.01741722  0.02788319  0.03215802  0.01369253  0.01117253 -0.03865702
 -0.17502576 -0.00169064  0.0591232 ]
Centroid 13: [ 0.00882778  0.06368265  0.02276249 -0.00211784 -0.02168064  0.01214146
 -0.0168342   0.8080601   0.20280005  0.04324035  0.04593499 -0.09820807
 -0.00539602 -0.00510744 -0.03374733]
Centroid 14: [ 2.4341732e-02  1.4142567e-01  4.0370885e-02  3.2718755e-02
  1.1101290e-02  7.6149637e-04 -3.5706401e-02  2.6474863e-01
  5.8577055e-01  1.5523127e-01  1.3152191e-01 -3.1177691e-01
 -1.6666964e-02 -3.1521462e-04 -3.7536152e-02]
Centroid 15: [ 0.0246556  -0.05020057 -0.03687408 -0.0046987  -0.00293116  0.01674208
 -0.02810698 -0.01839906 -0.03705579  0.00657255 -0.00532286  0.48508218
  0.02630486 -0.00279454 -0.00763875]
```

cosine similarity

In [ ]:

```
spectral_clustering(
    oe_X_train025,
    cuts=23,
    fname="one-hot_encoded_spectral_clustering",
    affinity="cosine_similarity",
)
```

```
eigenvalues: [9.9996889e-01 9.9996281e-01 9.9996221e-01 9.9996197e-01 9.9995911e-01
 9.9995828e-01 9.9995053e-01 9.9994850e-01 9.9994719e-01 9.9994266e-01
 9.9992621e-01 9.9992335e-01 9.9990380e-01 9.9978840e-01 9.9973905e-01
 9.9959689e-01 9.8116517e-01 9.2043281e-01 8.4043866e-01 6.5609217e-01
 4.5745876e-01 2.8215939e-01 1.0206217e-10].
Finished running k-means++
1.0     2533
7.0     2019
9.0     1366
0.0     1267
6.0     1092
15.0     837
20.0     461
11.0     452
5.0      410
16.0     407
4.0      262
12.0     255
8.0      208
3.0      192
13.0     190
21.0     165
17.0      68
10.0      66
2.0       54
22.0      22
19.0      12
14.0       9
18.0       3
dtype: int64
Completed iteration 1
1.0     2704
7.0     1694
9.0     1368
0.0     1272
6.0     1240
15.0     661
20.0     492
11.0     430
5.0      410
16.0     374
4.0      341
8.0      317
12.0     229
13.0     175
21.0     157
3.0      147
17.0     129
10.0      61
2.0       55
22.0      36
19.0      32
14.0      18
18.0       8
dtype: int64
Completed iteration 2
1.0     2736
7.0     1593
9.0     1367
6.0     1308
0.0     1278
15.0     604
20.0     490
11.0     424
5.0      396
16.0     357
4.0      348
8.0      326
12.0     270
17.0     171
13.0     166
21.0     152
3.0      146
2.0       59
10.0      57
19.0      44
22.0      35
14.0      12
18.0      11
dtype: int64
Completed iteration 3
1.0     2733
7.0     1570
9.0     1367
6.0     1334
0.0     1278
```

```
15.0     579
20.0     480
11.0     423
5.0      377
4.0      351
16.0     351
8.0      324
12.0     294
17.0     197
13.0     164
21.0     153
3.0      149
2.0       64
10.0      52
19.0      50
22.0      33
14.0      14
18.0      13
dtype: int64
Completed iteration 4
1.0     2726
7.0     1556
9.0     1367
6.0     1355
0.0     1277
15.0     562
20.0     476
11.0     424
5.0      363
16.0     349
4.0      348
12.0     323
8.0      315
17.0     213
13.0     164
21.0     153
3.0      151
2.0       69
19.0      50
10.0      47
22.0      32
14.0      16
18.0      14
dtype: int64
Completed iteration 5
1.0     2721
7.0     1544
6.0     1372
9.0     1367
0.0     1276
15.0     553
20.0     472
11.0     424
5.0      353
16.0     350
4.0      345
12.0     338
8.0      312
17.0     225
13.0     162
3.0      155
21.0     152
2.0       69
19.0      48
10.0      46
22.0      32
14.0      20
18.0      14
dtype: int64
Completed iteration 6
1.0     2717
7.0     1537
6.0     1383
9.0     1367
0.0     1276
15.0     550
20.0     474
11.0     423
16.0     359
12.0     345
4.0      344
5.0      340
8.0      309
17.0     224
3.0      162
13.0     160
```

```
21.0     151
2.0       70
10.0      45
19.0      45
22.0      33
14.0      22
18.0      14
dtype: int64
Completed iteration 7
1.0     2711
7.0     1538
6.0     1388
9.0     1367
0.0     1277
15.0     546
20.0     475
11.0     424
16.0     356
12.0     351
4.0      344
5.0      312
8.0      307
17.0     234
3.0      180
13.0     160
21.0     151
2.0       70
10.0      45
19.0      45
22.0      33
14.0      22
18.0      14
dtype: int64
Completed iteration 8
1.0     2707
7.0     1538
6.0     1392
9.0     1367
0.0     1277
15.0     543
20.0     485
11.0     424
12.0     353
16.0     348
4.0      346
8.0      306
5.0      285
17.0     245
3.0      194
13.0     159
21.0     151
2.0       70
10.0      45
19.0      44
22.0      32
14.0      25
18.0      14
dtype: int64
Completed iteration 9
1.0     2706
7.0     1534
6.0     1397
9.0     1366
0.0     1275
15.0     541
20.0     494
11.0     425
12.0     355
16.0     348
4.0      346
8.0      306
5.0      284
17.0     246
3.0      187
13.0     159
21.0     151
2.0       70
10.0      45
19.0      43
22.0      31
14.0      27
18.0      14
dtype: int64
Completed iteration 10
1.0     2706
7.0     1532
```

```
6.0     1399
9.0     1366
0.0     1273
15.0     541
20.0     508
11.0     425
12.0     355
16.0     348
4.0      346
8.0      306
5.0      284
17.0     238
3.0      182
13.0     159
21.0     151
2.0       70
10.0      45
19.0      43
22.0      31
14.0      28
18.0      14
dtype: int64
Completed iteration 11
1.0     2706
7.0     1532
6.0     1399
9.0     1366
0.0     1273
15.0     541
20.0     518
11.0     424
12.0     355
16.0     351
4.0      346
8.0      306
5.0      283
17.0     228
3.0      181
13.0     159
21.0     151
2.0       70
10.0      45
19.0      43
22.0      31
14.0      28
18.0      14
dtype: int64
Completed iteration 12
1.0     2706
7.0     1532
6.0     1399
9.0     1366
0.0     1273
15.0     541
20.0     524
11.0     424
12.0     355
16.0     352
4.0      346
8.0      306
5.0      282
17.0     226
3.0      177
13.0     159
21.0     151
2.0       70
10.0      45
19.0      43
22.0      31
14.0      28
18.0      14
dtype: int64
Completed iteration 13
1.0     2706
7.0     1532
6.0     1399
9.0     1366
0.0     1273
15.0     541
20.0     532
11.0     424
16.0     356
12.0     355
4.0      346
8.0      306
5.0      282
```

```
17.0     215
3.0      175
13.0     160
21.0     151
2.0       70
10.0      45
19.0      43
22.0      31
14.0      28
18.0      14
dtype: int64
Completed iteration 14
1.0     2706
7.0     1532
6.0     1399
9.0     1366
0.0     1272
15.0     541
20.0     539
11.0     424
12.0     355
16.0     355
4.0      346
8.0      306
5.0      282
17.0     212
3.0      172
13.0     161
21.0     151
2.0       70
10.0      45
19.0      43
22.0      31
14.0      28
18.0      14
dtype: int64
Completed iteration 15
1.0     2706
7.0     1532
6.0     1399
9.0     1366
0.0     1272
20.0     541
15.0     541
11.0     424
16.0     359
12.0     355
4.0      346
8.0      306
5.0      282
17.0     208
3.0      169
13.0     162
21.0     151
2.0       70
10.0      45
19.0      43
22.0      31
14.0      28
18.0      14
dtype: int64
Completed iteration 16
1.0     2706
7.0     1532
6.0     1399
9.0     1366
0.0     1272
20.0     543
15.0     541
11.0     424
16.0     360
12.0     355
4.0      346
8.0      306
5.0      282
17.0     205
3.0      168
13.0     163
21.0     151
2.0       70
10.0      45
19.0      43
22.0      31
14.0      28
18.0      14
dtype: int64
```

```
Completed iteration 17
Epsilon has a maximum value of 0.0068672941997647285
Centroids:
Centroid 1: [-9.6816076e-03 -1.7933410e-02 -3.0107272e-03  5.9436583e-03
  4.8012380e-03 -1.8369513e-02 -1.4310053e-02  1.3040262e-02
 -6.0518449e-03  5.0673839e-03 -4.6706498e-02  8.7496173e-03
 -3.3117848e-04 -4.4709612e-03  2.4807532e-04  1.8537717e-02
 -3.1095967e-01  3.6474836e-01  4.2583207e-03  4.5724310e-02
  6.0925990e-01  2.1746790e-01  3.5227987e-01]
Centroid 2: [-0.06812278 -0.07994535  0.0311847  -0.20940274  0.04718221  0.07159414
 -0.02003197 -0.02444188  0.09905709 -0.08679457 -0.02513746  0.01915696
  0.01391078  0.00459075  0.00193965  0.00606534 -0.00912897  0.02799938
 -0.16313146  0.04242485 -0.55429536  0.19337712  0.73056483]
Centroid 3: [ 3.23504694e-02  1.05945192e-01 -7.53316581e-02  2.00858265e-02
 -1.24854550e-01  4.39813652e-04 -1.55824628e-02 -1.30930021e-01
  1.33811504e-01  8.00497383e-02 -1.17329516e-01 -4.72988002e-03
  6.19730586e-03  2.83735245e-03  7.64822727e-03 -1.77427642e-02
  1.15437359e-02  3.48463445e-03  1.73854921e-02 -8.74112844e-01
  3.83779220e-02 -6.76777260e-03  1.05855264e-01]
Centroid 4: [-0.03315444 -0.06393675 -0.05348857 -0.01600012 -0.00289896 -0.02785937
 -0.02237956 -0.03796871 -0.03622524  0.00678073  0.03878318 -0.01718377
 -0.00492755  0.0309969  -0.0075807  -0.10445317  0.20123942  0.47012666
  0.4788611   0.00699609  0.08679859 -0.38925463  0.4001468 ]
Centroid 5: [-1.84498593e-01  1.84967611e-02  1.78844661e-01  1.61284462e-01
  1.55545175e-02  2.85865963e-02 -7.54052633e-03 -4.72129323e-02
 -4.70513701e-02  4.94753383e-02  4.51601669e-03  8.85061398e-02
 -3.49813257e-03  3.24522927e-02  4.40488540e-04 -9.59797949e-03
  4.42217618e-01 -2.85231084e-01 -1.70278609e-01  6.60979673e-02
  5.46419799e-01  2.32624456e-01  3.52459401e-01]
Centroid 6: [ 2.5649028e-02  2.3980392e-02  1.9172408e-02  1.1353222e-02
  9.2488844e-03  4.7346029e-02  9.3791457e-03 -3.9621670e-02
 -1.4716057e-02 -8.1702257e-03  1.6107177e-02  3.3786260e-03
  6.2544958e-04  3.3602722e-02  9.7039659e-03  1.2932934e-01
  4.1286707e-02  4.3116727e-01  7.2758973e-01  1.2028194e-02
  1.9211043e-01 -5.6565642e-02  2.5738415e-01]
Centroid 7: [ 8.8847667e-02  1.2133177e-01 -1.7714079e-02  2.8065705e-01
 -5.7917025e-02 -8.4356189e-02  5.9867181e-02  5.2932937e-02
 -1.6059020e-01  1.2316977e-01  7.6052070e-02 -1.3251435e-02
  1.9939600e-03 -8.2582543e-03  1.1667701e-02  6.3420396e-04
 -9.1820769e-03  2.5877221e-02 -1.5456219e-01  4.0158208e-02
 -5.2437210e-01  1.8296409e-01  6.9110948e-01]
Centroid 8: [-4.8790916e-04  3.9996557e-02  1.6828066e-02  4.7173429e-02
  2.2361178e-02 -9.4457157e-03  3.6956307e-02  1.6717447e-02
 -3.6071487e-02  4.1238267e-02  1.3607041e-02  7.1453750e-03
  6.6569708e-03 -5.1660184e-04  1.1783478e-02  6.3628885e-03
 -9.9611869e-03  2.8886734e-02 -1.6900934e-01  4.3902315e-02
 -5.7343715e-01  2.0011561e-01  7.5591362e-01]
Centroid 9: [ 0.2349699  -0.02112298 -0.1904662  -0.1770126  -0.03746465 -0.02285952
  0.02214289  0.03409421  0.05734808 -0.05768386  0.08880722 -0.06120718
 -0.00500325  0.01142182 -0.00090627 -0.01156342  0.43314666 -0.2917039
 -0.16574979  0.06434937  0.5256337   0.22496845  0.34095034]
Centroid 10: [-7.2444725e-04  3.2144302e-04 -1.9093649e-03 -1.9036291e-02
 -2.6708297e-03  5.8477474e-03 -9.0308459e-03 -6.9861622e-03
  1.2744408e-02 -4.7276482e-02 -1.5777962e-02 -6.2943599e-03
  3.6502024e-03 -1.2099957e-02  1.8700730e-02  1.6978631e-02
 -6.1845684e-01 -5.4753071e-01  5.8489915e-02  5.0869212e-02
 -1.6550471e-01  1.5432213e-01  4.5002180e-01]
Centroid 11: [-0.05064657 -0.20674539  0.067041   -0.02088618  0.16975279 -0.00325404
  0.05366849  0.16881439 -0.19164997 -0.11382622  0.1707229  -0.0059221
 -0.00904374 -0.00299342 -0.01093249  0.00746446 -0.00704542 -0.01416253
  0.00085694 -0.8375594   0.03746146  0.00353269  0.08931957]
Centroid 12: [-0.01547075 -0.02411535 -0.02747879 -0.02041469 -0.00090165 -0.00932159
 -0.0216436  -0.02024364 -0.01398224 -0.00505739 -0.00134374 -0.01286462
  0.00108571 -0.00473177 -0.00883803 -0.0357892   0.50745726  0.65359676
 -0.14272039 -0.01013856 -0.28101605 -0.06302771  0.24244364]
Centroid 13: [ 1.1003818e-02  6.4546597e-04  2.9108450e-03  2.3396071e-02
 -5.7673603e-03 -1.2753324e-02  1.2011887e-02 -1.2016475e-02
 -1.6341720e-02 -8.5888254e-03  3.3965629e-02  2.3753336e-02
  9.4301570e-03  3.2620251e-02  6.0390859e-05 -2.7197631e-02
  3.8015127e-01 -1.9096798e-01 -1.6893345e-01  7.2142437e-02
  6.5464914e-01  2.6862335e-01  4.0872875e-01]
Centroid 14: [-0.03084296 -0.06999986 -0.06669071 -0.0298383  -0.00602287 -0.0181568
 -0.03607574 -0.03951347 -0.00529825  0.01183977 -0.04667667 -0.00489347
 -0.00692505  0.01504874 -0.00862724  0.06065189  0.47222558  0.034985
  0.39358136  0.02202031 -0.15118551 -0.5089913   0.36379537]
Centroid 15: [ 0.07940041  0.01598432 -0.04370343  0.01936748 -0.04901031 -0.13839991
  0.06715829  0.0271769  -0.00050544  0.02701361 -0.07449444 -0.07287047
 -0.04230689  0.08734711 -0.02702699 -0.02875736 -0.00339809 -0.00703172
 -0.00135324  0.00399372  0.01139258 -0.01121939  0.03460384]
Centroid 16: [ 0.0131978   0.00370565  0.01832855 -0.01295195 -0.00535956  0.01463506
  0.01521182 -0.00598978  0.01152125  0.00681765  0.03917003  0.02807071
 -0.00121898 -0.00853572 -0.00071409  0.00600664  0.54881597 -0.4101203
 -0.18903346  0.06726236  0.49626276  0.22153372  0.3342819 ]
Centroid 17: [-1.17509715e-01  2.17641145e-02  1.14965588e-01  9.31118652e-02
  1.81783717e-02  1.98196732e-02  1.14365127e-02 -2.79915780e-02
 -2.51218285e-02  2.75625233e-02 -9.55450814e-03  5.59225567e-02
```

```
 -9.18267854e-03 -3.49547109e-03  7.41842552e-04  7.85087235e-03
 -7.96675980e-02 -9.70898122e-02 -1.25754014e-01  3.32123823e-02
  1.52114332e-01 -8.50547731e-01  2.72280008e-01]
Centroid 18: [ 0.02574667  0.00936392  0.01704395 -0.00952377  0.02156893  0.00505697
  0.00146218 -0.02322446  0.00927507  0.00938565  0.02263223 -0.00815919
  0.00807845 -0.00864005  0.0009412  -0.0097067  -0.22664073  0.11299133
  0.13989113  0.03155256  0.15755305 -0.73054296  0.4236891 ]
Centroid 19: [-1.59455508e-01 -1.21339865e-01  3.81886922e-02  1.59996048e-01
 -1.00552797e-01  2.27794915e-01 -4.60498303e-01 -9.49448068e-03
 -2.20994698e-03 -3.28545040e-03  1.19485363e-01 -6.19577095e-02
  1.47621837e-02 -1.42473131e-04 -6.36412642e-06 -4.43563476e-04
 -1.42036993e-02 -1.67850908e-02 -9.98884253e-03  4.22412856e-03
  1.23606587e-03 -3.08077838e-02  4.07105647e-02]
Centroid 20: [ 2.26499930e-01  2.69549578e-01  3.29600632e-01 -5.83096556e-02
  8.36726800e-02  2.39801221e-03  1.89173430e-01  1.99818797e-02
  5.53133637e-02  3.39478045e-03  1.70701277e-02 -1.28595636e-03
  1.15610575e-02  9.52786505e-02  1.22641551e-03 -1.64165512e-01
  1.08959228e-01  2.26593927e-01  2.17463121e-01  3.14617646e-04
  2.68709403e-03 -2.33243033e-02  1.38216481e-01]
Centroid 21: [ 6.56391904e-02 -2.96682888e-03 -4.94410917e-02 -5.33793345e-02
 -2.99734995e-03 -8.94266367e-03  1.90676656e-02  1.64380777e-04
  9.11477674e-03 -2.14037579e-02  1.02737807e-02 -1.16342613e-02
  1.00453924e-02 -1.09802438e-02 -1.98827335e-03  7.93150219e-04
 -5.23569249e-02 -1.05233245e-01 -1.08581975e-01  3.32764015e-02
  1.14286639e-01 -8.62685859e-01  2.96998978e-01]
Centroid 22: [ 4.6183015e-03 -8.1110643e-03  1.9734263e-02  2.7232007e-03
 -9.6934624e-03  1.7982854e-02 -8.2404092e-03 -4.3233456e-03
 -1.7074829e-03 -1.6782522e-03  5.7691690e-03 -2.2373546e-03
  5.0880649e-04  8.3220620e-03 -3.6084264e-05  1.1711448e-01
  2.1256997e-01 -2.1485701e-01  8.6628968e-01  3.0893775e-02
 -5.7246324e-02 -1.5856525e-02  1.2922280e-01]
Centroid 23: [-2.8405908e-01 -1.0540072e-01 -3.9886525e-01 -1.7667120e-02
 -6.8363503e-02 -7.4435040e-02 -5.9213165e-02 -1.4150135e-02
 -4.0192652e-02  1.1605669e-02 -3.7071776e-02  2.6551945e-02
  3.6468755e-03 -1.9023424e-01 -3.2687457e-03 -3.2142133e-01
 -2.3935159e-04  3.9103352e-03  1.7276989e-01  9.4189923e-03
  1.2533456e-02  9.0533094e-03  7.2304100e-02]
```

In [ ]:

```
spectral_clustering(
    oe_X_train025,
    cuts=len(np.unique(le_y_train025)),
    fname="one-hot_encoded_spectral_clustering",
    affinity="cosine_similarity",
)
```

```
eigenvalues: [9.9994719e-01 9.9994266e-01 9.9992621e-01 9.9992335e-01 9.9990380e-01
 9.9978840e-01 9.9973905e-01 9.9959689e-01 9.8116517e-01 9.2043281e-01
 8.4043866e-01 6.5609217e-01 4.5745876e-01 2.8215939e-01 1.0206217e-10].
Finished running k-means++
7.0     3030
1.0     2637
0.0     1313
5.0     1111
9.0      660
8.0      649
10.0     645
4.0      559
11.0     494
13.0     348
6.0      264
2.0      259
12.0     216
3.0      110
14.0      55
dtype: int64
Completed iteration 1
1.0     3005
7.0     2643
0.0     1287
5.0      962
10.0     738
8.0      704
9.0      585
11.0     449
4.0      436
6.0      409
13.0     393
2.0      269
12.0     230
14.0     132
3.0      108
dtype: int64
Completed iteration 2
1.0     3171
7.0     2477
0.0     1283
5.0      841
10.0     776
8.0      734
9.0      559
6.0      527
11.0     436
13.0     400
4.0      390
2.0      269
12.0     248
14.0     129
3.0      110
dtype: int64
Completed iteration 3
1.0     3242
7.0     2409
0.0     1286
10.0     808
8.0      753
5.0      748
6.0      619
9.0      541
11.0     431
13.0     397
4.0      353
2.0      269
12.0     258
14.0     126
3.0      110
dtype: int64
Completed iteration 4
1.0     3270
7.0     2381
0.0     1287
10.0     828
8.0      760
6.0      691
5.0      675
9.0      534
11.0     428
13.0     392
4.0      331
12.0     272
2.0      269
14.0     121
```

```
3.0      111
dtype: int64
Completed iteration 5
1.0     3286
7.0     2365
0.0     1287
10.0     853
6.0      762
8.0      760
5.0      603
9.0      534
11.0     426
13.0     388
4.0      307
12.0     279
2.0      268
14.0     117
3.0      115
dtype: int64
Completed iteration 6
1.0     3292
7.0     2358
0.0     1286
6.0      871
10.0     868
8.0      760
9.0      534
5.0      494
11.0     425
13.0     384
4.0      293
12.0     286
2.0      267
3.0      116
14.0     116
dtype: int64
Completed iteration 7
1.0     3296
7.0     2354
0.0     1285
6.0      924
10.0     882
8.0      760
9.0      534
5.0      441
11.0     424
13.0     381
12.0     291
4.0      279
2.0      267
3.0      116
14.0     116
dtype: int64
Completed iteration 8
1.0     3299
7.0     2351
0.0     1285
6.0      931
10.0     895
8.0      760
9.0      534
5.0      434
11.0     423
13.0     374
12.0     301
2.0      266
4.0      265
3.0      116
14.0     116
dtype: int64
Completed iteration 9
1.0     3302
7.0     2348
0.0     1285
6.0      934
10.0     903
8.0      760
9.0      534
5.0      431
11.0     423
13.0     367
12.0     310
2.0      265
4.0      256
3.0      116
14.0     116
```

```
dtype: int64
Completed iteration 10
1.0     3303
7.0     2347
0.0     1285
6.0      934
10.0     911
8.0      760
9.0      534
5.0      431
11.0     422
13.0     364
12.0     310
2.0      265
4.0      250
3.0      118
14.0     116
dtype: int64
Completed iteration 11
1.0     3303
7.0     2347
0.0     1286
6.0      934
10.0     915
8.0      760
9.0      534
5.0      431
11.0     420
13.0     366
12.0     311
2.0      265
4.0      246
3.0      116
14.0     116
dtype: int64
Completed iteration 12
1.0     3303
7.0     2347
0.0     1286
6.0      933
10.0     919
8.0      760
9.0      534
5.0      431
11.0     420
13.0     365
12.0     311
2.0      265
4.0      243
3.0      117
14.0     116
dtype: int64
Completed iteration 13
Epsilon has a maximum value of 0.006616553291678429
Centroids:
Centroid 1: [-6.2946295e-03  4.4715195e-03 -4.7600690e-02  8.1763668e-03
  1.6485753e-04 -3.8211953e-03  3.1468636e-04  1.6866498e-02
 -3.2377699e-01  3.8667914e-01  3.4392062e-03  4.7471166e-02
  6.3458765e-01  2.2645991e-01  3.6816230e-01]
Centroid 2: [ 0.08578718 -0.07445213 -0.02106255  0.0160051   0.01337026  0.00443199
  0.00352194  0.00606316 -0.00952632  0.02912285 -0.16942841  0.04408402
 -0.5759199   0.20094422  0.7591422 ]
Centroid 3: [ 4.2345995e-04 -4.9871118e-03  3.6842369e-02  2.0472301e-02
 -1.6696963e-02 -2.8441340e-01  3.0264290e-04 -1.0377134e-01
  4.5932028e-01 -2.9701692e-01 -1.7413637e-01  6.7201570e-02
  5.5174017e-01  2.3545863e-01  3.5668036e-01]
Centroid 4: [ 0.02494568  0.00824953  0.05004946 -0.00328314 -0.00578149 -0.03978412
  0.0010669   0.22520892 -0.24087657  0.2518489   0.69094086  0.02128222
  0.20590293 -0.01023358  0.23098733]
Centroid 5: [ 0.01552848  0.00929697  0.02972324 -0.01143768  0.00786547 -0.00357137
 -0.00180289 -0.01521215 -0.19878374  0.12743086  0.16037695  0.03176286
  0.1542171  -0.74416095  0.43672177]
Centroid 6: [ 0.05669849 -0.10140963 -0.06268106  0.01608032  0.00749722  0.01455666
  0.01636682 -0.01327647 -0.5897015  -0.53044575  0.08835019  0.05333924
 -0.1940511   0.17044933  0.50648785]
Centroid 7: [-0.00650526 -0.02217546  0.00583717 -0.01478483  0.00250975 -0.02249845
  0.02005777  0.02801256 -0.643324   -0.570308    0.04074023  0.05098585
 -0.1591983   0.15165569  0.4357153 ]
Centroid 8: [-0.13079934  0.10682788  0.05848216 -0.00312155  0.00394873 -0.00639505
  0.01245748  0.00315813 -0.00999901  0.02822383 -0.16766116  0.04351457
 -0.5683006   0.1982889   0.74898916]
Centroid 9: [ 0.01316202  0.00268338  0.04723608  0.02330196 -0.00092361  0.0548218
 -0.00059735  0.01899322  0.5493375  -0.4107742  -0.19090873  0.06896525
  0.5141579   0.22855373  0.3451667 ]
Centroid 10: [-1.4560033e-02 -3.8312571e-03  3.5668172e-02  2.0075427e-02
  8.3866846e-03  1.0426959e-01 -3.2480215e-04 -9.2508998e-03
```

```
  3.9376181e-01 -2.0162715e-01 -1.7362681e-01  7.3614284e-02
  6.6489369e-01  2.7333298e-01  4.1576019e-01]
Centroid 11: [-5.32448106e-03 -2.73928605e-03  1.80657674e-03  1.32518867e-02
  2.14800076e-03 -8.19021836e-03 -3.28771479e-04  2.37878226e-03
 -5.41158095e-02 -1.06023669e-01 -1.12576164e-01  3.41013446e-02
  1.26095340e-01 -8.79577279e-01  2.96814352e-01]
Centroid 12: [-0.01325454 -0.00293114 -0.00187474 -0.01057387  0.00101179 -0.0018198
 -0.00839485 -0.03622477  0.5491521   0.6634366  -0.14970274 -0.01024498
 -0.303908   -0.07337422  0.2531887 ]
Centroid 13: [-0.00280062  0.00991639 -0.0477018  -0.01333514 -0.0040251   0.01397328
 -0.00799119  0.04987062  0.34243008 -0.08285818  0.63179404  0.02463941
 -0.09754565 -0.20806445  0.22167529]
Centroid 14: [-0.03719118 -0.00643112  0.02247997 -0.00297054 -0.00137054  0.04733222
  0.0046488  -0.00634706  0.17588441  0.5066886   0.6302385   0.00706579
  0.13471796 -0.19502564  0.32729128]
Centroid 15: [ 7.34502263e-03  5.29413205e-03 -4.13188571e-03 -9.18349833e-04
  4.56091308e-04  6.51699957e-04  3.39425693e-04 -8.81360658e-03
  4.35113348e-03 -2.87750876e-03  1.16832992e-02 -9.17798817e-01
  4.07196656e-02 -3.08265304e-03  1.06642224e-01]
```

laplacian (gamma=1.0)

In [ ]:
```
spectral_clustering(
    oe_X_train025,
    cuts=23,
    fname="one-hot_encoded_spectral_clustering",
    affinity="laplacian",
    gamma=1.0,
)
```

```
eigenvalues: [1.12852871e-18 8.21319469e-19 4.90265193e-19 4.74683953e-19
 4.60184149e-19 3.18746734e-19 2.24813577e-19 1.67495776e-19
 1.52659090e-19 1.11929066e-19 1.00266142e-19 8.85960261e-20
 6.37222592e-20 4.53983313e-20 2.37740626e-20 1.95223769e-20
 1.60770751e-21 2.03856476e-22 9.69919692e-23 3.62433560e-23
 1.29987924e-23 3.75149594e-37 0.00000000e+00].
Finished running k-means++
0.0     3889
3.0     2911
9.0      470
8.0      458
11.0     451
22.0     415
18.0     384
7.0      315
4.0      295
10.0     266
21.0     261
12.0     261
6.0      227
14.0     214
19.0     211
2.0      210
16.0     204
20.0     203
1.0      179
17.0     173
5.0      167
15.0     151
13.0      35
dtype: int64
Completed iteration 1
0.0     3510
3.0     2775
8.0      471
9.0      454
22.0     447
11.0     438
7.0      368
18.0     347
4.0      315
10.0     290
2.0      287
12.0     287
21.0     286
14.0     285
5.0      267
16.0     239
19.0     239
1.0      231
17.0     209
6.0      207
20.0     194
15.0     177
13.0      27
dtype: int64
Completed iteration 2
0.0     3478
3.0     2762
8.0      479
22.0     454
11.0     433
9.0      422
7.0      346
18.0     344
14.0     324
2.0      306
12.0     305
5.0      290
4.0      290
10.0     282
21.0     279
1.0      239
17.0     238
19.0     238
6.0      232
15.0     209
16.0     190
20.0     184
13.0      26
dtype: int64
Completed iteration 3
0.0     3465
3.0     2748
8.0      470
22.0     458
11.0     455
9.0      406
7.0      349
18.0     341
14.0     321
2.0      312
5.0      309
12.0     308
4.0      294
21.0     276
10.0     271
17.0     257
1.0      246
6.0      243
19.0     235
15.0     232
20.0     180
16.0     148
13.0      26
dtype: int64
Completed iteration 4
0.0     3466
3.0     2746
11.0     467
22.0     460
8.0      460
9.0      408
7.0      357
18.0     345
14.0     321
12.0     311
2.0      301
5.0      288
10.0     276
4.0      275
21.0     275
6.0      262
17.0     258
15.0     254
1.0      251
19.0     236
20.0     178
16.0     129
13.0      26
dtype: int64
Completed iteration 5
0.0     3464
3.0     2746
11.0     470
8.0      462
22.0     459
9.0      415
7.0      358
18.0     353
14.0     322
12.0     314
2.0      297
5.0      282
21.0     268
6.0      267
4.0      265
10.0     262
15.0     262
17.0     261
1.0      256
19.0     241
20.0     179
16.0     121
13.0      26
dtype: int64
Completed iteration 6
0.0     3465
3.0     2742
11.0     479
8.0      473
22.0     455
9.0      418
7.0      353
18.0     342
12.0     318
14.0     315
2.0      290
5.0      282
10.0     272
15.0     269
6.0      263
17.0     263
1.0      261
21.0     260
4.0      255
19.0     248
20.0     180
16.0     121
13.0      26
dtype: int64
Completed iteration 7
0.0     3462
3.0     2742
11.0     486
8.0      467
22.0     461
9.0      409
7.0      355
18.0     328
12.0     317
14.0     315
2.0      294
5.0      279
15.0     277
1.0      274
10.0     274
17.0     272
6.0      260
4.0      254
19.0     249
21.0     249
20.0     180
16.0     120
13.0      26
dtype: int64
Completed iteration 8
0.0     3461
3.0     2738
11.0     488
8.0      472
22.0     458
9.0      406
7.0      353
12.0     325
18.0     323
14.0     313
2.0      295
15.0     290
17.0     282
5.0      278
1.0      275
10.0     271
6.0      259
21.0     246
4.0      245
19.0     245
20.0     181
16.0     120
13.0      26
dtype: int64
Completed iteration 9
0.0     3461
3.0     2734
11.0     478
22.0     475
8.0      464
9.0      409
7.0      351
12.0     329
14.0     317
18.0     312
2.0      297
15.0     295
1.0      283
10.0     276
5.0      276
17.0     275
6.0      259
4.0      245
19.0     243
21.0     243
20.0     181
16.0     121
13.0      26
dtype: int64
Completed iteration 10
0.0     3458
3.0     2732
22.0     492
11.0     476
8.0      455
9.0      406
7.0      353
12.0     332
14.0     316
18.0     302
2.0      302
1.0      295
15.0     293
10.0     280
17.0     278
5.0      275
6.0      252
4.0      244
19.0     241
21.0     240
20.0     181
16.0     121
13.0      26
dtype: int64
Completed iteration 11
0.0     3454
3.0     2731
22.0     507
11.0     475
8.0      452
9.0      406
7.0      354
12.0     331
14.0     317
2.0      303
15.0     297
1.0      291
18.0     290
10.0     281
5.0      276
17.0     276
6.0      254
4.0      247
19.0     240
21.0     239
20.0     182
16.0     121
13.0      26
dtype: int64
Completed iteration 12
0.0     3452
3.0     2727
22.0     505
11.0     476
8.0      445
9.0      409
7.0      356
12.0     330
14.0     311
2.0      305
1.0      298
15.0     294
18.0     294
10.0     284
5.0      273
17.0     272
6.0      256
19.0     249
4.0      248
21.0     237
20.0     182
16.0     121
13.0      26
dtype: int64
Completed iteration 13
0.0     3451
3.0     2724
22.0     515
11.0     480
8.0      445
9.0      408
7.0      355
12.0     328
14.0     313
2.0      311
18.0     296
1.0      294
15.0     289
10.0     279
5.0      270
17.0     270
6.0      255
19.0     254
4.0      247
21.0     237
20.0     182
16.0     121
13.0      26
dtype: int64
Completed iteration 14
0.0     3450
3.0     2723
22.0     511
11.0     478
8.0      451
9.0      413
7.0      354
12.0     328
14.0     316
2.0      316
18.0     298
15.0     292
1.0      287
10.0     275
5.0      270
17.0     268
19.0     259
6.0      251
4.0      249
21.0     231
20.0     183
16.0     121
13.0      26
dtype: int64
Completed iteration 15
0.0     3449
3.0     2721
22.0     505
11.0     479
8.0      461
9.0      411
7.0      349
12.0     325
2.0      322
14.0     318
18.0     297
15.0     290
1.0      289
10.0     276
5.0      269
17.0     269
19.0     261
6.0      250
4.0      249
21.0     230
20.0     183
16.0     121
13.0      26
dtype: int64
Completed iteration 16
0.0     3447
3.0     2721
22.0     511
11.0     477
8.0      463
9.0      413
7.0      346
2.0      327
12.0     323
14.0     314
15.0     297
18.0     294
1.0      287
10.0     271
17.0     269
5.0      268
19.0     267
4.0      251
6.0      247
21.0     227
20.0     183
16.0     121
13.0      26
dtype: int64
Completed iteration 17
0.0     3447
3.0     2722
22.0     514
11.0     475
8.0      463
9.0      413
7.0      342
2.0      328
12.0     324
14.0     316
15.0     308
1.0      286
18.0     286
10.0     268
5.0      267
19.0     267
17.0     265
4.0      252
6.0      249
21.0     228
20.0     183
16.0     121
13.0      26
dtype: int64
Completed iteration 18
0.0     3448
3.0     2721
22.0     513
11.0     478
8.0      468
9.0      413
7.0      336
2.0      331
12.0     326
14.0     313
15.0     311
1.0      282
18.0     281
10.0     271
19.0     266
17.0     265
5.0      262
4.0      255
6.0      251
21.0     229
20.0     183
16.0     121
13.0      26
dtype: int64
Completed iteration 19
0.0     3448
3.0     2721
22.0     517
11.0     479
8.0      466
9.0      412
2.0      337
7.0      335
12.0     324
14.0     312
15.0     310
1.0      282
18.0     280
17.0     273
10.0     269
19.0     269
4.0      258
5.0      255
6.0      243
21.0     230
20.0     183
16.0     121
13.0      26
dtype: int64
Completed iteration 20
0.0     3448
3.0     2720
22.0     518
11.0     478
8.0      464
9.0      411
2.0      343
7.0      337
12.0     326
14.0     314
15.0     307
1.0      283
18.0     275
19.0     275
10.0     273
17.0     268
4.0      256
5.0      254
6.0      242
21.0     228
20.0     183
16.0     121
13.0      26
dtype: int64
Completed iteration 21
Reached 21 iterations
Centroids:
Centroid 1: [ 2.0810931e-04 -2.5771419e-04 -4.1669191e-04 -2.0966068e-05
  1.6172914e-02 -2.1362974e-01  9.3950564e-04 -9.2779362e-01
 -2.2095545e-04  1.5092766e-04 -3.6278582e-04 -1.8896331e-04
 -4.3879329e-05 -1.4566650e-04  1.4238765e-04  2.9856653e-04
  6.1467191e-04 -1.5442545e-04  7.1307688e-05  1.7650086e-04
 -2.6372913e-04  3.5029009e-04  1.1469619e-04]
Centroid 2: [-0.00215189  0.08048998  0.18991476 -0.0341639  -0.01570984  0.0075185
  0.06153767  0.25698233  0.01469071  0.09252875  0.00040143 -0.13080552
 -0.01151762  0.00605795 -0.02499271  0.03878025  0.10458526  0.1132962
  0.01821636 -0.05028006 -0.13112587  0.24105425  0.01164649]
Centroid 3: [-0.01452025 -0.02984623 -0.15624288 -0.04829036  0.00792962 -0.01091558
 -0.00819828  0.24001692  0.15628655 -0.07649414 -0.02514199  0.24764577
  0.00316315  0.03423768 -0.05426337 -0.03800095  0.06652099  0.08586059
 -0.04018806 -0.03314348  0.00200932 -0.12753974 -0.01624285]
Centroid 4: [-1.8063713e-04  3.8487249e-04 -3.7855440e-05 -7.0387861e-05
  1.5730896e-03  1.0039569e-01 -2.7437203e-04  9.6571994e-01
 -5.5440824e-04  5.0565694e-04  5.4938032e-04  2.4120205e-04
 -3.6167118e-04  1.9987080e-04  4.9711735e-04  3.5471845e-04
 -1.2743407e-03  1.9651113e-04  2.6852870e-04  2.6523876e-05
 -7.1075019e-06 -3.5497252e-04  1.2318966e-04]
Centroid 5: [-0.06552842 -0.08140348  0.2238534  -0.04073731  0.0150909   0.01342925
  0.02317958 -0.16047576  0.02284926  0.02984252 -0.05031223 -0.13078979
 -0.00141961  0.00198656 -0.12995708 -0.08676885  0.06447145 -0.0096882
  0.00924033  0.18383329 -0.02786272 -0.1693484  -0.00144054]
Centroid 6: [ 0.03875311  0.02492944  0.10989853  0.06785952  0.01182659  0.01538793
  0.03499783 -0.13825418  0.06385414 -0.13007699 -0.00577669  0.16580367
 -0.00104041  0.01748356  0.22311774  0.0310641  -0.07959506 -0.10309098
 -0.01644886 -0.11717419  0.13963036 -0.05340349 -0.03676731]
Centroid 7: [-0.02428242  0.02523195 -0.02548617  0.01450553 -0.02157254  0.00533279
 -0.02933576 -0.10784613 -0.02226284  0.02759817  0.00514896 -0.09201729
 -0.0084434   0.06433875  0.08521777 -0.02422709  0.43543407 -0.04388664
  0.01665152 -0.10941427  0.04330755  0.02323511  0.00515194]
Centroid 8: [ 1.3728751e-04  7.5688057e-02 -2.3127607e-01 -2.8528819e-02
 -1.7796526e-02  1.9651212e-02  3.6348406e-02 -2.1107209e-01
  9.7420318e-03 -7.3370285e-02 -1.8932128e-02  3.2999337e-01
  7.4663926e-03 -1.8979069e-02 -3.2048132e-02  4.2419997e-03
 -2.8771903e-02  5.2875407e-02 -6.0700802e-03  5.1275235e-02
 -4.7094252e-02  2.0986098e-01  1.0284747e-02]
Centroid 9: [-0.00868018 -0.02495448 -0.1118535   0.01409657  0.01012326  0.00665388
 -0.02683152  0.16726658  0.01508211 -0.04530147 -0.01217588  0.10841615
 -0.00114909  0.02757377  0.03722243  0.00163654  0.01348044 -0.02128343
 -0.00520406  0.01283974  0.03593611  0.57568496  0.00915787]
Centroid 10: [-1.5523572e-02  1.8895227e-02 -1.6115431e-01  2.2503160e-02
  5.6486300e-05 -1.5151246e-02 -1.0865425e-02 -7.5728185e-02
 -2.9097425e-02 -4.1344427e-02 -1.0465671e-03  2.1847722e-01
 -2.0099664e-03 -2.6561432e-02 -9.4377929e-03  1.5059510e-02
 -4.0198624e-02 -1.9134881e-02 -1.7104569e-04  2.5707880e-02
 -3.2404017e-02 -5.5598521e-01  1.9772828e-03]
Centroid 11: [ 0.02419359  0.028321    0.02264819 -0.19040665 -0.01415247 -0.00452319
 -0.00526636 -0.06717964 -0.07468174 -0.05161906  0.01655903 -0.06539973
 -0.00796023 -0.01116963  0.05107486  0.04160088 -0.02113732  0.35772336
 -0.01992811  0.02319571  0.03861674 -0.22060445  0.04943648]
Centroid 12: [ 0.01090504  0.00508379  0.03732958 -0.01752383 -0.00633388 -0.00713023
  0.01495995  0.14593218 -0.01500585 -0.00136196  0.00531319 -0.08354613
 -0.00519677  0.0058463   0.01137679 -0.01456175  0.12441611  0.00907619
  0.00929208 -0.00152276  0.01218954 -0.61100197  0.00349509]
Centroid 13: [ 0.01552201 -0.01016299  0.10674673  0.04380187 -0.01078498  0.00345678
 -0.01106469 -0.14470193  0.00400919  0.07877836  0.01084909 -0.11844631
 -0.00277451 -0.00511873  0.01429042  0.02471871 -0.21369861 -0.04022953
  0.00893328 -0.08270984 -0.05862573 -0.47242638 -0.00377872]
Centroid 14: [-1.3405595e-03 -1.9092201e-03  7.0176125e-03  4.0106680e-03
 -4.6908692e-03 -3.3636403e-03 -7.2832877e-04  8.7700430e-03
  6.7970306e-03 -6.5929769e-03  6.9634696e-03  4.7828355e-03
 -9.8321521e-01  5.9754071e-03 -6.1535188e-03  2.0294279e-02
 -5.2851993e-03 -3.6572863e-03 -7.8812586e-03 -4.6072719e-03
  6.1152200e-04 -6.8142037e-03 -3.1547691e-03]
Centroid 15: [ 0.03084064  0.07774689  0.14718159  0.05469964  0.00200861 -0.02859944
  0.02352311  0.14894247  0.00989933  0.05543815  0.00956417 -0.34018844
  0.00478201 -0.01704805  0.01471712  0.0209265   0.02225447 -0.20811585
 -0.00854806  0.09468667  0.07825992 -0.10541323  0.01330571]
Centroid 16: [ 0.03342297 -0.01131485  0.00419943  0.00999227  0.07216616  0.01327325
  0.1268507   0.07113104 -0.22804362 -0.03044282  0.03072811  0.05447746
  0.09245108 -0.10092172 -0.00712836  0.03236868  0.01194356 -0.07267912
  0.02862416  0.05938123 -0.0063223   0.03787831  0.00929716]
Centroid 17: [ 3.6630898e-03 -8.0644786e-03 -7.5669861e-03  4.9573649e-05
  7.3812053e-02 -8.5564619e-01 -3.0362743e-03 -3.7437722e-02
  3.5351636e-03  6.6492949e-03 -6.6918335e-03  1.2086737e-03
  2.1649965e-03  8.4083304e-03 -1.1329402e-02 -1.1482188e-03
  2.2056943e-03 -3.2415318e-03  4.5422628e-03 -1.2910354e-03
 -1.0137765e-02 -4.1553155e-03  3.8539947e-04]
Centroid 18: [-0.007571   -0.34230638 -0.15431656  0.05771057 -0.09681659 -0.01426304
  0.00481722 -0.0440957   0.03708153  0.04096106  0.01205027 -0.06994268
  0.00184642  0.10191551  0.01932803 -0.02334484 -0.00581642 -0.05209623
  0.01153634 -0.00082454  0.01963509  0.00556549 -0.00650959]
Centroid 19: [ 0.0018689  -0.03375316  0.08695054 -0.03930486  0.00313327  0.00227094
 -0.00541917  0.03180893  0.03859086  0.02423314  0.01297077 -0.13468768
  0.00049486  0.01383861  0.04272125 -0.01162464 -0.41685116  0.09754649
  0.00088036  0.0627915  -0.00490179  0.25906792  0.00192136]
Centroid 20: [ 0.00426591 -0.02900773  0.05357153  0.17998794 -0.01849179  0.00541657
 -0.0477204  -0.06296394  0.01071936  0.04938981 -0.00537744  0.09272543
 -0.00377606  0.01662671 -0.20515952 -0.0433296  -0.08253968 -0.21676363
 -0.01157675 -0.16886239 -0.03328411  0.21175274 -0.00226596]
Centroid 21: [-1.4683573e-03 -1.0515603e-02 -1.2046794e-03 -1.8105303e-03
  1.1732039e-02  7.4939471e-01 -1.9941793e-03 -3.6754766e-01
 -5.5828933e-03  6.3405936e-03 -1.1925577e-02 -8.6144805e-03
 -1.8833558e-03 -3.1550229e-04  1.3782934e-03  4.3417080e-03
  3.3948657e-03  6.7420493e-05  3.1203392e-03  1.4075728e-03
  1.4973379e-03 -4.9684108e-03 -1.2753019e-03]
Centroid 22: [-0.0417612   0.27746367 -0.12337372  0.02337248  0.04219235 -0.02229424
 -0.31271732  0.05984326  0.00470293 -0.01091872 -0.00973863 -0.06077867
  0.00349153 -0.03350091 -0.0012692   0.00392547 -0.06751644  0.00568743
 -0.00563127  0.02758324 -0.01636257  0.04222904 -0.02078497]
Centroid 23: [-1.53136242e-03 -1.65007655e-02  7.93820620e-02 -3.58178727e-02
  9.16936668e-04  2.17807153e-03  6.31350884e-03 -1.75909251e-01
 -1.33932350e-04  2.81045586e-02  9.69470479e-03 -1.07603721e-01
  3.01661342e-03 -1.48161575e-02  1.86861604e-02 -3.39939166e-03
  4.68162186e-02  3.51738147e-02  5.16028376e-04 -9.45491157e-03
 -1.66036305e-03  5.83635628e-01 -1.29757607e-02]
```

In [ ]:
```
spectral_clustering(
    oe_X_train025,
    cuts=len(np.unique(le_y_train025)),
    fname="one-hot_encoded_spectral_clustering",
    affinity="laplacian",
    gamma=1.0,
)
```

```
eigenvalues: [1.52659090e-19 1.11929066e-19 1.00266142e-19 8.85960261e-20
 6.37222592e-20 4.53983313e-20 2.37740626e-20 1.95223769e-20
 1.60770751e-21 2.03856476e-22 9.69919692e-23 3.62433560e-23
 1.29987924e-23 3.75149594e-37 0.00000000e+00].
Finished running k-means++
7.0     1779
10.0    1495
12.0    1182
9.0      882
11.0     879
0.0      835
4.0      785
1.0      685
13.0     633
2.0      626
3.0      618
6.0      595
14.0     533
8.0      433
5.0      390
dtype: int64
Completed iteration 1
10.0    1487
12.0    1316
7.0     1283
4.0      827
1.0      769
0.0      762
3.0      757
9.0      757
13.0     730
11.0     727
6.0      671
2.0      641
14.0     635
8.0      524
5.0      464
dtype: int64
Completed iteration 2
10.0    1554
12.0    1329
7.0     1137
3.0      831
1.0      807
0.0      781
13.0     766
9.0      750
4.0      738
6.0      690
14.0     668
2.0      650
8.0      572
11.0     571
5.0      506
dtype: int64
Completed iteration 3
10.0    1577
12.0    1303
7.0     1087
3.0      879
1.0      827
0.0      810
13.0     795
9.0      747
14.0     721
6.0      716
2.0      666
8.0      597
5.0      571
4.0      564
11.0     490
dtype: int64
Completed iteration 4
10.0    1597
12.0    1273
7.0     1085
3.0      865
0.0      841
1.0      820
13.0     797
14.0     748
6.0      740
9.0      740
2.0      666
8.0      618
5.0      615
```

```
4.0      486
11.0     459
dtype: int64
Completed iteration 5
10.0    1597
12.0    1261
7.0     1087
0.0      861
3.0      844
1.0      825
13.0     775
14.0     764
6.0      745
9.0      740
2.0      671
5.0      633
8.0      632
4.0      462
11.0     453
dtype: int64
Completed iteration 6
10.0    1567
12.0    1249
7.0     1098
0.0      906
3.0      823
1.0      812
14.0     788
13.0     765
6.0      759
9.0      712
2.0      687
8.0      642
5.0      637
4.0      455
11.0     450
dtype: int64
Completed iteration 7
10.0    1531
12.0    1251
7.0     1111
0.0      949
3.0      810
1.0      809
14.0     786
6.0      773
13.0     756
9.0      701
2.0      696
8.0      645
5.0      633
4.0      452
11.0     447
dtype: int64
Completed iteration 8
10.0    1505
12.0    1257
7.0     1103
0.0      963
1.0      803
14.0     800
3.0      792
6.0      792
13.0     748
2.0      709
9.0      690
8.0      655
5.0      638
4.0      450
11.0     445
dtype: int64
Completed iteration 9
10.0    1491
12.0    1257
7.0     1100
0.0      976
6.0      809
14.0     804
1.0      796
3.0      768
13.0     747
2.0      730
9.0      676
8.0      662
5.0      643
4.0      447
```

```
11.0     444
dtype: int64
Completed iteration 10
10.0    1495
12.0    1263
7.0     1091
0.0      982
6.0      816
14.0     803
1.0      792
3.0      747
13.0     744
2.0      733
9.0      670
8.0      665
5.0      660
4.0      446
11.0     443
dtype: int64
Completed iteration 11
10.0    1492
12.0    1268
7.0     1090
0.0      989
6.0      822
14.0     810
1.0      796
2.0      749
13.0     741
3.0      719
8.0      673
5.0      665
9.0      648
4.0      447
11.0     441
dtype: int64
Completed iteration 12
10.0    1482
12.0    1288
7.0     1068
0.0      993
6.0      818
14.0     812
1.0      789
2.0      760
13.0     752
3.0      703
8.0      693
5.0      674
9.0      627
4.0      448
11.0     443
dtype: int64
Completed iteration 13
10.0    1475
12.0    1299
7.0     1064
0.0     1008
6.0      820
14.0     806
2.0      775
1.0      770
13.0     761
8.0      698
5.0      681
3.0      679
9.0      619
4.0      450
11.0     445
dtype: int64
Completed iteration 14
10.0    1469
12.0    1296
7.0     1060
0.0     1025
6.0      832
14.0     804
2.0      784
13.0     779
1.0      760
8.0      704
5.0      674
3.0      667
9.0      599
4.0      452
11.0     445
```

```
dtype: int64
Completed iteration 15
10.0    1460
12.0    1300
7.0     1057
0.0     1040
6.0      830
2.0      799
13.0     797
14.0     795
1.0      748
8.0      716
5.0      668
3.0      659
9.0      584
4.0      451
11.0     446
dtype: int64
Completed iteration 16
10.0    1458
12.0    1308
7.0     1056
0.0     1037
6.0      828
13.0     810
2.0      805
14.0     781
1.0      749
8.0      726
5.0      663
3.0      658
9.0      572
4.0      451
11.0     448
dtype: int64
Completed iteration 17
10.0    1462
12.0    1312
7.0     1052
0.0     1035
6.0      841
13.0     811
2.0      806
14.0     778
1.0      749
8.0      726
5.0      662
3.0      650
9.0      571
4.0      451
11.0     444
dtype: int64
Completed iteration 18
10.0    1476
12.0    1315
7.0     1047
0.0     1030
6.0      845
13.0     812
2.0      809
14.0     782
8.0      741
1.0      734
5.0      662
3.0      638
9.0      568
4.0      450
11.0     441
dtype: int64
Completed iteration 19
10.0    1483
12.0    1317
7.0     1051
0.0     1020
6.0      844
13.0     821
2.0      817
14.0     782
8.0      751
1.0      730
5.0      660
3.0      632
9.0      553
4.0      449
11.0     440
dtype: int64
```

```
Completed iteration 20
10.0    1476
12.0    1322
7.0     1049
0.0     1017
6.0      847
13.0     827
2.0      819
14.0     777
8.0      754
1.0      720
5.0      662
3.0      636
9.0      557
4.0      449
11.0     438
dtype: int64
Completed iteration 21
Reached 21 iterations
Centroids:
Centroid 1: [-1.1996777e-02  8.8743359e-02  1.7209219e-02 -3.6733511e-01
  1.0901358e-03  1.4840868e-02  2.8044190e-02  2.0310318e-02
 -8.7518252e-02  6.2270828e-02  2.6114441e-03  1.8912127e-02
  3.1554917e-04  5.0812399e-01  4.8394427e-03]
Centroid 2: [ 0.03982073  0.31300953  0.01198486 -0.13708983  0.00037584 -0.01851973
 -0.02744839  0.00614659  0.04561046 -0.04635058 -0.00531597  0.04109412
 -0.3749494  -0.01085404 -0.00666544]
Centroid 3: [ 0.02432948 -0.04359546 -0.01023989  0.25175464  0.00281973  0.00454077
  0.05470612  0.00641644 -0.4498238  -0.00336676  0.00554398  0.03806233
 -0.01903     0.25408614 -0.00212442]
Centroid 4: [ 0.49074745 -0.02774421 -0.03280019  0.04262779 -0.04605103 -0.01412565
 -0.13077572  0.02515771  0.00642384 -0.08835337  0.01573244 -0.06282829
  0.01773809  0.00908906 -0.00751019]
Centroid 5: [-1.5825260e-02  2.8830552e-02 -8.4459490e-01  1.9817652e-02
 -2.4091643e-03 -5.5395458e-03  4.6390150e-04  1.8840663e-02
 -7.2921291e-03 -4.1473052e-03 -5.4206522e-03  4.5475349e-04
  6.7966944e-03  1.0298374e-02 -7.5936678e-04]
Centroid 6: [ 0.04247471  0.03079061  0.0056716  -0.02765355 -0.00720979  0.09664632
  0.1338148   0.04316938  0.0386453   0.36680236 -0.0087334  -0.20726265
 -0.03533225 -0.0978068  -0.00191392]
Centroid 7: [-0.02475514  0.03974887  0.01259808 -0.15422277  0.00207401  0.0063767
  0.03479898  0.03105911 -0.36934096 -0.11091201 -0.00118418  0.06718186
  0.00212452 -0.44476494 -0.00597812]
Centroid 8: [-0.00283435 -0.09494688 -0.02243136  0.36798328  0.00216779 -0.00287737
  0.02695067 -0.01184075  0.0413467  -0.04857041  0.00131244 -0.0272432
 -0.00202084 -0.5035769  -0.0109759 ]
Centroid 9: [-0.01370198 -0.31867594  0.00065403 -0.02130214 -0.00381034 -0.06858423
 -0.06089724 -0.03623592 -0.05837583  0.05206131 -0.02354495  0.13752107
  0.28674594  0.01025153  0.00806554]
Centroid 10: [-0.5721465   0.02622003  0.00925508  0.05873947  0.00330362 -0.01051088
  0.00071004  0.02190016 -0.05447514 -0.02507305  0.01781349  0.02876393
 -0.03940321  0.06194107 -0.00158892]
Centroid 11: [-3.4976741e-03 -2.5730444e-02 -7.0776856e-03  8.2886003e-02
 -2.4316821e-04  3.5275202e-03  6.1655100e-03 -6.4004716e-03
  5.3504810e-02 -3.8154546e-02  1.9325006e-03 -2.0038810e-02
  1.1808213e-02  7.0662916e-01 -3.6214935e-03]
Centroid 12: [ 4.5774342e-03 -2.2270404e-02  8.3514410e-01 -9.2935320e-03
 -1.7523034e-04  1.7641682e-02  7.7527692e-03  5.0932867e-03
  4.6150116e-03 -1.0233945e-02  1.1606205e-02  5.8011683e-03
  1.0754661e-02 -4.9077551e-04  5.5151591e-03]
Centroid 13: [-0.00999466  0.02320632  0.00295999 -0.12307049 -0.00097144  0.00228816
 -0.0254208  -0.0055273   0.12185199  0.05426303  0.00211997  0.02395101
 -0.00206648 -0.6923187   0.00824421]
Centroid 14: [-0.04292586  0.01253261  0.01184144 -0.30578315  0.03171017  0.01712612
  0.02818787 -0.0268112   0.31290546 -0.2229788   0.00754656 -0.06288393
  0.1358822  -0.05967587  0.01178841]
Centroid 15: [ 0.04739321 -0.08124045 -0.00612255  0.37329027  0.00070727  0.0231532
 -0.03199393 -0.00684755  0.34848797  0.03757417 -0.00622292  0.03447136
 -0.02388413  0.21129192  0.00297442]
```

linear

In [ ]:

```
spectral_clustering(
    oe_X_train025,
    cuts=23,
    fname="one-hot_encoded_spectral_clustering",
    affinity="linear",
)
```

```
eigenvalues: [9.9988496e-01 9.9988317e-01 9.9986494e-01 9.9985027e-01 9.9984276e-01
 9.9983692e-01 9.9982095e-01 9.9980044e-01 9.9977779e-01 9.9972880e-01
 9.9965966e-01 9.9958605e-01 9.9956065e-01 9.9953741e-01 9.9930644e-01
 9.9900270e-01 9.9766284e-01 9.7574848e-01 9.6557194e-01 8.1612897e-01
 3.7445694e-01 9.3548057e-05 1.8744102e-11].
Finished running k-means++
10.0    3597
1.0     2035
4.0     1362
2.0      801
5.0      723
0.0      595
8.0      546
16.0     348
20.0     287
6.0      285
15.0     262
13.0     233
21.0     222
11.0     198
12.0     159
3.0      141
17.0     140
7.0      112
9.0      107
14.0      71
22.0      64
18.0      35
19.0      27
dtype: int64
Completed iteration 1
10.0    2943
1.0     2689
4.0     1349
2.0      811
5.0      709
0.0      579
8.0      568
20.0     316
6.0      298
16.0     283
15.0     229
13.0     226
21.0     212
7.0      160
12.0     152
11.0     147
17.0     135
3.0      134
9.0      107
14.0      98
18.0      76
22.0      75
19.0      54
dtype: int64
Completed iteration 2
1.0     2926
10.0    2706
4.0     1349
2.0      811
5.0      710
8.0      581
0.0      560
20.0     331
6.0      309
16.0     250
13.0     244
15.0     206
21.0     184
7.0      167
12.0     144
17.0     135
3.0      128
18.0     118
9.0      108
11.0     104
19.0     103
14.0     101
22.0      75
dtype: int64
Completed iteration 3
1.0     3059
10.0    2573
4.0     1349
2.0      813
5.0      708
```

```
8.0      588
0.0      542
20.0     330
6.0      327
16.0     234
13.0     232
15.0     193
21.0     175
7.0      169
12.0     152
17.0     135
3.0      131
18.0     123
19.0     122
14.0     110
9.0      108
11.0     102
22.0      75
dtype: int64
Completed iteration 4
1.0     3139
10.0    2493
4.0     1349
2.0      816
5.0      703
8.0      595
0.0      530
6.0      351
20.0     322
16.0     221
13.0     218
15.0     188
21.0     174
7.0      172
12.0     161
3.0      135
17.0     135
18.0     126
19.0     118
14.0     112
11.0     109
9.0      108
22.0      75
dtype: int64
Completed iteration 5
1.0     3183
10.0    2449
4.0     1349
2.0      816
5.0      702
8.0      600
0.0      525
6.0      371
20.0     314
16.0     215
13.0     207
15.0     187
7.0      176
21.0     165
12.0     165
3.0      145
17.0     135
18.0     133
14.0     111
11.0     110
19.0     109
9.0      108
22.0      75
dtype: int64
Completed iteration 6
1.0     3207
10.0    2425
4.0     1349
2.0      809
5.0      709
8.0      601
0.0      523
6.0      381
20.0     305
16.0     213
13.0     204
15.0     189
12.0     176
7.0      174
21.0     158
3.0      148
```

```
17.0     135
18.0     129
14.0     115
11.0     112
9.0      108
19.0     105
22.0      75
dtype: int64
Completed iteration 7
1.0     3227
10.0    2405
4.0     1349
2.0      807
5.0      710
8.0      602
0.0      523
6.0      389
20.0     300
16.0     212
15.0     194
13.0     192
7.0      177
12.0     170
21.0     161
3.0      150
17.0     135
18.0     127
14.0     120
11.0     116
9.0      108
19.0     101
22.0      75
dtype: int64
Completed iteration 8
1.0     3235
10.0    2397
4.0     1349
2.0      805
5.0      712
8.0      602
0.0      524
6.0      398
20.0     298
16.0     209
15.0     195
13.0     183
7.0      177
12.0     165
21.0     164
3.0      151
17.0     135
14.0     124
18.0     124
11.0     117
9.0      108
19.0     103
22.0      75
dtype: int64
Completed iteration 9
1.0     3239
10.0    2393
4.0     1349
2.0      804
5.0      713
8.0      602
0.0      525
6.0      400
20.0     297
16.0     210
15.0     204
13.0     180
7.0      171
12.0     167
21.0     165
3.0      151
17.0     135
14.0     123
18.0     119
11.0     117
9.0      108
19.0     103
22.0      75
dtype: int64
Completed iteration 10
1.0     3240
10.0    2392
```

```
4.0     1349
2.0      803
5.0      714
8.0      602
0.0      525
6.0      402
20.0     297
16.0     210
15.0     201
13.0     181
12.0     168
21.0     167
7.0      167
3.0      151
17.0     135
14.0     126
11.0     117
18.0     115
9.0      108
19.0     105
22.0      75
dtype: int64
Completed iteration 11
1.0     3240
10.0    2392
4.0     1349
2.0      803
5.0      714
8.0      602
0.0      525
6.0      402
20.0     296
16.0     210
15.0     202
13.0     181
12.0     170
21.0     167
7.0      161
3.0      151
17.0     135
14.0     133
11.0     117
18.0     111
9.0      108
19.0     106
22.0      75
dtype: int64
Completed iteration 12
1.0     3240
10.0    2392
4.0     1349
2.0      803
5.0      714
8.0      602
0.0      525
6.0      401
20.0     295
16.0     210
15.0     199
13.0     182
12.0     172
21.0     167
7.0      156
3.0      153
14.0     141
17.0     135
11.0     117
19.0     108
9.0      108
18.0     106
22.0      75
dtype: int64
Completed iteration 13
1.0     3240
10.0    2392
4.0     1349
2.0      803
5.0      714
8.0      602
0.0      525
6.0      401
20.0     294
16.0     211
15.0     196
13.0     182
12.0     173
```

```
21.0     169
3.0      152
14.0     151
7.0      149
17.0     135
11.0     117
19.0     110
9.0      108
18.0     102
22.0      75
dtype: int64
Completed iteration 14
1.0     3240
10.0    2392
4.0     1349
2.0      803
5.0      714
8.0      602
0.0      525
6.0      400
20.0     294
16.0     210
15.0     204
13.0     182
12.0     173
21.0     169
14.0     161
3.0      151
7.0      137
17.0     135
11.0     117
19.0     110
9.0      108
18.0      99
22.0      75
dtype: int64
Completed iteration 15
1.0     3240
10.0    2392
4.0     1349
2.0      803
5.0      714
8.0      602
0.0      525
6.0      397
20.0     294
15.0     210
16.0     207
13.0     181
21.0     175
12.0     173
14.0     172
3.0      151
17.0     135
7.0      123
11.0     117
19.0     111
9.0      108
18.0      96
22.0      75
dtype: int64
Completed iteration 16
1.0     3240
10.0    2392
4.0     1349
2.0      803
5.0      714
8.0      602
0.0      525
6.0      397
20.0     294
15.0     211
16.0     205
14.0     186
13.0     181
21.0     173
12.0     169
3.0      150
17.0     135
11.0     117
19.0     115
7.0      115
9.0      108
18.0      94
22.0      75
dtype: int64
```

```
Completed iteration 17
1.0     3240
10.0    2392
4.0     1349
2.0      803
5.0      714
8.0      602
0.0      525
6.0      397
20.0     294
15.0     217
16.0     204
14.0     193
13.0     181
21.0     173
12.0     165
3.0      150
17.0     135
11.0     117
19.0     114
9.0      108
7.0      108
18.0      94
22.0      75
dtype: int64
Completed iteration 18
1.0     3240
10.0    2392
4.0     1349
2.0      803
5.0      714
8.0      602
0.0      525
6.0      397
20.0     294
15.0     225
16.0     204
14.0     195
13.0     179
21.0     173
12.0     163
3.0      149
17.0     135
11.0     117
19.0     114
9.0      108
7.0      102
18.0      95
22.0      75
dtype: int64
Completed iteration 19
1.0     3240
10.0    2392
4.0     1349
2.0      803
5.0      714
8.0      602
0.0      525
6.0      395
20.0     294
15.0     229
16.0     203
14.0     194
21.0     179
13.0     179
12.0     160
3.0      149
17.0     135
11.0     117
19.0     114
9.0      108
7.0       99
18.0      95
22.0      75
dtype: int64
Completed iteration 20
1.0     3240
10.0    2392
4.0     1349
2.0      803
5.0      714
8.0      602
0.0      525
6.0      395
20.0     293
15.0     228
```

```
16.0     203
14.0     194
21.0     180
13.0     179
12.0     158
3.0      149
17.0     135
11.0     117
19.0     114
9.0      108
7.0      102
18.0      95
22.0      75
dtype: int64
Completed iteration 21
Reached 21 iterations
Centroids:
Centroid 1: [ 2.6260631e-03 -1.7661950e-02  4.0126216e-02  5.8560655e-03
  3.3175673e-03 -5.9794866e-02 -3.6313124e-02 -1.0475720e-02
 -7.1908403e-03 -3.2413539e-03 -1.7047040e-04 -1.8376848e-02
  1.0984639e-02 -1.5435387e-02  1.1923437e-02  2.0687928e-02
 -7.5355202e-02 -4.7030950e-01 -3.4837890e-01  6.3281059e-01
  1.4764947e-02  1.0752199e-01  4.2588684e-01]
Centroid 2: [-0.02253153 -0.03398385 -0.05960035  0.01057134 -0.02551912  0.05142368
 -0.02172633  0.0054603   0.03236221  0.01340246 -0.01046936  0.00390093
  0.02018143  0.00355969 -0.00594947 -0.00672737  0.21916312  0.09877443
  0.02123515 -0.2988253   0.05792861  0.36424983  0.837493  ]
Centroid 3: [-0.00882647  0.02167498  0.00659042 -0.0047013  -0.0035538  -0.00723112
  0.02951013 -0.01451353  0.01389978  0.00495742 -0.00279209  0.00787626
 -0.00323383 -0.00231957  0.00347128 -0.0035041   0.41080526  0.445741
  0.13350712  0.6406776   0.02339059  0.11250788  0.3748249 ]
Centroid 4: [-0.01234637 -0.21410134 -0.3414606  -0.02102937 -0.1978093   0.382242
  0.00761364  0.05098538  0.08402606 -0.00812396 -0.03487334  0.01765135
  0.00675213  0.06893181 -0.01636677 -0.02738235  0.01158159  0.11697128
 -0.26300707 -0.3480529   0.01831313 -0.08999071  0.20560324]
Centroid 5: [ 0.02570118  0.08556048  0.11604162  0.00731758  0.07282453 -0.11903065
  0.00781004 -0.00650561 -0.02298067 -0.00100722 -0.0031288   0.02712346
 -0.00690144 -0.01821176 -0.000974   -0.00170681 -0.7566731   0.05832364
  0.29237276 -0.08143537  0.03474703  0.19907036  0.47412217]
Centroid 6: [-1.3632672e-02 -2.7772579e-02 -7.0666005e-03 -2.1157253e-05
 -2.7094312e-02  5.8827680e-03 -5.1104631e-03 -2.5728608e-02
  2.6215583e-02  5.1192804e-03  3.3897087e-03 -9.0494072e-03
  3.9719115e-03  5.6642774e-03  1.1046413e-02  9.4632860e-03
  1.3730556e-01  2.9486665e-01  6.4013347e-02  7.5909817e-01
  2.6674092e-02  1.3633458e-01  4.7128442e-01]
Centroid 7: [ 0.00959055  0.07966764  0.13812521 -0.01186818  0.05824616 -0.14637673
 -0.00412052  0.0325429  -0.01268565  0.01195758  0.01087454  0.00828116
  0.01673353 -0.00641754 -0.02059964  0.0365581   0.02659871  0.24308562
 -0.5015018  -0.5954044   0.01452966  0.00797987  0.25331685]
Centroid 8: [-0.0514492   0.07741822 -0.00653168 -0.15405683  0.03811006 -0.02795705
  0.08589668  0.25027257  0.16926298  0.12209158 -0.02693774  0.08368057
  0.02193993 -0.07807238  0.19610366  0.15315889 -0.03302454  0.01656358
  0.00756974  0.05567646  0.01906404 -0.29654974  0.09005997]
Centroid 9: [-1.87605079e-02 -5.32665774e-02 -2.76278872e-02  3.00150074e-04
 -3.70858125e-02  5.32881394e-02 -8.82887188e-03 -4.07973351e-03
  1.93319730e-02  7.94334151e-03 -4.28430503e-04 -4.46748082e-03
  1.31511188e-03  1.31843155e-02  1.37297306e-02  2.27756910e-02
 -5.23532331e-01 -3.70445073e-01 -1.90863296e-01  5.69781959e-01
  1.63213518e-02  1.03118494e-01  4.01845902e-01]
Centroid 10: [-2.8488567e-02 -6.4803176e-03 -3.0931379e-03  1.9090917e-02
  1.5811684e-02  2.2121426e-03  1.5603610e-03 -2.7904436e-03
  4.6508838e-04  2.7853439e-03  3.1433657e-03 -3.8353917e-03
 -2.2379272e-02 -7.3007694e-03  5.9742513e-03 -1.6380204e-02
 -4.2040978e-02  1.5725955e-02 -1.7194803e-01 -6.8586692e-02
 -9.2632151e-01 -6.6796795e-02  1.3469698e-01]
Centroid 11: [-0.00552421 -0.06275538 -0.02129614 -0.02430474 -0.04319953  0.05126184
 -0.01580738  0.00693951  0.00324979 -0.01498194  0.01483735 -0.0260149
 -0.02099706  0.03281843  0.00534528  0.00708675  0.21911725  0.09895549
  0.0214143  -0.2981618   0.05786461  0.36381862  0.8365049 ]
Centroid 12: [ 2.94175465e-04  1.09786674e-01  5.70119545e-02 -2.62614246e-03
  6.23832271e-02 -5.66179156e-02  7.09232539e-02  4.24410626e-02
 -4.36007418e-02  5.90323098e-03 -2.04917025e-02  3.90021205e-02
 -9.73013416e-03 -2.54018046e-02 -7.35947071e-03  1.27174804e-04
  5.82730286e-02 -6.88809395e-01 -5.10239601e-01  1.66317686e-01
  1.29981991e-03  3.03810239e-02  2.08132342e-01]
Centroid 13: [ 1.41368657e-01  9.98015776e-02 -4.77441251e-02  8.04949030e-02
 -1.54937925e-02  9.97850001e-02 -1.07155308e-01  4.23884913e-02
 -2.26961404e-01  9.25151110e-02 -2.61382282e-01 -1.08890668e-01
 -1.37459412e-01 -8.34434256e-02  5.18632904e-02 -9.98076517e-03
 -1.94162838e-02  3.58359702e-02 -1.18549586e-04  7.07274303e-03
  2.27651298e-02 -3.53089094e-01  1.23318687e-01]
Centroid 14: [ 0.00178931  0.19751927  0.29283288  0.06013238  0.2070432  -0.33896896
 -0.03262769 -0.07255974 -0.05432519  0.02630686  0.03265264  0.00109774
 -0.01529928 -0.0378909  -0.00914241 -0.02851622  0.24451114 -0.34968126
 -0.11242157 -0.28510055  0.0257961  -0.22360946  0.25796536]
Centroid 15: [-4.12268341e-02  4.26870920e-02 -5.33562750e-02  9.81268808e-02
```

```
 -1.96532765e-03  1.83278024e-02 -1.06098615e-01 -6.33401200e-02
 -1.21661648e-02 -5.85867167e-02  2.48168215e-01 -1.48282394e-01
  1.11868521e-02  6.07249476e-02 -7.30782747e-02  2.56869048e-01
 -3.41149600e-04  3.92038263e-02  7.96936918e-03 -2.20950898e-02
  2.63804179e-02 -3.95306170e-01  1.48247704e-01]
Centroid 16: [-2.4794880e-02  7.5372383e-02 -2.1373888e-02  3.5231918e-02
 -6.7100339e-03 -3.4207884e-02  7.0692115e-02 -5.0832395e-02
 -8.7401718e-03  1.3994356e-02 -3.3039801e-02  1.0476573e-01
  4.1416350e-01 -2.5198970e-04 -5.2226905e-02 -4.4614758e-02
  4.0038288e-02  8.4130824e-02  4.4542111e-02 -1.0764499e-01
  3.0562963e-02 -4.1398475e-01  1.7996992e-01]
Centroid 17: [-0.02088759 -0.02987952 -0.124355    0.11540855  0.04246795  0.153549
 -0.05320548 -0.12237518  0.06659831 -0.04228335 -0.05484522  0.02673518
 -0.18556929 -0.09229617  0.06745271 -0.2993902   0.12937641 -0.31256634
 -0.1009896  -0.07471085  0.03259686 -0.39578465  0.2282149 ]
Centroid 18: [ 2.11820309e-03  7.41535379e-03  1.09137436e-02  3.19029810e-03
  1.02611342e-02 -8.84813908e-03 -5.13210613e-03 -1.53117655e-02
  7.63858669e-03 -2.05274345e-03  2.79765693e-04 -1.42329128e-03
  2.70696613e-03 -3.87009513e-03 -1.98386703e-03  3.68128857e-03
  1.38868600e-01 -3.89432788e-01  8.31567466e-01 -2.51222521e-01
  1.68606751e-02 -4.16772347e-03  1.36329547e-01]
Centroid 19: [-0.03251193 -0.12113474  0.1113463  -0.07660467 -0.17123841 -0.07723697
  0.12474407  0.08122277 -0.04035131  0.03931599  0.2529525  -0.00103626
 -0.08456744  0.05011107  0.1401624  -0.4683655  -0.02522362  0.06091129
  0.01767426  0.036146    0.02223272 -0.35017604  0.10323939]
Centroid 20: [ 0.05414848 -0.26425532  0.13299233 -0.01929192  0.17082459 -0.06861858
 -0.07430244 -0.02066489  0.00123942 -0.01334213 -0.19444844  0.03069863
 -0.04905453  0.23308076 -0.18670766  0.03017494 -0.03971407  0.07623456
  0.02448633  0.04869032  0.02118433 -0.34142378  0.09950604]
Centroid 21: [-0.00243956 -0.09230217 -0.09155609 -0.05208739 -0.04833     0.11015823
 -0.02617806  0.03647002  0.01704516  0.02704725  0.053122   -0.00285663
  0.06583109  0.09276357 -0.00430103  0.04616315  0.36735916 -0.63842267
 -0.14006907 -0.24419883  0.02448267 -0.16175252  0.26539147]
Centroid 22: [-0.02887157  0.06192584 -0.02250378 -0.04472601 -0.01691029 -0.049114
  0.18600504 -0.12989908  0.00325844 -0.18246007 -0.07186209  0.08745735
 -0.19813968 -0.1506005   0.04958363  0.02212799  0.02210582  0.1212507
  0.0232823  -0.13066106  0.02839316 -0.36987263  0.17565407]
Centroid 23: [-0.02652819 -0.07027968 -0.10870992  0.00690792 -0.04668325  0.16882765
  0.01552013 -0.01071534  0.04417666  0.01767763 -0.00802109  0.01257633
 -0.01064197  0.03219848  0.01196888 -0.02094307 -0.7462961  -0.270421
  0.16635245 -0.06895057  0.01520779 -0.04553255  0.1772211 ]
```

In [ ]:

```
spectral_clustering(
    oe_X_train025,
    cuts=len(np.unique(le_y_train025)),
    fname="one-hot_encoded_spectral_clustering",
    affinity="linear",
)
```

```
eigenvalues: [9.9977779e-01 9.9972880e-01 9.9965966e-01 9.9958605e-01 9.9956065e-01
 9.9953741e-01 9.9930644e-01 9.9900270e-01 9.9766284e-01 9.7574848e-01
 9.6557194e-01 8.1612897e-01 3.7445694e-01 9.3548057e-05 1.8744102e-11].
Finished running k-means++
1.0     5696
2.0     1432
10.0     924
0.0      853
9.0      649
4.0      572
11.0     509
7.0      432
5.0      361
3.0      301
6.0      214
8.0      146
12.0     120
13.0     108
14.0      33
dtype: int64
Completed iteration 1
1.0     5645
2.0     1418
10.0     835
0.0      713
4.0      678
9.0      612
7.0      540
11.0     509
5.0      324
3.0      302
6.0      279
8.0      173
12.0     144
13.0     108
14.0      70
dtype: int64
Completed iteration 2
1.0     5644
2.0     1417
4.0      779
10.0     739
0.0      654
7.0      595
9.0      588
11.0     500
5.0      304
3.0      284
6.0      276
8.0      197
12.0     163
13.0     108
14.0     102
dtype: int64
Completed iteration 3
1.0     5644
2.0     1417
4.0      842
10.0     678
0.0      625
7.0      624
9.0      574
11.0     496
5.0      291
6.0      271
3.0      261
8.0      224
12.0     169
14.0     126
13.0     108
dtype: int64
Completed iteration 4
1.0     5644
2.0     1417
4.0      880
7.0      643
10.0     641
0.0      605
9.0      567
11.0     498
5.0      287
6.0      266
8.0      240
3.0      236
12.0     169
14.0     149
```

```
13.0     108
dtype: int64
Completed iteration 5
1.0     5644
2.0     1419
4.0      902
7.0      651
10.0     622
0.0      594
9.0      561
11.0     497
5.0      290
6.0      265
8.0      246
3.0      223
12.0     171
14.0     157
13.0     108
dtype: int64
Completed iteration 6
1.0     5644
2.0     1419
4.0      913
7.0      655
10.0     612
0.0      589
9.0      558
11.0     497
5.0      295
6.0      265
8.0      246
3.0      211
12.0     171
14.0     167
13.0     108
dtype: int64
Completed iteration 7
1.0     5644
2.0     1419
4.0      920
7.0      655
10.0     607
0.0      587
9.0      555
11.0     497
5.0      304
6.0      267
8.0      238
3.0      200
14.0     179
12.0     170
13.0     108
dtype: int64
Completed iteration 8
1.0     5644
2.0     1417
4.0      923
7.0      655
10.0     604
0.0      587
9.0      557
11.0     498
5.0      302
6.0      274
8.0      237
3.0      189
14.0     186
12.0     169
13.0     108
dtype: int64
Completed iteration 9
1.0     5644
2.0     1417
4.0      927
7.0      655
10.0     600
0.0      588
9.0      556
11.0     498
5.0      294
6.0      277
8.0      245
14.0     189
3.0      178
12.0     174
13.0     108
```

```
dtype: int64
Completed iteration 10
1.0     5644
2.0     1417
4.0      930
7.0      655
10.0     597
0.0      588
9.0      557
11.0     500
5.0      290
6.0      282
8.0      246
14.0     194
3.0      173
12.0     169
13.0     108
dtype: int64
Completed iteration 11
1.0     5644
2.0     1417
4.0      930
7.0      655
10.0     597
0.0      588
9.0      558
11.0     500
5.0      292
6.0      286
8.0      242
14.0     194
3.0      170
12.0     169
13.0     108
dtype: int64
Completed iteration 12
1.0     5644
2.0     1418
4.0      930
7.0      655
10.0     597
0.0      588
9.0      560
11.0     500
5.0      290
6.0      290
8.0      238
14.0     196
12.0     169
3.0      167
13.0     108
dtype: int64
Completed iteration 13
1.0     5644
2.0     1418
4.0      930
7.0      655
10.0     597
0.0      588
9.0      561
11.0     500
6.0      291
5.0      287
8.0      239
14.0     196
12.0     169
3.0      167
13.0     108
dtype: int64
Completed iteration 14
Epsilon has a maximum value of 0.006618378218263388
Centroids:
Centroid 1: [-0.01508594 -0.00227116 -0.00502196 -0.00730466  0.0072803  -0.01932076
  0.00800706  0.01719548 -0.03709081 -0.53210896 -0.38353533  0.55646133
  0.01182683  0.09494086  0.38546613]
Centroid 2: [ 2.0248532e-02  1.3522451e-03  3.3825898e-04 -8.8670431e-03
  2.6377458e-03  1.6050996e-02 -1.1474084e-03 -8.4229448e-04
  2.2027521e-01  9.9301748e-02  2.1439480e-02 -3.0027732e-01
  5.8197983e-02  3.6613360e-01  8.4178597e-01]
Centroid 3: [-2.1295907e-02 -7.2940340e-04 -3.0324922e-03  2.6686748e-02
 -7.5646541e-03 -1.6767086e-02 -2.1392130e-04 -2.8679501e-03
 -7.7634960e-01  4.7720056e-02  3.0135950e-01 -8.3772987e-02
  3.4735657e-02  1.9330691e-01  4.7176650e-01]
Centroid 4: [-0.2763725   0.27066463 -0.03372123 -0.13360871 -0.18088871 -0.1128895
  0.16695766  0.21494919 -0.01743626  0.072143    0.02260419  0.00815752
  0.02795529 -0.41800818  0.14373486]
```

```
Centroid 5: [ 0.01412642  0.00413407 -0.00162502  0.00400073 -0.00162477 -0.00347526
  0.00436012 -0.00186913  0.4042998   0.4233737   0.11362347  0.65718454
  0.02363744  0.11547181  0.38705823]
Centroid 6: [ 0.02956348 -0.0340289   0.06994446 -0.01021455 -0.22602499 -0.0535185
  0.0938352  -0.39776653  0.07239816 -0.23544796 -0.10677175 -0.0341021
  0.03408882 -0.44459435  0.21924476]
Centroid 7: [ 0.00621415  0.03758718 -0.03959071  0.11728431  0.4556133   0.01784125
 -0.06681456 -0.09426131  0.03072565  0.08490881  0.04461762 -0.09826764
  0.03486514 -0.48230588  0.20137951]
Centroid 8: [ 2.00115684e-02  8.20846763e-03  1.13428410e-04 -5.03381621e-03
  1.22684299e-03  1.38113108e-02  1.38211837e-02  2.25013830e-02
 -5.16601801e-01 -3.75545532e-01 -1.96782634e-01  5.65205038e-01
  1.65244918e-02  1.01634376e-01  4.04221177e-01]
Centroid 9: [ 0.02011232 -0.19431438 -0.20017746  0.1001883  -0.16126426 -0.17225718
  0.03395928 -0.20525312  0.06856965  0.16065258  0.06492479 -0.2313125
  0.03433914 -0.42282715  0.2275199 ]
Centroid 10: [-0.0102069   0.02058755  0.03594626  0.00462581  0.03638062  0.03594781
 -0.00296741  0.01910948  0.3251768  -0.58536863  0.07009371 -0.27639747
  0.02491813 -0.15271372  0.25946274]
Centroid 11: [ 0.02873132  0.00645607  0.0028989  -0.00665359  0.00295206  0.00926446
  0.01140968  0.00981078  0.08944596  0.298398    0.0798496   0.76706886
  0.02726573  0.13829404  0.47815794]
Centroid 12: [ 0.00625048  0.01704266  0.01228227  0.00712918  0.01963263  0.01328411
 -0.01785063  0.03515948  0.00705892  0.21835966 -0.56504613 -0.5972966
  0.01452339  0.01622118  0.2671746 ]
Centroid 13: [ 0.12791993  0.00510506 -0.31593138  0.05322684 -0.10766099  0.20138238
 -0.11810794  0.21609712 -0.02426622  0.04469857  0.01668129  0.04455138
  0.02949483 -0.46273828  0.14532094]
Centroid 14: [ 0.0057666   0.00291822  0.00269508 -0.00286745 -0.01999474 -0.00784029
  0.00569685 -0.01694569 -0.04147241  0.01465846 -0.1707714  -0.06786076
 -0.9350957  -0.06696951  0.13509789]
Centroid 15: [ 0.00582567 -0.11464406  0.3278179  -0.15977389  0.02450473  0.08370727
 -0.0674567   0.30403158  0.01254381  0.01834717  0.00749848 -0.03733635
  0.03179684 -0.46712673  0.18453541]
```

poly (gamma=1.0 / n_features)

In [ ]:

```
n_features = oe_X_train025.shape[1]
spectral_clustering(
    oe_X_train025,
    cuts=23,
    fname="one-hot_encoded_spectral_clustering",
    affinity="poly",
    gamma=1.0 / n_features,
)
```

```
eigenvalues: [9.9992383e-01 9.9990869e-01 9.9990058e-01 9.9989259e-01 9.9987674e-01
 9.9986768e-01 9.9984252e-01 9.9983776e-01 9.9980867e-01 9.9975407e-01
 9.9968064e-01 9.9941415e-01 9.9935758e-01 9.9691677e-01 9.9616539e-01
 9.9608505e-01 9.8240721e-01 9.7884780e-01 9.7031039e-01 8.7653720e-01
 4.2079127e-01 3.1842557e-16 2.1136516e-18].
Finished running k-means++
3.0     6505
4.0      654
6.0      559
20.0     500
10.0     462
1.0      443
9.0      423
12.0     404
0.0      373
13.0     343
2.0      322
8.0      322
16.0     241
22.0     192
5.0      170
17.0     105
21.0     102
7.0       95
15.0      58
11.0      34
18.0      17
19.0      14
14.0      12
dtype: int64
Completed iteration 1
3.0     6503
4.0      596
6.0      553
20.0     494
10.0     474
1.0      419
12.0     408
9.0      383
13.0     349
8.0      320
2.0      317
16.0     303
0.0      290
22.0     245
5.0      200
17.0     109
7.0       97
21.0      97
15.0      88
11.0      34
18.0      28
14.0      27
19.0      16
dtype: int64
Completed iteration 2
3.0     6503
4.0      568
6.0      532
20.0     493
10.0     476
12.0     407
1.0      393
9.0      376
13.0     350
8.0      348
16.0     332
2.0      307
22.0     282
0.0      279
5.0      196
17.0     105
7.0      100
21.0      94
15.0      91
18.0      35
11.0      34
14.0      33
19.0      16
dtype: int64
Completed iteration 3
3.0     6503
4.0      552
6.0      522
20.0     490
10.0     474
```

```
12.0     408
1.0      380
9.0      375
8.0      360
16.0     347
13.0     342
22.0     309
2.0      301
0.0      277
5.0      194
17.0     105
7.0      101
21.0      92
15.0      91
14.0      39
18.0      39
11.0      34
19.0      15
dtype: int64
Completed iteration 4
3.0     6503
4.0      547
6.0      511
20.0     489
10.0     473
12.0     409
1.0      379
9.0      374
8.0      362
16.0     356
13.0     333
22.0     326
2.0      297
0.0      276
5.0      191
17.0     104
7.0      102
21.0      90
15.0      88
14.0      49
18.0      42
11.0      34
19.0      15
dtype: int64
Completed iteration 5
3.0     6503
4.0      546
20.0     489
6.0      489
10.0     474
12.0     412
1.0      380
9.0      371
16.0     363
8.0      358
22.0     338
13.0     320
2.0      299
0.0      276
5.0      189
17.0     106
7.0      102
15.0     101
21.0      89
14.0      53
18.0      43
11.0      34
19.0      15
dtype: int64
Completed iteration 6
3.0     6503
4.0      546
20.0     488
10.0     478
6.0      464
12.0     416
1.0      380
9.0      371
16.0     370
8.0      353
22.0     341
13.0     308
2.0      305
0.0      273
5.0      189
15.0     121
```

```
17.0     107
7.0      102
21.0      89
14.0      55
18.0      41
11.0      34
19.0      16
dtype: int64
Completed iteration 7
3.0     6503
4.0      542
20.0     490
10.0     484
6.0      451
12.0     416
1.0      380
16.0     376
9.0      370
22.0     353
8.0      353
2.0      305
13.0     293
0.0      266
5.0      189
15.0     133
17.0     107
7.0      102
21.0      89
14.0      59
18.0      39
11.0      34
19.0      16
dtype: int64
Completed iteration 8
3.0     6503
4.0      540
20.0     491
10.0     486
6.0      437
12.0     416
16.0     381
1.0      380
9.0      370
8.0      353
22.0     351
2.0      305
13.0     288
0.0      261
5.0      191
15.0     151
17.0     107
7.0      102
21.0      89
14.0      60
18.0      38
11.0      34
19.0      16
dtype: int64
Completed iteration 9
3.0     6503
4.0      541
20.0     491
10.0     487
6.0      430
12.0     416
16.0     384
1.0      380
9.0      370
8.0      353
22.0     349
2.0      310
13.0     279
0.0      258
5.0      191
15.0     162
17.0     107
7.0      102
21.0      89
14.0      60
18.0      38
11.0      34
19.0      16
dtype: int64
Completed iteration 10
3.0     6503
4.0      541
```

```
20.0     491
10.0     488
6.0      427
12.0     416
16.0     384
1.0      380
9.0      369
8.0      353
22.0     349
2.0      317
13.0     270
0.0      261
5.0      193
15.0     161
17.0     107
7.0      102
21.0      89
14.0      60
18.0      38
11.0      34
19.0      17
dtype: int64
Completed iteration 11
3.0     6503
4.0      541
20.0     491
10.0     488
6.0      422
12.0     416
16.0     385
1.0      380
9.0      369
8.0      353
22.0     348
2.0      317
13.0     270
0.0      262
5.0      194
15.0     163
17.0     107
7.0      102
21.0      89
14.0      61
18.0      38
11.0      34
19.0      17
dtype: int64
Completed iteration 12
3.0     6503
4.0      541
20.0     493
10.0     488
6.0      420
12.0     416
16.0     386
1.0      380
9.0      369
8.0      353
22.0     348
2.0      317
13.0     270
0.0      263
5.0      194
15.0     159
17.0     107
7.0      102
21.0      89
14.0      63
18.0      38
11.0      34
19.0      17
dtype: int64
Completed iteration 13
3.0     6503
4.0      541
20.0     493
10.0     488
6.0      418
12.0     416
16.0     387
1.0      380
9.0      369
8.0      353
22.0     348
2.0      317
13.0     270
```

```
0.0      264
5.0      194
15.0     159
17.0     107
7.0      102
21.0      89
14.0      63
18.0      38
11.0      34
19.0      17
dtype: int64
Completed iteration 14
Epsilon has a maximum value of 0.0054685017094016075
Centroids:
Centroid 1: [ 0.00117378  0.00605659  0.0230412   0.01046638  0.01608162 -0.01651069
 -0.03595284  0.00793162 -0.04420156 -0.03735094 -0.01081714  0.02227688
  0.31920692 -0.238861    0.01140166 -0.29852787  0.2661187   0.22885032
 -0.06272376  0.44923353  0.01846825  0.1609718  -0.45151654]
Centroid 2: [-0.00355207  0.01095002  0.01813655  0.05048731  0.05614728  0.00637661
 -0.03985981  0.01376168 -0.09314255 -0.0958084  -0.04480248 -0.07622663
  0.03354336  0.24285294  0.06473736 -0.0679646  -0.03988386 -0.37726104
 -0.29908225 -0.7116563   0.00377009  0.07174534 -0.23568016]
Centroid 3: [ 0.26018694  0.3826865  -0.03859051  0.03330296  0.05180551  0.0304681
 -0.11456379  0.01324885 -0.31759828 -0.06406088  0.04255879 -0.03022962
 -0.3034606   0.03635583  0.01005361 -0.00599366 -0.21554807 -0.21400733
 -0.05570198  0.48276326  0.01733045  0.13535768 -0.35116386]
Centroid 4: [ 0.01217997  0.01430557 -0.00980508 -0.01015283  0.00966988  0.01309227
  0.00495394 -0.00545777 -0.01869551  0.00978644  0.01182524 -0.01211092
 -0.17726429  0.02695229  0.00325834 -0.01263045 -0.04827908 -0.04425123
  0.02211435 -0.02054165  0.02446616  0.35945114 -0.9029029 ]
Centroid 5: [-0.16698171 -0.22977246  0.02178775 -0.07360536 -0.02626301  0.00645225
  0.119981   -0.00701407  0.2057549   0.08514551 -0.05805249  0.02954449
  0.14918953  0.23364452 -0.04165246  0.457139   -0.19538498 -0.18428414
 -0.06521212  0.46966088  0.01715885  0.13741358 -0.36114866]
Centroid 6: [ 0.02109807  0.063316   -0.00862361 -0.04667101 -0.12556656  0.00038821
  0.17431957 -0.20525667  0.10484234  0.06373132 -0.04652671 -0.07177105
 -0.12530331 -0.3107356  -0.02950973  0.25358787  0.33919215  0.07356341
 -0.27900118 -0.31948054  0.00206715  0.01578273 -0.14782098]
Centroid 7: [-0.16309649 -0.16880715  0.1249183  -0.01192942 -0.00191433 -0.0581543
 -0.00356255  0.03686449  0.01231099 -0.07731099 -0.00414049 -0.00959847
 -0.11925195 -0.2978361   0.06859939 -0.64775896  0.17315522  0.14207743
 -0.00784252  0.31499082  0.01446027  0.12337413 -0.3414219 ]
Centroid 8: [-1.04255341e-02  5.52329002e-04  7.83717667e-04  1.73266232e-02
  4.18808348e-02 -1.09213041e-02  3.81212756e-02  5.73233441e-02
  4.50578518e-02 -1.88690379e-01 -4.65444438e-02 -3.28059569e-02
 -3.94114405e-02 -2.81024426e-01 -4.89453711e-02  1.71746373e-01
 -2.38580436e-01  8.19767192e-02  7.20567465e-01 -2.07558036e-01
  4.09957767e-03 -1.47785507e-02 -1.19772255e-01]
Centroid 9: [ 0.02530368  0.02213814  0.00639548 -0.01240833 -0.05248527 -0.00605702
 -0.06695345 -0.10290239 -0.13136014  0.33637226  0.07817984  0.00615632
  0.07041748  0.05893791  0.0173212  -0.11216871 -0.16024129 -0.19660154
 -0.09129345  0.03594502  0.00486732 -0.6641432  -0.23497604]
Centroid 10: [ 0.00556586  0.05339462 -0.04486368  0.03632146  0.03592531  0.0090468
  0.00313242  0.04097053 -0.02565212 -0.11787359 -0.01240732 -0.02601026
 -0.19306982  0.24202883  0.01406395  0.249876    0.32476172  0.26987317
  0.19743618 -0.51238316  0.00494651 -0.20475695 -0.28285637]
Centroid 11: [ 0.04144153 -0.001913    0.00460508 -0.04277195 -0.01152607  0.0177041
 -0.02386868  0.01165172 -0.02602006 -0.04128652  0.00983328  0.02697856
 -0.02761284  0.2358765   0.02782916  0.00981745  0.32995752  0.29201525
  0.0253928   0.07862374  0.00558521 -0.7521464  -0.2732447 ]
Centroid 12: [ 0.21095358 -0.06719222  0.01261035 -0.46740407 -0.26636904  0.06980767
 -0.11691409  0.09036171  0.0208533  -0.03997545  0.37701845  0.4167856
 -0.04317114 -0.02905243  0.02338205  0.0868796  -0.07252495 -0.1245183
  0.04162456 -0.32929578  0.00174377  0.03151861 -0.10799237]
Centroid 13: [-0.03216304 -0.00138259 -0.00519808  0.07356631  0.07374989 -0.00526206
  0.08407754  0.04955485  0.10902826 -0.24638993 -0.06878667 -0.05519229
 -0.01483613 -0.35146987 -0.03989952  0.06140435 -0.28907964 -0.23718747
  0.02097359  0.00451746  0.00505478 -0.67096686 -0.2446365 ]
Centroid 14: [ 0.1333826   0.25003546  0.08513473  0.01042992  0.02685693 -0.04676203
 -0.05588327  0.00637705 -0.16853929 -0.02171689  0.03493486 -0.04533594
 -0.43370295 -0.1098282   0.04934468 -0.3376999  -0.1349655  -0.13925108
 -0.02427654  0.4636888   0.01875386  0.14997748 -0.39385116]
Centroid 15: [-0.02042268  0.00939029 -0.11528647 -0.0064321  -0.03362648 -0.04025025
  0.05463811  0.07698841  0.22036941 -0.04999427 -0.0908004   0.06058981
 -0.0404972   0.18938696  0.03257528 -0.1595755   0.07117159  0.03150986
  0.05468259 -0.00810934 -0.02523592 -0.00486939 -0.05858217]
Centroid 16: [-0.41719684 -0.46298596 -0.04078741 -0.03217494 -0.13257447 -0.01777188
 -0.09098683 -0.0583273  -0.19801229  0.08113472  0.04980464 -0.02263693
 -0.05175388 -0.13330726  0.00221455 -0.13098891  0.11091883  0.0906856
 -0.03573768  0.20659201  0.00844621  0.04389219 -0.20930225]
Centroid 17: [ 0.27166468  0.32894936 -0.06379808  0.05119952  0.04885663  0.00105993
 -0.02626692 -0.01122079 -0.01418523  0.01745451 -0.02938206  0.04742309
  0.49209654 -0.05889528 -0.03914876  0.13593681  0.18855141  0.16629182
 -0.07639102  0.35173377  0.01318742  0.1162449  -0.327879  ]
Centroid 18: [-0.04195381  0.02740557  0.01786052  0.06513727 -0.06223539 -0.0156312
 -0.09689689 -0.15346734 -0.17892645  0.492595    0.01909543 -0.12428044
```

```
  0.02174248  0.15876779 -0.00156619  0.06745145 -0.17774415 -0.06941944
  0.32765555 -0.36565623  0.00404993 -0.14366841 -0.19642915]
Centroid 19: [ 0.00053838 -0.03117455  0.06642117  0.04822103  0.05039962  0.23268498
  0.14898343 -0.10238223 -0.02691115 -0.05188728  0.12754254  0.01182667
  0.02129152  0.02778187  0.10158423 -0.00864555 -0.16834441  0.1712259
 -0.078417   -0.05738958 -0.16364038  0.00916591 -0.05770598]
Centroid 20: [ 1.0344697e-02  9.2847226e-03  5.0603896e-01  1.6003549e-03
  2.5722489e-03 -3.2997918e-01  4.5331120e-02  4.1458543e-02
  1.0829770e-02 -1.6833053e-05  9.9733762e-02 -1.9516334e-02
 -6.7416131e-02  2.3311551e-03 -3.4737610e-03  2.1939028e-02
  3.1625472e-02  1.8983517e-02 -1.3069370e-02 -5.1793982e-03
  1.5525972e-03  2.0847706e-02 -5.9889715e-02]
Centroid 21: [-0.01195385 -0.05388495 -0.04244424  0.00618041  0.01504511 -0.00998911
  0.0028999   0.01061047  0.12218446 -0.01364013 -0.07979859  0.06619275
  0.83396584 -0.17383887  0.02027443 -0.23313574  0.08953924  0.0815869
  0.08297645 -0.15478359  0.007475    0.11168201 -0.29682612]
Centroid 22: [ 0.02059052 -0.09028733  0.00211848  0.01219122  0.14983587  0.00704263
 -0.26583064  0.29095805  0.12473151  0.24752313  0.02121029 -0.04305662
 -0.04869536 -0.13531569 -0.3695497   0.03827251 -0.26409405  0.39834386
 -0.37335247 -0.30487713 -0.02517544  0.00564863 -0.12146033]
Centroid 23: [-0.01927987 -0.0042924   0.05233447 -0.04909229  0.00584359 -0.00242558
  0.03675954 -0.00376236 -0.00956162  0.03848698 -0.01276294 -0.00912299
 -0.15981951  0.11232854 -0.00377997  0.15566823 -0.23797306 -0.23170178
 -0.06361322  0.61246794  0.02321256  0.18501553 -0.48477006]
```

In [ ]:

```
n_features = oe_X_train025.shape[1]
spectral_clustering(
    oe_X_train025,
    cuts=len(np.unique(le_y_train025)),
    fname="one-hot_encoded_spectral_clustering",
    affinity="poly",
    gamma=1.0 / n_features,
)
```

```
eigenvalues: [9.9980867e-01 9.9975407e-01 9.9968064e-01 9.9941415e-01 9.9935758e-01
 9.9691677e-01 9.9616539e-01 9.9608505e-01 9.8240721e-01 9.7884780e-01
 9.7031039e-01 8.7653720e-01 4.2079127e-01 3.1842557e-16 2.1136516e-18].
Finished running k-means++
3.0     6524
1.0      703
0.0      695
7.0      674
4.0      569
2.0      556
6.0      527
13.0     523
5.0      445
8.0      436
9.0      241
11.0     224
10.0     113
12.0     109
14.0      11
dtype: int64
Completed iteration 1
3.0     6521
1.0      730
7.0      657
13.0     606
0.0      564
2.0      548
6.0      507
8.0      463
4.0      446
9.0      426
5.0      399
11.0     224
10.0     110
12.0     106
14.0      43
dtype: int64
Completed iteration 2
3.0     6521
1.0      736
7.0      660
13.0     632
9.0      567
2.0      542
0.0      518
6.0      502
8.0      450
5.0      394
4.0      314
11.0     221
10.0     107
12.0     100
14.0      86
dtype: int64
Completed iteration 3
3.0     6521
1.0      741
13.0     648
7.0      607
9.0      582
2.0      535
0.0      518
6.0      503
8.0      443
5.0      394
4.0      333
11.0     216
14.0     107
10.0     104
12.0      98
dtype: int64
Completed iteration 4
3.0     6520
1.0      743
13.0     654
9.0      583
7.0      573
2.0      532
0.0      520
6.0      503
8.0      439
5.0      394
4.0      358
11.0     216
14.0     119
10.0      98
```

```
12.0      98
dtype: int64
Completed iteration 5
3.0     6520
1.0      745
13.0     649
9.0      589
7.0      565
2.0      530
0.0      521
6.0      502
8.0      436
5.0      395
4.0      364
11.0     217
14.0     126
12.0      98
10.0      93
dtype: int64
Completed iteration 6
3.0     6520
1.0      744
13.0     644
9.0      590
7.0      549
2.0      531
0.0      522
6.0      501
8.0      437
5.0      395
4.0      384
11.0     217
14.0     127
12.0      98
10.0      91
dtype: int64
Completed iteration 7
3.0     6520
1.0      744
13.0     636
9.0      593
7.0      551
2.0      532
0.0      522
6.0      502
8.0      437
5.0      395
4.0      386
11.0     214
14.0     129
12.0      98
10.0      91
dtype: int64
Completed iteration 8
3.0     6521
1.0      744
13.0     631
9.0      595
7.0      546
2.0      534
0.0      522
6.0      502
8.0      437
5.0      395
4.0      394
11.0     212
14.0     129
12.0      98
10.0      90
dtype: int64
Completed iteration 9
3.0     6521
1.0      743
13.0     626
9.0      598
2.0      536
7.0      536
0.0      522
6.0      501
8.0      437
4.0      406
5.0      395
11.0     209
14.0     132
12.0      98
10.0      90
```

```
dtype: int64
Completed iteration 10
3.0     6522
1.0      740
13.0     623
9.0      600
2.0      534
7.0      533
0.0      522
6.0      501
8.0      436
4.0      410
5.0      394
11.0     209
14.0     138
12.0      98
10.0      90
dtype: int64
Completed iteration 11
3.0     6522
1.0      735
13.0     621
9.0      603
7.0      533
2.0      532
0.0      522
6.0      501
8.0      435
4.0      409
5.0      395
11.0     205
14.0     150
12.0      98
10.0      89
dtype: int64
Completed iteration 12
3.0     6522
1.0      729
13.0     619
9.0      605
7.0      531
2.0      527
0.0      522
6.0      501
8.0      433
4.0      410
5.0      393
11.0     204
14.0     167
12.0      98
10.0      89
dtype: int64
Completed iteration 13
3.0     6522
1.0      691
13.0     619
9.0      605
7.0      527
2.0      524
0.0      522
6.0      500
8.0      429
4.0      414
5.0      388
14.0     223
11.0     200
12.0      99
10.0      87
dtype: int64
Completed iteration 14
3.0     6522
1.0      624
13.0     619
9.0      607
7.0      525
0.0      522
2.0      513
6.0      500
8.0      429
4.0      416
5.0      387
14.0     298
11.0     201
12.0     100
10.0      87
dtype: int64
```

```
Completed iteration 15
3.0     6524
13.0     619
9.0      607
1.0      580
7.0      526
0.0      522
2.0      509
6.0      500
8.0      432
4.0      419
5.0      391
14.0     334
11.0     198
12.0     100
10.0      89
dtype: int64
Completed iteration 16
3.0     6525
13.0     619
9.0      609
1.0      547
7.0      526
0.0      522
2.0      508
6.0      500
8.0      432
4.0      420
5.0      393
14.0     343
11.0     215
12.0     101
10.0      90
dtype: int64
Completed iteration 17
3.0     6525
13.0     619
9.0      610
1.0      535
7.0      526
0.0      522
2.0      508
6.0      501
8.0      432
4.0      419
5.0      392
14.0     332
11.0     236
12.0     103
10.0      90
dtype: int64
Completed iteration 18
3.0     6523
13.0     618
9.0      610
1.0      527
7.0      526
0.0      522
2.0      508
6.0      504
8.0      431
4.0      420
5.0      392
14.0     330
11.0     247
12.0     102
10.0      90
dtype: int64
Completed iteration 19
3.0     6523
13.0     618
9.0      610
7.0      526
0.0      522
1.0      522
2.0      508
6.0      506
8.0      433
4.0      420
5.0      392
14.0     331
11.0     249
12.0     100
10.0      90
dtype: int64
Completed iteration 20
```

```
3.0     6523
13.0     618
9.0      610
7.0      526
0.0      522
1.0      520
2.0      508
6.0      506
8.0      434
4.0      420
5.0      392
14.0     332
11.0     249
12.0     100
10.0      90
dtype: int64
Completed iteration 21
Epsilon has a maximum value of 0.005158719606697559
Centroids:
Centroid 1: [-0.06742578  0.01711222 -0.01768128  0.04283453  0.53545505 -0.1272435
 -0.03902733  0.06348261  0.26943564  0.23745811 -0.08986755  0.4223514
  0.01604445  0.14219922 -0.40302527]
Centroid 2: [ 0.07234347 -0.19715847 -0.04094512 -0.03018692  0.00483759 -0.27740803
 -0.0228842   0.00768249 -0.25537044 -0.25452605 -0.05592525  0.01600708
  0.00505673 -0.67909324 -0.2446577 ]
Centroid 3: [-0.0049307  -0.04005955  0.00770878  0.03016189 -0.02174577  0.23607995
  0.02904231  0.00349338  0.33219364  0.29130524  0.02207081  0.07757121
  0.00562363 -0.7551131  -0.27507845]
Centroid 4: [-0.01849082  0.00962934  0.01203815 -0.01203419 -0.17842388  0.02712712
  0.00327129 -0.0126988  -0.04858618 -0.0445341   0.02225075 -0.02066447
  0.02461985  0.3617076  -0.9085679 ]
Centroid 5: [-0.30609894 -0.01239292  0.06478734 -0.05930661 -0.45624357 -0.1040901
  0.04321386 -0.29907274 -0.1519361  -0.15596096 -0.03371105  0.48252207
  0.01897939  0.15128314 -0.39647278]
Centroid 6: [-0.10092669 -0.08284421 -0.03096598 -0.06345893  0.03565007  0.24701585
  0.06540515 -0.06981578 -0.04810688 -0.38223365 -0.29418287 -0.71354043
  0.00380301  0.06853372 -0.23727289]
Centroid 7: [ 0.13044268 -0.00886586 -0.08032798  0.06610595  0.82631797 -0.16724904
  0.02098829 -0.23474729  0.08869747  0.0823926   0.08631736 -0.1523828
  0.00741802  0.10820206 -0.29380643]
Centroid 8: [-0.1671965   0.00458273  0.0128502  -0.01981161 -0.2463848   0.09352097
  0.00062883  0.11185811 -0.25764653 -0.25252083 -0.06806912  0.6226407
  0.02310417  0.18279473 -0.47718912]
Centroid 9: [-1.81816965e-02 -1.02836475e-01 -1.18916743e-02 -2.45785266e-02
 -1.98005572e-01  2.20109284e-01  7.33644411e-05  2.57839441e-01
  3.53326976e-01  2.99658537e-01  1.70229584e-01 -4.54809099e-01
  4.47412301e-03 -1.75898790e-01 -2.63643414e-01]
Centroid 10: [-0.00068397 -0.07019205 -0.00609838 -0.00288948 -0.0437248  -0.30698842
  0.06236809 -0.6264189   0.20385255  0.16941895 -0.01884145  0.36160254
  0.01619434  0.13885958 -0.38557836]
Centroid 11: [ 7.1611935e-03 -1.4203013e-01 -1.4667416e-02 -4.8632381e-04
 -2.7879190e-02 -2.4547516e-01 -4.4558488e-02  1.4573354e-01
 -2.2081324e-01  1.5262714e-01  8.2926917e-01 -1.3466647e-01
  4.2384351e-03 -6.0709198e-03 -1.0036641e-01]
Centroid 12: [ 1.3437842e-01 -1.0697644e-02  3.5482759e-04 -1.4532220e-02
 -8.6426578e-02 -2.8883329e-01  1.9823816e-02  1.9777089e-01
  1.5098883e-01 -6.1608981e-02 -1.8810521e-01 -4.0263659e-01
 -2.4524866e-02  9.7950380e-03 -1.6420960e-01]
Centroid 13: [ 0.11650015  0.2359215   0.02152709 -0.04039078 -0.0460629  -0.12513155
 -0.39021596  0.0294274  -0.31173652  0.4416816  -0.40543717 -0.32934248
 -0.04138614  0.00618512 -0.13119563]
Centroid 14: [ 0.23195164  0.0758917  -0.06778049  0.03459797  0.15062584  0.24505188
 -0.04142889  0.4669111  -0.21203832 -0.2006859  -0.06972734  0.51661736
  0.01895734  0.15177344 -0.3988887 ]
Centroid 15: [-0.16034973  0.5128787   0.06736645 -0.04868226  0.05819589  0.09580738
  0.0036029  -0.04203127 -0.18981706 -0.13128525  0.10617141 -0.06740869
  0.00482178 -0.5497249  -0.2319413 ]
```

poly (gamma=0.1)

In [ ]:

```python
spectral_clustering(
    oe_X_train025,
    cuts=23,
    fname="one-hot_encoded_spectral_clustering",
    affinity="poly",
    gamma=0.1,
)
```

```
eigenvalues: [9.9992156e-01 9.9990118e-01 9.9988675e-01 9.9986696e-01 9.9986386e-01
 9.9984586e-01 9.9982715e-01 9.9977434e-01 9.9974847e-01 9.9972093e-01
 9.9952489e-01 9.9941665e-01 9.9932396e-01 9.9691987e-01 9.9616468e-01
 9.9606234e-01 9.8240614e-01 9.7884965e-01 9.7031581e-01 8.7656683e-01
 4.2073143e-01 3.8275317e-16 3.0867708e-20].
Finished running k-means++
1.0     6507
0.0      940
12.0     542
5.0      505
13.0     442
2.0      436
4.0      434
21.0     411
22.0     360
7.0      355
16.0     293
8.0      277
6.0      143
11.0     127
3.0      113
17.0     104
10.0     101
20.0      91
15.0      71
9.0       70
19.0      14
18.0       8
14.0       6
dtype: int64
Completed iteration 1
1.0     6503
0.0      817
12.0     529
5.0      494
2.0      435
4.0      425
13.0     404
7.0      366
8.0      366
22.0     348
21.0     318
16.0     261
6.0      185
9.0      180
3.0      173
17.0     104
15.0     100
11.0     100
10.0      94
20.0      84
19.0      37
18.0      18
14.0       9
dtype: int64
Completed iteration 2
1.0     6503
0.0      668
12.0     567
5.0      489
8.0      443
2.0      430
4.0      420
13.0     393
7.0      361
22.0     343
21.0     316
16.0     246
6.0      219
9.0      203
3.0      177
11.0     112
17.0     101
15.0      99
10.0      92
20.0      89
19.0      44
18.0      23
14.0      12
dtype: int64
Completed iteration 3
1.0     6503
0.0      594
12.0     572
8.0      492
5.0      487
2.0      425
4.0      415
13.0     387
7.0      358
22.0     345
21.0     336
16.0     242
6.0      235
9.0      192
3.0      178
11.0     114
17.0     103
15.0      98
20.0      98
10.0      90
19.0      48
18.0      25
14.0      13
dtype: int64
Completed iteration 4
1.0     6503
12.0     593
0.0      544
8.0      496
5.0      487
2.0      427
4.0      413
13.0     386
7.0      354
22.0     347
21.0     332
6.0      242
16.0     234
9.0      208
3.0      177
11.0     113
17.0     104
15.0      99
20.0      97
10.0      88
19.0      56
18.0      37
14.0      13
dtype: int64
Completed iteration 5
1.0     6503
12.0     612
0.0      495
5.0      487
8.0      481
2.0      428
4.0      412
13.0     386
7.0      351
22.0     349
21.0     326
6.0      253
16.0     221
9.0      218
3.0      177
11.0     112
17.0     104
15.0      97
20.0      97
10.0      88
18.0      80
19.0      59
14.0      14
dtype: int64
Completed iteration 6
1.0     6503
12.0     623
5.0      487
8.0      469
0.0      466
2.0      429
4.0      413
13.0     386
22.0     349
7.0      349
21.0     318
6.0      254
9.0      232
16.0     221
3.0      177
11.0     111
17.0     104
15.0      98
20.0      97
18.0      93
10.0      88
19.0      64
14.0      19
dtype: int64
Completed iteration 7
1.0     6503
12.0     624
5.0      487
0.0      458
8.0      458
2.0      431
4.0      413
13.0     386
22.0     349
7.0      348
21.0     313
6.0      262
9.0      245
16.0     218
3.0      176
11.0     111
17.0     104
15.0      99
20.0      96
18.0      90
10.0      88
19.0      65
14.0      26
dtype: int64
Completed iteration 8
1.0     6503
12.0     624
5.0      487
0.0      456
8.0      450
2.0      434
4.0      413
13.0     386
22.0     349
7.0      347
21.0     310
6.0      261
9.0      253
16.0     223
3.0      176
11.0     111
17.0     104
15.0      97
20.0      94
18.0      89
10.0      88
19.0      67
14.0      28
dtype: int64
Completed iteration 9
1.0     6503
12.0     624
5.0      488
0.0      456
8.0      441
2.0      436
4.0      413
13.0     386
22.0     349
7.0      344
21.0     312
6.0      258
9.0      256
16.0     230
3.0      176
11.0     111
17.0     104
15.0      97
20.0      94
18.0      89
10.0      88
19.0      67
14.0      28
dtype: int64
Completed iteration 10
1.0     6503
12.0     623
5.0      488
0.0      456
2.0      439
8.0      432
4.0      413
13.0     386
22.0     349
7.0      344
21.0     312
9.0      263
6.0      261
16.0     230
3.0      175
11.0     111
17.0     104
15.0      97
20.0      92
18.0      89
10.0      88
19.0      67
14.0      28
dtype: int64
Completed iteration 11
1.0     6503
12.0     623
5.0      488
0.0      456
2.0      444
8.0      421
4.0      413
13.0     386
22.0     349
7.0      344
21.0     315
6.0      266
9.0      263
16.0     233
3.0      175
11.0     111
17.0     104
15.0      98
18.0      89
10.0      88
20.0      86
19.0      67
14.0      28
dtype: int64
Completed iteration 12
1.0     6503
12.0     621
5.0      488
0.0      456
2.0      446
8.0      414
4.0      413
13.0     386
22.0     350
7.0      339
21.0     319
6.0      267
9.0      263
16.0     237
3.0      175
11.0     111
17.0     104
15.0      99
18.0      89
10.0      88
20.0      87
19.0      67
14.0      28
dtype: int64
Completed iteration 13
1.0     6503
12.0     621
5.0      488
0.0      457
2.0      449
4.0      413
8.0      406
13.0     385
22.0     350
7.0      338
21.0     324
9.0      265
6.0      262
16.0     242
3.0      174
11.0     111
17.0     104
15.0      99
18.0      89
10.0      88
20.0      87
19.0      67
14.0      28
dtype: int64
Completed iteration 14
1.0     6503
12.0     621
5.0      488
0.0      456
2.0      451
4.0      413
8.0      392
13.0     385
22.0     350
7.0      335
21.0     332
9.0      266
6.0      266
16.0     244
3.0      173
11.0     111
17.0     104
15.0      99
18.0      89
20.0      89
10.0      88
19.0      67
14.0      28
dtype: int64
Completed iteration 15
1.0     6503
12.0     618
5.0      488
0.0      456
2.0      454
4.0      413
13.0     385
8.0      380
22.0     350
21.0     335
7.0      333
9.0      275
6.0      261
16.0     252
3.0      172
11.0     111
17.0     104
15.0      99
18.0      89
20.0      89
10.0      88
19.0      67
14.0      28
dtype: int64
Completed iteration 16
1.0     6503
12.0     617
5.0      488
0.0      456
2.0      454
4.0      413
13.0     385
8.0      357
22.0     350
21.0     345
7.0      324
6.0      275
9.0      272
16.0     255
3.0      171
11.0     111
17.0     104
15.0      99
20.0      99
18.0      89
10.0      88
19.0      67
14.0      28
dtype: int64
Completed iteration 17
1.0     6503
12.0     616
5.0      488
0.0      456
2.0      455
4.0      413
13.0     384
21.0     352
22.0     350
8.0      340
7.0      308
6.0      285
9.0      268
16.0     260
3.0      171
20.0     115
11.0     111
17.0     104
15.0      99
18.0      89
10.0      88
19.0      67
14.0      28
dtype: int64
Completed iteration 18
1.0     6503
12.0     614
5.0      488
0.0      456
2.0      455
4.0      413
13.0     383
21.0     359
22.0     350
8.0      317
6.0      301
7.0      279
16.0     268
9.0      262
3.0      169
20.0     147
11.0     111
17.0     104
15.0      99
18.0      89
10.0      88
19.0      67
14.0      28
dtype: int64
Completed iteration 19
1.0     6503
12.0     614
5.0      488
0.0      456
2.0      456
4.0      413
13.0     383
21.0     362
22.0     350
6.0      311
8.0      298
16.0     274
9.0      262
7.0      231
20.0     194
3.0      169
11.0     111
17.0     104
15.0      99
18.0      89
10.0      88
19.0      67
14.0      28
dtype: int64
Completed iteration 20
1.0     6503
12.0     614
5.0      488
2.0      461
0.0      456
4.0      413
13.0     383
21.0     370
22.0     350
6.0      318
16.0     283
8.0      279
9.0      257
20.0     222
7.0      198
3.0      169
11.0     111
17.0     104
15.0      99
18.0      89
10.0      88
19.0      67
14.0      28
dtype: int64
Completed iteration 21
Reached 21 iterations
Centroids:
Centroid 1: [ 0.20285809  0.08492577 -0.00513225 -0.05994312 -0.00481943  0.02580819
 -0.0414805   0.11621748 -0.01373131 -0.00274499 -0.03712721 -0.0083631
  0.5157289  -0.11717034  0.03486182 -0.07374325 -0.23942815 -0.21053629
  0.08549444 -0.40756556 -0.01554527  0.12113612 -0.39337626]
Centroid 2: [ 1.38628082e-02 -8.90808273e-03 -8.81559961e-03  1.07178595e-02
  1.25009017e-02 -2.20568758e-03 -1.42016783e-02  5.33763901e-04
 -5.95095009e-03  7.24671409e-04  2.60962360e-03  2.80272285e-03
 -1.78401366e-01  2.49521881e-02 -2.56871385e-03  1.20594306e-02
  4.86330017e-02  4.41590510e-02 -2.22169217e-02  2.04739682e-02
 -2.45682411e-02  3.22867125e-01 -9.20821905e-01]
Centroid 3: [ 3.1823628e-02  5.6835290e-02  3.3569396e-02 -8.1968801e-03
 -1.1563861e-02  3.1064820e-02 -1.2314015e-02 -2.3684870e-02
  2.8305776e-02 -2.7385096e-03 -1.1734827e-03  2.6516054e-02
 -3.1392906e-02  2.3686139e-01 -2.9350528e-02  3.2034170e-04
 -3.3019853e-01 -2.8854707e-01 -1.7000593e-02 -9.6538857e-02
 -5.5894260e-03 -7.7794731e-01 -2.4006064e-01]
Centroid 4: [ 0.03242657  0.04854395  0.04720576  0.1243647   0.00306197 -0.32627296
  0.06226254  0.06782065 -0.13603795  0.00398767  0.04223448 -0.0601827
 -0.12963712 -0.3346211   0.03014453 -0.2707837  -0.34614736 -0.08937551
  0.28245005  0.28093103 -0.00191131  0.00137239 -0.1409007 ]
Centroid 5: [ 0.00117796 -0.04644539 -0.05731417 -0.10026065  0.01002565 -0.03267426
  0.0909358  -0.18210061  0.19424093  0.04544796  0.02502106 -0.05373745
 -0.01117063 -0.3506172   0.03870115 -0.06322449  0.29081327  0.23722053
 -0.01820732 -0.00988595 -0.00509041 -0.68931514 -0.21747474]
Centroid 6: [-0.04558261  0.03545724 -0.05244336 -0.03258684 -0.00871919 -0.00480835
  0.12817346 -0.03173894 -0.01356573 -0.01262706 -0.0680076  -0.03576441
  0.83803236 -0.16639699 -0.01286096  0.24182557 -0.08921922 -0.08225439
 -0.08586734  0.15424353 -0.00757761  0.10040399 -0.30494362]
Centroid 7: [ 0.3067273   0.09628261  0.00658228 -0.06047899 -0.04788672  0.10429852
 -0.20411685  0.17476942  0.17056693 -0.01098988  0.00425322  0.02213725
 -0.31553975  0.04568632 -0.0097685  -0.01479548  0.23424624  0.23106058
  0.06098434 -0.52758044 -0.01901775  0.13259026 -0.39217383]
Centroid 8: [ 0.04203356 -0.03782031 -0.05164122 -0.0413439   0.02530394  0.00802164
 -0.00108117 -0.07099198  0.10013679 -0.00650035  0.02011826 -0.00793653
 -0.18464641  0.1801713  -0.01828836 -0.2707934  -0.26051474 -0.1991764
 -0.20308006  0.61397284 -0.00387803 -0.00229286 -0.23641582]
Centroid 9: [ 0.20364638  0.04794114  0.02169654 -0.04008931 -0.04336917  0.06748373
 -0.17929323  0.08614691  0.08666303  0.00319833  0.05476059  0.01912676
 -0.45953217 -0.12481763 -0.03737622  0.34587896  0.13751832  0.14159188
  0.02472763 -0.45977095 -0.01850629  0.1314703  -0.39328682]
Centroid 10: [-0.11591415  0.0061499  -0.0588052   0.06057306  0.03248188 -0.07837056
  0.19655067  0.03173427 -0.0535239   0.01340785 -0.06229526 -0.00692615
  0.02159648  0.19201745  0.01490347 -0.34259483  0.22365107  0.21250337
  0.06798334 -0.56843185 -0.02129841  0.15171078 -0.454454  ]
Centroid 11: [-0.03038532 -0.04538812  0.02968211 -0.15701175 -0.00320996  0.3974575
  0.12792255  0.04889949 -0.25432456  0.01240156  0.00747191 -0.039296
 -0.04760578 -0.13239709  0.36873835 -0.05134349  0.26477847 -0.40160322
  0.37377995  0.3052064   0.02541787  0.00059807 -0.12169292]
Centroid 12: [-8.4125539e-03 -3.2918472e-02 -1.8174196e-02  9.7746916e-02
 -1.7850352e-02 -2.7453689e-02 -1.7702408e-01  3.8197222e-01
 -3.4498367e-01  3.3122964e-02  2.5372783e-02 -1.0499650e-01
  5.4177740e-03  1.3975924e-01  1.7898228e-05 -7.3589191e-02
  1.8528022e-01  7.9789005e-02 -3.2066262e-01  3.7222093e-01
 -4.0298449e-03 -1.4822701e-01 -1.9075334e-01]
Centroid 13: [-2.0143753e-01 -5.6566939e-02 -5.5668538e-04  7.6291971e-02
  2.4634998e-02  3.3064250e-02 -5.9289180e-02 -3.0031171e-02
  4.7296092e-02  3.1788028e-03  2.5778344e-02  5.1922295e-03
 -4.4428669e-02 -3.0018166e-01 -3.5362273e-02  5.7116431e-01
 -1.9158882e-01 -1.5855069e-01  1.8624635e-02 -3.3281162e-01
 -1.4884307e-02  1.1291115e-01 -3.5993645e-01]
Centroid 14: [ 0.01357746 -0.01193619 -0.03374179 -0.02996885  0.0029245   0.05281777
 -0.05842353  0.02707884  0.1284615  -0.00494436  0.01933247 -0.07672464
  0.02024987  0.24049    -0.06351526  0.07282645  0.04292974  0.38005975
  0.3011935   0.7130667  -0.00377957  0.06156765 -0.23900415]
Centroid 15: [ 0.0394957  -0.01230286  0.19416256 -0.21572347 -0.30746594 -0.07385363
 -0.1337439  -0.06163844 -0.03638729 -0.01947027  0.13879256  0.03558791
  0.02882695  0.00084027  0.0005702   0.01040256 -0.00731385 -0.00401187
  0.00103483  0.00234575 -0.00132493  0.01569218 -0.04775574]
Centroid 16: [-0.28126293  0.00459461  0.11337277  0.11781892  0.01971677 -0.02037995
  0.19245234 -0.20728867 -0.04262756  0.01191455 -0.08661976  0.17420721
  0.02816097  0.03014455 -0.01773156  0.06655169 -0.13955753 -0.0873278
 -0.01081005  0.06005787 -0.00232378 -0.06202333 -0.09311313]
Centroid 17: [-7.64781907e-02 -3.85082774e-02  4.90305573e-02  4.26156111e-02
 -1.90092027e-02 -5.27144119e-04 -1.22888505e-01 -2.25678459e-02
 -6.98492900e-02  4.15171683e-03  8.18359405e-02  4.19301959e-03
 -1.98613808e-01  8.27444941e-02 -3.12869716e-03 -1.12619579e-01
  2.23306865e-01  2.16513991e-01  5.99190556e-02 -5.90600729e-01
 -2.25231647e-02  1.60032868e-01 -4.78437066e-01]
Centroid 18: [-0.00825619 -0.01458465 -0.02874772 -0.05192889  0.00379809  0.00502137
  0.05823391 -0.12485111  0.16804288  0.0007564   0.01487068 -0.038347
 -0.03963659 -0.2824329   0.0435708  -0.17750058  0.23999691 -0.07717629
 -0.7116883   0.21213725 -0.00409928 -0.02249462 -0.12087341]
Centroid 19: [ 0.45353162  0.14783879 -0.04607652 -0.29680705 -0.015388   -0.05644153
  0.3334214  -0.27152166  0.13074234  0.00426201  0.00091952  0.01691485
  0.26219213  0.02041317 -0.00596589  0.07307105 -0.06990573 -0.05264514
  0.03373248 -0.30494544 -0.01224518  0.09087991 -0.2864717 ]
Centroid 20: [ 0.00636407 -0.03795997 -0.07556786  0.09308831  0.08757249  0.00253902
 -0.05674359 -0.02998992  0.13845026 -0.03554383 -0.04965055  0.0378092
  0.04052929  0.0426881  -0.05521493  0.01210297  0.04101814 -0.10450672
  0.06875214  0.07545292  0.11817123  0.01036165 -0.05422364]
Centroid 21: [ 0.03226223  0.03213403 -0.02549795 -0.01511846 -0.05528192  0.0320892
  0.00886936 -0.05887799  0.1423867  -0.00281117  0.02952155 -0.01606458
 -0.18660939  0.27214983 -0.0296547  -0.20951386 -0.387838   -0.31245172
 -0.15074967  0.40063795 -0.00589677 -0.4234862  -0.30555773]
Centroid 22: [-0.2327899  -0.06258186  0.0044904   0.04181153  0.0243708  -0.09863286
  0.15170209 -0.14810872 -0.1636604   0.00667317  0.02802015 -0.01105338
  0.18540484  0.26429242  0.02989957 -0.50158364  0.19516432  0.18166287
  0.06655259 -0.44718805 -0.01608309  0.11440949 -0.3427048 ]
Centroid 23: [ 3.4547519e-02  2.0797584e-02  1.7498357e-02  7.9182990e-02
 -2.1966363e-04 -7.0009860e-03 -1.3692014e-01  2.6071137e-01
 -2.6153365e-01  3.1762239e-02 -3.0935304e-02  1.1312108e-02
  6.5184504e-02  6.0086347e-02 -1.3646243e-02  1.1330256e-01
  1.6009311e-01  1.9494794e-01  9.0367958e-02 -3.4109078e-02
 -4.8616976e-03 -6.7086047e-01 -2.0704190e-01]
```

In [ ]:

```python
spectral_clustering(
    oe_X_train025,
    cuts=len(np.unique(le_y_train025)),
    fname="one-hot_encoded_spectral_clustering",
    affinity="poly",
    gamma=0.1,
)
```

```
eigenvalues: [9.9974847e-01 9.9972093e-01 9.9952489e-01 9.9941665e-01 9.9932396e-01
 9.9691987e-01 9.9616468e-01 9.9606234e-01 9.8240614e-01 9.7884965e-01
 9.7031581e-01 8.7656683e-01 4.2073143e-01 3.8275317e-16 3.0867708e-20].
Finished running k-means++
3.0     6525
0.0     1102
9.0      862
4.0      734
5.0      566
6.0      520
11.0     516
8.0      372
7.0      304
1.0      218
2.0      190
12.0     180
13.0     142
10.0     106
14.0      13
dtype: int64
Completed iteration 1
3.0     6521
0.0     1036
4.0      821
9.0      797
5.0      535
6.0      535
11.0     402
8.0      389
7.0      315
2.0      306
1.0      215
12.0     203
13.0     146
10.0     114
14.0      15
dtype: int64
Completed iteration 2
3.0     6521
0.0      931
4.0      841
9.0      781
6.0      628
5.0      519
8.0      392
11.0     364
2.0      354
7.0      318
12.0     206
1.0      198
13.0     158
10.0     124
14.0      15
dtype: int64
Completed iteration 3
3.0     6520
0.0      835
4.0      830
9.0      768
6.0      745
5.0      514
2.0      393
8.0      392
11.0     328
7.0      309
12.0     205
1.0      189
13.0     161
10.0     146
14.0      15
dtype: int64
Completed iteration 4
3.0     6520
6.0      843
4.0      807
0.0      767
9.0      759
5.0      509
2.0      406
8.0      390
7.0      325
11.0     310
12.0     203
1.0      175
10.0     161
13.0     160
14.0      15
dtype: int64
Completed iteration 5
3.0     6520
6.0      898
4.0      800
9.0      753
0.0      723
5.0      507
2.0      416
8.0      390
7.0      341
11.0     296
12.0     202
10.0     167
1.0      163
13.0     159
14.0      15
dtype: int64
Completed iteration 6
3.0     6520
6.0      921
4.0      796
9.0      749
0.0      707
5.0      503
2.0      423
8.0      391
7.0      362
11.0     291
12.0     200
10.0     169
13.0     160
1.0      143
14.0      15
dtype: int64
Completed iteration 7
3.0     6520
6.0      928
4.0      795
9.0      746
0.0      700
5.0      500
2.0      426
8.0      392
7.0      377
11.0     291
12.0     199
10.0     172
13.0     160
1.0      129
14.0      15
dtype: int64
Completed iteration 8
3.0     6520
6.0      932
4.0      794
9.0      746
0.0      694
5.0      500
2.0      429
8.0      393
7.0      391
11.0     288
12.0     192
10.0     173
13.0     161
1.0      122
14.0      15
dtype: int64
Completed iteration 9
3.0     6520
6.0      936
4.0      794
9.0      746
0.0      690
5.0      497
2.0      432
8.0      395
7.0      392
11.0     286
12.0     192
10.0     174
13.0     160
1.0      121
14.0      15
dtype: int64
Completed iteration 10
3.0     6520
6.0      938
4.0      794
9.0      745
0.0      689
5.0      497
2.0      433
8.0      396
7.0      391
11.0     285
12.0     192
10.0     175
13.0     160
1.0      120
14.0      15
dtype: int64
Completed iteration 11
Epsilon has a maximum value of 0.006253564264625311
Centroids:
Centroid 1: [ 0.0455634   0.0052612   0.02447174  0.00483571 -0.03630269 -0.3193515
 -0.03668178  0.5997603  -0.20330425 -0.16815828  0.02273642 -0.3748068
 -0.01664437  0.12615342 -0.4016139 ]
Centroid 2: [ 0.16076097 -0.00926672  0.01237975  0.01162274 -0.05639213 -0.22246265
  0.04800214 -0.24991685 -0.49734613 -0.2888882   0.21902083  0.13989177
 -0.00218276  0.0118297  -0.14701684]
Centroid 3: [ 0.18888032  0.04845166  0.0231927  -0.05488637 -0.00949397 -0.36181912
  0.04006988 -0.06169358  0.30580616  0.24888344 -0.01751865 -0.01870142
 -0.00537886 -0.73480904 -0.22897175]
Centroid 4: [-6.0133585e-03  7.0349168e-04  2.5597338e-03  2.8178114e-03
 -1.7902954e-01  2.5047338e-02 -2.5766455e-03  1.2057274e-02
  4.8782516e-02  4.4296153e-02 -2.2268772e-02  2.0512082e-02
 -2.4636777e-02  3.2377163e-01 -9.2339218e-01]
Centroid 5: [-0.11492458  0.00829417  0.01204376 -0.00669871  0.09875685  0.2376835
  0.02264322 -0.43377715  0.2266816   0.21419089  0.07324102 -0.55331486
 -0.02031743  0.14449753 -0.43272343]
Centroid 6: [ 0.01742568 -0.00131899 -0.00152128  0.0212645  -0.02521527  0.24035244
 -0.02947936 -0.00529668 -0.33999568 -0.30165753 -0.03306311 -0.07640787
 -0.00572574 -0.7780374  -0.24811494]
Centroid 7: [-0.00094754 -0.00801196 -0.05701035 -0.02157503  0.72529125 -0.1408212
  0.01117832  0.08599461 -0.17393743 -0.15483363 -0.00180305 -0.12126245
 -0.01170684  0.11196654 -0.35740548]
Centroid 8: [ 0.10947367 -0.00435289  0.02205698 -0.00802459 -0.19546068  0.2686039
 -0.02578654 -0.2453421  -0.32589728 -0.27327642 -0.21641211  0.52644134
 -0.00504203 -0.20984343 -0.2777647 ]
Centroid 9: [ 0.13128924 -0.00491768  0.02271468 -0.08232718  0.01513965  0.23333497
 -0.06281084  0.05997832  0.03576568  0.3742645   0.2947191   0.7326136
 -0.00383165  0.07091417 -0.24339071]
Centroid 10: [ 0.10548095 -0.00253189  0.03804599  0.01970387 -0.40694773 -0.01808429
 -0.02246497  0.12850621  0.21913819  0.21799886  0.05213576 -0.5802912
 -0.02210574  0.1559569  -0.46445477]
Centroid 11: [-1.6472025e-02  1.6335329e-02  2.3680132e-02 -6.9844782e-02
 -2.8976589e-02 -1.6529958e-01  3.2546908e-02 -1.6555099e-01
  2.5388041e-01  2.8383374e-04 -6.0339123e-01  3.1722775e-01
 -4.3570953e-03 -6.2112618e-02 -1.6113482e-01]
Centroid 12: [-0.45075956  0.04583402 -0.01776761 -0.03235337  0.06330742  0.0723373
 -0.0013537   0.07235355  0.21402577  0.15641268 -0.06975157  0.00726574
 -0.00545267 -0.7012691  -0.23285843]
Centroid 13: [-0.2895029   0.01404957  0.03732931 -0.08781453 -0.09109711 -0.30261055
  0.19408154 -0.17274831  0.0020753  -0.20351152  0.3814361   0.40334824
  0.01664568  0.01432648 -0.15598376]
Centroid 14: [ 0.04514423 -0.02611733 -0.13874157  0.21209231  0.05844351  0.14780408
 -0.07410567  0.2036788   0.00091788  0.1786646   0.32836366  0.04061121
  0.04376836 -0.34913573 -0.1441133 ]
Centroid 15: [ 0.01027916  0.12368204  0.6810583   0.2651993   0.06384774 -0.00634599
 -0.00139623  0.01830512  0.01574697  0.01296125 -0.0041723  -0.00179896
 -0.00302056  0.01093525 -0.10951355]
```

poly (gamma=0.15)

```
In [ ]: spectral_clustering(
            oe_X_train025,
            cuts=23,
            fname="one-hot_encoded_spectral_clustering",
            affinity="poly",
            gamma=0.15,
        )
```

```
eigenvalues: [9.9991715e-01 9.9991059e-01 9.9988377e-01 9.9987543e-01 9.9986768e-01
 9.9984992e-01 9.9982774e-01 9.9980414e-01 9.9978685e-01 9.9972618e-01
 9.9955457e-01 9.9947590e-01 9.9938643e-01 9.9691558e-01 9.9616969e-01
 9.9605697e-01 9.8241097e-01 9.7884613e-01 9.7032988e-01 8.7656701e-01
 4.2072964e-01 5.5125371e-17 1.5734539e-17].
Finished running k-means++
4.0     6503
22.0     604
12.0     573
13.0     524
5.0      498
2.0      461
7.0      437
17.0     428
20.0     337
0.0      309
3.0      301
15.0     239
11.0     238
10.0     196
1.0      189
6.0      145
16.0     138
9.0      103
8.0       85
19.0      17
18.0      14
21.0       6
14.0       5
dtype: int64
Completed iteration 1
4.0     6503
22.0     522
13.0     518
5.0      493
12.0     478
7.0      470
2.0      408
11.0     341
20.0     339
3.0      334
15.0     323
17.0     312
0.0      289
16.0     203
1.0      201
10.0     200
6.0      176
9.0       94
8.0       73
18.0      35
19.0      24
14.0       9
21.0       5
dtype: int64
Completed iteration 2
4.0     6503
13.0     512
5.0      489
7.0      486
22.0     476
12.0     448
2.0      391
11.0     368
15.0     356
20.0     351
3.0      348
17.0     284
0.0      284
1.0      216
16.0     216
6.0      182
10.0     180
9.0       92
8.0       66
18.0      52
19.0      24
14.0      21
21.0       5
dtype: int64
Completed iteration 3
4.0     6503
13.0     506
7.0      504
5.0      489
12.0     435
22.0     432
2.0      389
11.0     370
15.0     365
3.0      353
20.0     342
0.0      284
17.0     280
1.0      240
16.0     220
10.0     169
6.0      165
9.0       91
8.0       66
18.0      66
14.0      53
19.0      23
21.0       5
dtype: int64
Completed iteration 4
4.0     6503
7.0      518
13.0     500
5.0      489
12.0     431
2.0      384
15.0     369
11.0     357
3.0      357
22.0     356
20.0     336
1.0      306
0.0      286
17.0     281
16.0     219
6.0      163
10.0     162
9.0       92
18.0      86
8.0       65
14.0      62
19.0      23
21.0       5
dtype: int64
Completed iteration 5
4.0     6503
7.0      522
13.0     497
5.0      491
1.0      427
12.0     425
2.0      382
15.0     376
3.0      363
11.0     343
20.0     338
0.0      284
17.0     282
22.0     236
16.0     217
6.0      158
10.0     157
18.0      99
9.0       92
14.0      66
8.0       64
19.0      23
21.0       5
dtype: int64
Completed iteration 6
4.0     6503
7.0      526
13.0     494
5.0      489
1.0      463
12.0     424
2.0      383
15.0     376
3.0      370
20.0     328
11.0     307
17.0     286
0.0      283
22.0     233
16.0     218
10.0     158
6.0      154
18.0     103
9.0       92
14.0      71
8.0       61
19.0      23
21.0       5
dtype: int64
Completed iteration 7
4.0     6503
7.0      523
5.0      489
13.0     486
1.0      468
12.0     423
2.0      383
3.0      377
15.0     376
20.0     320
17.0     288
0.0      283
22.0     276
11.0     261
16.0     226
10.0     159
6.0      151
18.0     102
9.0       92
14.0      74
8.0       62
19.0      23
21.0       5
dtype: int64
Completed iteration 8
4.0     6503
7.0      522
5.0      489
13.0     481
1.0      475
12.0     419
2.0      383
3.0      382
15.0     375
22.0     324
20.0     309
17.0     296
0.0      284
16.0     228
11.0     213
10.0     161
6.0      151
18.0     100
9.0       92
14.0      74
8.0       61
19.0      23
21.0       5
dtype: int64
Completed iteration 9
4.0     6503
7.0      519
5.0      489
1.0      479
13.0     477
12.0     415
3.0      386
2.0      383
15.0     374
22.0     341
20.0     301
17.0     298
0.0      284
16.0     232
11.0     198
10.0     166
6.0      151
18.0      99
9.0       92
14.0      74
8.0       61
19.0      23
21.0       5
dtype: int64
Completed iteration 10
4.0     6503
7.0      514
5.0      489
1.0      481
13.0     477
12.0     414
3.0      387
2.0      383
15.0     373
22.0     339
17.0     304
20.0     297
0.0      283
16.0     235
11.0     200
10.0     166
6.0      151
18.0     100
9.0       92
14.0      73
8.0       61
19.0      23
21.0       5
dtype: int64
Completed iteration 11
4.0     6503
7.0      511
5.0      489
1.0      482
13.0     475
12.0     414
3.0      387
2.0      383
15.0     373
22.0     339
17.0     308
20.0     291
0.0      285
16.0     241
11.0     199
10.0     165
6.0      151
18.0     100
9.0       92
14.0      73
8.0       61
19.0      23
21.0       5
dtype: int64
Completed iteration 12
4.0     6503
7.0      508
5.0      489
1.0      484
13.0     475
12.0     414
3.0      388
2.0      383
15.0     373
22.0     337
17.0     310
20.0     285
0.0      285
16.0     242
11.0     199
10.0     170
6.0      151
18.0     100
9.0       92
14.0      73
8.0       61
19.0      23
21.0       5
dtype: int64
Completed iteration 13
4.0     6503
7.0      506
5.0      489
1.0      485
13.0     475
12.0     414
3.0      389
2.0      383
15.0     373
22.0     336
17.0     311
0.0      284
20.0     280
16.0     246
11.0     199
10.0     172
6.0      151
18.0     100
9.0       92
14.0      73
8.0       61
19.0      23
21.0       5
dtype: int64
Completed iteration 14
4.0     6503
7.0      504
5.0      489
1.0      485
13.0     475
12.0     414
3.0      390
2.0      383
15.0     373
22.0     336
17.0     313
0.0      283
20.0     277
16.0     248
11.0     199
10.0     173
6.0      151
18.0     100
9.0       92
14.0      73
8.0       61
19.0      23
21.0       5
dtype: int64
Completed iteration 15
4.0     6503
7.0      501
5.0      489
1.0      485
13.0     475
12.0     414
3.0      391
2.0      383
15.0     373
22.0     336
17.0     315
0.0      282
20.0     276
16.0     250
11.0     199
10.0     173
6.0      151
18.0     100
9.0       92
14.0      73
8.0       61
19.0      23
21.0       5
dtype: int64
Completed iteration 16
4.0     6503
7.0      499
5.0      489
1.0      485
13.0     475
12.0     414
3.0      391
2.0      383
15.0     373
22.0     336
17.0     316
0.0      282
20.0     276
16.0     251
11.0     199
10.0     173
6.0      151
18.0     100
9.0       92
14.0      73
8.0       61
19.0      23
21.0       5
dtype: int64
Completed iteration 17
Epsilon has a maximum value of 0.0098012275993824
Centroids:
Centroid 1: [-6.0179420e-03  2.9201014e-02  1.4401461e-02  1.2696657e-02
  5.4351483e-03  1.4881912e-02  3.1404819e-02  6.4500891e-02
 -3.0024855e-03 -1.6604817e-02 -2.9911013e-02  4.1304557e-03
 -3.0638874e-01  2.3273401e-01  8.4497180e-05 -3.0919984e-01
  2.6096782e-01 -2.2336219e-01  6.0312919e-02  4.4180605e-01
  1.8220708e-02  3.7837300e-01  2.8274018e-01]
Centroid 2: [ 1.1469039e-02 -3.9649144e-02 -2.7524199e-02  2.1170061e-02
  5.1016812e-03  2.0701149e-02  4.3699667e-02  1.2338788e-03
  5.0378256e-03 -3.2160334e-02  5.3986127e-04  2.6168838e-02
  2.7294127e-02 -2.3704447e-01  2.6926186e-02  1.0859083e-02
  3.3076307e-01 -2.9021877e-01 -2.3204474e-02  8.1851333e-02
  5.5907932e-03 -4.7811827e-01  6.4570898e-01]
Centroid 3: [ 2.5821716e-02 -1.4833056e-03  2.1710683e-02 -3.9753880e-02
 -3.6712928e-04  5.7486787e-02  3.1475812e-02  1.0097743e-01
 -1.2335216e-02 -8.7584510e-02 -7.1607074e-03 -9.1631182e-02
 -2.9717650e-02 -2.4649036e-01  5.8946643e-02 -6.5501496e-02
 -4.4195853e-02  3.7807697e-01  2.9546380e-01 -7.1416479e-01
  3.7817212e-03  1.9080974e-01  1.5699802e-01]
Centroid 4: [ 0.3477392  -0.25858727  0.03800746 -0.06116373  0.0387389   0.03383914
  0.00071102 -0.00203172 -0.01640571  0.01778072 -0.04573649  0.00226027
 -0.49367467  0.05958561 -0.03112498  0.13367917  0.18438493 -0.16222647
  0.07512899  0.352161    0.0132528   0.27873486  0.20946886]
Centroid 5: [ 2.1469509e-03 -2.0116696e-02  3.6093451e-03 -6.6156825e-03
  1.4990333e-02  1.0913730e-03  2.4400840e-03  5.9182756e-03
 -1.6497409e-02 -4.1666607e-04  9.5755942e-03  2.3799320e-03
  1.7770509e-01 -2.6932759e-02  2.5111618e-03 -1.3470537e-02
 -4.8549343e-02  4.4172578e-02 -2.2212634e-02 -2.0457936e-02
  2.4557948e-02  8.0192661e-01  5.5521697e-01]
Centroid 6: [-0.05059993  0.01120903  0.02827484  0.02533658 -0.00636217 -0.00248869
 -0.03347869 -0.08229421  0.08638248  0.0253313  -0.04292309 -0.00805362
 -0.84560627  0.16667303  0.00905388 -0.23525141  0.0883007  -0.08152592
 -0.08515736 -0.15301017  0.00751876  0.2584206   0.18627281]
Centroid 7: [-0.01878655 -0.03037456 -0.04860175 -0.05968203  0.01060878 -0.34913304
 -0.06293637 -0.09619893  0.06503474  0.07958207  0.00150184 -0.09909863
  0.110701    0.34286618  0.01185835  0.2107609   0.2779986   0.04158521
  0.31638664 -0.42805555  0.00262316  0.10357507  0.13017651]
Centroid 8: [-2.2426328e-01  1.4515379e-01  1.7474042e-02  6.2291618e-02
 -2.7220134e-02 -8.3946951e-02 -8.4763311e-02 -1.8307932e-01
  1.2349589e-01  1.0919022e-01 -1.5680626e-02  8.8058252e-05
 -1.5437090e-01 -2.2918200e-01 -2.2683920e-02  4.7070757e-01
 -1.9485116e-01  1.8219578e-01  6.5490611e-02  4.6457484e-01
  1.6936786e-02  3.1021142e-01  2.2185476e-01]
Centroid 9: [-0.08844194  0.03340593 -0.0166028  -0.00829941 -0.00823643 -0.06803739
 -0.01268711 -0.01929738 -0.01410783  0.03571383  0.01219044 -0.01235057
  0.14041391  0.1722518  -0.10423163  0.31007877  0.5524481  -0.49115795
  0.12897229  0.10775523  0.00074009  0.07141865  0.06759589]
Centroid 10: [ 0.03541874 -0.01020127  0.03365364  0.17806163 -0.01159134  0.40169087
 -0.03924688 -0.09868516 -0.03997184  0.21632527 -0.00156373 -0.02708833
  0.04859352  0.12943304 -0.33651718  0.04908062 -0.27864474 -0.40965247
  0.36967117 -0.2977262  -0.03302214  0.07042567  0.09584428]
Centroid 11: [-0.07468903 -0.1644471   0.09778696 -0.02298335  0.03374618 -0.02048101
 -0.03966469 -0.1568931  -0.14025678 -0.08706772  0.01322396 -0.01130172
  0.19755358 -0.07463153  0.00656172  0.08108519 -0.21324755  0.2075342
  0.05634026  0.58201736  0.0223707   0.40851134  0.29183257]
Centroid 12: [ 0.02270779  0.0590838   0.06716919 -0.11046995  0.00131692  0.02143493
 -0.03073832  0.04154667 -0.00075342  0.01084359 -0.01161169 -0.10043728
  0.05991659  0.12383982 -0.02495115  0.18916613 -0.16302411 -0.03896701
 -0.52130765 -0.3584635   0.0038983   0.0686083   0.14960428]
Centroid 13: [ 0.02133039  0.04570788  0.05618476 -0.06160883 -0.0045559   0.02359532
 -0.00989378 -0.02060247  0.23806068 -0.16074602 -0.0477824  -0.05774914
  0.01866808  0.35070655 -0.03391451  0.05081317 -0.28896537  0.2365362
 -0.01496129  0.01744696  0.00508468 -0.43476367  0.5831793 ]
Centroid 14: [-2.6992589e-01  1.7637090e-01  4.8870421e-03  4.7552545e-02
  8.8102240e-03 -8.2325442e-03  2.7172647e-02  4.6797171e-02
 -1.1777513e-02 -4.8560362e-02  7.8482283e-03  2.3019667e-04
  1.1839565e-01  2.7568278e-01  3.4995381e-02 -6.0449278e-01
  1.6627280e-01 -1.3630180e-01  8.9471443e-03  2.9387754e-01
  1.3455267e-02  2.7212358e-01  2.0171879e-01]
Centroid 15: [-0.32770675  0.05410597 -0.1292831   0.2190608  -0.02711052 -0.03572314
  0.10052084 -0.07285552  0.0922318  -0.09816926  0.00088987  0.30355
 -0.06852968  0.05017184  0.02091775  0.01362434  0.06766247  0.01826625
  0.04220074 -0.18006516  0.0019301   0.00837322  0.12126397]
Centroid 16: [ 0.00511725 -0.02463748 -0.03949805  0.02225155  0.00634957 -0.0586173
 -0.02423045  0.04549905 -0.326656    0.26385674 -0.03397544  0.01541697
 -0.065575   -0.0690776   0.00987139 -0.09817972 -0.16451369  0.19085346
  0.0668717   0.00463352  0.00483524 -0.39867657  0.54741484]
Centroid 17: [ 0.2329416  -0.11536226  0.00690278 -0.04510786  0.09798738  0.04566181
  0.08822614  0.14180955 -0.09196079 -0.0414372   0.02872296 -0.00576718
  0.44089898  0.11384922  0.03434089 -0.362333   -0.12528278  0.12994264
  0.02211431  0.44877878  0.01825899  0.33423468  0.23900935]
Centroid 18: [ 0.39461496 -0.21963057 -0.00104387 -0.08401845  0.03303653  0.09645325
  0.14272241  0.23203099 -0.15835997 -0.09945394  0.0260982  -0.00218215
  0.30518204 -0.03057058  0.01040913 -0.01778084 -0.21214914  0.2101273
```

```
 0.05510855  0.48013717  0.01730255  0.30684283  0.21751459]
Centroid 19: [-0.02826001 -0.03378569 -0.01337713 -0.07032414  0.04774387 -0.02844792
 -0.07491022 -0.05860313 -0.04940231  0.07562279  0.02969737  0.01369261
  0.00507165 -0.23157912  0.07380857 -0.10777716 -0.00877725 -0.07375188
 -0.13660504 -0.03478827 -0.06640104  0.03485296  0.03946408]
Centroid 20: [ 3.3563644e-01  3.2588008e-01  8.4042856e-03  1.7020582e-01
 -4.2018527e-01 -6.6307567e-02 -3.4513146e-02 -1.8762611e-02
 -2.3752304e-02 -1.8107304e-02 -6.0514554e-02  3.6240980e-02
  2.6637258e-02  2.9683062e-03  3.3775094e-04 -3.3893883e-03
  6.1415550e-03 -1.1550296e-03  1.7730460e-03 -4.4876002e-03
  1.3261602e-03  4.1279156e-02  3.0132104e-02]
Centroid 21: [-0.03082074  0.13801236 -0.03963874  0.02695682  0.00809807 -0.02218878
  0.04579384  0.08950914  0.03204933  0.10284714  0.0024652  -0.0012186
  0.1344747  -0.12000579 -0.00223111  0.20239307 -0.2333406   0.22516835
  0.06454598  0.57668155  0.02159912  0.39209816  0.27962628]
Centroid 22: [-0.03360284 -0.03749343 -0.051064   -0.20203026 -0.07223484 -0.46873647
  0.07192694  0.16360189  0.06664716 -0.1083977   0.01051213  0.04868465
 -0.04487467 -0.15673804 -0.4988431  -0.11860447 -0.21532357 -0.1252386
  0.123073   -0.11505725 -0.06593926  0.04952145  0.05201216]
Centroid 23: [ 0.05734083 -0.01650646 -0.01592804  0.00606799  0.02648886  0.03914303
  0.0495743   0.01123454  0.06633224 -0.11244355  0.01379135 -0.0045502
  0.19800706 -0.24554436  0.02851521  0.24935588  0.34153876 -0.2765856
 -0.18935272 -0.50665236  0.00520466 -0.03801916  0.3795312 ]
```

In [ ]:

```python
spectral_clustering(
    oe_X_train025,
    cuts=len(np.unique(le_y_train025)),
    fname="one-hot_encoded_spectral_clustering",
    affinity="poly",
    gamma=0.15,
)
```

```
eigenvalues: [9.9978685e-01 9.9972618e-01 9.9955457e-01 9.9947590e-01 9.9938643e-01
 9.9691558e-01 9.9616969e-01 9.9605697e-01 9.8241097e-01 9.7884613e-01
 9.7032988e-01 8.7656701e-01 4.2072964e-01 5.5125371e-17 1.5734539e-17].
Finished running k-means++
2.0     6521
5.0      658
13.0     643
0.0      618
6.0      609
12.0     545
3.0      531
11.0     519
4.0      458
8.0      453
9.0      285
1.0      254
10.0     127
7.0      108
14.0      21
dtype: int64
Completed iteration 1
2.0     6518
5.0      683
13.0     672
6.0      643
3.0      544
12.0     536
11.0     506
0.0      479
8.0      451
4.0      398
9.0      360
1.0      290
10.0     136
7.0      103
14.0      31
dtype: int64
Completed iteration 2
2.0     6519
5.0      708
13.0     694
6.0      667
3.0      551
11.0     507
12.0     495
0.0      442
8.0      416
9.0      385
4.0      371
1.0      316
10.0     139
7.0      100
14.0      40
dtype: int64
Completed iteration 3
2.0     6519
5.0      719
13.0     712
6.0      685
3.0      549
11.0     507
12.0     464
0.0      425
4.0      402
9.0      396
8.0      395
1.0      278
10.0     150
7.0       96
14.0      53
dtype: int64
Completed iteration 4
2.0     6519
13.0     715
5.0      710
6.0      703
3.0      548
11.0     508
12.0     454
4.0      429
0.0      411
9.0      398
8.0      393
1.0      240
10.0     161
7.0       95
14.0      66
dtype: int64
Completed iteration 5
2.0     6519
13.0     731
5.0      713
6.0      709
3.0      544
11.0     505
12.0     443
4.0      411
9.0      398
0.0      397
8.0      397
1.0      217
10.0     170
14.0     103
7.0       93
dtype: int64
Completed iteration 6
2.0     6519
13.0     738
6.0      717
5.0      713
3.0      541
11.0     501
12.0     445
9.0      397
8.0      396
4.0      393
0.0      382
1.0      204
10.0     186
14.0     123
7.0       95
dtype: int64
Completed iteration 7
2.0     6519
13.0     736
6.0      725
5.0      713
3.0      541
11.0     500
12.0     457
9.0      397
8.0      396
4.0      389
0.0      368
1.0      201
10.0     184
14.0     127
7.0       97
dtype: int64
Completed iteration 8
2.0     6520
13.0     740
6.0      731
5.0      713
3.0      541
11.0     498
12.0     460
9.0      396
8.0      395
4.0      388
0.0      360
1.0      200
10.0     184
14.0     127
7.0       97
dtype: int64
Completed iteration 9
2.0     6520
13.0     741
6.0      733
5.0      712
3.0      541
11.0     497
12.0     467
8.0      395
9.0      392
4.0      388
0.0      356
1.0      200
10.0     183
14.0     128
7.0       97
dtype: int64
Completed iteration 10
2.0     6520
13.0     743
6.0      735
5.0      711
3.0      542
11.0     497
12.0     469
8.0      395
4.0      388
9.0      387
0.0      354
1.0      200
10.0     182
14.0     130
7.0       97
dtype: int64
Completed iteration 11
2.0     6520
13.0     747
6.0      735
5.0      711
3.0      542
11.0     497
12.0     468
8.0      395
4.0      389
9.0      386
0.0      351
1.0      201
10.0     179
14.0     132
7.0       97
dtype: int64
Completed iteration 12
2.0     6520
13.0     747
6.0      735
5.0      707
3.0      542
11.0     497
12.0     470
8.0      396
4.0      389
9.0      385
0.0      350
1.0      201
10.0     174
14.0     139
7.0       98
dtype: int64
Completed iteration 13
2.0     6520
13.0     747
6.0      735
5.0      704
3.0      540
11.0     498
12.0     470
8.0      395
4.0      391
9.0      384
0.0      351
1.0      201
10.0     167
14.0     149
7.0       98
dtype: int64
Completed iteration 14
2.0     6520
13.0     747
6.0      734
5.0      694
3.0      542
11.0     498
12.0     471
8.0      395
4.0      393
9.0      383
0.0      352
1.0      201
14.0     166
10.0     156
7.0       98
dtype: int64
Completed iteration 15
2.0     6520
13.0     748
6.0      735
5.0      673
3.0      539
11.0     498
12.0     474
4.0      396
8.0      394
9.0      382
0.0      352
1.0      201
14.0     200
10.0     140
7.0       98
dtype: int64
Completed iteration 16
2.0     6520
13.0     753
6.0      735
5.0      592
3.0      519
11.0     499
12.0     475
4.0      399
8.0      393
9.0      382
0.0      351
14.0     302
1.0      201
10.0     130
7.0       99
dtype: int64
Completed iteration 17
2.0     6520
13.0     755
6.0      736
5.0      569
11.0     500
12.0     477
3.0      471
4.0      401
8.0      397
9.0      382
0.0      351
14.0     341
1.0      205
10.0     145
7.0      100
dtype: int64
Completed iteration 18
2.0     6520
13.0     756
6.0      737
5.0      570
11.0     499
12.0     478
3.0      455
4.0      399
8.0      399
9.0      382
0.0      351
14.0     336
1.0      212
10.0     154
7.0      102
dtype: int64
Completed iteration 19
2.0     6520
13.0     759
6.0      737
5.0      568
11.0     500
12.0     477
3.0      442
4.0      399
8.0      399
9.0      383
0.0      351
14.0     335
1.0      215
10.0     164
7.0      101
dtype: int64
Completed iteration 20
2.0     6520
13.0     759
6.0      738
5.0      568
11.0     500
12.0     476
3.0      438
8.0      400
4.0      399
9.0      383
0.0      351
14.0     336
1.0      216
10.0     167
7.0       99
dtype: int64
Completed iteration 21
Reached 21 iterations
Centroids:
Centroid 1: [ 0.08832168 -0.06981185 -0.0252884   0.00719782 -0.2816089   0.23866613
  0.00517916 -0.37730908  0.2846613  -0.24241021  0.05491779  0.42126757
  0.0175429   0.36594766  0.27419385]
Centroid 2: [ 0.04583681  0.08968431  0.01616804 -0.07271098  0.12413043  0.33245444
 -0.00975016  0.25164932  0.35818017 -0.07786417  0.28134045 -0.32054514
 -0.00695471  0.10036778  0.11827993]
Centroid 3: [-1.6326696e-02 -5.2438764e-04  9.6059274e-03  2.4587286e-03
  1.7827009e-01 -2.7019016e-02  2.5211100e-03 -1.3504827e-02
 -4.8699215e-02  4.4310577e-02 -2.2278780e-02 -2.0516954e-02
  2.4633061e-02  8.0437291e-01  5.5691123e-01]
Centroid 4: [ 0.21850258 -0.14249313 -0.04845653 -0.05526386  0.01528137  0.34560615
 -0.03325873  0.04473333 -0.29284272  0.24141964 -0.01066591  0.0238286
  0.00519765 -0.44848382  0.59837866]
Centroid 5: [ 0.06931103 -0.10046113  0.0142101  -0.01896896  0.19240375 -0.25480723
  0.02555847  0.24791527  0.3306451  -0.2767531  -0.20614487 -0.5149432
  0.00501098 -0.01337234  0.3522582 ]
Centroid 6: [ 0.01525301 -0.03168196 -0.00080907  0.04625259  0.00433523 -0.2380259
  0.03315741 -0.03680982  0.29640612 -0.21801485  0.04676484  0.07900779
  0.0054309  -0.46458662  0.62665534]
Centroid 7: [ 1.3231428e-01  9.9747136e-02 -1.1509929e-02  3.2333159e-04
 -1.0239208e-01 -2.2734626e-01 -1.8947700e-02  4.4368458e-01
 -2.2645989e-01  2.1391888e-01  7.1654834e-02  5.4110408e-01
  1.9861644e-02  3.6254427e-01  2.5899065e-01]
Centroid 8: [-0.04336176  0.22057553 -0.00097085 -0.02701971  0.04930496  0.12902917
 -0.39413887  0.04493809 -0.31821844 -0.45158324  0.4112121  -0.33366206
 -0.0420773   0.07875955  0.10720821]
Centroid 9: [-0.0162846  -0.08678807 -0.00698349 -0.07520774 -0.02941746 -0.24576539
  0.05975265 -0.06503932 -0.04472426  0.37989524  0.29613918 -0.71626455
  0.0038174   0.18939443  0.16019754]
Centroid 10: [-0.11606674  0.04798156 -0.05606387  0.00058768 -0.5873831   0.10033843
 -0.04231598  0.1682905   0.24584043 -0.2177314   0.09555743  0.4200847
  0.01567643  0.33363146  0.25082842]
Centroid 11: [ 0.1072624  -0.10235785 -0.01402997  0.07147817  0.03619724  0.2310197
  0.00241095  0.15024343 -0.22564611 -0.02537633 -0.5169456  -0.23637927
 -0.02537429  0.04332789  0.12557961]
Centroid 12: [ 0.08939759  0.02565781 -0.04272539 -0.00545941 -0.8440021   0.16461223
  0.00961528 -0.23642945  0.08984402 -0.08220411 -0.08554045 -0.15381758
  0.00747439  0.25487518  0.18665226]
Centroid 13: [-0.02372235 -0.04060111  0.01299002 -0.00090209  0.20841813  0.28990307
  0.04232641 -0.6713867   0.13987875 -0.11120354  0.00535789  0.3294504
  0.01508725  0.3002927   0.22136399]
Centroid 14: [-0.17000888 -0.07121165  0.02721163 -0.00728921  0.37835813 -0.0050646
  0.01746687 -0.08798031 -0.22238544  0.22049583  0.05434475  0.57389635
  0.02175951  0.3929426   0.2797321 ]
Centroid 15: [-4.2544159e-01  3.6970699e-01 -3.6024176e-02 -3.4153052e-02
 -5.1418826e-02 -8.9584149e-02  9.9265446e-05 -3.9523248e-02
 -1.9086063e-01  1.3157824e-01 -1.0496103e-01 -6.4431317e-02
  4.7983774e-03 -3.2669583e-01  4.9322110e-01]
```

rbf (gamma=1.0)

In [ ]:

```python
spectral_clustering(
    oe_X_train025,
    cuts=23,
    fname="one-hot_encoded_spectral_clustering",
    affinity="rbf",
    gamma=1.0,
)
```

```
eigenvalues: [2.4629940e-18 2.3657874e-18 2.0934130e-18 1.9427139e-18 7.1408889e-19
 5.5135900e-19 4.8116305e-19 2.1318256e-19 9.0738734e-20 5.0641458e-20
 2.9820843e-20 2.9043849e-20 2.2551359e-20 1.1376185e-20 8.9454995e-21
 1.0490562e-21 4.2276659e-22 1.2666420e-22 9.3549500e-23 1.1989572e-23
 1.0035311e-24 3.7470262e-28 0.0000000e+00].
Finished running k-means++
19.0    2447
4.0     2057
0.0     1571
18.0     809
1.0      596
22.0     517
11.0     395
21.0     394
2.0      389
3.0      388
13.0     296
20.0     272
12.0     271
6.0      263
16.0     255
9.0      249
14.0     230
7.0      211
17.0     208
5.0      181
10.0     159
8.0      144
15.0      48
dtype: int64
Completed iteration 1
19.0    2273
4.0     1986
0.0     1492
18.0     669
1.0      609
22.0     459
21.0     401
3.0      396
11.0     390
13.0     330
2.0      325
14.0     308
16.0     301
12.0     299
17.0     299
6.0      279
9.0      277
20.0     250
5.0      249
7.0      230
8.0      204
10.0     195
15.0     129
dtype: int64
Completed iteration 2
19.0    2245
4.0     1923
0.0     1483
18.0     698
1.0      580
22.0     432
21.0     384
11.0     375
3.0      353
13.0     335
14.0     321
9.0      315
17.0     307
6.0      306
12.0     297
16.0     295
2.0      294
20.0     280
5.0      261
7.0      249
8.0      226
10.0     203
15.0     188
dtype: int64
Completed iteration 3
19.0    2234
4.0     1856
0.0     1479
18.0     759
1.0      555
22.0     404
21.0     376
11.0     356
3.0      334
6.0      327
13.0     321
17.0     320
14.0     311
16.0     309
20.0     309
12.0     304
9.0      291
2.0      287
5.0      279
7.0      274
15.0     235
8.0      235
10.0     195
dtype: int64
Completed iteration 4
19.0    2230
4.0     1819
0.0     1476
18.0     797
1.0      544
22.0     385
21.0     365
11.0     340
20.0     328
6.0      328
16.0     326
3.0      319
13.0     317
17.0     316
14.0     312
12.0     299
7.0      294
2.0      284
5.0      279
15.0     279
9.0      269
8.0      242
10.0     202
dtype: int64
Completed iteration 5
19.0    2225
4.0     1794
0.0     1476
18.0     821
1.0      525
22.0     372
21.0     362
6.0      334
11.0     332
16.0     329
20.0     328
7.0      326
14.0     319
17.0     316
3.0      315
13.0     310
12.0     307
15.0     295
5.0      287
2.0      281
9.0      250
8.0      236
10.0     210
dtype: int64
Completed iteration 6
19.0    2222
4.0     1782
0.0     1476
18.0     836
1.0      500
22.0     377
7.0      359
21.0     348
16.0     342
20.0     331
14.0     329
6.0      328
3.0      319
11.0     317
13.0     312
12.0     309
17.0     306
15.0     303
5.0      291
2.0      280
9.0      239
8.0      235
10.0     209
dtype: int64
Completed iteration 7
19.0    2219
4.0     1680
0.0     1475
18.0     937
1.0      486
7.0      376
22.0     376
16.0     347
21.0     339
20.0     334
14.0     333
6.0      328
3.0      321
15.0     317
13.0     314
11.0     313
12.0     303
17.0     301
5.0      291
2.0      275
8.0      238
9.0      235
10.0     212
dtype: int64
Completed iteration 8
19.0    2218
4.0     1639
0.0     1471
18.0     982
1.0      475
7.0      393
22.0     370
16.0     357
14.0     343
21.0     339
6.0      333
15.0     330
20.0     327
3.0      323
13.0     308
11.0     308
17.0     299
5.0      295
12.0     289
2.0      275
8.0      233
9.0      232
10.0     211
dtype: int64
Completed iteration 9
19.0    2219
4.0     1612
0.0     1468
18.0    1012
1.0      462
7.0      405
22.0     372
16.0     348
14.0     343
20.0     335
21.0     334
15.0     333
6.0      330
3.0      318
13.0     312
11.0     305
17.0     303
5.0      294
12.0     289
2.0      276
8.0      244
9.0      225
10.0     211
dtype: int64
Completed iteration 10
19.0    2217
4.0     1589
```

```
0.0     1468
18.0    1036
1.0      458
7.0      418
22.0     373
16.0     350
14.0     344
20.0     336
21.0     333
6.0      331
15.0     331
3.0      312
13.0     311
17.0     300
5.0      299
11.0     299
12.0     290
2.0      273
8.0      249
9.0      221
10.0     212
dtype: int64
Completed iteration 11
19.0    2216
4.0     1579
0.0     1466
18.0    1045
1.0      457
7.0      425
22.0     373
14.0     357
16.0     346
21.0     336
20.0     332
6.0      330
15.0     325
13.0     314
3.0      311
5.0      306
17.0     299
11.0     297
12.0     290
2.0      268
8.0      245
9.0      219
10.0     214
dtype: int64
Completed iteration 12
19.0    2214
4.0     1576
0.0     1466
18.0    1048
1.0      454
7.0      430
22.0     371
14.0     353
16.0     346
21.0     339
6.0      329
20.0     329
15.0     327
5.0      311
13.0     311
3.0      310
12.0     297
17.0     297
11.0     296
2.0      262
8.0      249
9.0      220
10.0     215
dtype: int64
Completed iteration 13
19.0    2213
4.0     1574
0.0     1466
18.0    1049
1.0      454
7.0      436
22.0     371
14.0     357
16.0     344
21.0     339
15.0     327
6.0      326
20.0     326
13.0     310
3.0      310
5.0      307
12.0     299
17.0     299
11.0     294
2.0      262
8.0      252
9.0      221
10.0     214
dtype: int64
Completed iteration 14
19.0    2214
4.0     1575
0.0     1466
18.0    1049
1.0      457
7.0      441
22.0     369
14.0     354
16.0     347
21.0     341
15.0     325
6.0      324
20.0     321
3.0      310
13.0     308
17.0     306
5.0      302
12.0     299
11.0     292
8.0      258
2.0      257
9.0      221
10.0     214
dtype: int64
Completed iteration 15
19.0    2213
4.0     1575
0.0     1466
18.0    1049
1.0      453
7.0      449
22.0     365
14.0     355
16.0     346
21.0     344
15.0     324
6.0      323
20.0     315
3.0      312
13.0     306
17.0     305
5.0      303
12.0     299
11.0     292
8.0      259
2.0      258
9.0      220
10.0     219
dtype: int64
Completed iteration 16
19.0    2213
4.0     1575
0.0     1466
18.0    1051
7.0      450
1.0      449
22.0     365
14.0     356
21.0     344
16.0     340
15.0     325
6.0      323
3.0      313
17.0     307
20.0     306
5.0      304
12.0     304
13.0     304
11.0     293
2.0      262
8.0      260
10.0     221
9.0      219
dtype: int64
Completed iteration 17
19.0    2214
4.0     1575
0.0     1466
18.0    1052
1.0      450
7.0      449
22.0     365
14.0     355
21.0     348
16.0     332
15.0     327
6.0      325
3.0      312
17.0     308
5.0      305
20.0     305
13.0     304
12.0     303
11.0     294
2.0      263
8.0      260
9.0      219
10.0     219
dtype: int64
Completed iteration 18
19.0    2214
4.0     1575
0.0     1466
18.0    1052
1.0      451
7.0      447
22.0     365
14.0     356
21.0     349
16.0     331
15.0     330
6.0      323
3.0      312
5.0      307
17.0     307
20.0     305
12.0     304
13.0     300
11.0     298
2.0      264
8.0      258
10.0     219
9.0      217
dtype: int64
Completed iteration 19
19.0    2214
4.0     1576
0.0     1466
18.0    1052
1.0      449
7.0      447
22.0     366
14.0     356
21.0     347
15.0     333
16.0     332
6.0      321
3.0      316
17.0     306
5.0      305
20.0     305
12.0     304
13.0     299
11.0     296
2.0      265
8.0      258
10.0     219
9.0      218
dtype: int64
Completed iteration 20
19.0    2214
4.0     1576
0.0     1467
18.0    1052
1.0      449
7.0      447
22.0     369
14.0     355
21.0     346
16.0     332
15.0     330
6.0      322
3.0      316
12.0     307
20.0     304
5.0      302
17.0     301
13.0     299
11.0     297
2.0      266
8.0      258
10.0     223
9.0      218
dtype: int64
Completed iteration 21
Reached 21 iterations
Centroids:
Centroid 1: [ 2.57463753e-03 -3.94428847e-04 -1.24830640e-05  8.28939378e-01
  1.58101239e-03  5.87152841e-04 -4.31195986e-06  3.90222791e-04
 -9.21006082e-04  5.24185907e-06  2.86830564e-05 -1.06261075e-04
  6.90467050e-03  4.63903307e-05 -4.63777775e-04  6.48372588e-05
 -4.94538963e-01  5.34714945e-02 -7.22013472e-04  4.77429101e-04
  1.21148757e-03  1.34203001e-04  1.25604507e-04]
Centroid 2: [ 0.00471934  0.0014263  -0.01290043 -0.00310128 -0.04942428  0.01812906
 -0.00179309 -0.04902349 -0.00370287  0.00089898 -0.02002186  0.00581132
  0.12637682 -0.04299645  0.03969628 -0.00276889  0.05265048  0.16513592
  0.00832458 -0.15442228  0.02611667 -0.5836166  -0.0018103 ]
Centroid 3: [-0.01766368  0.00077403  0.00503809  0.03994719 -0.21318808 -0.00848545
  0.00858963  0.11140802  0.01085839  0.00972409 -0.01876673 -0.0028186
 -0.17841342  0.00927927  0.07198723 -0.01895547 -0.1950685  -0.22568175
  0.02564523 -0.11621195  0.00870671 -0.4108002   0.00185072]
Centroid 4: [-0.0058765  -0.00238851 -0.00070431 -0.02613641 -0.1807471   0.04479695
  0.00533442 -0.03364424  0.01053836 -0.01162223  0.01097158  0.00377077
  0.19152282 -0.02047206 -0.08433253  0.05393482  0.13564591  0.24168572
  0.00373705  0.07623653  0.06433467  0.4557769   0.00660214]
Centroid 5: [-8.8530618e-01  2.4913328e-05 -1.8181672e-04  3.2723531e-01
  3.9172120e-04  2.2839554e-04 -1.7446262e-04 -8.5495070e-05
 -2.6103698e-05 -6.1184604e-05 -3.2131703e-04  2.1685504e-04
  2.6934538e-03  4.8980297e-04 -2.5070988e-04 -4.3592739e-04
 -2.3632866e-01  2.8573254e-02 -1.5734380e-05  1.6229560e-04
  3.0814554e-04  4.5165344e-04  3.4406249e-04]
Centroid 6: [-0.06133693 -0.00565434  0.01562882 -0.00444801 -0.3317774  -0.00405847
  0.01978318  0.29760623 -0.01808888 -0.01806613  0.05898418 -0.00329019
  0.03970188  0.08080414 -0.03638619 -0.04280235  0.02540377  0.04045807
 -0.04124741  0.1002482  -0.01695368 -0.01231337  0.01139925]
Centroid 7: [ 5.5858821e-02  9.5373588e-03 -1.3786722e-03  1.3488273e-02
  1.3681155e-01  1.8168267e-02  9.1623198e-03  4.6033774e-02
 -5.2765585e-03  3.5399079e-02  1.0997825e-02  8.9465473e-03
  5.0775148e-02  1.2891860e-02 -3.7722507e-01 -4.4190912e-03
 -2.8691361e-02  6.8997800e-02 -2.0454245e-02 -6.1855096e-02
  6.0034893e-04 -3.0921099e-01  2.5738834e-04]
Centroid 8: [-0.01496786  0.00311552  0.00328303 -0.00722844 -0.01664886 -0.00297363
 -0.00294398 -0.02439123 -0.00924715 -0.0174551  -0.00790912  0.01219285
  0.35643923 -0.00724738 -0.02428674  0.0046656   0.07692555  0.47700402
  0.0089447  -0.05772301 -0.01077999 -0.09856325 -0.00739505]
Centroid 9: [-0.05964018 -0.00533034  0.0247082   0.07828216  0.00996843  0.06371292
  0.00536131 -0.21851091 -0.03777374  0.02074021  0.23420851 -0.01263008
  0.06370673  0.02911063  0.27898622  0.01175609 -0.05836304  0.07859305
  0.02854501 -0.01738672  0.10811938 -0.05287648  0.01885672]
Centroid 10: [ 0.236478    0.00415863 -0.01009608 -0.5567382  -0.01391019 -0.00417836
  0.01118314 -0.02958599 -0.00449556  0.01237226 -0.02765027 -0.00234791
 -0.0122362  -0.00274205  0.00651492 -0.00596758  0.44473425 -0.06314693
  0.01012157  0.00060827  0.01609668 -0.01587859 -0.00789319]
Centroid 11: [ 0.04344647  0.00190851 -0.01401702 -0.04676203 -0.02291038  0.0787928
  0.01385172 -0.08266577  0.02731662 -0.01204069 -0.02505564 -0.00933565
  0.04418232 -0.26257113  0.1163691  -0.06830443  0.05989862  0.06368607
  0.05454472  0.146297   -0.20440038 -0.00739254  0.00307047]
Centroid 12: [ 0.03597681 -0.00358619  0.01599016 -0.01534842  0.27962115 -0.04574075
  0.01790008  0.00241909  0.01341608  0.01411884 -0.01003193 -0.00841925
  0.22555527  0.02573464  0.03284642  0.00393442  0.03345468  0.31209165
  0.02142088  0.09914733  0.0041425   0.35471198  0.00325922]
Centroid 13: [-0.01006683  0.00361406 -0.00562528  0.00368966  0.2349396  -0.07146553
  0.01689126  0.13404311  0.00170489 -0.01592291  0.01419752  0.00624675
 -0.14158209  0.04189292  0.14933106 -0.05316951  0.06940098 -0.19780673
 -0.0074746  -0.04105112 -0.03953534 -0.34995502 -0.01330459]
Centroid 14: [-7.1904412e-03 -1.0876783e-02  2.0623256e-03  4.6332367e-03
  1.5850154e-01  3.2478411e-02  1.0258748e-02  5.0942534e-01
  1.4364811e-02 -3.9925217e-03 -1.5655629e-02 -1.9972411e-04
  2.9976273e-02  1.0020142e-02  1.9756863e-02 -5.1771333e-03
 -1.2086027e-02  3.4412470e-02 -1.0989549e-02  1.1586038e-02
 -1.3966336e-02  1.3301727e-01 -6.1691790e-03]
Centroid 15: [ 0.01235515 -0.00443793 -0.00196235  0.01890731  0.35315123  0.01472495
  0.01788293 -0.35306245 -0.00202411 -0.00057686  0.00108689 -0.00441333
 -0.05073985  0.04302577 -0.07417106  0.02614474 -0.03271615 -0.07721686
  0.00967882  0.04165486 -0.01126916  0.04768991  0.00190808]
Centroid 16: [ 0.00187292  0.00036287  0.00692599  0.01036195  0.03349227 -0.07880294
 -0.04413527 -0.02372825 -0.04511185 -0.01568514 -0.1783113   0.00623367
  0.00156738 -0.07032105  0.1124609   0.02880909 -0.04636751  0.01319938
 -0.02910936 -0.14187118 -0.00569994  0.04382344  0.00613764]
Centroid 17: [-0.00145108  0.00359229 -0.01789088  0.00675452 -0.00951732  0.01120591
 -0.00626783 -0.06471369  0.00314106 -0.00871774 -0.00629185 -0.00220867
 -0.3445163  -0.01569995  0.01033062  0.00548741 -0.00780365 -0.4926117
  0.01068677 -0.0655167  -0.03053664 -0.17127486 -0.00526567]
Centroid 18: [ 1.3799855e-02 -7.6271729e-03  6.3801897e-03  1.0718566e-04
 -3.9841005e-01 -2.1479251e-02 -1.3462546e-02 -2.7393526e-01
  1.8155383e-02  1.9628963e-02  2.7453871e-03  1.6851019e-03
  1.0711241e-02  3.2231747e-03 -1.1698521e-01 -2.7816514e-02
 -1.2220826e-02  1.5125097e-02 -3.5723324e-03 -5.2595410e-02
  5.3505633e-02 -6.0566716e-02 -1.9879064e-04]
Centroid 19: [-9.5213693e-01  3.9967745e-05 -1.1047685e-05 -1.2378959e-01
 -2.0984963e-03 -5.7504798e-04 -3.0769914e-04 -1.6030572e-04
  2.4266960e-04 -5.4091163e-04  7.9787307e-04 -1.5686257e-04
 -1.2129130e-03  1.3959472e-03  3.2754874e-04 -1.3820176e-03
  4.9036767e-02 -3.9230720e-03 -5.3026725e-04  1.8199539e-03
  2.8339995e-04 -1.2749007e-03 -3.3569805e-04]
Centroid 20: [ 9.6911180e-01 -3.2610088e-04 -1.7970425e-04 -3.6067851e-02
 -1.1260330e-03 -6.3881831e-05  2.5523148e-04  2.7007409e-04
 -3.5040537e-04 -1.0891062e-04 -3.3275087e-04  1.7971761e-04
  6.1640603e-04 -6.7051628e-04  1.8798131e-04  5.0964020e-04
  5.2619688e-02 -6.6955662e-03 -1.6351895e-04  4.1209342e-04
  3.0323968e-04  3.8463029e-04  3.7697802e-05]
Centroid 21: [ 0.04391092 -0.00104948 -0.01771438 -0.02312496 -0.09069278 -0.02392124
 -0.0071451   0.0816108   0.02011276  0.01836732  0.00991049 -0.00283477
 -0.1957721  -0.00884691 -0.3353692   0.01324271 -0.05351932 -0.27492815
 -0.02720801  0.05491486 -0.00154079  0.1990541   0.00823478]
Centroid 22: [-0.02057052 -0.00390649 -0.0005836  -0.01028823  0.09702236  0.01310079
 -0.0052138   0.03059091  0.00589643 -0.0040117   0.00127162 -0.00156012
 -0.25680628 -0.00301722  0.164183    0.01583338  0.04646564 -0.36763826
  0.01504077  0.09674592  0.00129589  0.3197998  -0.00318839]
Centroid 23: [-0.002869    0.00157814  0.00351607 -0.00361258 -0.07355774 -0.01877592
 -0.0115775  -0.03106117  0.00452434  0.01590394  0.00285219 -0.00131927
 -0.06402439  0.00148866  0.04773659 -0.02269993 -0.10208892 -0.07511628
  0.0200549   0.18664615 -0.01649792  0.58980846 -0.00444759]
```

In [ ]:

```python
spectral_clustering(
    oe_X_train025,
    cuts=len(np.unique(le_y_train025)),
    fname="one-hot_encoded_spectral_clustering",
    affinity="rbf",
    gamma=1.0,
)
```

```
eigenvalues: [9.0738734e-20 5.0641458e-20 2.9820843e-20 2.9043849e-20 2.2551359e-20
 1.1376185e-20 8.9454995e-21 1.0490562e-21 4.2276659e-22 1.2666420e-22
 9.3549500e-23 1.1989572e-23 1.0035311e-24 3.7470262e-28 0.0000000e+00].
Finished running k-means++
0.0     4492
7.0     2554
10.0     717
8.0      547
5.0      533
2.0      470
4.0      463
14.0     421
11.0     376
9.0      369
1.0      363
6.0      329
3.0      307
13.0     249
12.0     160
dtype: int64
Completed iteration 1
0.0     4189
7.0     2380
10.0     636
5.0      595
8.0      570
4.0      490
11.0     489
14.0     465
2.0      458
6.0      413
3.0      408
9.0      368
1.0      358
13.0     277
12.0     254
dtype: int64
Completed iteration 2
0.0     4164
7.0     2369
10.0     606
5.0      578
8.0      561
11.0     537
4.0      490
3.0      476
14.0     474
6.0      424
2.0      419
9.0      362
1.0      346
13.0     277
12.0     267
dtype: int64
Completed iteration 3
0.0     4162
7.0     2369
10.0     595
5.0      572
8.0      551
11.0     547
3.0      515
4.0      500
14.0     448
6.0      441
2.0      413
9.0      350
1.0      328
13.0     283
12.0     276
dtype: int64
Completed iteration 4
0.0     4161
7.0     2369
5.0      583
10.0     573
3.0      559
8.0      542
11.0     539
4.0      505
6.0      436
14.0     431
2.0      421
9.0      343
1.0      334
13.0     278
12.0     276
dtype: int64
Completed iteration 5
0.0     4161
7.0     2364
5.0      596
3.0      566
10.0     553
8.0      543
11.0     525
4.0      519
2.0      426
6.0      425
14.0     411
9.0      348
1.0      345
12.0     289
13.0     279
dtype: int64
Completed iteration 6
0.0     4160
7.0     2362
5.0      594
3.0      563
8.0      549
10.0     547
4.0      525
11.0     521
2.0      444
6.0      427
14.0     397
1.0      346
9.0      329
12.0     295
13.0     291
dtype: int64
Completed iteration 7
0.0     4159
7.0     2360
5.0      589
3.0      566
8.0      557
10.0     543
4.0      529
11.0     514
2.0      443
6.0      432
14.0     389
1.0      337
9.0      331
12.0     302
13.0     299
dtype: int64
Completed iteration 8
0.0     4159
7.0     2362
5.0      584
8.0      564
3.0      562
4.0      541
10.0     540
11.0     509
2.0      448
6.0      431
14.0     380
1.0      332
9.0      328
12.0     312
13.0     298
dtype: int64
Completed iteration 9
0.0     4154
7.0     2362
5.0      578
8.0      573
3.0      557
4.0      542
10.0     540
11.0     507
2.0      449
6.0      433
14.0     376
9.0      326
1.0      321
12.0     316
13.0     316
dtype: int64
Completed iteration 10
0.0     4154
7.0     2364
8.0      580
5.0      575
3.0      551
4.0      546
10.0     538
11.0     506
2.0      451
6.0      429
14.0     375
1.0      322
9.0      322
13.0     320
12.0     317
dtype: int64
Completed iteration 11
0.0     4153
7.0     2366
8.0      583
5.0      575
4.0      548
3.0      547
10.0     540
11.0     508
2.0      456
6.0      424
14.0     372
1.0      322
9.0      322
13.0     318
12.0     316
dtype: int64
Completed iteration 12
0.0     4153
7.0     2365
8.0      589
5.0      576
4.0      546
3.0      542
10.0     539
11.0     507
2.0      459
6.0      424
14.0     370
1.0      328
9.0      321
12.0     316
13.0     315
dtype: int64
Completed iteration 13
0.0     4150
7.0     2365
8.0      593
5.0      577
4.0      546
3.0      539
10.0     535
11.0     507
2.0      463
6.0      418
14.0     367
1.0      337
9.0      319
12.0     319
13.0     315
dtype: int64
Completed iteration 14
0.0     4149
7.0     2364
8.0      591
5.0      578
4.0      543
3.0      540
10.0     535
11.0     504
2.0      463
6.0      415
14.0     366
1.0      347
12.0     323
9.0      320
13.0     312
dtype: int64
Completed iteration 15
0.0     4149
7.0     2364
8.0      595
5.0      579
4.0      542
3.0      537
10.0     532
11.0     508
2.0      460
6.0      416
14.0     364
1.0      349
9.0      321
12.0     321
13.0     313
dtype: int64
Completed iteration 16
0.0     4148
7.0     2364
8.0      598
5.0      580
4.0      539
3.0      538
10.0     532
11.0     513
2.0      459
6.0      421
14.0     366
1.0      350
12.0     316
9.0      315
13.0     311
dtype: int64
Completed iteration 17
0.0     4148
7.0     2364
8.0      604
5.0      582
4.0      539
10.0     534
3.0      532
11.0     513
2.0      460
6.0      420
14.0     367
1.0      342
12.0     317
9.0      316
13.0     312
dtype: int64
Completed iteration 18
0.0     4149
7.0     2367
8.0      604
5.0      587
4.0      538
10.0     534
3.0      527
11.0     516
2.0      462
6.0      419
14.0     365
1.0      340
9.0      316
12.0     316
13.0     310
dtype: int64
Completed iteration 19
0.0     4148
7.0     2367
8.0      609
5.0      590
4.0      535
10.0     532
3.0      526
11.0     518
2.0      465
6.0      419
14.0     366
1.0      336
12.0     316
9.0      313
13.0     310
dtype: int64
Completed iteration 20
```

```
0.0     4147
7.0     2367
8.0      610
5.0      590
4.0      533
10.0     527
3.0      525
11.0     519
2.0      466
6.0      421
14.0     366
1.0      338
12.0     317
13.0     313
9.0      311
dtype: int64
Completed iteration 21
Reached 21 iterations
Centroids:
Centroid 1: [-2.8568303e-04 -9.8932964e-05 -3.7201600e-05 -3.7474488e-04
  9.5316563e-03  1.9382454e-04 -8.3201652e-04 -5.5896275e-05
 -9.8537374e-01  1.1098563e-01  3.8771375e-04  3.4880589e-04
 -6.3504430e-04 -1.2192803e-04  3.4945135e-04]
Centroid 2: [-0.07717764  0.00321954  0.3637653  -0.00720641  0.02159339  0.06790491
  0.28499746 -0.00937812  0.03722658  0.01924196  0.06882101 -0.02674196
  0.06986555 -0.10923154  0.02500512]
Centroid 3: [ 0.00384616 -0.00740611 -0.04242994  0.00238787 -0.35504064 -0.00783368
 -0.03284334  0.05097236 -0.00412363 -0.52242255 -0.0066286  -0.04164164
 -0.05798948  0.20558333 -0.01095447]
Centroid 4: [-6.6425838e-02 -1.3495118e-02 -2.0718937e-01 -1.7331251e-03
  4.9806000e-03 -4.8474766e-02  1.1253252e-01 -6.1322633e-02
  5.4667145e-02  1.9575553e-02 -1.1511577e-02  1.1829473e-01
 -7.4573971e-02 -5.3076085e-02 -1.6192211e-04]
Centroid 5: [-3.78609588e-03 -1.07475035e-02 -3.38565675e-04  5.07372897e-03
  3.62043053e-01  2.44095605e-02  1.10284975e-02 -8.71945918e-03
  1.16340332e-01  4.81890142e-01  4.16467944e-03  8.82308409e-02
  3.11833285e-02  2.79652297e-01 -1.69583407e-04]
Centroid 6: [-0.00913992  0.00864382 -0.01324669  0.00684346  0.04279199 -0.05035732
 -0.03325813 -0.01465383  0.00555095  0.04941746  0.00704917 -0.18530832
 -0.01072692 -0.65227467  0.00618003]
Centroid 7: [ 0.00506889  0.00956726  0.03602186 -0.00294433  0.06376303  0.18359096
 -0.46191478 -0.04091755  0.00756681  0.07366797 -0.05615798  0.00944479
  0.01434731 -0.14223327 -0.00700227]
Centroid 8: [ 4.3431253e-04  4.6825773e-04 -2.1650872e-04 -1.9966660e-04
 -5.4816483e-03  1.4236764e-03 -3.4308559e-04  1.1827274e-03
  9.7646779e-01 -1.1330804e-01 -3.4119053e-05 -1.3157443e-04
  6.8366050e-04 -1.8671614e-03 -2.8899487e-04]
Centroid 9: [ 5.6977090e-03 -7.0315035e-04 -1.2552430e-02  3.1655640e-04
 -3.0411685e-01  2.0515362e-02  6.0301978e-02 -3.0356519e-02
 -6.4057961e-02 -4.1074353e-01  1.8043684e-02 -5.6884922e-02
  7.6455078e-03 -3.9605060e-01 -1.3210840e-02]
Centroid 10: [ 0.01276438  0.02818186  0.0596595  -0.0017204  -0.19197701  0.00574369
 -0.22694199 -0.06559193 -0.18593675 -0.2801437  -0.0525532   0.33099407
  0.03824399  0.20785326  0.0037132 ]
Centroid 11: [ 0.00992543 -0.01800426 -0.01815144  0.01184571  0.33051974 -0.02977663
  0.03427881  0.01900561  0.01389799  0.46710718 -0.0121935  -0.10424072
  0.02665758 -0.3338353  -0.00779238]
Centroid 12: [ 0.00317199  0.00554212 -0.01598475  0.00261866  0.05425382  0.03775638
 -0.08132398  0.00823783  0.02063614  0.06503626  0.01305965  0.13966732
 -0.03433561  0.6644581   0.00664705]
Centroid 13: [-0.03055819  0.01832025  0.02576981  0.00954605  0.03940383 -0.3273893
 -0.30137905  0.10483836  0.13282244  0.04030612  0.08470732 -0.06510694
 -0.02986746  0.19348826  0.03458522]
Centroid 14: [ 0.14168629 -0.01350605 -0.01780179 -0.00437209  0.03605976 -0.09537337
  0.23657273  0.06583481 -0.17253532  0.05218761 -0.02053215 -0.32673895
 -0.0244929   0.13737324 -0.01601169]
Centroid 15: [ 0.01565719  0.01872427  0.01293048 -0.02016457 -0.13272767  0.02994702
  0.34666377 -0.02890893 -0.01074788 -0.19834885  0.01543845  0.19731826
  0.05251171  0.4524578   0.00496662]
```

sigmoid (gamma=1.0)

In [ ]:

```
spectral_clustering(
    oe_X_train025,
    cuts=23,
    fname="one-hot_encoded_spectral_clustering",
    affinity="sigmoid",
    gamma=1.0,
)
```

```
eigenvalues: [9.9998307e-01 9.9998295e-01 9.9998224e-01 9.9998140e-01 9.9998116e-01
 9.9998021e-01 9.9997973e-01 9.9997580e-01 9.9997330e-01 9.9996972e-01
 9.9996853e-01 9.9996841e-01 9.9996662e-01 9.9996483e-01 9.9995112e-01
 9.9994552e-01 9.9993980e-01 9.9992824e-01 9.9991274e-01 9.9991250e-01
 9.9990833e-01 9.9983191e-01 3.5868186e-09].
Finished running k-means++
15.0    5203
0.0     1756
13.0    1010
16.0     743
1.0      645
12.0     546
8.0      486
7.0      408
3.0      282
10.0     227
9.0      190
2.0      135
4.0      124
20.0      95
22.0      83
5.0       81
17.0      74
6.0       68
18.0      63
11.0      59
21.0      48
19.0      22
14.0       2
dtype: int64
Completed iteration 1
15.0    4824
0.0     1317
13.0    1057
12.0     629
16.0     626
1.0      622
8.0      548
7.0      421
10.0     351
3.0      283
9.0      241
2.0      193
17.0     180
4.0      176
18.0     157
5.0      146
6.0      135
11.0     110
22.0     102
20.0      94
21.0      78
19.0      58
14.0       2
dtype: int64
Completed iteration 2
15.0    4401
0.0     1229
13.0    1167
12.0     695
1.0      593
8.0      571
16.0     544
10.0     487
7.0      460
3.0      341
9.0      219
2.0      215
18.0     203
17.0     185
4.0      184
6.0      155
5.0      149
11.0     127
22.0     121
21.0     109
19.0      97
20.0      96
14.0       2
dtype: int64
Completed iteration 3
15.0    4108
13.0    1322
0.0     1202
12.0     697
8.0      615
```

```
1.0      580
16.0     488
7.0      483
10.0     452
3.0      446
2.0      257
18.0     228
9.0      207
4.0      193
17.0     180
6.0      154
5.0      139
11.0     135
21.0     128
22.0     128
19.0     110
20.0      96
14.0       2
dtype: int64
Completed iteration 4
15.0    3874
13.0    1433
0.0     1175
12.0     702
8.0      635
3.0      594
1.0      565
7.0      493
16.0     455
10.0     423
2.0      284
18.0     245
9.0      219
4.0      184
17.0     175
6.0      144
5.0      138
11.0     131
21.0     129
22.0     129
19.0     125
20.0      96
14.0       2
dtype: int64
Completed iteration 5
15.0    3712
13.0    1523
0.0     1172
3.0      717
12.0     701
8.0      656
1.0      542
7.0      501
16.0     410
10.0     392
2.0      307
18.0     252
9.0      228
4.0      179
17.0     169
5.0      147
6.0      136
22.0     135
19.0     126
11.0     125
21.0     123
20.0      95
14.0       2
dtype: int64
Completed iteration 6
15.0    3641
13.0    1590
0.0     1185
3.0      762
12.0     689
8.0      658
1.0      532
7.0      502
10.0     389
16.0     374
2.0      317
18.0     254
9.0      236
4.0      183
17.0     164
5.0      150
```

```
22.0     137
6.0      129
21.0     126
19.0     118
11.0     118
20.0      94
14.0       2
dtype: int64
Completed iteration 7
15.0    3571
13.0    1674
0.0     1206
3.0      776
12.0     684
8.0      652
1.0      533
7.0      503
10.0     392
16.0     337
2.0      326
18.0     253
9.0      235
4.0      182
17.0     159
5.0      152
22.0     135
21.0     127
6.0      126
11.0     117
19.0     115
20.0      93
14.0       2
dtype: int64
Completed iteration 8
15.0    3526
13.0    1752
0.0     1205
3.0      777
12.0     675
8.0      642
1.0      538
7.0      508
10.0     397
2.0      332
16.0     312
18.0     253
9.0      237
4.0      179
5.0      157
17.0     149
22.0     132
6.0      126
21.0     125
11.0     119
19.0     114
20.0      93
14.0       2
dtype: int64
Completed iteration 9
15.0    3482
13.0    1822
0.0     1206
3.0      777
12.0     663
8.0      634
1.0      538
7.0      513
10.0     394
2.0      343
16.0     287
18.0     260
9.0      235
4.0      175
5.0      164
17.0     156
22.0     129
6.0      125
21.0     120
11.0     119
19.0     112
20.0      94
14.0       2
dtype: int64
Completed iteration 10
15.0    3427
13.0    1897
```

```
0.0     1204
3.0      769
12.0     667
8.0      623
1.0      535
7.0      516
10.0     387
2.0      345
16.0     269
18.0     258
9.0      231
5.0      186
4.0      174
17.0     155
22.0     128
6.0      126
21.0     120
19.0     118
11.0     118
20.0      95
14.0       2
dtype: int64
Completed iteration 11
15.0    3378
13.0    1960
0.0     1196
3.0      762
12.0     676
8.0      614
1.0      531
7.0      522
10.0     378
2.0      346
16.0     269
18.0     245
9.0      234
5.0      214
4.0      174
17.0     152
22.0     130
6.0      125
11.0     119
19.0     118
21.0     110
20.0      95
14.0       2
dtype: int64
Completed iteration 12
15.0    3342
13.0    2010
0.0     1198
3.0      754
12.0     683
8.0      605
1.0      535
7.0      520
10.0     373
2.0      343
16.0     253
18.0     246
5.0      238
9.0      235
4.0      176
17.0     150
22.0     128
6.0      126
19.0     120
11.0     120
21.0      98
20.0      95
14.0       2
dtype: int64
Completed iteration 13
15.0    3288
13.0    2072
0.0     1199
3.0      753
12.0     683
8.0      597
1.0      539
7.0      521
10.0     374
2.0      343
5.0      251
16.0     247
18.0     241
```

```
9.0      234
4.0      178
17.0     150
22.0     130
6.0      126
19.0     120
11.0     120
20.0      95
21.0      87
14.0       2
dtype: int64
Completed iteration 14
15.0    3240
13.0    2130
0.0     1204
3.0      755
12.0     683
8.0      591
1.0      540
7.0      521
10.0     376
2.0      343
5.0      252
18.0     242
16.0     232
9.0      232
4.0      181
17.0     150
22.0     127
6.0      126
19.0     122
11.0     122
20.0      95
21.0      84
14.0       2
dtype: int64
Completed iteration 15
15.0    3184
13.0    2198
0.0     1198
3.0      754
12.0     689
8.0      587
1.0      539
7.0      523
10.0     378
2.0      346
5.0      254
18.0     243
9.0      231
16.0     223
4.0      180
17.0     148
22.0     127
6.0      125
11.0     122
19.0     121
20.0      95
21.0      83
14.0       2
dtype: int64
Completed iteration 16
15.0    3109
13.0    2277
0.0     1189
3.0      760
12.0     693
8.0      581
1.0      537
7.0      526
10.0     377
2.0      346
5.0      261
18.0     241
9.0      231
16.0     218
4.0      182
17.0     147
22.0     127
6.0      125
11.0     123
19.0     121
20.0      95
21.0      82
14.0       2
dtype: int64
```

```
Completed iteration 17
15.0    3035
13.0    2357
0.0     1185
3.0      758
12.0     698
8.0      574
1.0      536
7.0      530
10.0     376
2.0      346
5.0      264
18.0     239
9.0      231
16.0     215
4.0      182
17.0     149
22.0     126
6.0      126
19.0     122
11.0     122
20.0      95
21.0      82
14.0       2
dtype: int64
Completed iteration 18
15.0    2967
13.0    2426
0.0     1182
3.0      759
12.0     699
8.0      568
1.0      537
7.0      532
10.0     376
2.0      346
5.0      268
18.0     241
9.0      229
16.0     211
4.0      182
17.0     150
6.0      126
11.0     125
22.0     125
19.0     122
20.0      95
21.0      82
14.0       2
dtype: int64
Completed iteration 19
15.0    2908
13.0    2484
0.0     1179
3.0      759
12.0     701
8.0      563
1.0      540
7.0      534
10.0     377
2.0      347
5.0      270
18.0     241
9.0      228
16.0     210
4.0      182
17.0     151
11.0     126
6.0      125
22.0     124
19.0     123
20.0      95
21.0      81
14.0       2
dtype: int64
Completed iteration 20
15.0    2855
13.0    2538
0.0     1176
3.0      759
12.0     700
8.0      560
1.0      543
7.0      538
10.0     376
2.0      347
```

```
5.0      271
18.0     238
9.0      228
16.0     213
4.0      183
17.0     151
11.0     126
6.0      125
22.0     124
19.0     122
20.0      95
21.0      80
14.0       2
dtype: int64
Completed iteration 21
Reached 21 iterations
Centroids:
Centroid 1: [-0.00866251 -0.02451079 -0.27336344 -0.01762087 -0.02604278  0.04194725
  0.03279433  0.00510852  0.01024331  0.12988734  0.00563654  0.01107448
  0.00360076 -0.01546653 -0.04064959  0.02700802  0.04018614 -0.0088744
 -0.00556757  0.00871566 -0.05215811 -0.0470721  -0.8698591 ]
Centroid 2: [-2.4515012e-02 -2.3157675e-02 -2.9244500e-01 -3.3369072e-02
 -4.9820496e-03 -4.2308483e-02 -3.1477656e-02  1.7320564e-02
  5.8751609e-02 -3.2800165e-01  2.7534166e-02  1.5851706e-02
 -6.2330082e-02 -5.8092026e-04 -1.5986998e-02 -1.4005965e-01
  1.6321145e-02  1.1716002e-02  7.2753853e-03  6.0680844e-03
 -3.5329852e-02 -1.2578539e-02 -7.1136159e-01]
Centroid 3: [ 0.03075865 -0.04353406  0.16289921 -0.01649646 -0.06575429 -0.04773531
  0.01054614  0.00631004 -0.0193712  -0.13192758 -0.02270605 -0.02242431
  0.44766495  0.02128591  0.03037527 -0.02524713  0.02524016 -0.02372778
  0.04462058  0.02131566 -0.04803638  0.01251325 -0.5242005 ]
Centroid 4: [ 0.02999168  0.03012635  0.01640646 -0.00275697 -0.01590852 -0.14943835
  0.0160133  -0.01530223 -0.08069733  0.2111428  -0.01999831 -0.00961774
  0.03883627  0.00843313  0.01850717 -0.03097207 -0.00579489  0.01080232
  0.00390126  0.00227255  0.00616237  0.07059723 -0.88807213]
Centroid 5: [ 0.03876614 -0.01390761 -0.25976825 -0.03540338 -0.04613655  0.07055662
  0.08553204  0.00708824  0.41564703  0.06987759  0.00888684 -0.0180813
  0.06555118 -0.05073521 -0.05450209  0.02874826  0.01134103  0.02392809
 -0.02953553 -0.00636432 -0.06595874 -0.04988277 -0.6092757 ]
Centroid 6: [ 0.07713991  0.06244513  0.09125289 -0.02867403 -0.1104272   0.03505493
  0.16900676 -0.06117163 -0.05936734  0.35252887 -0.12624922  0.00182173
 -0.07053928 -0.02829512 -0.01809405  0.14827777  0.02478831 -0.02894637
 -0.01226144  0.03063164 -0.04624357  0.144311   -0.5220118 ]
Centroid 7: [-0.54229665  0.01189278  0.02988039  0.04024782 -0.03178921  0.02094614
  0.01081133 -0.01630297 -0.01844654  0.0250039  -0.01335966  0.00149797
 -0.00594929  0.00174517 -0.01905633  0.02818847 -0.00235735 -0.03207182
  0.01379404  0.02085563 -0.01142419  0.03465018 -0.39006922]
Centroid 8: [ 1.94972120e-02  7.18261988e-04  9.04252157e-02  1.87828820e-02
  1.69211552e-02 -1.34927168e-01 -1.00355655e-01 -1.48843853e-02
  2.52089873e-02 -6.78890944e-02  6.26226654e-03 -2.74839588e-02
  6.09226152e-03 -4.61898977e-03  2.09603868e-02 -1.32534832e-01
 -4.68868427e-02  2.90067904e-02 -2.33283807e-02 -3.37517522e-02
  2.13263873e-02 -2.67776281e-01 -7.93817163e-01]
Centroid 9: [-0.00639843  0.02544755 -0.09720858  0.0036616   0.02319673 -0.15278384
  0.04403569 -0.00688843 -0.01440341 -0.12264073 -0.02673159  0.00973948
 -0.4644407  -0.01278778 -0.01423999 -0.0992319  -0.00149853 -0.00635152
 -0.02959498  0.01505647 -0.00785636 -0.09988782 -0.62018734]
Centroid 10: [ 0.02696916  0.01968821 -0.00672213 -0.06936759 -0.09384966  0.01881122
 -0.5162041  -0.0689842  -0.02152891  0.03128746 -0.05107652  0.01171988
 -0.02498415 -0.02087517  0.01907565  0.03312364  0.01295372 -0.0090099
 -0.02252363  0.02562072 -0.04686302  0.03018708 -0.40183485]
Centroid 11: [ 0.01513137  0.06273739  0.11646114 -0.01473906 -0.01128238 -0.01645059
  0.3955395   0.00271367 -0.02024044  0.0840394   0.02559865 -0.04349876
  0.02216916 -0.02728884 -0.00333446 -0.0408163  -0.03523336 -0.01056745
  0.00867252 -0.00268231  0.0401722  -0.02081449 -0.7150292 ]
Centroid 12: [ 0.05192081 -0.00156457  0.03556899 -0.15874448  0.35011214  0.0080593
  0.03756101  0.00308351 -0.00243546 -0.0257857  -0.04656221  0.00728024
  0.00721505 -0.0054423  -0.01374375  0.01020278  0.05706457 -0.04555211
 -0.01555122 -0.0017044   0.01036123  0.02197786 -0.2669026 ]
Centroid 13: [ 3.2398091e-03  6.3039281e-04  7.2461836e-02 -3.6308698e-03
 -2.1750284e-03 -4.2680491e-02 -2.1769287e-02  6.5564755e-03
  1.6319880e-02 -3.7090337e-01  3.5382126e-02 -1.0991894e-02
 -1.1646473e-01 -2.2740241e-03  2.4837188e-02 -1.5560293e-01
 -2.2084476e-02  1.6660400e-02  2.9160688e-02  1.0655304e-02
  4.6458724e-03  3.9923012e-02 -7.3089868e-01]
Centroid 14: [-5.4343510e-03  5.0831013e-03  7.8763463e-02  8.5205119e-03
  2.8353292e-02  3.0227691e-02 -3.4403801e-02  4.2490014e-03
 -1.5256933e-02 -5.7690162e-02 -1.4095538e-02  1.4924492e-02
  5.1979419e-02  2.1811424e-02  2.3302678e-02  2.7965374e-02
 -2.2952675e-03 -1.0994846e-04  1.1849509e-02 -5.9090387e-03
  1.3895801e-02 -2.7464947e-03 -9.6162933e-01]
Centroid 15: [ 7.9160812e-04  2.3199189e-03 -1.5786529e-05 -2.4413534e-03
 -1.0988056e-03  4.0509505e-03  3.6293813e-03 -1.3549716e-03
 -6.6573527e-03 -4.1992370e-02  1.6523942e-03 -6.5495307e-04
 -3.8907449e-03  2.0970083e-03  2.0794854e-03 -3.6711636e-01
  1.1728306e-03  5.7540281e-05  5.6967330e-03  2.2861841e-03
```

```
 -3.9486669e-04  9.1785169e-01 -2.4847420e-02]
Centroid 16: [-8.6833863e-03 -8.1803249e-03  1.2133053e-01  1.3187267e-02
  1.3311594e-02  6.0588136e-02 -2.1144025e-04  8.3814822e-03
 -1.6102033e-02  9.2431426e-02  1.3189525e-03  1.0641050e-02
  8.9485057e-02  9.7048394e-03  3.9594597e-03  2.5515167e-02
  6.4657093e-03 -4.1748318e-03  2.2545686e-02  4.7748853e-03
  9.4668195e-03 -4.1465897e-02 -9.5082760e-01]
Centroid 17: [ 0.02167456  0.01292513 -0.42160243 -0.06585103 -0.07073228  0.08064404
  0.18133996 -0.02151696 -0.0411188   0.21613288 -0.06228745  0.02284658
 -0.08410487 -0.01751712 -0.06222492  0.10709952  0.08010734 -0.03749737
 -0.0186875   0.02732783 -0.08097916  0.09606536 -0.5211101 ]
Centroid 18: [ 0.043229    0.24634516  0.00221283 -0.00843717 -0.15058793  0.01121471
  0.12652671 -0.00943899  0.05083193 -0.08872578 -0.04578258 -0.03541276
  0.03616194 -0.00465589  0.01886608  0.00316547 -0.07803995 -0.00931957
 -0.01450326  0.04139913  0.2703225   0.01678293 -0.36508358]
Centroid 19: [ 0.0252449   0.00915261 -0.05285556  0.00916413 -0.03546337  0.5185297
  0.03333795 -0.01613528  0.03244846  0.10461073  0.01833037 -0.00799248
 -0.03968212  0.00399806 -0.00824651  0.03940937  0.01413284 -0.00620592
 -0.00484106  0.02473683  0.00241387  0.01922228 -0.49448937]
Centroid 20: [ 0.037623   -0.2598211  -0.00235097 -0.04689475 -0.03882731  0.01477917
 -0.03740988 -0.02238451 -0.01359373  0.03209564  0.1649099   0.01247499
 -0.016802    0.04375789 -0.02412153  0.02076728  0.1742338  -0.01120588
  0.05162063 -0.02302334 -0.24643682  0.02592435 -0.3475854 ]
Centroid 21: [ 1.1643381e-02 -1.4756655e-02  7.0634469e-02 -7.0018098e-03
 -1.6720934e-02 -7.2631818e-01 -1.7140621e-02  6.0840932e-05
  6.9052212e-02  3.7237190e-02 -1.3864423e-02 -2.0039210e-02
 -1.0909396e-01 -2.2115773e-02 -2.4183199e-02  4.8073824e-03
 -9.8458175e-03  9.1607561e-03  2.5899002e-05 -3.1969419e-03
 -1.3870297e-02 -1.8193262e-02 -2.3871358e-01]
Centroid 22: [ 0.00410163  0.01947788 -0.15745938 -0.04141976 -0.03143437  0.05649493
 -0.07691616 -0.04482401 -0.5809711   0.03496438 -0.03371925 -0.00307214
 -0.06533307  0.0136943   0.01782743  0.02815715 -0.01347525 -0.00810187
 -0.02940425  0.00496264  0.03870443  0.02315379 -0.34387118]
Centroid 23: [ 0.28213492  0.05730062  0.10912652  0.36600655 -0.01130661  0.04474311
 -0.06091224 -0.03805846 -0.01816742  0.03223439  0.01470753 -0.00517293
 -0.0186147   0.06488201 -0.01182669  0.02812014 -0.01938904 -0.01400087
 -0.01691095  0.01311935 -0.03022088  0.03211042 -0.3390779 ]
```

In [ ]:

```
spectral_clustering(
    oe_X_train025,
    cuts=len(np.unique(le_y_train025)),
    fname="one-hot_encoded_spectral_clustering",
    affinity="sigmoid",
    gamma=1.0,
)
```

```
eigenvalues: [9.9997330e-01 9.9996972e-01 9.9996853e-01 9.9996841e-01 9.9996662e-01
 9.9996483e-01 9.9995112e-01 9.9994552e-01 9.9993980e-01 9.9992824e-01
 9.9991274e-01 9.9991250e-01 9.9990833e-01 9.9983191e-01 3.5868186e-09].
Finished running k-means++
13.0    4902
0.0     2559
3.0     1211
12.0    1108
10.0     710
11.0     488
7.0      280
2.0      260
5.0      227
9.0      209
4.0      167
8.0       83
1.0       79
6.0       65
14.0       2
dtype: int64
Completed iteration 1
13.0    4938
0.0     2232
12.0    1208
3.0     1020
10.0     607
11.0     482
7.0      340
5.0      339
2.0      331
4.0      265
9.0      197
1.0      141
8.0      141
6.0      107
14.0       2
dtype: int64
Completed iteration 2
13.0    5013
0.0     1951
12.0    1148
3.0     1002
10.0     599
7.0      525
11.0     426
5.0      353
2.0      335
4.0      306
9.0      202
8.0      171
1.0      169
6.0      148
14.0       2
dtype: int64
Completed iteration 3
13.0    4902
0.0     1917
12.0    1080
3.0      987
7.0      696
10.0     602
11.0     376
5.0      359
2.0      339
4.0      329
9.0      212
8.0      190
1.0      186
6.0      173
14.0       2
dtype: int64
Completed iteration 4
13.0    4738
0.0     2073
12.0    1035
3.0      908
7.0      759
10.0     589
5.0      365
2.0      354
4.0      349
11.0     345
9.0      220
8.0      213
1.0      206
6.0      194
14.0       2
dtype: int64
Completed iteration 5
13.0    4633
0.0     2154
12.0    1020
3.0      883
7.0      760
10.0     573
5.0      364
4.0      362
2.0      356
11.0     331
8.0      256
9.0      234
6.0      212
1.0      210
14.0       2
dtype: int64
Completed iteration 6
13.0    4578
0.0     2148
12.0    1010
3.0      922
7.0      750
10.0     548
4.0      374
2.0      368
5.0      368
11.0     326
8.0      276
9.0      242
6.0      227
1.0      211
14.0       2
dtype: int64
Completed iteration 7
13.0    4540
0.0     2110
12.0    1006
3.0      983
7.0      727
10.0     525
2.0      385
4.0      374
5.0      362
11.0     325
8.0      303
9.0      247
6.0      242
1.0      219
14.0       2
dtype: int64
Completed iteration 8
13.0    4529
0.0     1982
3.0     1128
12.0    1001
7.0      717
10.0     502
2.0      384
4.0      371
5.0      356
11.0     333
8.0      310
9.0      253
6.0      251
1.0      231
14.0       2
dtype: int64
Completed iteration 9
13.0    4481
0.0     1836
3.0     1322
12.0     998
7.0      701
10.0     487
2.0      393
4.0      374
5.0      350
11.0     336
8.0      319
6.0      260
9.0      255
1.0      236
14.0       2
dtype: int64
Completed iteration 10
13.0    4437
0.0     1767
3.0     1448
12.0     995
7.0      681
10.0     463
2.0      403
4.0      374
11.0     357
5.0      347
8.0      320
9.0      260
6.0      258
1.0      238
14.0       2
dtype: int64
Completed iteration 11
13.0    4415
0.0     1752
3.0     1502
12.0     991
7.0      655
10.0     451
2.0      419
4.0      372
11.0     370
5.0      347
8.0      320
9.0      265
6.0      254
1.0      235
14.0       2
dtype: int64
Completed iteration 12
13.0    4399
0.0     1772
3.0     1498
12.0     985
7.0      645
10.0     445
2.0      428
11.0     375
4.0      370
5.0      350
8.0      322
9.0      269
6.0      251
1.0      239
14.0       2
dtype: int64
Completed iteration 13
13.0    4392
0.0     1797
3.0     1481
12.0     977
7.0      638
10.0     443
2.0      434
11.0     375
4.0      372
5.0      351
8.0      322
9.0      275
6.0      253
1.0      238
14.0       2
dtype: int64
Completed iteration 14
13.0    4386
0.0     1821
3.0     1466
12.0     972
7.0      637
10.0     444
2.0      436
4.0      371
11.0     371
5.0      351
8.0      321
9.0      281
6.0      252
1.0      239
14.0       2
dtype: int64
Completed iteration 15
13.0    4387
0.0     1827
3.0     1461
12.0     970
7.0      637
10.0     442
2.0      436
4.0      371
11.0     370
5.0      350
8.0      323
9.0      284
6.0      251
1.0      239
14.0       2
dtype: int64
Completed iteration 16
Epsilon has a maximum value of 0.00852470938116312
Centroids:
Centroid 1: [ 0.01945323  0.14447753  0.01965215 -0.00377686  0.08030927 -0.01606437
 -0.02341309 -0.0088664   0.01038201  0.00392016  0.01219641  0.00364531
 -0.00640873 -0.12641023 -0.9422967 ]
Centroid 2: [-0.01708128  0.08554678  0.3037909   0.05677773 -0.02334643  0.17494424
 -0.03411942  0.04475827  0.15166971 -0.03414135  0.03236789 -0.01271197
 -0.19084334  0.04031102 -0.42340645]
Centroid 3: [-1.01516791e-01  3.87182087e-01 -1.88054010e-01 -1.47419414e-04
  3.25215831e-02 -4.13343497e-02 -4.94280830e-02  1.70107514e-01
  6.48309439e-02 -5.61135784e-02 -2.48095859e-02  3.02870683e-02
 -1.14797354e-01  1.78538501e-01 -6.11164927e-01]
Centroid 4: [-0.06641286  0.23034564 -0.00451896  0.00268242  0.03233751  0.00279852
 -0.0093655   0.02275498  0.02292868 -0.0020003   0.00607357  0.01451095
 -0.02451501  0.06532802 -0.91274405]
Centroid 5: [ 0.04929734 -0.46568957  0.00692579  0.0145882  -0.38581976 -0.02778297
 -0.01358525 -0.12544282  0.02027011 -0.00913433  0.01226807  0.02717857
 -0.00546685  0.0237301  -0.6292285 ]
Centroid 6: [-0.06980243 -0.02468231 -0.00177373 -0.0448995   0.5339325   0.06209921
  0.04721852 -0.02414148  0.0120466  -0.02382365  0.03881252  0.02594368
 -0.03901901  0.00501545 -0.594194  ]
Centroid 7: [-0.23868375  0.03587369 -0.15328291 -0.03984706 -0.05903682 -0.04372717
  0.03212363  0.04321922 -0.11120197  0.02142523 -0.00571279  0.05050049
  0.25406858  0.03940891 -0.36869952]
Centroid 8: [ 0.04286189 -0.10991481  0.00457529 -0.03041211  0.00672986 -0.01289914
  0.01108698 -0.1500361  -0.05131786  0.02834456 -0.03867104 -0.03794768
  0.02856995 -0.2952946  -0.84520125]
Centroid 9: [ 0.44933033  0.10427824 -0.01288331 -0.04332958  0.0707294  -0.08369451
 -0.05767941  0.05719995  0.00275147  0.01763508 -0.02066133  0.00302831
 -0.06345078 -0.00775915 -0.65937424]
Centroid 10: [ 0.07776884 -0.53089505 -0.0256555   0.03277994  0.20173325 -0.02216693
 -0.00156283 -0.06894284  0.01346978 -0.06525566  0.02842072  0.01723976
 -0.02016856  0.03738019 -0.5913704 ]
Centroid 11: [-1.6667116e-02 -1.0643810e-01 -1.6215565e-02  2.3320458e-04
 -4.7525337e-01 -1.6104717e-02  3.9751749e-03 -1.3881165e-01
 -3.5949502e-02  7.5464901e-03 -5.5997770e-02 -1.4631918e-03
  2.5170207e-02 -2.1765457e-01 -6.9973797e-01]
Centroid 12: [-0.05193531  0.15172648 -0.09221786  0.02785723 -0.48921397 -0.01926696
 -0.02612835  0.07324933  0.06489651 -0.03970679 -0.00758852  0.04957802
 -0.07236055  0.09598146 -0.6366299 ]
Centroid 13: [ 0.02503186 -0.31096512  0.05120171 -0.01127991 -0.0695163   0.009582
  0.02419125 -0.16860324 -0.01164422  0.02758047  0.03186585  0.00816043
 -0.00384961  0.06120215 -0.8486463 ]
Centroid 14: [-0.02369893 -0.01186094 -0.0136357   0.01540716  0.0613142   0.01937821
  0.01827109  0.03651153  0.00100504 -0.00524163  0.01363753 -0.0023432
  0.01288014 -0.00323291 -0.9773422 ]
Centroid 15: [-6.6585722e-03 -4.1998837e-02  1.6526437e-03 -6.5499800e-04
 -3.8913905e-03  2.0974381e-03  2.0798924e-03 -3.6715803e-01
  1.1731395e-03  5.7500089e-05  5.6978199e-03  2.2866465e-03
 -3.9504259e-04  9.1792858e-01 -2.4850771e-02]
```

DBSCAN

Functions

In [ ]:

```python
def DBSCAN(data, eps, min_pts, fname=""):
    core = []
    labelled = np.ones(data.shape[0]) * -1
    checked = np.zeros(data.shape[0])
    nn = (
        NearestNeighbors(radius=eps)
        .fit(data)
        .radius_neighbors(data, return_distance=False)
    )
    for i in range(nn.shape[0]):
```

```
        if len(nn[i]) >= min_pts:
            core.append(i)
    cluster = 0
    for x in core:
        if labelled[x] != -1:
            continue
        cluster += 1
        labelled[x] = cluster
        labelled, checked = density_connected(
            data, eps, x, cluster, labelled, nn, core, checked
        )
    noise = []
    border = []
    for i in range(data.shape[0]):
        if labelled[i] == -1:
            noise.append(i)
        elif i not in core:
            border.append(i)
    dlabels = pd.DataFrame(labelled)
    path_label = (
        f"/content/drive/My Drive/pattern/2/labels_{eps}_{min_pts}_{fname}_DBSCAN.csv"
    )
    with open(path_label, "w", encoding="utf-8-sig") as f:
        dlabels.to_csv(f)
    return core, noise, border, labelled, cluster


def density_connected(data, eps, x, k, labelled, nn, core, checked):
    iter_list = [x]
    checked[x] = 1
    while len(iter_list):
        x = iter_list.pop(0)
        for y in nn[x]:
            labelled[y] = k
            if y in core and not checked[y]:
                iter_list.append(y)
                checked[y] = 1
    return labelled, checked
```

https://stats.stackexchange.com/questions/88872/a-routine-to-choose-eps-and-minpts-for-dbscan https://medium.com/@tarammullin/dbscan-parameter-estimation-ff8330e3a3bd

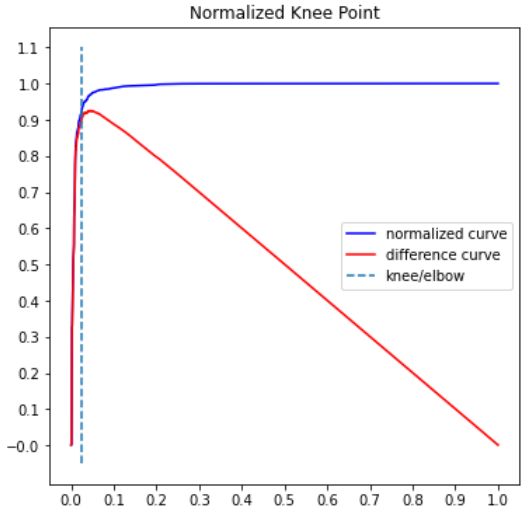
Will use min_pts = 1 to cluster all points (no noise)

label encoded run

In [ ]:
```
min_pts = le_X_train004.shape[1] * 2
nbrs = NearestNeighbors(n_neighbors=min_pts).fit(le_X_train004.to_numpy())
distances, indices = nbrs.kneighbors(le_X_train004.to_numpy())
distance_desc = sorted(distances[:, min_pts - 1], reverse=True)[7:]
px.line(x=list(range(1, len(distance_desc) + 1)), y=distance_desc)
```

In [ ]:
```
kneedle = KneeLocator(
    range(1, len(distance_desc) + 1),  # x values
    distance_desc,  # y values
    S=1,  # parameter suggested from paper
    curve="convex",  # parameter from figure
    direction="decreasing",
)  # parameter from figure
kneedle.plot_knee_normalized()
eps = round(kneedle.knee_y)
print(eps)
```

```
3561
```



In [ ]:
```
core, noise, border, labelled, clusters = DBSCAN(
    le_X_train004.to_numpy(), eps, 1, fname="label_encoded"
)
```

In [ ]:
```
print(f"noise indices: {noise}")
print(f"number of clusters: {clusters}")
print(f"Labels: {labelled}")
```

```
noise indices: []
number of clusters: 9
Labels: [1. 1. 1. ... 1. 1. 1.]
```

Attempt to decrease eps, to increase the numbers of clusters to closer to 11 (the number of labels, i.e. the real number of clusters)

In [ ]:
```
print(len(np.unique(le_y_train004)))
```

11

In [ ]:
```
core, noise, border, labelled, clusters = DBSCAN(
    le_X_train004.to_numpy(), 2550, 1, fname="label_encoded"
)
```

In [ ]:
```
print(f"noise indices: {noise}")
print(f"number of clusters: {clusters}")
print(f"Labels: {labelled}")
```

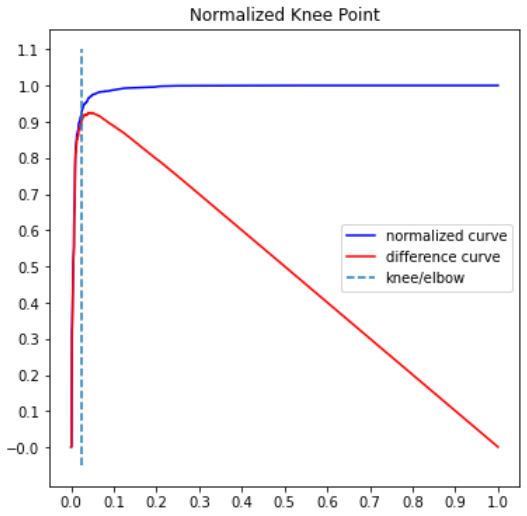
```
noise indices: []
number of clusters: 11
Labels: [1. 1. 1. ... 1. 1. 1.]
```

one-hot encoded run

In [ ]:
```
min_pts = le_X_train004.shape[1] * 2
nbrs = NearestNeighbors(n_neighbors=min_pts).fit(oe_X_train004.to_numpy())
distances, indices = nbrs.kneighbors(oe_X_train004.to_numpy())
distance_desc = sorted(distances[:, min_pts - 1], reverse=True)[7:]
px.line(x=list(range(1, len(distance_desc) + 1)), y=distance_desc)
```

In [ ]:
```
kneedle = KneeLocator(
    range(1, len(distance_desc) + 1),  # x values
    distance_desc,  # y values
    S=1,  # parameter suggested from paper
    curve="convex",  # parameter from figure
    direction="decreasing",
)  # parameter from figure
kneedle.plot_knee_normalized()
eps = round(kneedle.knee_y)
print(eps)
```

```
3561
```



In [ ]:
```
core, noise, border, labelled, clusters = DBSCAN(
    oe_X_train004.to_numpy(), eps, 1, fname="one-hot_encoded"
)
```

In [ ]:
```
print(f"noise indices: {noise}")
print(f"number of clusters: {clusters}")
print(f"Labels: {labelled}")
```

```
noise indices: []
number of clusters: 9
Labels: [1. 1. 1. ... 1. 1. 1.]
```

Attempt to decrease eps, to increase the numbers of clusters to closer to 11 (the number of labels, i.e. the real number of clusters)

In [ ]:
```
print(len(np.unique(le_y_train004)))
```

```
11
```

In [ ]:
```
core, noise, border, labelled, clusters = DBSCAN(
    oe_X_train004.to_numpy(), 2550, 1, fname="one-hot_encoded"
)
```

In [ ]:
```
print(f"noise indices: {noise}")
print(f"number of clusters: {clusters}")
print(f"Labels: {labelled}")
```

```
noise indices: []
number of clusters: 11
Labels: [1. 1. 1. ... 1. 1. 1.]
```

Evaluation

Conditional entropy

In [ ]:
```
def conditional_entropy(y_true, y_pred):
    n = len(y_true)
    y_true_labels = np.unique(y_true)
    y_pred_labels = np.unique(y_pred)
    # Calculate H(T|C)
    H_T_C_total = 0
    for pred_label in y_pred_labels:
        indices = np.where(y_pred == pred_label)[0]
        cluster = y_true[indices]
        H_T_C = 0
        for true_label in y_true_labels:
            p = np.mean(cluster == true_label)
            if p > 0:
                H_T_C -= p * np.log2(p)
        H_T_C_total += len(cluster) * H_T_C / n
    return H_T_C_total
```

Precision, Recall, F1 score

In [ ]:
```
def precision_recall_f1_weighted(y_true, y_pred):
    # Compute F1 score with average=weighted
```

```
    n_classes = len(set(y_true))
    precisions = []
    recalls = []
    f1_scores = []
    for c in range(n_classes):
        weight = np.sum(y_true == c) / len(y_true)
        tp = np.sum((y_true == c) & (y_pred == c))
        fp = np.sum((y_true != c) & (y_pred == c))
        fn = np.sum((y_true == c) & (y_pred != c))
        precision = weight * tp / (tp + fp) if (tp + fp) > 0 else 0
        recall = weight * tp / (tp + fn) if (tp + fn) > 0 else 0
        precisions.append(precision)
        recalls.append(recall)
        f1_scores.append(
            2 * precision * recall / (precision + recall)
            if (precision + recall) > 0
            else 0
        )
    print("Weighted:")
    print(f"Precision: {sum(precisions) }")
    print(f"Recall: {sum(recalls)}")
    print(f"F1 score: {sum(f1_scores)}")
    return sum(precisions), sum(recalls), sum(f1_scores)
```

Plotting Values

In [ ]:
```
def plot_conditional_entropy_precision_recall_f1(
    cond_entropies, precisions, recalls, f1_scores, x_axis, name
):
    fig, (ax1, ax2) = plt.subplots(1, 2)
    fig.set_size_inches(18.5, 6)
    plt.rcParams.update({"font.size": 10})
    fig.suptitle(name)
    ax1.plot(x_axis, cond_entropies)
    ax1.set_xlabel("number of clusters")
    ax1.set_ylabel("conditional entropy")
    ax2.plot(x_axis, precisions, label="precision")
    ax2.plot(x_axis, recalls, label="recall")
    ax2.plot(x_axis, f1_scores, label="f1_score")
    ax2.set_xlabel("number of clusters")
    ax2.set_ylabel("score")
    ax2.legend()
    plt.show()
```

Maximum matching

In [ ]:
```
def max_matching_hungarian(labels, ground_truth):
    n_labels = len(np.unique(labels))
    n_ground_truth = len(np.unique(ground_truth))
    cost_matrix = np.zeros((n_labels, n_ground_truth))
    for i in range(n_labels):
        for j in range(n_ground_truth):
            cost_matrix[i, j] = np.sum((labels == i) & (ground_truth == j))
    padded = np.zeros(2 * [max(cost_matrix.shape)])
    padded[0 : cost_matrix.shape[0], 0 : cost_matrix.shape[1]] = cost_matrix
    cost_matrix = padded
    row_ind, col_ind = linear_sum_assignment(cost_matrix, maximize=True)
    new_labels = np.zeros_like(labels)
    for i in range(len(row_ind)):
        new_labels[labels == row_ind[i]] = col_ind[i]
    print(f"Accuracy: {accuracy_score(ground_truth, new_labels)}")
    return new_labels
```

Purity matching

In [ ]:
```
def purity_matching(y_true, y_pred):
    # get the unique classes
    max_count = max(len(np.unique(y_true)), len(np.unique(y_pred)))
    max_value = np.max(np.unique(y_true))
    potential_labels = set([*range(max_value + 1, max_value + max_count)])
    clusters = np.unique(y_pred)
    # create a dictionary to store the mapping
    mapping = {}
    mapped = []
    # loop through the classes
    for c in clusters:
        # get the index of the class
        idx = np.where(y_pred == c)
        # get the most common label in the predicted labels
        sorted = np.argsort(np.bincount(y_true[idx])).tolist()
```

```
        for label in mapped:
            if label in sorted:
                sorted.remove(label)
        if len(sorted) == 0:
            label = potential_labels.pop()
        else:
            label = sorted[-1]
        # map the class to the label
        mapping[c] = label
        mapped.append(label)
    # create a new list of labels
    for i in range(len(y_pred)):
        y_pred[i] = mapping[y_pred[i]]
    print(f"Accuracy: {accuracy_score(y_true, y_pred)}")
    return y_pred
```

Labels and Centroids loading functions

In [ ]:
```
def load_kmeans_labels(k=23, fname="label_encoded_kmeans"):
    path = "/content/drive/My Drive/pattern/2/"
    files = os.listdir(path)
    files = [file for file in files if file.startswith("labels")]
    candidates = []
    for file in files:
        # regex to get the file which will look like labels_{iter}_{k}_{fname}.csv
        if re.search(f"labels_[0-9]+_{k}_{fname}.csv", file):
            candidates.append(file)
    # get the file with max iter
    candidates.sort(key=lambda x: int(x.split("_")[1]))
    print(f"Loading: {candidates[-1]}")
    labels = pd.read_csv(path + candidates[-1], index_col=0)
    return labels
```

In [ ]:
```
def load_kmeans_centroids(k=23, fname="spectral_clustering"):
    path = "/content/drive/My Drive/pattern/2/"
    files = os.listdir(path)
    files = [file for file in files if file.startswith("centroids")]
    candidates = []
    for file in files:
        # regex to get the file which will look like labels_{iter}_{k}_{fname}.csv
        if re.search(f"centroids_[0-9]+_{k}_{fname}.csv", file):
            candidates.append(file)
    # get the file with max iter
    candidates.sort(key=lambda x: int(x.split("_")[1]))
    print(candidates[-1])
    centroids = pd.read_csv(path + candidates[-1], index_col=0)
    return centroids
```

In [ ]:
```
def load_dbscan_labels(fname=""):
    path = "/content/drive/My Drive/pattern/2/"
    files = os.listdir(path)
    files = [file for file in files if file.startswith("labels")]
    candidates = []
    for file in files:
        # regex to get the file which will look like labels_{fname}_DBSCAN.csv
        if re.search(f"labels_{fname}_DBSCAN.csv", file):
            candidates.append(file)
    # get the file with max iter
    candidates.sort(key=lambda x: int(x.split("_")[1]))
    print(f"Loading: {candidates[-1]}")
    labels = pd.read_csv(path + candidates[-1], index_col=0)
    return labels
```

KMeans

Using test data

Maximum matching

label encoded

In [ ]:
```
precision_label_encoded_kmean_test = []
recall_label_encoded_kmean_test = []
f1_label_encoded_kmean_test = []
con_entr_label_encoded_kmean_test = []
```

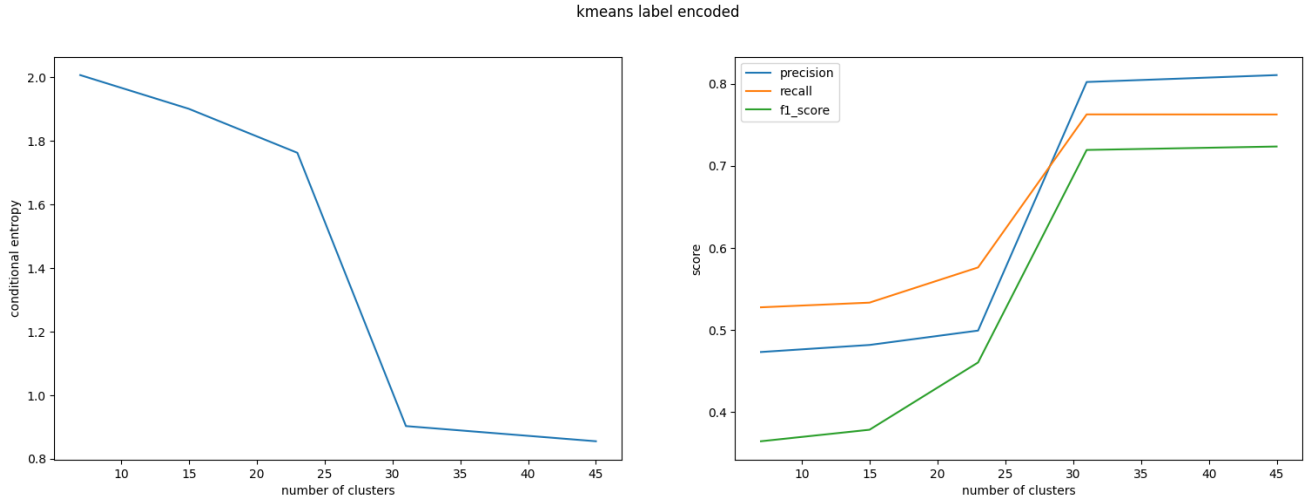
In [ ]:
```
clusters = [7, 15, 23, 31, 45]
for k in clusters:
```

```
    centroids = load_kmeans_centroids(k=k, fname="label_encoded_kmeans")
    centroids = centroids.to_numpy()
    labels = np.array(k_means_predict(le_test.to_numpy(), centroids)).astype(np.int64)
    print(f"k= {k}")
    new_labels = max_matching_hungarian(labels, le_y_test)
    prec, recall, f1 = precision_recall_f1_weighted(le_y_test, new_labels)
    precision_label_encoded_kmean_test.append(prec)
    recall_label_encoded_kmean_test.append(recall)
    f1_label_encoded_kmean_test.append(f1)
    con_entr = conditional_entropy(le_y_test, new_labels)
    con_entr_label_encoded_kmean_test.append(con_entr)
    print(f"Conditional entropy: {con_entr}")
```

```
centroids_9_7_label_encoded_kmeans.csv
k= 7
Accuracy: 0.5276163958987747
Weighted:
Precision: 0.47319717186600935
Recall: 0.5276163958987747
F1 score: 0.36452223064423
Conditional entropy: 2.0070435581419477
centroids_11_15_label_encoded_kmeans.csv
k= 15
Accuracy: 0.5333296895144826
Weighted:
Precision: 0.4817797139950501
Recall: 0.5333296895144826
F1 score: 0.37852807223197243
Conditional entropy: 1.9009496043577163
centroids_11_23_label_encoded_kmeans.csv
k= 23
Accuracy: 0.5761906446022718
Weighted:
Precision: 0.4992798123251458
Recall: 0.5761906446022718
F1 score: 0.46045814279959163
Conditional entropy: 1.76246569098425
centroids_11_31_label_encoded_kmeans.csv
k= 31
Accuracy: 0.7625462577444547
Weighted:
Precision: 0.8020043115539865
Recall: 0.7625462577444547
F1 score: 0.7192353472061755
Conditional entropy: 0.902351889216086
centroids_11_45_label_encoded_kmeans.csv
k= 45
Accuracy: 0.7624240826418115
Weighted:
Precision: 0.8104041422814647
Recall: 0.7624240826418116
F1 score: 0.7234448367188854
Conditional entropy: 0.8546426862318236
```

In [ ]:

```
plot_conditional_entropy_precision_recall_f1(
    con_entr_label_encoded_kmean_test,
    precision_label_encoded_kmean_test,
    recall_label_encoded_kmean_test,
    f1_label_encoded_kmean_test,
    clusters,
    "kmeans label encoded",
)
```



one-hot encoded

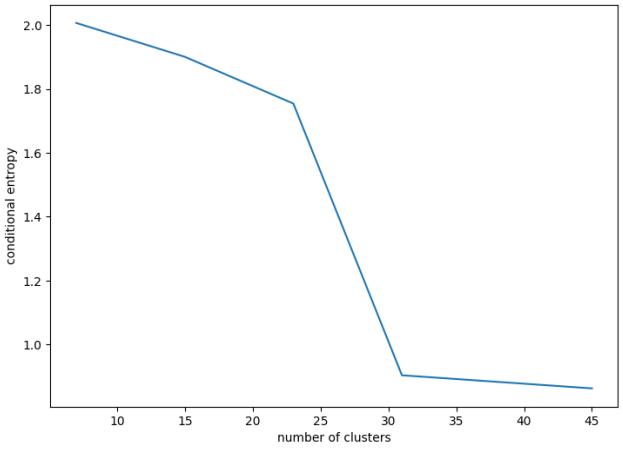
In [ ]:
```
precision_one_hot_encoded_kmean_test = []
recall_one_hot_encoded_kmean_test = []
f1_one_hot_encoded_kmean_test = []
con_entr_one_hot_encoded_kmean_test = []
```

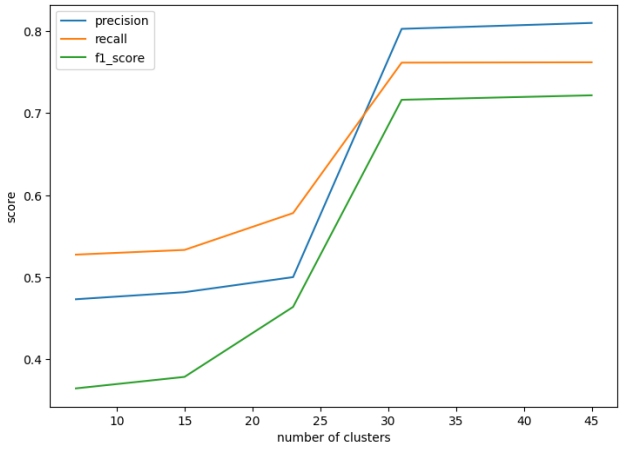
In [ ]:
```
clusters = [7, 15, 23, 31, 45]
for k in clusters:
    centroids = load_kmeans_centroids(k=k, fname="one-hot_encoded_kmeans")
    centroids = centroids.to_numpy()
    labels = np.array(k_means_predict(oe_test.to_numpy(), centroids)).astype(np.int64)
    print(f"k= {k}")
    new_labels = max_matching_hungarian(labels, le_y_test)
    prec, recall, f1 = precision_recall_f1_weighted(le_y_test, new_labels)
    precision_one_hot_encoded_kmean_test.append(prec)
    recall_one_hot_encoded_kmean_test.append(recall)
    f1_one_hot_encoded_kmean_test.append(f1)
    con_entr = conditional_entropy(le_y_test, new_labels)
    con_entr_one_hot_encoded_kmean_test.append(con_entr)
    print(f"Conditional entropy: {con_entr}")
```

```
centroids_9_7_one-hot_encoded_kmeans.csv
k= 7
Accuracy: 0.5276163958987747
Weighted:
Precision: 0.47319717186600935
Recall: 0.5276163958987747
F1 score: 0.36452223064423
Conditional entropy: 2.0070435581419477
centroids_11_15_one-hot_encoded_kmeans.csv
k= 15
Accuracy: 0.5333296895144826
Weighted:
Precision: 0.4817797139950501
Recall: 0.5333296895144826
F1 score: 0.37852807223197243
Conditional entropy: 1.9009496043577163
centroids_11_23_one-hot_encoded_kmeans.csv
k= 23
Accuracy: 0.578245115407245
Weighted:
Precision: 0.500174839756438
Recall: 0.578245115407245
F1 score: 0.46385112099050596
Conditional entropy: 1.7545007116440827
centroids_11_31_one-hot_encoded_kmeans.csv
k= 31
Accuracy: 0.7616846017573924
Weighted:
Precision: 0.8028689770844921
Recall: 0.7616846017573925
F1 score: 0.716368351473006
Conditional entropy: 0.9033757482008209
centroids_11_45_one-hot_encoded_kmeans.csv
k= 45
Accuracy: 0.7620993540795231
Weighted:
Precision: 0.81008831658732
Recall: 0.7620993540795231
F1 score: 0.7218483150788502
Conditional entropy: 0.8623669343651951
```

In [ ]:
```
plot_conditional_entropy_precision_recall_f1(
    con_entr_one_hot_encoded_kmean_test,
    precision_one_hot_encoded_kmean_test,
    recall_one_hot_encoded_kmean_test,
    f1_one_hot_encoded_kmean_test,
    clusters,
    "kmeans one-hot encoded",
)
```

kmeans one-hot encoded





Purity matching

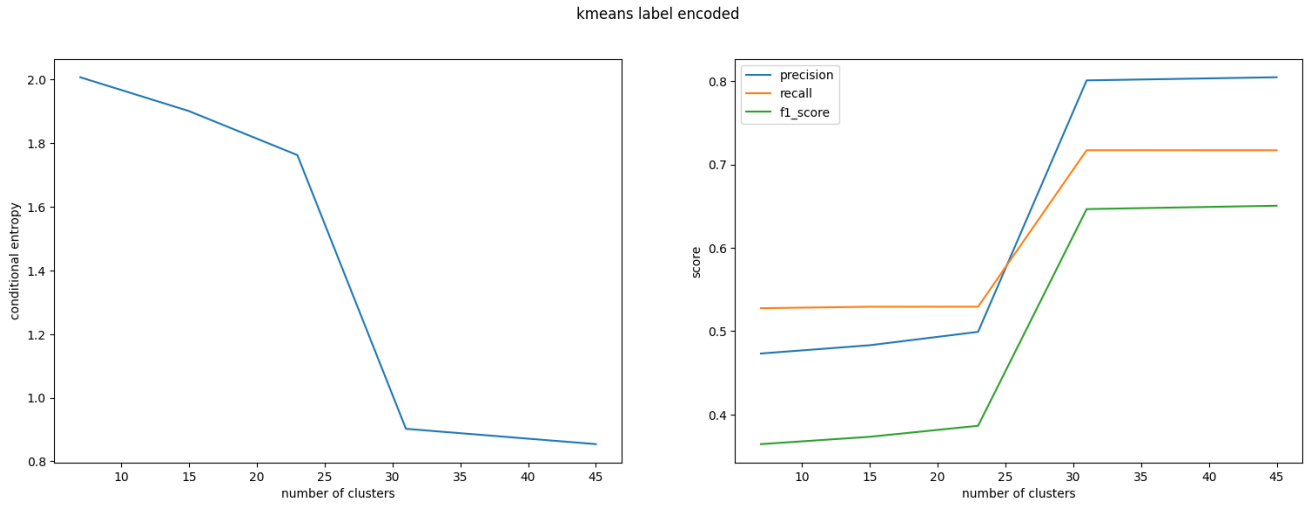
label encoded

In [ ]:
```
precision_label_encoded_kmean_test = []
recall_label_encoded_kmean_test = []
f1_label_encoded_kmean_test = []
con_entr_label_encoded_kmean_test = []
```

In [ ]:
```
clusters = [7, 15, 23, 31, 45]
for k in clusters:
    centroids = load_kmeans_centroids(k=k, fname="label_encoded_kmeans")
    centroids = centroids.to_numpy()
    labels = np.array(k_means_predict(le_test.to_numpy(), centroids)).astype(np.int64)
    print(f"k= {k}")
    new_labels = purity_matching(le_y_test, labels)
    prec, recall, f1 = precision_recall_f1_weighted(le_y_test, new_labels)
    precision_label_encoded_kmean_test.append(prec)
    recall_label_encoded_kmean_test.append(recall)
    f1_label_encoded_kmean_test.append(f1)
    con_entr = conditional_entropy(le_y_test, new_labels)
    con_entr_label_encoded_kmean_test.append(con_entr)
    print(f"Conditional entropy: {con_entr}")
```

```
centroids_9_7_label_encoded_kmeans.csv
k= 7
Accuracy: 0.527587459690254
Weighted:
Precision: 0.47320020838171833
Recall: 0.527587459690254
F1 score: 0.36446106396427613
Conditional entropy: 2.0070435581419477
centroids_11_15_label_encoded_kmeans.csv
k= 15
Accuracy: 0.5293172019329387
Weighted:
Precision: 0.48309122521286463
Recall: 0.5293172019329387
F1 score: 0.37323147599919504
Conditional entropy: 1.9009496043577163
centroids_11_23_label_encoded_kmeans.csv
k= 23
Accuracy: 0.5294007954242209
Weighted:
Precision: 0.49918108687329216
Recall: 0.5294007954242209
F1 score: 0.38647268034960175
Conditional entropy: 1.76246569098425
centroids_11_31_label_encoded_kmeans.csv
k= 31
Accuracy: 0.7171646373810803
Weighted:
Precision: 0.8009624599703624
Recall: 0.7171646373810802
F1 score: 0.6464864518930077
Conditional entropy: 0.902351889216086
centroids_11_45_label_encoded_kmeans.csv
k= 45
Accuracy: 0.717119625501159
Weighted:
Precision: 0.8047199416082651
Recall: 0.717119625501159
F1 score: 0.6505372616708462
Conditional entropy: 0.8542425154845061
```

In [ ]:
```
plot_conditional_entropy_precision_recall_f1(
    con_entr_label_encoded_kmean_test,
    precision_label_encoded_kmean_test,
    recall_label_encoded_kmean_test,
    f1_label_encoded_kmean_test,
    clusters,
    "kmeans label encoded",
)
```



one-hot encoded

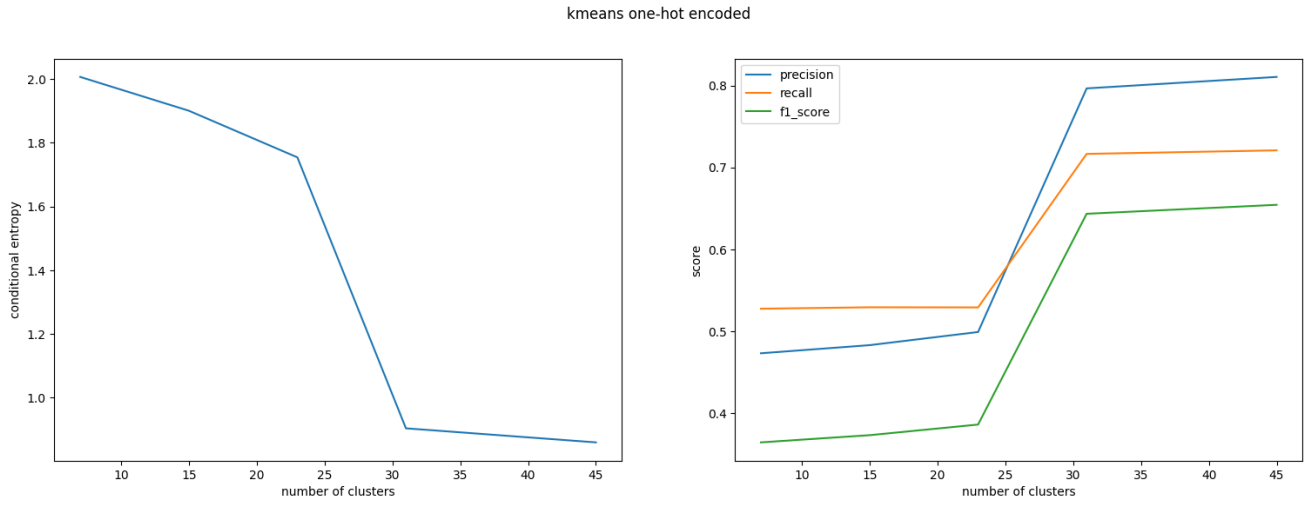
In [ ]:
```
precision_one_hot_encoded_kmean_test = []
recall_one_hot_encoded_kmean_test = []
f1_one_hot_encoded_kmean_test = []
con_entr_one_hot_encoded_kmean_test = []
```

In [ ]:
```
clusters = [7, 15, 23, 31, 45]
for k in clusters:
    centroids = load_kmeans_centroids(k=k, fname="one-hot_encoded_kmeans")
    centroids = centroids.to_numpy()
    labels = np.array(k_means_predict(oe_test.to_numpy(), centroids)).astype(np.int64)
```

```
    print(f"k= {k}")
    new_labels = purity_matching(le_y_test, labels)
    prec, recall, f1 = precision_recall_f1_weighted(le_y_test, new_labels)
    precision_one_hot_encoded_kmean_test.append(prec)
    recall_one_hot_encoded_kmean_test.append(recall)
    f1_one_hot_encoded_kmean_test.append(f1)
    con_entr = conditional_entropy(le_y_test, new_labels)
    con_entr_one_hot_encoded_kmean_test.append(con_entr)
    print(f"Conditional entropy: {con_entr}")
```

```
centroids_9_7_one-hot_encoded_kmeans.csv
k= 7
Accuracy: 0.527587459690254
Weighted:
Precision: 0.47320020838171833
Recall: 0.527587459690254
F1 score: 0.36446106396427613
Conditional entropy: 2.0070435581419477
centroids_11_15_one-hot_encoded_kmeans.csv
k= 15
Accuracy: 0.5293172019329387
Weighted:
Precision: 0.48309122521286463
Recall: 0.5293172019329387
F1 score: 0.37323147599919504
Conditional entropy: 1.9009496043577163
centroids_11_23_one-hot_encoded_kmeans.csv
k= 23
Accuracy: 0.5291628754874947
Weighted:
Precision: 0.49914064112653816
Recall: 0.5291628754874946
F1 score: 0.38620430665312133
Conditional entropy: 1.7545007116440827
centroids_11_31_one-hot_encoded_kmeans.csv
k= 31
Accuracy: 0.7165183953907835
Weighted:
Precision: 0.7964567934807149
Recall: 0.7165183953907835
F1 score: 0.6434367268723267
Conditional entropy: 0.9033757482008209
centroids_11_45_one-hot_encoded_kmeans.csv
k= 45
Accuracy: 0.7208234601918149
Weighted:
Precision: 0.8104277459463206
Recall: 0.7208234601918149
F1 score: 0.6543608888459882
Conditional entropy: 0.8592353595878717
```

In [ ]:
```
plot_conditional_entropy_precision_recall_f1(
    con_entr_one_hot_encoded_kmean_test,
    precision_one_hot_encoded_kmean_test,
    recall_one_hot_encoded_kmean_test,
    f1_one_hot_encoded_kmean_test,
    clusters,
    "kmeans one-hot encoded",
)
```



Using training data

Maximum matching

label encoded

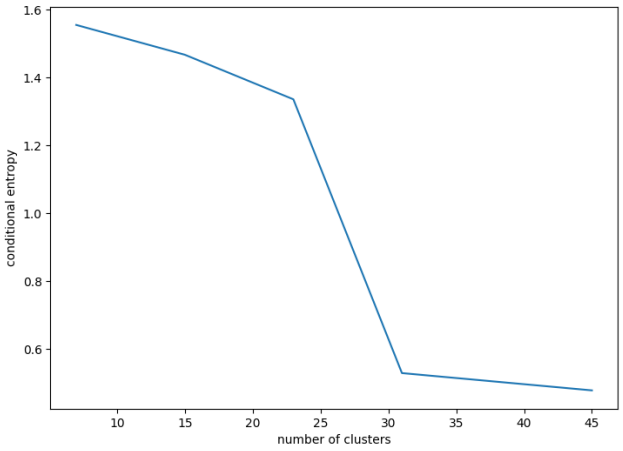
In [ ]:
```
precision_label_encoded_kmean_train = []
recall_label_encoded_kmean_train = []
f1_label_encoded_kmean_train = []
con_entr_label_encoded_kmean_train = []
```

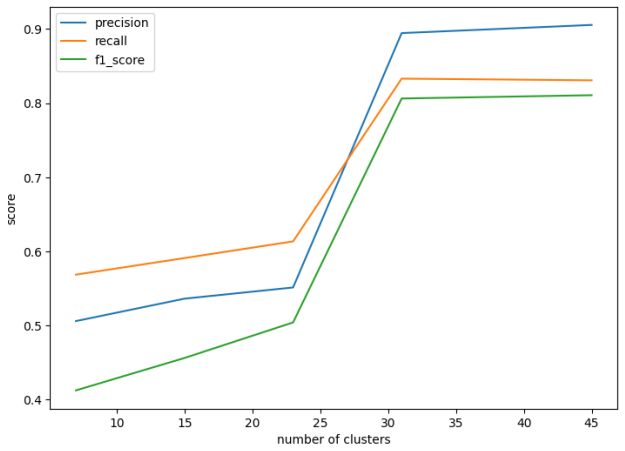
In [ ]:
```
clusters = [7, 15, 23, 31, 45]
for k in clusters:
    print(f"k= {k}")
    labels = load_kmeans_labels(k=k, fname="label_encoded_kmeans")
    labels = labels.to_numpy().reshape(-1)
    new_labels = max_matching_hungarian(labels, le_y_train_10_percent)
    prec, recall, f1 = precision_recall_f1_weighted(le_y_train_10_percent, new_labels)
    precision_label_encoded_kmean_train.append(prec)
    recall_label_encoded_kmean_train.append(recall)
    f1_label_encoded_kmean_train.append(f1)
    con_entr = conditional_entropy(le_y_train_10_percent, new_labels)
    con_entr_label_encoded_kmean_train.append(con_entr)
    print(f"Conditional entropy: {con_entr}")
```

```
k= 7
Loading: labels_9_7_label_encoded_kmeans.csv
Accuracy: 0.5686074073774192
Weighted:
Precision: 0.5059549714702325
Recall: 0.5686074073774191
F1 score: 0.4124629551498325
Conditional entropy: 1.555616299708753
k= 15
Loading: labels_11_15_label_encoded_kmeans.csv
Accuracy: 0.5909505871207904
Weighted:
Precision: 0.5361831284498593
Recall: 0.5909505871207904
F1 score: 0.4561441952183603
Conditional entropy: 1.4677963604890603
k= 23
Loading: labels_11_23_label_encoded_kmeans.csv
Accuracy: 0.6134476064782671
Weighted:
Precision: 0.5512803173254756
Recall: 0.6134476064782671
F1 score: 0.504100225908116
Conditional entropy: 1.3363884292614905
k= 31
Loading: labels_11_31_label_encoded_kmeans.csv
Accuracy: 0.8330313893538939
Weighted:
Precision: 0.8944603993883612
Recall: 0.8330313893538938
F1 score: 0.8062192971874526
Conditional entropy: 0.5294019358718293
k= 45
Loading: labels_11_45_label_encoded_kmeans.csv
Accuracy: 0.8307703518676332
Weighted:
Precision: 0.9054694984696837
Recall: 0.8307703518676333
F1 score: 0.8106739927715784
Conditional entropy: 0.4784610408282507
```

In [ ]:
```
plot_conditional_entropy_precision_recall_f1(
    con_entr_label_encoded_kmean_train,
    precision_label_encoded_kmean_train,
    recall_label_encoded_kmean_train,
    f1_label_encoded_kmean_train,
    clusters,
    "kmeans label encoded",
)
```

kmeans label encoded





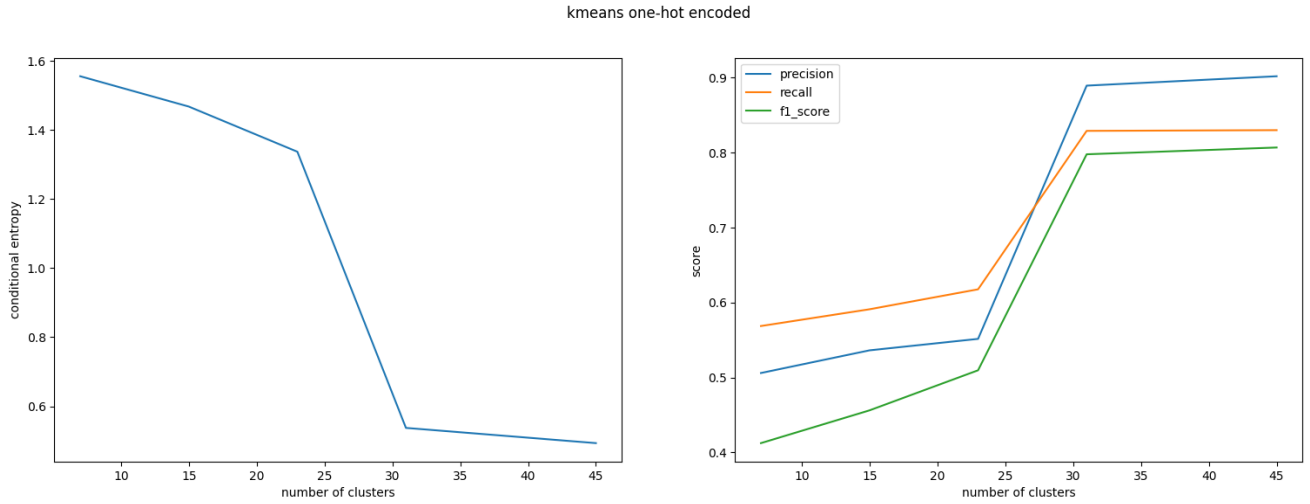
one-hot encoded

In [ ]:
```
precision_one_hot_encoded_kmean_train = []
recall_one_hot_encoded_kmean_train = []
f1_one_hot_encoded_kmean_train = []
con_entr_one_hot_encoded_kmean_train = []
```

In [ ]:
```
clusters = [7, 15, 23, 31, 45]
for k in clusters:
    print(f"k= {k}")
    labels = load_kmeans_labels(k=k, fname="one-hot_encoded_kmeans")
    labels = labels.to_numpy().reshape(-1)
    new_labels = max_matching_hungarian(labels, le_y_train_10_percent)
    prec, recall, f1 = precision_recall_f1_weighted(le_y_train_10_percent, new_labels)
    precision_one_hot_encoded_kmean_train.append(prec)
    recall_one_hot_encoded_kmean_train.append(recall)
    f1_one_hot_encoded_kmean_train.append(f1)
    con_entr = conditional_entropy(le_y_train_10_percent, new_labels)
    con_entr_one_hot_encoded_kmean_train.append(con_entr)
    print(f"Conditional entropy: {con_entr}")
```

```
k= 7
Loading: labels_9_7_one-hot_encoded_kmeans.csv
Accuracy: 0.5686074073774192
Weighted:
Precision: 0.5059549714702325
Recall: 0.5686074073774191
F1 score: 0.4124629551498325
Conditional entropy: 1.555616299708753
k= 15
Loading: labels_11_15_one-hot_encoded_kmeans.csv
Accuracy: 0.5909505871207904
Weighted:
Precision: 0.5361831284498593
Recall: 0.5909505871207904
F1 score: 0.4561441952183603
Conditional entropy: 1.4677963604890603
k= 23
Loading: labels_11_23_one-hot_encoded_kmeans.csv
Accuracy: 0.6175607919501398
Weighted:
Precision: 0.5514688631684094
Recall: 0.6175607919501397
F1 score: 0.5095895101013227
Conditional entropy: 1.3370603934626917
k= 31
Loading: labels_11_31_one-hot_encoded_kmeans.csv
Accuracy: 0.828845332485866
Weighted:
Precision: 0.8891547705865438
Recall: 0.828845332485866
F1 score: 0.7976041471956613
Conditional entropy: 0.5373994436677895
k= 45
Loading: labels_11_45_one-hot_encoded_kmeans.csv
Accuracy: 0.8297967090467814
Weighted:
Precision: 0.9016778000150121
Recall: 0.8297967090467815
F1 score: 0.8066530758068461
Conditional entropy: 0.49335297410466317
```

In [ ]:
```
plot_conditional_entropy_precision_recall_f1(
    con_entr_one_hot_encoded_kmean_train,
    precision_one_hot_encoded_kmean_train,
    recall_one_hot_encoded_kmean_train,
    f1_one_hot_encoded_kmean_train,
    clusters,
    "kmeans one-hot encoded",
)
```



Purity matching

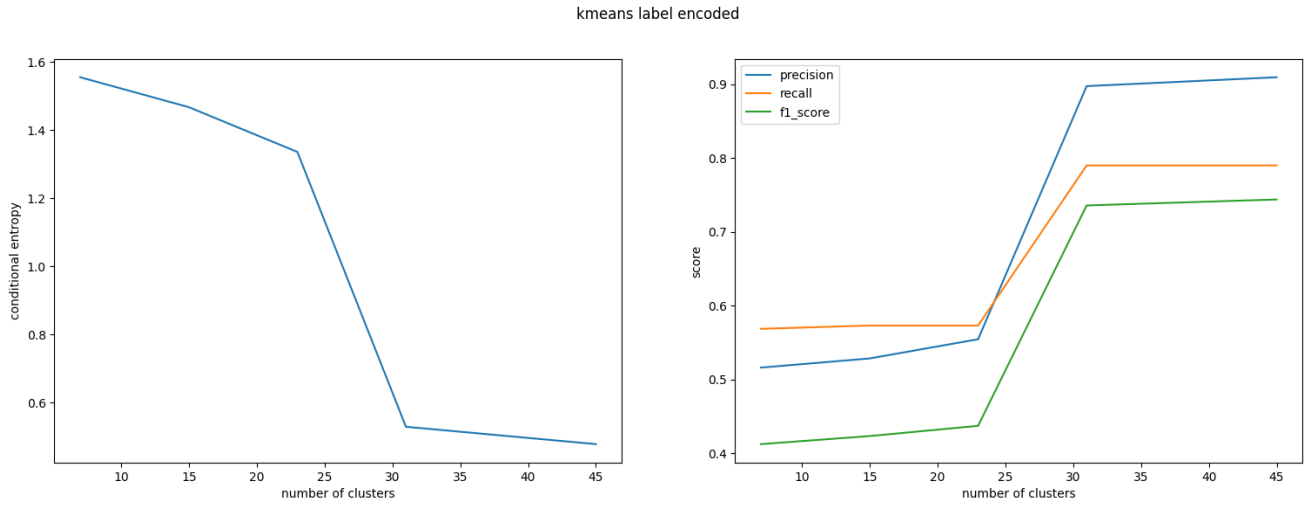
label encoded

In [ ]:
```
precision_label_encoded_kmean_train = []
recall_label_encoded_kmean_train = []
f1_label_encoded_kmean_train = []
con_entr_label_encoded_kmean_train = []
```

In [ ]:
```
clusters = [7, 15, 23, 31, 45]
for k in clusters:
    print(f"k= {k}")
    labels = load_kmeans_labels(k=k, fname="label_encoded_kmeans")
    labels = labels.to_numpy().reshape(-1)
    new_labels = purity_matching(le_y_train_10_percent, labels)
    prec, recall, f1 = precision_recall_f1_weighted(le_y_train_10_percent, new_labels)
    precision_label_encoded_kmean_train.append(prec)
    recall_label_encoded_kmean_train.append(recall)
    f1_label_encoded_kmean_train.append(f1)
    con_entr = conditional_entropy(le_y_train_10_percent, new_labels)
    con_entr_label_encoded_kmean_train.append(con_entr)
    print(f"Conditional entropy: {con_entr}")
```

```
k= 7
Loading: labels_9_7_label_encoded_kmeans.csv
Accuracy: 0.5685790685011366
Weighted:
Precision: 0.5160682902572175
Recall: 0.5685790685011365
F1 score: 0.41239936092439017
Conditional entropy: 1.555616299708753
k= 15
Loading: labels_11_15_label_encoded_kmeans.csv
Accuracy: 0.5730221994611565
Weighted:
Precision: 0.5284208184267467
Recall: 0.5730221994611564
F1 score: 0.42328718311489655
Conditional entropy: 1.4677963604890603
k= 23
Loading: labels_11_23_label_encoded_kmeans.csv
Accuracy: 0.5729918363794252
Weighted:
Precision: 0.5544586055706119
Recall: 0.5729918363794251
F1 score: 0.43716685746181705
Conditional entropy: 1.3363884292614905
k= 31
Loading: labels_11_31_label_encoded_kmeans.csv
Accuracy: 0.7899360553498738
Weighted:
Precision: 0.8973673323059633
Recall: 0.7899360553498738
F1 score: 0.7357341141522582
Conditional entropy: 0.5294019358718293
k= 45
Loading: labels_11_45_label_encoded_kmeans.csv
Accuracy: 0.7899320069389762
Weighted:
Precision: 0.9093927020462017
Recall: 0.7899320069389764
F1 score: 0.7437991273308314
Conditional entropy: 0.47846104082825064
```

In [ ]:
```
plot_conditional_entropy_precision_recall_f1(
    con_entr_label_encoded_kmean_train,
    precision_label_encoded_kmean_train,
    recall_label_encoded_kmean_train,
    f1_label_encoded_kmean_train,
    clusters,
    "kmeans label encoded",
)
```



one-hot encoded

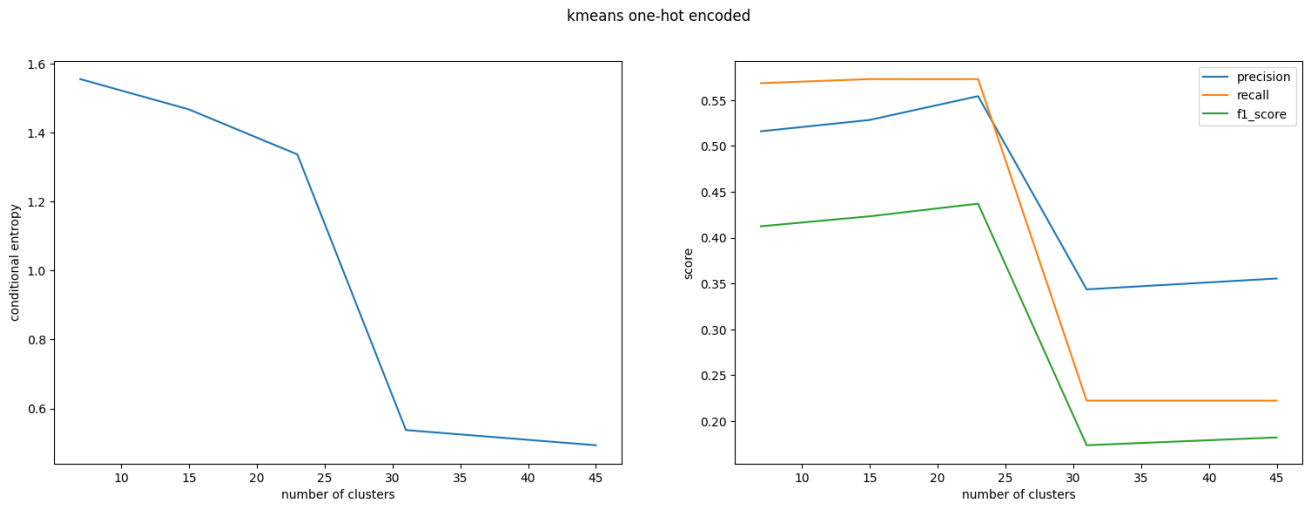
In [ ]:
```
precision_one_hot_encoded_kmean_train = []
recall_one_hot_encoded_kmean_train = []
f1_one_hot_encoded_kmean_train = []
con_entr_one_hot_encoded_kmean_train = []
```

In [ ]:
```
clusters = [7, 15, 23, 31, 45]
for k in clusters:
    print(f"k= {k}")
    labels = load_kmeans_labels(k=k, fname="one-hot_encoded_kmeans")
    labels = labels.to_numpy().reshape(-1)
```

```
    new_labels = purity_matching(le_y_train_10_percent, labels)
    prec, recall, f1 = precision_recall_f1_weighted(le_y_train_10_percent, new_labels)
    precision_one_hot_encoded_kmean_train.append(prec)
    recall_one_hot_encoded_kmean_train.append(recall)
    f1_one_hot_encoded_kmean_train.append(f1)
    con_entr = conditional_entropy(le_y_train_10_percent, new_labels)
    con_entr_one_hot_encoded_kmean_train.append(con_entr)
    print(f"Conditional entropy: {con_entr}")
```

```
k= 7
Loading: labels_9_7_one-hot_encoded_kmeans.csv
Accuracy: 0.5685790685011366
Weighted:
Precision: 0.5160682902572175
Recall: 0.5685790685011365
F1 score: 0.41239936092439017
Conditional entropy: 1.555616299708753
k= 15
Loading: labels_11_15_one-hot_encoded_kmeans.csv
Accuracy: 0.5730221994611565
Weighted:
Precision: 0.5284208184267467
Recall: 0.5730221994611564
F1 score: 0.42328718311489655
Conditional entropy: 1.4677963604890603
k= 23
Loading: labels_11_23_one-hot_encoded_kmeans.csv
Accuracy: 0.5729938605848739
Weighted:
Precision: 0.5543930698412595
Recall: 0.5729938605848739
F1 score: 0.4371092179436616
Conditional entropy: 1.3370603934626917
k= 31
Loading: labels_11_31_one-hot_encoded_kmeans.csv
Accuracy: 0.2221342817410596
Weighted:
Precision: 0.34357635038690015
Recall: 0.22213428174105962
F1 score: 0.17347837751031353
Conditional entropy: 0.5373994436677894
k= 45
Loading: labels_11_45_one-hot_encoded_kmeans.csv
Accuracy: 0.2221201123029183
Weighted:
Precision: 0.3554060849167459
Recall: 0.22212011230291834
F1 score: 0.18201710789676623
Conditional entropy: 0.4933529741046632
```

In [ ]:
```
plot_conditional_entropy_precision_recall_f1(
    con_entr_one_hot_encoded_kmean_train,
    precision_one_hot_encoded_kmean_train,
    recall_one_hot_encoded_kmean_train,
    f1_one_hot_encoded_kmean_train,
    clusters,
    "kmeans one-hot encoded",
)
```



Comment

The difference between using label and one-hot encoding is trivial and they appear to produce approximately the same results.

Test data: Maximum matching yields better F1-score results than purity with a maximum of 0.723 for Maximum matching vs Purity matching's 0.654 for the testing data.

Training data: Maximum matching yields better F1-score results than purity with a maximum of 0.811 for Maximum matching vs Purity matching's 0.744 for the training data.

After a certain point, precision has the highest value of all the scores.

Conditional entropy is slightly improved by the use of label encoding for both training and testing data.

Training data evaluation shows overall better results, this may be due to the additional classes present in the testing data.

Spectral Clustering

Maximum matching

label encoded

additive chi2

In [ ]:
```
clusters = [len(np.unique(le_y_train025)), 23]
for k in clusters:
    print(f"k= {k}")
    labels = load_kmeans_labels(
        k=k, fname="label_encoded_spectral_clustering_additive_chi2_1.0"
    )
    labels = labels.to_numpy().reshape(-1)
    new_labels = max_matching_hungarian(labels, le_y_train025)
    precision_recall_f1_weighted(le_y_train025, new_labels)
    con_entr = conditional_entropy(le_y_train025, new_labels)
    print(f"Conditional entropy: {con_entr}")
```

```
k= 15
Loading: labels_21_15_label_encoded_spectral_clustering_additive_chi2_1.0.csv
Accuracy: 0.5491497975708503
Weighted:
Precision: 0.8767381352860629
Recall: 0.5491497975708503
F1 score: 0.6374081941031435
Conditional entropy: 0.5820853743177853
k= 23
Loading: labels_21_23_label_encoded_spectral_clustering_additive_chi2_1.0.csv
Accuracy: 0.5363562753036437
Weighted:
Precision: 0.9235809009260006
Recall: 0.5363562753036437
F1 score: 0.6226551210552266
Conditional entropy: 0.42263953236723323
```

chi2 (gamma=1.0)

In [ ]:
```
clusters = [len(np.unique(le_y_train025)), 23]
for k in clusters:
    print(f"k= {k}")
    labels = load_kmeans_labels(k=k, fname="label_encoded_spectral_clustering_chi2_1.0")
    labels = labels.to_numpy().reshape(-1)
    new_labels = max_matching_hungarian(labels, le_y_train025)
    precision_recall_f1_weighted(le_y_train025, new_labels)
    con_entr = conditional_entropy(le_y_train025, new_labels)
    print(f"Conditional entropy: {con_entr}")
```

```
k= 15
Loading: labels_21_15_label_encoded_spectral_clustering_chi2_1.0.csv
Accuracy: 0.3848582995951417
Weighted:
Precision: 0.8315248030996434
Recall: 0.38485829959514173
F1 score: 0.3791162386375192
Conditional entropy: 0.9470902498506792
k= 23
Loading: labels_21_23_label_encoded_spectral_clustering_chi2_1.0.csv
Accuracy: 0.374331983805668
Weighted:
Precision: 0.8362056773414028
Recall: 0.37433198380566807
F1 score: 0.3672055851886507
Conditional entropy: 0.9093129020744071
```

cosine similarity

In [ ]:
```
clusters = [len(np.unique(le_y_train025)), 23]
for k in clusters:
    print(f"k= {k}")
    labels = load_kmeans_labels(
        k=k, fname="label_encoded_spectral_clustering_cosine_similarity_1.0"
    )
    labels = labels.to_numpy().reshape(-1)
    new_labels = max_matching_hungarian(labels, le_y_train025)
    precision_recall_f1_weighted(le_y_train025, new_labels)
    con_entr = conditional_entropy(le_y_train025, new_labels)
    print(f"Conditional entropy: {con_entr}")
```

```
k= 15
Loading: labels_10_15_label_encoded_spectral_clustering_cosine_similarity_1.0.csv
Accuracy: 0.6248582995951417
Weighted:
Precision: 0.9711622706447117
Recall: 0.6248582995951416
F1 score: 0.7349806696003095
Conditional entropy: 0.1380135935608835
k= 23
Loading: labels_12_23_label_encoded_spectral_clustering_cosine_similarity_1.0.csv
Accuracy: 0.39619433198380566
Weighted:
Precision: 0.9737565019705356
Recall: 0.39619433198380566
F1 score: 0.5522230317554143
Conditional entropy: 0.12324804827245744
```

laplacian (gamma=1.0)

In [ ]:
```
clusters = [len(np.unique(le_y_train025)), 23]
for k in clusters:
    print(f"k= {k}")
    labels = load_kmeans_labels(
        k=k, fname="label_encoded_spectral_clustering_laplacian_1.0"
    )
    labels = labels.to_numpy().reshape(-1)
    new_labels = max_matching_hungarian(labels, le_y_train025)
    precision_recall_f1_weighted(le_y_train025, new_labels)
    con_entr = conditional_entropy(le_y_train025, new_labels)
    print(f"Conditional entropy: {con_entr}")
```

```
k= 15
Loading: labels_21_15_label_encoded_spectral_clustering_laplacian_1.0.csv
Accuracy: 0.27076923076923076
Weighted:
Precision: 0.7405166081551856
Recall: 0.2707692307692308
F1 score: 0.28942773003534544
Conditional entropy: 1.0246564104232805
k= 23
Loading: labels_21_23_label_encoded_spectral_clustering_laplacian_1.0.csv
Accuracy: 0.20461538461538462
Weighted:
Precision: 0.3997138576911516
Recall: 0.20461538461538462
F1 score: 0.2680531384387752
Conditional entropy: 0.8885444356751017
```

linear

In [ ]:
```
clusters = [len(np.unique(le_y_train025)), 23]
for k in clusters:
    print(f"k= {k}")
    labels = load_kmeans_labels(
        k=k, fname="label_encoded_spectral_clustering_linear_1.0"
    )
    labels = labels.to_numpy().reshape(-1)
    new_labels = max_matching_hungarian(labels, le_y_train025)
    precision_recall_f1_weighted(le_y_train025, new_labels)
    con_entr = conditional_entropy(le_y_train025, new_labels)
    print(f"Conditional entropy: {con_entr}")
```

```
k= 15
Loading: labels_21_15_label_encoded_spectral_clustering_linear_1.0.csv
Accuracy: 0.6064777327935222
Weighted:
Precision: 0.9747396517969084
Recall: 0.6064777327935224
F1 score: 0.7046024623279346
Conditional entropy: 0.17849702652699273
k= 23
Loading: labels_20_23_label_encoded_spectral_clustering_linear_1.0.csv
Accuracy: 0.5807287449392713
Weighted:
Precision: 0.9816040958772438
Recall: 0.5807287449392712
F1 score: 0.6760960461018586
Conditional entropy: 0.15520461218506706
```

poly (gamma=1.0 / n_features)

In [ ]:
```python
n_features = le_X_train025.shape[1]
clusters = [len(np.unique(le_y_train025)), 23]
for k in clusters:
    print(f"k= {k}")
    labels = load_kmeans_labels(
        k=k, fname=f"label_encoded_spectral_clustering_poly_{1.0 / n_features}"
    )
    labels = labels.to_numpy().reshape(-1)
    new_labels = max_matching_hungarian(labels, le_y_train025)
    precision_recall_f1_weighted(le_y_train025, new_labels)
    con_entr = conditional_entropy(le_y_train025, new_labels)
    print(f"Conditional entropy: {con_entr}")
```

```
k= 15
Loading: labels_15_15_label_encoded_spectral_clustering_poly_0.024390243902439025.csv
Accuracy: 0.6527125506072875
Weighted:
Precision: 0.9832610543549498
Recall: 0.6527125506072875
F1 score: 0.7276710376353052
Conditional entropy: 0.20629991090827574
k= 23
Loading: labels_16_23_label_encoded_spectral_clustering_poly_0.024390243902439025.csv
Accuracy: 0.574412955465587
Weighted:
Precision: 0.9844401551937698
Recall: 0.574412955465587
F1 score: 0.6756018386715089
Conditional entropy: 0.13889966082365454
```

poly (gamma=0.1)

In [ ]:
```python
clusters = [len(np.unique(le_y_train025)), 23]
for k in clusters:
    print(f"k= {k}")
    labels = load_kmeans_labels(
        k=k, fname=f"label_encoded_spectral_clustering_poly_0.1"
    )
    labels = labels.to_numpy().reshape(-1)
    new_labels = max_matching_hungarian(labels, le_y_train025)
    precision_recall_f1_weighted(le_y_train025, new_labels)
    con_entr = conditional_entropy(le_y_train025, new_labels)
    print(f"Conditional entropy: {con_entr}")
```

```
k= 15
Loading: labels_10_15_label_encoded_spectral_clustering_poly_0.1.csv
Accuracy: 0.6496356275303644
Weighted:
Precision: 0.9828892962172853
Recall: 0.6496356275303643
F1 score: 0.7250533180307432
Conditional entropy: 0.13504145816994298
k= 23
Loading: labels_21_23_label_encoded_spectral_clustering_poly_0.1.csv
Accuracy: 0.6185425101214574
Weighted:
Precision: 0.9824505231787914
Recall: 0.6185425101214574
F1 score: 0.6853349952123226
Conditional entropy: 0.12787814358439453
```

poly (gamma=0.15)

In [ ]:
```python
clusters = [len(np.unique(le_y_train025)), 23]
for k in clusters:
    print(f"k= {k}")
```

```
    labels = load_kmeans_labels(
        k=k, fname=f"label_encoded_spectral_clustering_poly_0.15"
    )
    labels = labels.to_numpy().reshape(-1)
    new_labels = max_matching_hungarian(labels, le_y_train025)
    precision_recall_f1_weighted(le_y_train025, new_labels)
    con_entr = conditional_entropy(le_y_train025, new_labels)
    print(f"Conditional entropy: {con_entr}")
```

```
k= 15
Loading: labels_8_15_label_encoded_spectral_clustering_poly_0.15.csv
Accuracy: 0.6498785425101214
Weighted:
Precision: 0.9836365902102305
Recall: 0.6498785425101216
F1 score: 0.7237627886802386
Conditional entropy: 0.1306486016007698
k= 23
Loading: labels_21_23_label_encoded_spectral_clustering_poly_0.15.csv
Accuracy: 0.6364372469635627
Weighted:
Precision: 0.9831107518567752
Recall: 0.6364372469635626
F1 score: 0.7061668745871591
Conditional entropy: 0.12146353446596238
```

rbf (gamma=1.0)

In [ ]:
```
clusters = [len(np.unique(le_y_train025)), 23]
for k in clusters:
    print(f"k= {k}")
    labels = load_kmeans_labels(
        k=k, fname="label_encoded_spectral_clustering_rbf_1.0"
    )
    labels = labels.to_numpy().reshape(-1)
    new_labels = max_matching_hungarian(labels, le_y_train025)
    precision_recall_f1_weighted(le_y_train025, new_labels)
    con_entr = conditional_entropy(le_y_train025, new_labels)
    print(f"Conditional entropy: {con_entr}")
```

```
k= 15
Loading: labels_21_15_label_encoded_spectral_clustering_rbf_1.0.csv
Accuracy: 0.30955465587044534
Weighted:
Precision: 0.7457384287870625
Recall: 0.3095546558704454
F1 score: 0.31645830386869933
Conditional entropy: 0.8955250817897876
k= 23
Loading: labels_21_23_label_encoded_spectral_clustering_rbf_1.0.csv
Accuracy: 0.29724696356275304
Weighted:
Precision: 0.7560056043560033
Recall: 0.2972469635627531
F1 score: 0.2963822076829016
Conditional entropy: 0.892133853382763
```

sigmoid (gamma=1.0)

In [ ]:
```
clusters = [len(np.unique(le_y_train025)), 23]
for k in clusters:
    print(f"k= {k}")
    labels = load_kmeans_labels(
        k=k, fname="label_encoded_spectral_clustering_sigmoid_1.0"
    )
    labels = labels.to_numpy().reshape(-1)
    new_labels = max_matching_hungarian(labels, le_y_train025)
    precision_recall_f1_weighted(le_y_train025, new_labels)
    con_entr = conditional_entropy(le_y_train025, new_labels)
    print(f"Conditional entropy: {con_entr}")
```

```
k= 15
Loading: labels_16_15_label_encoded_spectral_clustering_sigmoid_1.0.csv
Accuracy: 0.2625910931174089
Weighted:
Precision: 0.4140440493346744
Recall: 0.2625910931174089
F1 score: 0.31957192125738876
Conditional entropy: 1.546599244070808
k= 23
Loading: labels_21_23_label_encoded_spectral_clustering_sigmoid_1.0.csv
Accuracy: 0.1986234817813765
Weighted:
Precision: 0.4127001328453496
Recall: 0.19862348178137654
F1 score: 0.2605782173385421
Conditional entropy: 1.543728389893449
```

Comment

The best similarity matrix was cosine similarity, that had the best f1 score (weighted) of 0.73498, with one of the lowest conditional entropy values of 0.13801.

one-hot encoded

additive chi2

In [ ]:
```
clusters = [len(np.unique(le_y_train025)), 23]
for k in clusters:
    print(f"k= {k}")
    labels = load_kmeans_labels(
        k=k, fname="one-hot_encoded_spectral_clustering_additive_chi2_1.0"
    )
    labels = labels.to_numpy().reshape(-1)
    new_labels = max_matching_hungarian(labels, le_y_train025)
    precision_recall_f1_weighted(le_y_train025, new_labels)
    con_entr = conditional_entropy(le_y_train025, new_labels)
    print(f"Conditional entropy: {con_entr}")
```

```
k= 15
Loading: labels_17_15_one-hot_encoded_spectral_clustering_additive_chi2_1.0.csv
Accuracy: 0.5638056680161944
Weighted:
Precision: 0.8830318403660401
Recall: 0.5638056680161944
F1 score: 0.6478879133395228
Conditional entropy: 0.5253176595543924
k= 23
Loading: labels_21_23_one-hot_encoded_spectral_clustering_additive_chi2_1.0.csv
Accuracy: 0.5305263157894737
Weighted:
Precision: 0.9452439046760479
Recall: 0.5305263157894736
F1 score: 0.6160615000705733
Conditional entropy: 0.36003875947225567
```

chi2 (gamma=1.0)

In [ ]:
```
clusters = [len(np.unique(le_y_train025)), 23]
for k in clusters:
    print(f"k= {k}")
    labels = load_kmeans_labels(k=k, fname="one-hot_encoded_spectral_clustering_chi2_1.0")
    labels = labels.to_numpy().reshape(-1)
    new_labels = max_matching_hungarian(labels, le_y_train025)
    precision_recall_f1_weighted(le_y_train025, new_labels)
    con_entr = conditional_entropy(le_y_train025, new_labels)
    print(f"Conditional entropy: {con_entr}")
```

```
k= 15
Loading: labels_19_15_one-hot_encoded_spectral_clustering_chi2_1.0.csv
Accuracy: 0.37587044534412956
Weighted:
Precision: 0.8400786149751478
Recall: 0.3758704453441296
F1 score: 0.37982180033911583
Conditional entropy: 0.8769431602743892
k= 23
Loading: labels_21_23_one-hot_encoded_spectral_clustering_chi2_1.0.csv
Accuracy: 0.36898785425101216
Weighted:
Precision: 0.8517834070514931
Recall: 0.36898785425101216
F1 score: 0.37208892282752715
Conditional entropy: 0.8315063932810333
```

cosine similarity

In [ ]:
```
clusters = [len(np.unique(le_y_train025)), 23]
for k in clusters:
    print(f"k= {k}")
    labels = load_kmeans_labels(
        k=k, fname="one-hot_encoded_spectral_clustering_cosine_similarity_1.0"
    )
    labels = labels.to_numpy().reshape(-1)
    new_labels = max_matching_hungarian(labels, le_y_train025)
    precision_recall_f1_weighted(le_y_train025, new_labels)
    con_entr = conditional_entropy(le_y_train025, new_labels)
    print(f"Conditional entropy: {con_entr}")
```

```
k= 15
Loading: labels_13_15_one-hot_encoded_spectral_clustering_cosine_similarity_1.0.csv
Accuracy: 0.44445344129554654
Weighted:
Precision: 0.9593494500297154
Recall: 0.4444534412955466
F1 score: 0.5990315782412331
Conditional entropy: 0.16599022533969648
k= 23
Loading: labels_17_23_one-hot_encoded_spectral_clustering_cosine_similarity_1.0.csv
Accuracy: 0.3654251012145749
Weighted:
Precision: 0.9593935519163186
Recall: 0.365425101214575
F1 score: 0.5155449619296383
Conditional entropy: 0.1639923786144153
```

laplacian (gamma=1.0)

In [ ]:
```
clusters = [len(np.unique(le_y_train025)), 23]
for k in clusters:
    print(f"k= {k}")
    labels = load_kmeans_labels(
        k=k, fname="one-hot_encoded_spectral_clustering_laplacian_1.0"
    )
    labels = labels.to_numpy().reshape(-1)
    new_labels = max_matching_hungarian(labels, le_y_train025)
    precision_recall_f1_weighted(le_y_train025, new_labels)
    con_entr = conditional_entropy(le_y_train025, new_labels)
    print(f"Conditional entropy: {con_entr}")
```

```
k= 15
Loading: labels_21_15_one-hot_encoded_spectral_clustering_laplacian_1.0.csv
Accuracy: 0.1419433198380567
Weighted:
Precision: 0.6106299421287622
Recall: 0.1419433198380567
F1 score: 0.21948172080180317
Conditional entropy: 1.3372063045871108
k= 23
Loading: labels_21_23_one-hot_encoded_spectral_clustering_laplacian_1.0.csv
Accuracy: 0.34307692307692306
Weighted:
Precision: 0.810393175227923
Recall: 0.3430769230769231
F1 score: 0.347203854929599
Conditional entropy: 0.7508464852080923
```

linear

In [ ]:
```
clusters = [len(np.unique(le_y_train025)), 23]
for k in clusters:
    print(f"k= {k}")
    labels = load_kmeans_labels(
        k=k, fname="one-hot_encoded_spectral_clustering_linear_1.0"
    )
    labels = labels.to_numpy().reshape(-1)
    new_labels = max_matching_hungarian(labels, le_y_train025)
    precision_recall_f1_weighted(le_y_train025, new_labels)
    con_entr = conditional_entropy(le_y_train025, new_labels)
    print(f"Conditional entropy: {con_entr}")
```

```
k= 15
Loading: labels_14_15_one-hot_encoded_spectral_clustering_linear_1.0.csv
Accuracy: 0.5765182186234817
Weighted:
Precision: 0.9555319851246479
Recall: 0.5765182186234817
F1 score: 0.6814423980675436
Conditional entropy: 0.1785731850938518
k= 23
Loading: labels_21_23_one-hot_encoded_spectral_clustering_linear_1.0.csv
Accuracy: 0.36145748987854254
Weighted:
Precision: 0.952682065184693
Recall: 0.36145748987854254
F1 score: 0.5064818771645001
Conditional entropy: 0.1325883166649188
```

poly (gamma=1.0 / n_features)

In [ ]:
```
n_features = oe_X_train025.shape[1]
clusters = [len(np.unique(le_y_train025)), 23]
for k in clusters:
    print(f"k= {k}")
    labels = load_kmeans_labels(
        k=k, fname=f"one-hot_encoded_spectral_clustering_poly_{1.0 / n_features}"
    )
    labels = labels.to_numpy().reshape(-1)
    new_labels = max_matching_hungarian(labels, le_y_train025)
    precision_recall_f1_weighted(le_y_train025, new_labels)
    con_entr = conditional_entropy(le_y_train025, new_labels)
    print(f"Conditional entropy: {con_entr}")
```

```
k= 15
Loading: labels_21_15_one-hot_encoded_spectral_clustering_poly_0.008403361344537815.csv
Accuracy: 0.628421052631579
Weighted:
Precision: 0.9816596213220036
Recall: 0.628421052631579
F1 score: 0.6983642022329283
Conditional entropy: 0.13784581409333485
k= 23
Loading: labels_14_23_one-hot_encoded_spectral_clustering_poly_0.008403361344537815.csv
Accuracy: 0.6152226720647773
Weighted:
Precision: 0.9693587683052114
Recall: 0.6152226720647772
F1 score: 0.6835397553446224
Conditional entropy: 0.12834203346052694
```

poly (gamma=0.1)

In [ ]:
```
clusters = [len(np.unique(le_y_train025)), 23]
for k in clusters:
    print(f"k= {k}")
    labels = load_kmeans_labels(
        k=k, fname=f"one-hot_encoded_spectral_clustering_poly_0.1"
    )
    labels = labels.to_numpy().reshape(-1)
    new_labels = max_matching_hungarian(labels, le_y_train025)
    precision_recall_f1_weighted(le_y_train025, new_labels)
    con_entr = conditional_entropy(le_y_train025, new_labels)
    print(f"Conditional entropy: {con_entr}")
```

```
k= 15
Loading: labels_11_15_one-hot_encoded_spectral_clustering_poly_0.1.csv
Accuracy: 0.6391902834008097
Weighted:
Precision: 0.9825841466034744
Recall: 0.6391902834008096
F1 score: 0.7106517493372888
Conditional entropy: 0.1986373163728129
k= 23
Loading: labels_21_23_one-hot_encoded_spectral_clustering_poly_0.1.csv
Accuracy: 0.6247773279352227
Weighted:
Precision: 0.9837100948954508
Recall: 0.6247773279352227
F1 score: 0.6937376317753637
Conditional entropy: 0.11999720945584741
```

poly (gamma=0.15)

In [ ]:
```
clusters = [len(np.unique(le_y_train025)), 23]
for k in clusters:
    print(f"k= {k}")
```

```
    labels = load_kmeans_labels(
        k=k, fname=f"one-hot_encoded_spectral_clustering_poly_0.15"
    )
    labels = labels.to_numpy().reshape(-1)
    new_labels = max_matching_hungarian(labels, le_y_train025)
    precision_recall_f1_weighted(le_y_train025, new_labels)
    con_entr = conditional_entropy(le_y_train025, new_labels)
    print(f"Conditional entropy: {con_entr}")
```

```
k= 15
Loading: labels_21_15_one-hot_encoded_spectral_clustering_poly_0.15.csv
Accuracy: 0.6452631578947369
Weighted:
Precision: 0.9803960051409684
Recall: 0.6452631578947369
F1 score: 0.7185462722872592
Conditional entropy: 0.13585147538729814
k= 23
Loading: labels_17_23_one-hot_encoded_spectral_clustering_poly_0.15.csv
Accuracy: 0.6162753036437247
Weighted:
Precision: 0.9844234427652382
Recall: 0.6162753036437246
F1 score: 0.681712892089806
Conditional entropy: 0.1106168751926946
```

rbf (gamma=1.0)

In [ ]:
```
clusters = [len(np.unique(le_y_train025)), 23]
for k in clusters:
    print(f"k= {k}")
    labels = load_kmeans_labels(
        k=k, fname="one-hot_encoded_spectral_clustering_rbf_1.0"
    )
    labels = labels.to_numpy().reshape(-1)
    new_labels = max_matching_hungarian(labels, le_y_train025)
    precision_recall_f1_weighted(le_y_train025, new_labels)
    con_entr = conditional_entropy(le_y_train025, new_labels)
    print(f"Conditional entropy: {con_entr}")
```

```
k= 15
Loading: labels_21_15_one-hot_encoded_spectral_clustering_rbf_1.0.csv
Accuracy: 0.33757085020242916
Weighted:
Precision: 0.7874629354998931
Recall: 0.3375708502024292
F1 score: 0.33667316803296027
Conditional entropy: 0.942106738140963
k= 23
Loading: labels_21_23_one-hot_encoded_spectral_clustering_rbf_1.0.csv
Accuracy: 0.2623481781376518
Weighted:
Precision: 0.6224187419854702
Recall: 0.2623481781376519
F1 score: 0.36251487395719073
Conditional entropy: 0.79320641322648
```

sigmoid (gamma=1.0)

In [ ]:
```
clusters = [len(np.unique(le_y_train025)), 23]
for k in clusters:
    print(f"k= {k}")
    labels = load_kmeans_labels(
        k=k, fname="one-hot_encoded_spectral_clustering_sigmoid_1.0"
    )
    labels = labels.to_numpy().reshape(-1)
    new_labels = max_matching_hungarian(labels, le_y_train025)
    precision_recall_f1_weighted(le_y_train025, new_labels)
    con_entr = conditional_entropy(le_y_train025, new_labels)
    print(f"Conditional entropy: {con_entr}")
```

```
k= 15
Loading: labels_16_15_one-hot_encoded_spectral_clustering_sigmoid_1.0.csv
Accuracy: 0.2625910931174089
Weighted:
Precision: 0.4140440493346744
Recall: 0.2625910931174089
F1 score: 0.31957192125738876
Conditional entropy: 1.546599244070808
k= 23
Loading: labels_21_23_one-hot_encoded_spectral_clustering_sigmoid_1.0.csv
Accuracy: 0.1986234817813765
Weighted:
Precision: 0.4127001328453496
Recall: 0.19862348178137654
F1 score: 0.2605782173385421
Conditional entropy: 1.543728389893449
```

Comment

The best similarity matrix was polynomial kernel (gamma=0.15), that had the best f1 score (weighted) of 0.71855, with the lowest conditional entropy of 0.13585.

Purity matching

label encoded

additive chi2

In [ ]:
```
clusters = [len(np.unique(le_y_train025)), 23]
for k in clusters:
    print(f"k= {k}")
    labels = load_kmeans_labels(
        k=k, fname="label_encoded_spectral_clustering_additive_chi2_1.0"
    )
    labels = labels.to_numpy().reshape(-1)
    new_labels = purity_matching(le_y_train025, labels)
    precision_recall_f1_weighted(le_y_train025, new_labels)
    con_entr = conditional_entropy(le_y_train025, new_labels)
    print(f"Conditional entropy: {con_entr}")
```

```
k= 15
Loading: labels_21_15_label_encoded_spectral_clustering_additive_chi2_1.0.csv
Accuracy: 0.1282591093117409
Weighted:
Precision: 0.8533002852519829
Recall: 0.12825910931174087
F1 score: 0.21272908943506372
Conditional entropy: 0.5820853743177854
k= 23
Loading: labels_21_23_label_encoded_spectral_clustering_additive_chi2_1.0.csv
Accuracy: 0.5022672064777328
Weighted:
Precision: 0.7611253663536747
Recall: 0.5022672064777329
F1 score: 0.5728425221543895
Conditional entropy: 0.4226395323672331
```

chi2 (gamma=1.0)

In [ ]:
```
clusters = [len(np.unique(le_y_train025)), 23]
for k in clusters:
    print(f"k= {k}")
    labels = load_kmeans_labels(k=k, fname="label_encoded_spectral_clustering_chi2_1.0")
    labels = labels.to_numpy().reshape(-1)
    new_labels = purity_matching(le_y_train025, labels)
    precision_recall_f1_weighted(le_y_train025, new_labels)
    con_entr = conditional_entropy(le_y_train025, new_labels)
    print(f"Conditional entropy: {con_entr}")
```

```
k= 15
Loading: labels_21_15_label_encoded_spectral_clustering_chi2_1.0.csv
Accuracy: 0.2540890688259109
Weighted:
Precision: 0.693204097307214
Recall: 0.254089068825911
F1 score: 0.2106742493651458
Conditional entropy: 0.947090249850679
k= 23
Loading: labels_21_23_label_encoded_spectral_clustering_chi2_1.0.csv
Accuracy: 0.23668016194331984
Weighted:
Precision: 0.711644471665132
Recall: 0.23668016194331984
F1 score: 0.18203470552254825
Conditional entropy: 0.9093129020744072
```

cosine similarity

In [ ]:
```
clusters = [len(np.unique(le_y_train025)), 23]
for k in clusters:
    print(f"k= {k}")
    labels = load_kmeans_labels(
        k=k, fname="label_encoded_spectral_clustering_cosine_similarity_1.0"
    )
    labels = labels.to_numpy().reshape(-1)
    new_labels = purity_matching(le_y_train025, labels)
    precision_recall_f1_weighted(le_y_train025, new_labels)
    con_entr = conditional_entropy(le_y_train025, new_labels)
    print(f"Conditional entropy: {con_entr}")
```

```
k= 15
Loading: labels_10_15_label_encoded_spectral_clustering_cosine_similarity_1.0.csv
Accuracy: 0.622753036437247
Weighted:
Precision: 0.9707729610762553
Recall: 0.622753036437247
F1 score: 0.7343336656338307
Conditional entropy: 0.13801359356088352
k= 23
Loading: labels_12_23_label_encoded_spectral_clustering_cosine_similarity_1.0.csv
Accuracy: 0.3751417004048583
Weighted:
Precision: 0.9817005429360948
Recall: 0.3751417004048583
F1 score: 0.5240778792632539
Conditional entropy: 0.12324804827245746
```

laplacian (gamma=1.0)

In [ ]:
```
clusters = [len(np.unique(le_y_train025)), 23]
for k in clusters:
    print(f"k= {k}")
    labels = load_kmeans_labels(
        k=k, fname="label_encoded_spectral_clustering_laplacian_1.0"
    )
    labels = labels.to_numpy().reshape(-1)
    new_labels = purity_matching(le_y_train025, labels)
    precision_recall_f1_weighted(le_y_train025, new_labels)
    con_entr = conditional_entropy(le_y_train025, new_labels)
    print(f"Conditional entropy: {con_entr}")
```

```
k= 15
Loading: labels_21_15_label_encoded_spectral_clustering_laplacian_1.0.csv
Accuracy: 0.2699595141700405
Weighted:
Precision: 0.7413752204722548
Recall: 0.26995951417004055
F1 score: 0.2881982213017947
Conditional entropy: 1.0246564104232805
k= 23
Loading: labels_21_23_label_encoded_spectral_clustering_laplacian_1.0.csv
Accuracy: 0.11732793522267207
Weighted:
Precision: 0.7261391212037215
Recall: 0.1173279352226721
F1 score: 0.1633929102050621
Conditional entropy: 0.8885444356751018
```

linear

In [ ]:
```
clusters = [len(np.unique(le_y_train025)), 23]
for k in clusters:
    print(f"k= {k}")
    labels = load_kmeans_labels(
```

```
        k=k, fname="label_encoded_spectral_clustering_linear_1.0"
    )
    labels = labels.to_numpy().reshape(-1)
    new_labels = purity_matching(le_y_train025, labels)
    precision_recall_f1_weighted(le_y_train025, new_labels)
    con_entr = conditional_entropy(le_y_train025, new_labels)
    print(f"Conditional entropy: {con_entr}")
```

```
k= 15
Loading: labels_21_15_label_encoded_spectral_clustering_linear_1.0.csv
Accuracy: 0.5808097165991902
Weighted:
Precision: 0.9766996716693849
Recall: 0.5808097165991903
F1 score: 0.6805509248865148
Conditional entropy: 0.17849702652699273
k= 23
Loading: labels_20_23_label_encoded_spectral_clustering_linear_1.0.csv
Accuracy: 0.5638866396761134
Weighted:
Precision: 0.8783012804158302
Recall: 0.5638866396761134
F1 score: 0.6511001335828434
Conditional entropy: 0.15520461218506706
```

poly (gamma=1.0 / n_features)

In [ ]:
```
n_features = le_X_train025.shape[1]
clusters = [len(np.unique(le_y_train025)), 23]
for k in clusters:
    print(f"k= {k}")
    labels = load_kmeans_labels(
        k=k, fname=f"label_encoded_spectral_clustering_poly_{1.0 / n_features}"
    )
    labels = labels.to_numpy().reshape(-1)
    new_labels = purity_matching(le_y_train025, labels)
    precision_recall_f1_weighted(le_y_train025, new_labels)
    con_entr = conditional_entropy(le_y_train025, new_labels)
    print(f"Conditional entropy: {con_entr}")
```

```
k= 15
Loading: labels_15_15_label_encoded_spectral_clustering_poly_0.024390243902439025.csv
Accuracy: 0.0951417004048583
Weighted:
Precision: 0.48602796679047655
Recall: 0.0951417004048583
F1 score: 0.15215366989286952
Conditional entropy: 0.20629991090827574
k= 23
Loading: labels_16_23_label_encoded_spectral_clustering_poly_0.024390243902439025.csv
Accuracy: 0.5102834008097166
Weighted:
Precision: 0.9829622018275518
Recall: 0.5102834008097166
F1 score: 0.5890421069436199
Conditional entropy: 0.1388996608236545
```

poly (gamma=0.1)

In [ ]:
```
clusters = [len(np.unique(le_y_train025)), 23]
for k in clusters:
    print(f"k= {k}")
    labels = load_kmeans_labels(
        k=k, fname=f"label_encoded_spectral_clustering_poly_0.1"
    )
    labels = labels.to_numpy().reshape(-1)
    new_labels = purity_matching(le_y_train025, labels)
    precision_recall_f1_weighted(le_y_train025, new_labels)
    con_entr = conditional_entropy(le_y_train025, new_labels)
    print(f"Conditional entropy: {con_entr}")
```

```
k= 15
Loading: labels_10_15_label_encoded_spectral_clustering_poly_0.1.csv
Accuracy: 0.5962753036437247
Weighted:
Precision: 0.9769361525675471
Recall: 0.5962753036437247
F1 score: 0.6508120568758267
Conditional entropy: 0.13504145816994298
k= 23
Loading: labels_21_23_label_encoded_spectral_clustering_poly_0.1.csv
Accuracy: 0.5979757085020243
Weighted:
Precision: 0.9833175860665935
Recall: 0.5979757085020242
F1 score: 0.6564551364417242
Conditional entropy: 0.12787814358439453
```

poly (gamma=0.15)

In [ ]:
```
clusters = [len(np.unique(le_y_train025)), 23]
for k in clusters:
    print(f"k= {k}")
    labels = load_kmeans_labels(
        k=k, fname=f"label_encoded_spectral_clustering_poly_0.15"
    )
    labels = labels.to_numpy().reshape(-1)
    new_labels = purity_matching(le_y_train025, labels)
    precision_recall_f1_weighted(le_y_train025, new_labels)
    con_entr = conditional_entropy(le_y_train025, new_labels)
    print(f"Conditional entropy: {con_entr}")
```

```
k= 15
Loading: labels_8_15_label_encoded_spectral_clustering_poly_0.15.csv
Accuracy: 0.5851821862348178
Weighted:
Precision: 0.8543875377280109
Recall: 0.5851821862348179
F1 score: 0.6342742859083861
Conditional entropy: 0.1306486016007698
k= 23
Loading: labels_21_23_label_encoded_spectral_clustering_poly_0.15.csv
Accuracy: 0.5840485829959514
Weighted:
Precision: 0.9826903974895195
Recall: 0.5840485829959513
F1 score: 0.6427407384983441
Conditional entropy: 0.12146353446596236
```

rbf (gamma=1.0)

In [ ]:
```
clusters = [len(np.unique(le_y_train025)), 23]
for k in clusters:
    print(f"k= {k}")
    labels = load_kmeans_labels(
        k=k, fname="label_encoded_spectral_clustering_rbf_1.0"
    )
    labels = labels.to_numpy().reshape(-1)
    new_labels = purity_matching(le_y_train025, labels)
    precision_recall_f1_weighted(le_y_train025, new_labels)
    con_entr = conditional_entropy(le_y_train025, new_labels)
    print(f"Conditional entropy: {con_entr}")
```

```
k= 15
Loading: labels_21_15_label_encoded_spectral_clustering_rbf_1.0.csv
Accuracy: 0.2867206477732793
Weighted:
Precision: 0.39481556585638056
Recall: 0.2867206477732794
F1 score: 0.30903475055522744
Conditional entropy: 0.8955250817897877
k= 23
Loading: labels_21_23_label_encoded_spectral_clustering_rbf_1.0.csv
Accuracy: 0.29578947368421055
Weighted:
Precision: 0.7361175022986304
Recall: 0.2957894736842106
F1 score: 0.293786408084183
Conditional entropy: 0.892133853382763
```

sigmoid (gamma=1.0)

In [ ]:
```
clusters = [len(np.unique(le_y_train025)), 23]
for k in clusters:
    print(f"k= {k}")
    labels = load_kmeans_labels(
```

```
        k=k, fname="label_encoded_spectral_clustering_sigmoid_1.0"
    )
    labels = labels.to_numpy().reshape(-1)
    new_labels = purity_matching(le_y_train025, labels)
    precision_recall_f1_weighted(le_y_train025, new_labels)
    con_entr = conditional_entropy(le_y_train025, new_labels)
    print(f"Conditional entropy: {con_entr}")
```

```
k= 15
Loading: labels_16_15_label_encoded_spectral_clustering_sigmoid_1.0.csv
Accuracy: 0.09578947368421052
Weighted:
Precision: 0.408077836550324
Recall: 0.09578947368421054
F1 score: 0.15132405807611082
Conditional entropy: 1.546599244070808
k= 23
Loading: labels_21_23_label_encoded_spectral_clustering_sigmoid_1.0.csv
Accuracy: 0.06979757085020243
Weighted:
Precision: 0.4061342059301873
Recall: 0.06979757085020245
F1 score: 0.11788547029849468
Conditional entropy: 1.543728389893449
```

Comment

The best similarity matrix was cosine similarity, that had the best f1 score (weighted) of 0.73433, with one of the lowest conditional entropy values of 0.13801.

one-hot encoded

additive chi2

In [ ]:
```
clusters = [len(np.unique(le_y_train025)), 23]
for k in clusters:
    print(f"k= {k}")
    labels = load_kmeans_labels(
        k=k, fname="one-hot_encoded_spectral_clustering_additive_chi2_1.0"
    )
    labels = labels.to_numpy().reshape(-1)
    new_labels = purity_matching(le_y_train025, labels)
    precision_recall_f1_weighted(le_y_train025, new_labels)
    con_entr = conditional_entropy(le_y_train025, new_labels)
    print(f"Conditional entropy: {con_entr}")
```

```
k= 15
Loading: labels_17_15_one-hot_encoded_spectral_clustering_additive_chi2_1.0.csv
Accuracy: 0.0782995951417004
Weighted:
Precision: 0.730876689884327
Recall: 0.07829959514170041
F1 score: 0.13333405602772716
Conditional entropy: 0.5253176595543924
k= 23
Loading: labels_21_23_one-hot_encoded_spectral_clustering_additive_chi2_1.0.csv
Accuracy: 0.06736842105263158
Weighted:
Precision: 0.6970812226419958
Recall: 0.06736842105263159
F1 score: 0.11780609149961424
Conditional entropy: 0.3600387594722557
```

chi2 (gamma=1.0)

In [ ]:
```
clusters = [len(np.unique(le_y_train025)), 23]
for k in clusters:
    print(f"k= {k}")
    labels = load_kmeans_labels(k=k, fname="one-hot_encoded_spectral_clustering_chi2_1.0")
    labels = labels.to_numpy().reshape(-1)
    new_labels = purity_matching(le_y_train025, labels)
    precision_recall_f1_weighted(le_y_train025, new_labels)
    con_entr = conditional_entropy(le_y_train025, new_labels)
    print(f"Conditional entropy: {con_entr}")
```

```
k= 15
Loading: labels_19_15_one-hot_encoded_spectral_clustering_chi2_1.0.csv
Accuracy: 0.277085020242915
Weighted:
Precision: 0.677237356059211
Recall: 0.277085020242915
F1 score: 0.2482546442022301
Conditional entropy: 0.8769431602743892
k= 23
Loading: labels_21_23_one-hot_encoded_spectral_clustering_chi2_1.0.csv
Accuracy: 0.3336842105263158
Weighted:
Precision: 0.8452159579322361
Recall: 0.33368421052631586
F1 score: 0.3100840555133353
Conditional entropy: 0.8315063932810333
```

cosine similarity

In [ ]:
```
clusters = [len(np.unique(le_y_train025)), 23]
for k in clusters:
    print(f"k= {k}")
    labels = load_kmeans_labels(
        k=k, fname="one-hot_encoded_spectral_clustering_cosine_similarity_1.0"
    )
    labels = labels.to_numpy().reshape(-1)
    new_labels = purity_matching(le_y_train025, labels)
    precision_recall_f1_weighted(le_y_train025, new_labels)
    con_entr = conditional_entropy(le_y_train025, new_labels)
    print(f"Conditional entropy: {con_entr}")
```

```
k= 15
Loading: labels_13_15_one-hot_encoded_spectral_clustering_cosine_similarity_1.0.csv
Accuracy: 0.36785425101214575
Weighted:
Precision: 0.7674589570711119
Recall: 0.36785425101214575
F1 score: 0.492352836501978
Conditional entropy: 0.16599022533969648
k= 23
Loading: labels_17_23_one-hot_encoded_spectral_clustering_cosine_similarity_1.0.csv
Accuracy: 0.3233198380566802
Weighted:
Precision: 0.9623729410352093
Recall: 0.32331983805668024
F1 score: 0.4549042046489629
Conditional entropy: 0.16399237861441526
```

laplacian (gamma=1.0)

In [ ]:
```
clusters = [len(np.unique(le_y_train025)), 23]
for k in clusters:
    print(f"k= {k}")
    labels = load_kmeans_labels(
        k=k, fname="one-hot_encoded_spectral_clustering_laplacian_1.0"
    )
    labels = labels.to_numpy().reshape(-1)
    new_labels = purity_matching(le_y_train025, labels)
    precision_recall_f1_weighted(le_y_train025, new_labels)
    con_entr = conditional_entropy(le_y_train025, new_labels)
    print(f"Conditional entropy: {con_entr}")
```

```
k= 15
Loading: labels_21_15_one-hot_encoded_spectral_clustering_laplacian_1.0.csv
Accuracy: 0.09182186234817814
Weighted:
Precision: 0.49068944222164873
Recall: 0.09182186234817813
F1 score: 0.14869097574357532
Conditional entropy: 1.3372063045871105
k= 23
Loading: labels_21_23_one-hot_encoded_spectral_clustering_laplacian_1.0.csv
Accuracy: 0.23838056680161943
Weighted:
Precision: 0.7275282739058148
Recall: 0.23838056680161943
F1 score: 0.22976696671050265
Conditional entropy: 0.7508464852080924
```

linear

In [ ]:
```
clusters = [len(np.unique(le_y_train025)), 23]
for k in clusters:
    print(f"k= {k}")
    labels = load_kmeans_labels(
```

```
        k=k, fname="one-hot_encoded_spectral_clustering_linear_1.0"
    )
    labels = labels.to_numpy().reshape(-1)
    new_labels = purity_matching(le_y_train025, labels)
    precision_recall_f1_weighted(le_y_train025, new_labels)
    con_entr = conditional_entropy(le_y_train025, new_labels)
    print(f"Conditional entropy: {con_entr}")
```

```
k= 15
Loading: labels_14_15_one-hot_encoded_spectral_clustering_linear_1.0.csv
Accuracy: 0.5089068825910931
Weighted:
Precision: 0.772908130587909
Recall: 0.5089068825910931
F1 score: 0.5828141773369007
Conditional entropy: 0.17857318509385184
k= 23
Loading: labels_21_23_one-hot_encoded_spectral_clustering_linear_1.0.csv
Accuracy: 0.3208906882591093
Weighted:
Precision: 0.9668322698796501
Recall: 0.3208906882591093
F1 score: 0.4517453980802243
Conditional entropy: 0.1325883166649188
```

poly (gamma=1.0 / n_features)

In [ ]:
```
n_features = oe_X_train025.shape[1]
clusters = [len(np.unique(le_y_train025)), 23]
for k in clusters:
    print(f"k= {k}")
    labels = load_kmeans_labels(
        k=k, fname=f"one-hot_encoded_spectral_clustering_poly_{1.0 / n_features}"
    )
    labels = labels.to_numpy().reshape(-1)
    new_labels = purity_matching(le_y_train025, labels)
    precision_recall_f1_weighted(le_y_train025, new_labels)
    con_entr = conditional_entropy(le_y_train025, new_labels)
    print(f"Conditional entropy: {con_entr}")
```

```
k= 15
Loading: labels_21_15_one-hot_encoded_spectral_clustering_poly_0.008403361344537815.csv
Accuracy: 0.6166801619433199
Weighted:
Precision: 0.9822824581874219
Recall: 0.6166801619433199
F1 score: 0.6882318059064889
Conditional entropy: 0.13784581409333485
k= 23
Loading: labels_14_23_one-hot_encoded_spectral_clustering_poly_0.008403361344537815.csv
Accuracy: 0.5831578947368421
Weighted:
Precision: 0.9603966722941455
Recall: 0.5831578947368421
F1 score: 0.6342843937131989
Conditional entropy: 0.12834203346052694
```

poly (gamma=0.1)

In [ ]:
```
clusters = [len(np.unique(le_y_train025)), 23]
for k in clusters:
    print(f"k= {k}")
    labels = load_kmeans_labels(
        k=k, fname=f"one-hot_encoded_spectral_clustering_poly_0.1"
    )
    labels = labels.to_numpy().reshape(-1)
    new_labels = purity_matching(le_y_train025, labels)
    precision_recall_f1_weighted(le_y_train025, new_labels)
    con_entr = conditional_entropy(le_y_train025, new_labels)
    print(f"Conditional entropy: {con_entr}")
```

```
k= 15
Loading: labels_11_15_one-hot_encoded_spectral_clustering_poly_0.1.csv
Accuracy: 0.5935222672064777
Weighted:
Precision: 0.8267851092216479
Recall: 0.5935222672064777
F1 score: 0.6411929801794537
Conditional entropy: 0.1986373163728129
k= 23
Loading: labels_21_23_one-hot_encoded_spectral_clustering_poly_0.1.csv
Accuracy: 0.6068016194331984
Weighted:
Precision: 0.9822185877612429
Recall: 0.6068016194331983
F1 score: 0.6741859571924104
Conditional entropy: 0.1199972094558474
```

poly (gamma=0.15)

In [ ]:
```
clusters = [len(np.unique(le_y_train025)), 23]
for k in clusters:
    print(f"k= {k}")
    labels = load_kmeans_labels(
        k=k, fname=f"one-hot_encoded_spectral_clustering_poly_0.15"
    )
    labels = labels.to_numpy().reshape(-1)
    new_labels = purity_matching(le_y_train025, labels)
    precision_recall_f1_weighted(le_y_train025, new_labels)
    con_entr = conditional_entropy(le_y_train025, new_labels)
    print(f"Conditional entropy: {con_entr}")
```

```
k= 15
Loading: labels_21_15_one-hot_encoded_spectral_clustering_poly_0.15.csv
Accuracy: 0.5754655870445344
Weighted:
Precision: 0.9029755807672595
Recall: 0.5754655870445344
F1 score: 0.6183479873072703
Conditional entropy: 0.1358514753872981
k= 23
Loading: labels_17_23_one-hot_encoded_spectral_clustering_poly_0.15.csv
Accuracy: 0.591174089068826
Weighted:
Precision: 0.9818673002998712
Recall: 0.5911740890688258
F1 score: 0.653894879849089
Conditional entropy: 0.11061687519269459
```

rbf (gamma=1.0)

In [ ]:
```
clusters = [len(np.unique(le_y_train025)), 23]
for k in clusters:
    print(f"k= {k}")
    labels = load_kmeans_labels(
        k=k, fname="one-hot_encoded_spectral_clustering_rbf_1.0"
    )
    labels = labels.to_numpy().reshape(-1)
    new_labels = purity_matching(le_y_train025, labels)
    precision_recall_f1_weighted(le_y_train025, new_labels)
    con_entr = conditional_entropy(le_y_train025, new_labels)
    print(f"Conditional entropy: {con_entr}")
```

```
k= 15
Loading: labels_21_15_one-hot_encoded_spectral_clustering_rbf_1.0.csv
Accuracy: 0.22534412955465588
Weighted:
Precision: 0.6109351512520851
Recall: 0.2253441295546559
F1 score: 0.20255961563747474
Conditional entropy: 0.9421067381409629
k= 23
Loading: labels_21_23_one-hot_encoded_spectral_clustering_rbf_1.0.csv
Accuracy: 0.16623481781376517
Weighted:
Precision: 0.796796017093835
Recall: 0.16623481781376517
F1 score: 0.23398137675255798
Conditional entropy: 0.7932064132264798
```

sigmoid (gamma=1.0)

In [ ]:
```
clusters = [len(np.unique(le_y_train025)), 23]
for k in clusters:
    print(f"k= {k}")
    labels = load_kmeans_labels(
```

```
        k=k, fname="one-hot_encoded_spectral_clustering_sigmoid_1.0"
    )
    labels = labels.to_numpy().reshape(-1)
    new_labels = purity_matching(le_y_train025, labels)
    precision_recall_f1_weighted(le_y_train025, new_labels)
    con_entr = conditional_entropy(le_y_train025, new_labels)
    print(f"Conditional entropy: {con_entr}")
```

```
k= 15
Loading: labels_16_15_one-hot_encoded_spectral_clustering_sigmoid_1.0.csv
Accuracy: 0.09578947368421052
Weighted:
Precision: 0.408077836550324
Recall: 0.09578947368421054
F1 score: 0.15132405807611082
Conditional entropy: 1.546599244070808
k= 23
Loading: labels_21_23_one-hot_encoded_spectral_clustering_sigmoid_1.0.csv
Accuracy: 0.06979757085020243
Weighted:
Precision: 0.4061342059301873
Recall: 0.06979757085020245
F1 score: 0.11788547029849468
Conditional entropy: 1.543728389893449
```

Comment

The best similarity matrix was polynomial kernel (gamma=1.0 / n_features), that had the best f1 score (weighted) of 0.68823, with one of the lowest conditional entropy values of 0.13785.

DBSCAN

Maximum matching

label encoded

In [ ]:
```
labels = load_dbscan_labels(fname="3561_1_label_encoded")
labels = labels.to_numpy().reshape(-1)
new_labels = max_matching_hungarian(labels, le_y_train004)
precision_recall_f1_weighted(le_y_train004, new_labels)
con_entr = conditional_entropy(le_y_train004, new_labels)
print(f"Conditional entropy: {con_entr}")
```

```
Loading: labels_3561_1_label_encoded_DBSCAN.csv
Accuracy: 0.5769230769230769
Weighted:
Precision: 0.5287109415550711
Recall: 0.576923076923077
F1 score: 0.42786332328126425
Conditional entropy: 1.4924965958339524
```

In [ ]:
```
labels = load_dbscan_labels(fname="2550_1_label_encoded")
labels = labels.to_numpy().reshape(-1)
new_labels = max_matching_hungarian(labels, le_y_train004)
precision_recall_f1_weighted(le_y_train004, new_labels)
con_entr = conditional_entropy(le_y_train004, new_labels)
print(f"Conditional entropy: {con_entr}")
```

```
Loading: labels_2550_1_label_encoded_DBSCAN.csv
Accuracy: 0.5759109311740891
Weighted:
Precision: 0.5287597809564804
Recall: 0.5759109311740891
F1 score: 0.42607613751615075
Conditional entropy: 1.4912341915263154
```

one-hot encoded

In [ ]:
```
labels = load_dbscan_labels(fname="3561_1_one-hot_encoded")
labels = labels.to_numpy().reshape(-1)
new_labels = max_matching_hungarian(labels, le_y_train004)
precision_recall_f1_weighted(le_y_train004, new_labels)
con_entr = conditional_entropy(le_y_train004, new_labels)
print(f"Conditional entropy: {con_entr}")
```

```
Loading: labels_3561_1_one-hot_encoded_DBSCAN.csv
Accuracy: 0.5769230769230769
Weighted:
Precision: 0.5287109415550711
Recall: 0.576923076923077
F1 score: 0.42786332328126425
Conditional entropy: 1.4924965958339524
```

In [ ]:
```
labels = load_dbscan_labels(fname="2550_1_one-hot_encoded")
labels = labels.to_numpy().reshape(-1)
new_labels = max_matching_hungarian(labels, le_y_train004)
precision_recall_f1_weighted(le_y_train004, new_labels)
con_entr = conditional_entropy(le_y_train004, new_labels)
print(f"Conditional entropy: {con_entr}")
```

```
Loading: labels_2550_1_one-hot_encoded_DBSCAN.csv
Accuracy: 0.5759109311740891
Weighted:
Precision: 0.5287597809564804
Recall: 0.5759109311740891
F1 score: 0.42607613751615075
Conditional entropy: 1.4912341915263154
```

Purity matching

label encoded

In [ ]:
```
labels = load_dbscan_labels(fname="3561_1_label_encoded")
labels = labels.to_numpy().reshape(-1)
new_labels = purity_matching(le_y_train004, labels)
precision_recall_f1_weighted(le_y_train004, new_labels)
con_entr = conditional_entropy(le_y_train004, new_labels)
print(f"Conditional entropy: {con_entr}")
```

```
Loading: labels_3561_1_label_encoded_DBSCAN.csv
Accuracy: 0.5769230769230769
Weighted:
Precision: 0.5287109415550711
Recall: 0.576923076923077
F1 score: 0.42786332328126425
Conditional entropy: 1.4924965958339524
```

In [ ]:
```
labels = load_dbscan_labels(fname="2550_1_label_encoded")
labels = labels.to_numpy().reshape(-1)
new_labels = purity_matching(le_y_train004, labels)
precision_recall_f1_weighted(le_y_train004, new_labels)
con_entr = conditional_entropy(le_y_train004, new_labels)
print(f"Conditional entropy: {con_entr}")
```

```
Loading: labels_2550_1_label_encoded_DBSCAN.csv
Accuracy: 0.5759109311740891
Weighted:
Precision: 0.5292152465435249
Recall: 0.5759109311740891
F1 score: 0.4263158562461742
Conditional entropy: 1.4888607320445884
```

one-hot encoded

In [ ]:
```
labels = load_dbscan_labels(fname="3561_1_one-hot_encoded")
labels = labels.to_numpy().reshape(-1)
new_labels = purity_matching(le_y_train004, labels)
precision_recall_f1_weighted(le_y_train004, new_labels)
con_entr = conditional_entropy(le_y_train004, new_labels)
print(f"Conditional entropy: {con_entr}")
```

```
Loading: labels_3561_1_one-hot_encoded_DBSCAN.csv
Accuracy: 0.5769230769230769
Weighted:
Precision: 0.5287109415550711
Recall: 0.576923076923077
F1 score: 0.42786332328126425
Conditional entropy: 1.4924965958339524
```

In [ ]:
```
labels = load_dbscan_labels(fname="2550_1_one-hot_encoded")
labels = labels.to_numpy().reshape(-1)
new_labels = purity_matching(le_y_train004, labels)
precision_recall_f1_weighted(le_y_train004, new_labels)
con_entr = conditional_entropy(le_y_train004, new_labels)
print(f"Conditional entropy: {con_entr}")
```

```
Loading: labels_2550_1_one-hot_encoded_DBSCAN.csv
Accuracy: 0.5759109311740891
Weighted:
Precision: 0.5292152465435249
Recall: 0.5759109311740891
F1 score: 0.4263158562461742
Conditional entropy: 1.4888607320445884
```

Comments

Spectral clustering yields worse results than KMeans, this may be attributed to the limited data size used for training spectral clustering.

KMeans also performed better than DBSCAN with DBSCAN having a maximum F1-Score of 0.428 compared to KMeans' 0.811, this may also be attributed to the limited data.