In [45]:
```
!pip install xelatex
import numpy as np
import pandas as pd
from scipy.spatial.distance import pdist
from sklearn.manifold.t_sne import _joint_probabilities
from scipy import linalg
from sklearn.metrics import pairwise_distances
from scipy.spatial.distance import squareform
from sklearn.manifold import TSNE
from matplotlib import pyplot as plt
import seaborn as sns
sns.set(rc={'figure.figsize':(11.7,8.27)})
palette = sns.color_palette("bright", 10)
```

```
ERROR: Could not find a version that satisfies the requirement xelatex (from versions: n
one)
ERROR: No matching distribution found for xelatex
```

In [2]:
```
X, y = load_digits(return_X_y=True)
```

In [28]:
```
load_digits= pd.read_csv('HIGGS_6M.csv')
```

In [31]:
```
np.ravel(load_digits)
```

Out[31]:
```
array([1.        , 0.90754211, 0.32914728, ..., 0.80705976, 1.81057131,
       1.78045082])
```

In [32]:
```
MACHINE_EPSILON = np.finfo(np.double).eps
n_components = 2
perplexity = 30
```

In [33]:
```
def fit(X):
    n_samples = X.shape[0]

    # Compute euclidean distance
    distances = pairwise_distances(X, metric='euclidean', squared=True)

    # Compute joint probabilities p_ij from distances.
    P = _joint_probabilities(distances=distances, desired_perplexity=perplexity, verbos

    # The embedding is initialized with iid samples from Gaussians with standard deviat
    X_embedded = 1e-4 * np.random.mtrand._rand.randn(n_samples, n_components).astype(np

    # degrees_of_freedom = n_components - 1 comes from
    # "Learning a Parametric Embedding by Preserving Local Structure"
    # Laurens van der Maaten, 2009.
    degrees_of_freedom = max(n_components - 1, 1)

    return _tsne(P, degrees_of_freedom, n_samples, X_embedded=X_embedded)
```

In [34]:
```
def _tsne(P, degrees_of_freedom, n_samples, X_embedded):
    params = X_embedded.ravel()

    obj_func = _kl_divergence

    params = _gradient_descent(obj_func, params, [P, degrees_of_freedom, n_samples, n_c
```

```
    X_embedded = params.reshape(n_samples, n_components)
    return X_embedded
```

In [35]:
```
np.ravel(data)
```

Out[35]:
```
array([1.        , 0.90754211, 0.32914728, ..., 0.80705976, 1.81057131,
       1.78045082])
```

In [36]:
```
def _kl_divergence(params, P, degrees_of_freedom, n_samples, n_components):
    X_embedded = params.reshape(n_samples, n_components)

    dist = pdist(X_embedded, "sqeuclidean")
    dist /= degrees_of_freedom
    dist += 1.
    dist **= (degrees_of_freedom + 1.0) / -2.0
    Q = np.maximum(dist / (2.0 * np.sum(dist)), MACHINE_EPSILON)

    # Kullback-Leibler divergence of P and Q
    kl_divergence = 2.0 * np.dot(P, np.log(np.maximum(P, MACHINE_EPSILON) / Q))

    # Gradient: dC/dY
    grad = np.ndarray((n_samples, n_components), dtype=params.dtype)
    PQd = squareform((P - Q) * dist)
    for i in range(n_samples):
        grad[i] = np.dot(np.ravel(PQd[i], order='K'),
                         X_embedded[i] - X_embedded)
    grad = grad.ravel()
    c = 2.0 * (degrees_of_freedom + 1.0) / degrees_of_freedom
    grad *= c
    return kl_divergence, grad
```

In [37]:
```
def _gradient_descent(obj_func, p0, args, it=0, n_iter=1000,
                      n_iter_check=1, n_iter_without_progress=300,
                      momentum=0.8, learning_rate=200.0, min_gain=0.01,
                      min_grad_norm=1e-7):

    p = p0.copy().ravel()
    update = np.zeros_like(p)
    gains = np.ones_like(p)
    error = np.finfo(np.float).max
    best_error = np.finfo(np.float).max
    best_iter = i = it

    for i in range(it, n_iter):
        error, grad = obj_func(p, *args)
        grad_norm = linalg.norm(grad)
        inc = update * grad < 0.0
        dec = np.invert(inc)
        gains[inc] += 0.2
        gains[dec] *= 0.8
        np.clip(gains, min_gain, np.inf, out=gains)
        grad *= gains
        update = momentum * update - learning_rate * grad
        p += update
        print("[t-SNE] Iteration %d: error = %.7f,"
                      " gradient norm = %.7f"
                      % (i + 1, error, grad_norm))

        if error < best_error:
                best_error = error
```

```
                best_iter = i
            elif i - best_iter > n_iter_without_progress:
                break

            if grad_norm <= min_grad_norm:
                break
        return p
```

In [38]:
```
X_embedded = fit(X)
```

```
[t-SNE] Iteration 1: error = 4.0229677, gradient norm = 0.0000049
[t-SNE] Iteration 2: error = 4.0229676, gradient norm = 0.0000049
[t-SNE] Iteration 3: error = 4.0229676, gradient norm = 0.0000059
[t-SNE] Iteration 4: error = 4.0229676, gradient norm = 0.0000090
[t-SNE] Iteration 5: error = 4.0229676, gradient norm = 0.0000151
[t-SNE] Iteration 6: error = 4.0229674, gradient norm = 0.0000272
[t-SNE] Iteration 7: error = 4.0229668, gradient norm = 0.0000524
[t-SNE] Iteration 8: error = 4.0229642, gradient norm = 0.0001069
[t-SNE] Iteration 9: error = 4.0229522, gradient norm = 0.0002300
[t-SNE] Iteration 10: error = 4.0228910, gradient norm = 0.0005202
[t-SNE] Iteration 11: error = 4.0225493, gradient norm = 0.0012309
[t-SNE] Iteration 12: error = 4.0204793, gradient norm = 0.0030095
[t-SNE] Iteration 13: error = 4.0075027, gradient norm = 0.0071979
[t-SNE] Iteration 14: error = 3.9377645, gradient norm = 0.0139717
[t-SNE] Iteration 15: error = 3.7162107, gradient norm = 0.0179606
[t-SNE] Iteration 16: error = 3.3647474, gradient norm = 0.0160889
[t-SNE] Iteration 17: error = 3.0201331, gradient norm = 0.0129086
[t-SNE] Iteration 18: error = 2.7339572, gradient norm = 0.0106259
[t-SNE] Iteration 19: error = 2.5017633, gradient norm = 0.0090249
[t-SNE] Iteration 20: error = 2.3130744, gradient norm = 0.0078566
[t-SNE] Iteration 21: error = 2.1592920, gradient norm = 0.0069437
[t-SNE] Iteration 22: error = 2.0347284, gradient norm = 0.0062249
[t-SNE] Iteration 23: error = 1.9345706, gradient norm = 0.0056685
[t-SNE] Iteration 24: error = 1.8533832, gradient norm = 0.0053237
[t-SNE] Iteration 25: error = 1.7860364, gradient norm = 0.0052621
[t-SNE] Iteration 26: error = 1.7277172, gradient norm = 0.0050768
[t-SNE] Iteration 27: error = 1.6759973, gradient norm = 0.0046016
[t-SNE] Iteration 28: error = 1.6314033, gradient norm = 0.0043627
[t-SNE] Iteration 29: error = 1.5933157, gradient norm = 0.0041404
[t-SNE] Iteration 30: error = 1.5603930, gradient norm = 0.0038968
[t-SNE] Iteration 31: error = 1.5312892, gradient norm = 0.0037832
[t-SNE] Iteration 32: error = 1.5049135, gradient norm = 0.0035337
[t-SNE] Iteration 33: error = 1.4811029, gradient norm = 0.0033952
[t-SNE] Iteration 34: error = 1.4597543, gradient norm = 0.0031980
[t-SNE] Iteration 35: error = 1.4408534, gradient norm = 0.0031310
[t-SNE] Iteration 36: error = 1.4236344, gradient norm = 0.0030098
[t-SNE] Iteration 37: error = 1.4076109, gradient norm = 0.0028768
[t-SNE] Iteration 38: error = 1.3924752, gradient norm = 0.0027486
[t-SNE] Iteration 39: error = 1.3781158, gradient norm = 0.0026088
[t-SNE] Iteration 40: error = 1.3647464, gradient norm = 0.0024254
[t-SNE] Iteration 41: error = 1.3527055, gradient norm = 0.0023836
[t-SNE] Iteration 42: error = 1.3414732, gradient norm = 0.0022892
[t-SNE] Iteration 43: error = 1.3308052, gradient norm = 0.0021945
[t-SNE] Iteration 44: error = 1.3206100, gradient norm = 0.0020703
[t-SNE] Iteration 45: error = 1.3108637, gradient norm = 0.0019632
[t-SNE] Iteration 46: error = 1.3015601, gradient norm = 0.0019093
[t-SNE] Iteration 47: error = 1.2926039, gradient norm = 0.0018349
[t-SNE] Iteration 48: error = 1.2839572, gradient norm = 0.0017486
[t-SNE] Iteration 49: error = 1.2756518, gradient norm = 0.0016660
[t-SNE] Iteration 50: error = 1.2677368, gradient norm = 0.0016247
[t-SNE] Iteration 51: error = 1.2601691, gradient norm = 0.0016011
[t-SNE] Iteration 52: error = 1.2527813, gradient norm = 0.0015927
[t-SNE] Iteration 53: error = 1.2454489, gradient norm = 0.0015320
[t-SNE] Iteration 54: error = 1.2382871, gradient norm = 0.0014576
```

```
[t-SNE] Iteration 55: error = 1.2313377, gradient norm = 0.0014170
[t-SNE] Iteration 56: error = 1.2245866, gradient norm = 0.0013343
[t-SNE] Iteration 57: error = 1.2183287, gradient norm = 0.0013531
[t-SNE] Iteration 58: error = 1.2123211, gradient norm = 0.0013874
[t-SNE] Iteration 59: error = 1.2063144, gradient norm = 0.0013685
[t-SNE] Iteration 60: error = 1.2003301, gradient norm = 0.0013161
[t-SNE] Iteration 61: error = 1.1944503, gradient norm = 0.0012216
[t-SNE] Iteration 62: error = 1.1887844, gradient norm = 0.0011510
[t-SNE] Iteration 63: error = 1.1833480, gradient norm = 0.0011290
[t-SNE] Iteration 64: error = 1.1780690, gradient norm = 0.0010856
[t-SNE] Iteration 65: error = 1.1729297, gradient norm = 0.0010630
[t-SNE] Iteration 66: error = 1.1679064, gradient norm = 0.0010348
[t-SNE] Iteration 67: error = 1.1629825, gradient norm = 0.0010097
[t-SNE] Iteration 68: error = 1.1581347, gradient norm = 0.0009855
[t-SNE] Iteration 69: error = 1.1533624, gradient norm = 0.0009436
[t-SNE] Iteration 70: error = 1.1486838, gradient norm = 0.0009240
[t-SNE] Iteration 71: error = 1.1440813, gradient norm = 0.0009012
[t-SNE] Iteration 72: error = 1.1395474, gradient norm = 0.0008887
[t-SNE] Iteration 73: error = 1.1350883, gradient norm = 0.0008702
[t-SNE] Iteration 74: error = 1.1307208, gradient norm = 0.0008317
[t-SNE] Iteration 75: error = 1.1264467, gradient norm = 0.0008198
[t-SNE] Iteration 76: error = 1.1222366, gradient norm = 0.0008111
[t-SNE] Iteration 77: error = 1.1180715, gradient norm = 0.0007990
[t-SNE] Iteration 78: error = 1.1139467, gradient norm = 0.0007863
[t-SNE] Iteration 79: error = 1.1098635, gradient norm = 0.0007629
[t-SNE] Iteration 80: error = 1.1058297, gradient norm = 0.0007416
[t-SNE] Iteration 81: error = 1.1018588, gradient norm = 0.0007303
[t-SNE] Iteration 82: error = 1.0980293, gradient norm = 0.0007085
[t-SNE] Iteration 83: error = 1.0944455, gradient norm = 0.0007192
[t-SNE] Iteration 84: error = 1.0909078, gradient norm = 0.0007304
[t-SNE] Iteration 85: error = 1.0874299, gradient norm = 0.0007337
[t-SNE] Iteration 86: error = 1.0840788, gradient norm = 0.0007511
[t-SNE] Iteration 87: error = 1.0807774, gradient norm = 0.0006943
[t-SNE] Iteration 88: error = 1.0775281, gradient norm = 0.0006709
[t-SNE] Iteration 89: error = 1.0743332, gradient norm = 0.0006902
[t-SNE] Iteration 90: error = 1.0711936, gradient norm = 0.0006596
[t-SNE] Iteration 91: error = 1.0681176, gradient norm = 0.0006497
[t-SNE] Iteration 92: error = 1.0650885, gradient norm = 0.0006424
[t-SNE] Iteration 93: error = 1.0621040, gradient norm = 0.0006190
[t-SNE] Iteration 94: error = 1.0591704, gradient norm = 0.0006420
[t-SNE] Iteration 95: error = 1.0562599, gradient norm = 0.0006277
[t-SNE] Iteration 96: error = 1.0533948, gradient norm = 0.0006508
[t-SNE] Iteration 97: error = 1.0505813, gradient norm = 0.0006508
[t-SNE] Iteration 98: error = 1.0478267, gradient norm = 0.0006389
[t-SNE] Iteration 99: error = 1.0451277, gradient norm = 0.0006332
[t-SNE] Iteration 100: error = 1.0424770, gradient norm = 0.0006043
[t-SNE] Iteration 101: error = 1.0398767, gradient norm = 0.0005919
[t-SNE] Iteration 102: error = 1.0373130, gradient norm = 0.0005689
[t-SNE] Iteration 103: error = 1.0347870, gradient norm = 0.0005599
[t-SNE] Iteration 104: error = 1.0323044, gradient norm = 0.0005497
[t-SNE] Iteration 105: error = 1.0298821, gradient norm = 0.0005264
[t-SNE] Iteration 106: error = 1.0275478, gradient norm = 0.0005061
[t-SNE] Iteration 107: error = 1.0253079, gradient norm = 0.0005180
[t-SNE] Iteration 108: error = 1.0231073, gradient norm = 0.0005337
[t-SNE] Iteration 109: error = 1.0209026, gradient norm = 0.0005093
[t-SNE] Iteration 110: error = 1.0187218, gradient norm = 0.0004945
[t-SNE] Iteration 111: error = 1.0165764, gradient norm = 0.0004837
[t-SNE] Iteration 112: error = 1.0144692, gradient norm = 0.0004857
[t-SNE] Iteration 113: error = 1.0123960, gradient norm = 0.0004736
[t-SNE] Iteration 114: error = 1.0103563, gradient norm = 0.0004774
[t-SNE] Iteration 115: error = 1.0083384, gradient norm = 0.0004674
[t-SNE] Iteration 116: error = 1.0063421, gradient norm = 0.0004603
[t-SNE] Iteration 117: error = 1.0043624, gradient norm = 0.0004681
[t-SNE] Iteration 118: error = 1.0023903, gradient norm = 0.0004551
[t-SNE] Iteration 119: error = 1.0004248, gradient norm = 0.0004702
```

```
[t-SNE] Iteration 120: error = 0.9984560, gradient norm = 0.0004780
[t-SNE] Iteration 121: error = 0.9964787, gradient norm = 0.0004713
[t-SNE] Iteration 122: error = 0.9944995, gradient norm = 0.0004731
[t-SNE] Iteration 123: error = 0.9925866, gradient norm = 0.0004424
[t-SNE] Iteration 124: error = 0.9908790, gradient norm = 0.0005062
[t-SNE] Iteration 125: error = 0.9891517, gradient norm = 0.0004943
[t-SNE] Iteration 126: error = 0.9874113, gradient norm = 0.0004803
[t-SNE] Iteration 127: error = 0.9857026, gradient norm = 0.0004785
[t-SNE] Iteration 128: error = 0.9840282, gradient norm = 0.0004696
[t-SNE] Iteration 129: error = 0.9823883, gradient norm = 0.0004397
[t-SNE] Iteration 130: error = 0.9807992, gradient norm = 0.0004482
[t-SNE] Iteration 131: error = 0.9792415, gradient norm = 0.0004581
[t-SNE] Iteration 132: error = 0.9776975, gradient norm = 0.0004289
[t-SNE] Iteration 133: error = 0.9761771, gradient norm = 0.0004083
[t-SNE] Iteration 134: error = 0.9746825, gradient norm = 0.0004166
[t-SNE] Iteration 135: error = 0.9732049, gradient norm = 0.0004214
[t-SNE] Iteration 136: error = 0.9717407, gradient norm = 0.0004100
[t-SNE] Iteration 137: error = 0.9702854, gradient norm = 0.0003972
[t-SNE] Iteration 138: error = 0.9688386, gradient norm = 0.0003913
[t-SNE] Iteration 139: error = 0.9674267, gradient norm = 0.0003938
[t-SNE] Iteration 140: error = 0.9660744, gradient norm = 0.0004039
[t-SNE] Iteration 141: error = 0.9647241, gradient norm = 0.0004051
[t-SNE] Iteration 142: error = 0.9633477, gradient norm = 0.0004048
[t-SNE] Iteration 143: error = 0.9619827, gradient norm = 0.0004011
[t-SNE] Iteration 144: error = 0.9606405, gradient norm = 0.0004088
[t-SNE] Iteration 145: error = 0.9593007, gradient norm = 0.0004132
[t-SNE] Iteration 146: error = 0.9579662, gradient norm = 0.0003967
[t-SNE] Iteration 147: error = 0.9566540, gradient norm = 0.0003764
[t-SNE] Iteration 148: error = 0.9553820, gradient norm = 0.0003611
[t-SNE] Iteration 149: error = 0.9541679, gradient norm = 0.0003582
[t-SNE] Iteration 150: error = 0.9530046, gradient norm = 0.0003587
[t-SNE] Iteration 151: error = 0.9518578, gradient norm = 0.0003808
[t-SNE] Iteration 152: error = 0.9506988, gradient norm = 0.0003681
[t-SNE] Iteration 153: error = 0.9495353, gradient norm = 0.0003440
[t-SNE] Iteration 154: error = 0.9483848, gradient norm = 0.0003375
[t-SNE] Iteration 155: error = 0.9472505, gradient norm = 0.0003299
[t-SNE] Iteration 156: error = 0.9461260, gradient norm = 0.0003331
[t-SNE] Iteration 157: error = 0.9450063, gradient norm = 0.0003278
[t-SNE] Iteration 158: error = 0.9438914, gradient norm = 0.0003359
[t-SNE] Iteration 159: error = 0.9427814, gradient norm = 0.0003606
[t-SNE] Iteration 160: error = 0.9416745, gradient norm = 0.0003780
[t-SNE] Iteration 161: error = 0.9405675, gradient norm = 0.0003655
[t-SNE] Iteration 162: error = 0.9394624, gradient norm = 0.0003303
[t-SNE] Iteration 163: error = 0.9383602, gradient norm = 0.0003389
[t-SNE] Iteration 164: error = 0.9372528, gradient norm = 0.0003530
[t-SNE] Iteration 165: error = 0.9361480, gradient norm = 0.0003283
[t-SNE] Iteration 166: error = 0.9350633, gradient norm = 0.0003528
[t-SNE] Iteration 167: error = 0.9339835, gradient norm = 0.0003473
[t-SNE] Iteration 168: error = 0.9329175, gradient norm = 0.0003427
[t-SNE] Iteration 169: error = 0.9318659, gradient norm = 0.0003319
[t-SNE] Iteration 170: error = 0.9308304, gradient norm = 0.0003167
[t-SNE] Iteration 171: error = 0.9298162, gradient norm = 0.0003288
[t-SNE] Iteration 172: error = 0.9288159, gradient norm = 0.0003249
[t-SNE] Iteration 173: error = 0.9278267, gradient norm = 0.0003234
[t-SNE] Iteration 174: error = 0.9268492, gradient norm = 0.0003016
[t-SNE] Iteration 175: error = 0.9258912, gradient norm = 0.0003080
[t-SNE] Iteration 176: error = 0.9249453, gradient norm = 0.0002970
[t-SNE] Iteration 177: error = 0.9240114, gradient norm = 0.0002871
[t-SNE] Iteration 178: error = 0.9230890, gradient norm = 0.0002894
[t-SNE] Iteration 179: error = 0.9221752, gradient norm = 0.0002831
[t-SNE] Iteration 180: error = 0.9212701, gradient norm = 0.0002921
[t-SNE] Iteration 181: error = 0.9203714, gradient norm = 0.0002794
[t-SNE] Iteration 182: error = 0.9194796, gradient norm = 0.0002693
[t-SNE] Iteration 183: error = 0.9185954, gradient norm = 0.0002776
[t-SNE] Iteration 184: error = 0.9177164, gradient norm = 0.0002753
```

```
[t-SNE] Iteration 185: error = 0.9168429, gradient norm = 0.0002658
[t-SNE] Iteration 186: error = 0.9159750, gradient norm = 0.0002713
[t-SNE] Iteration 187: error = 0.9151109, gradient norm = 0.0002755
[t-SNE] Iteration 188: error = 0.9142504, gradient norm = 0.0002711
[t-SNE] Iteration 189: error = 0.9133936, gradient norm = 0.0002674
[t-SNE] Iteration 190: error = 0.9125409, gradient norm = 0.0002663
[t-SNE] Iteration 191: error = 0.9116909, gradient norm = 0.0002649
[t-SNE] Iteration 192: error = 0.9108429, gradient norm = 0.0002619
[t-SNE] Iteration 193: error = 0.9099976, gradient norm = 0.0002598
[t-SNE] Iteration 194: error = 0.9091529, gradient norm = 0.0002570
[t-SNE] Iteration 195: error = 0.9083087, gradient norm = 0.0002641
[t-SNE] Iteration 196: error = 0.9074634, gradient norm = 0.0002676
[t-SNE] Iteration 197: error = 0.9066140, gradient norm = 0.0002572
[t-SNE] Iteration 198: error = 0.9057623, gradient norm = 0.0002545
[t-SNE] Iteration 199: error = 0.9049072, gradient norm = 0.0002645
[t-SNE] Iteration 200: error = 0.9040454, gradient norm = 0.0002720
[t-SNE] Iteration 201: error = 0.9031770, gradient norm = 0.0002713
[t-SNE] Iteration 202: error = 0.9023042, gradient norm = 0.0002740
[t-SNE] Iteration 203: error = 0.9014272, gradient norm = 0.0002877
[t-SNE] Iteration 204: error = 0.9005437, gradient norm = 0.0003043
[t-SNE] Iteration 205: error = 0.8996478, gradient norm = 0.0002948
[t-SNE] Iteration 206: error = 0.8987386, gradient norm = 0.0002928
[t-SNE] Iteration 207: error = 0.8978145, gradient norm = 0.0003059
[t-SNE] Iteration 208: error = 0.8968717, gradient norm = 0.0003045
[t-SNE] Iteration 209: error = 0.8959157, gradient norm = 0.0003292
[t-SNE] Iteration 210: error = 0.8949525, gradient norm = 0.0003724
[t-SNE] Iteration 211: error = 0.8939893, gradient norm = 0.0003887
[t-SNE] Iteration 212: error = 0.8930402, gradient norm = 0.0003303
[t-SNE] Iteration 213: error = 0.8921132, gradient norm = 0.0003320
[t-SNE] Iteration 214: error = 0.8911851, gradient norm = 0.0003807
[t-SNE] Iteration 215: error = 0.8902609, gradient norm = 0.0003490
[t-SNE] Iteration 216: error = 0.8893509, gradient norm = 0.0003089
[t-SNE] Iteration 217: error = 0.8884463, gradient norm = 0.0003468
[t-SNE] Iteration 218: error = 0.8875391, gradient norm = 0.0003379
[t-SNE] Iteration 219: error = 0.8866391, gradient norm = 0.0003050
[t-SNE] Iteration 220: error = 0.8857474, gradient norm = 0.0003290
[t-SNE] Iteration 221: error = 0.8848501, gradient norm = 0.0003237
[t-SNE] Iteration 222: error = 0.8839517, gradient norm = 0.0003212
[t-SNE] Iteration 223: error = 0.8830508, gradient norm = 0.0002991
[t-SNE] Iteration 224: error = 0.8821493, gradient norm = 0.0003050
[t-SNE] Iteration 225: error = 0.8812452, gradient norm = 0.0003296
[t-SNE] Iteration 226: error = 0.8803347, gradient norm = 0.0003315
[t-SNE] Iteration 227: error = 0.8794193, gradient norm = 0.0003493
[t-SNE] Iteration 228: error = 0.8784964, gradient norm = 0.0003006
[t-SNE] Iteration 229: error = 0.8775741, gradient norm = 0.0002982
[t-SNE] Iteration 230: error = 0.8766491, gradient norm = 0.0003275
[t-SNE] Iteration 231: error = 0.8757137, gradient norm = 0.0003201
[t-SNE] Iteration 232: error = 0.8747692, gradient norm = 0.0003275
[t-SNE] Iteration 233: error = 0.8738124, gradient norm = 0.0003342
[t-SNE] Iteration 234: error = 0.8728408, gradient norm = 0.0003840
[t-SNE] Iteration 235: error = 0.8718428, gradient norm = 0.0004423
[t-SNE] Iteration 236: error = 0.8708016, gradient norm = 0.0003857
[t-SNE] Iteration 237: error = 0.8697221, gradient norm = 0.0003130
[t-SNE] Iteration 238: error = 0.8686119, gradient norm = 0.0003710
[t-SNE] Iteration 239: error = 0.8674512, gradient norm = 0.0003834
[t-SNE] Iteration 240: error = 0.8662296, gradient norm = 0.0003364
[t-SNE] Iteration 241: error = 0.8649543, gradient norm = 0.0003593
[t-SNE] Iteration 242: error = 0.8636103, gradient norm = 0.0003714
[t-SNE] Iteration 243: error = 0.8621955, gradient norm = 0.0003611
[t-SNE] Iteration 244: error = 0.8607464, gradient norm = 0.0003823
[t-SNE] Iteration 245: error = 0.8592711, gradient norm = 0.0003667
[t-SNE] Iteration 246: error = 0.8577777, gradient norm = 0.0003693
[t-SNE] Iteration 247: error = 0.8563403, gradient norm = 0.0003874
[t-SNE] Iteration 248: error = 0.8549872, gradient norm = 0.0003936
[t-SNE] Iteration 249: error = 0.8539208, gradient norm = 0.0004563
```

```
[t-SNE] Iteration 250: error = 0.8529304, gradient norm = 0.0004466
[t-SNE] Iteration 251: error = 0.8518576, gradient norm = 0.0003901
[t-SNE] Iteration 252: error = 0.8509711, gradient norm = 0.0004991
[t-SNE] Iteration 253: error = 0.8499326, gradient norm = 0.0004395
[t-SNE] Iteration 254: error = 0.8489518, gradient norm = 0.0004370
[t-SNE] Iteration 255: error = 0.8480264, gradient norm = 0.0004240
[t-SNE] Iteration 256: error = 0.8471390, gradient norm = 0.0004177
[t-SNE] Iteration 257: error = 0.8463120, gradient norm = 0.0003916
[t-SNE] Iteration 258: error = 0.8455885, gradient norm = 0.0003561
[t-SNE] Iteration 259: error = 0.8449044, gradient norm = 0.0003663
[t-SNE] Iteration 260: error = 0.8442271, gradient norm = 0.0003757
[t-SNE] Iteration 261: error = 0.8435679, gradient norm = 0.0003428
[t-SNE] Iteration 262: error = 0.8429009, gradient norm = 0.0003521
[t-SNE] Iteration 263: error = 0.8422112, gradient norm = 0.0003232
[t-SNE] Iteration 264: error = 0.8415242, gradient norm = 0.0003133
[t-SNE] Iteration 265: error = 0.8408444, gradient norm = 0.0003128
[t-SNE] Iteration 266: error = 0.8401678, gradient norm = 0.0002974
[t-SNE] Iteration 267: error = 0.8394940, gradient norm = 0.0003080
[t-SNE] Iteration 268: error = 0.8388202, gradient norm = 0.0002806
[t-SNE] Iteration 269: error = 0.8381532, gradient norm = 0.0002716
[t-SNE] Iteration 270: error = 0.8374954, gradient norm = 0.0002585
[t-SNE] Iteration 271: error = 0.8368471, gradient norm = 0.0002468
[t-SNE] Iteration 272: error = 0.8362052, gradient norm = 0.0002494
[t-SNE] Iteration 273: error = 0.8355646, gradient norm = 0.0002478
[t-SNE] Iteration 274: error = 0.8349247, gradient norm = 0.0002503
[t-SNE] Iteration 275: error = 0.8342831, gradient norm = 0.0002492
[t-SNE] Iteration 276: error = 0.8336414, gradient norm = 0.0002610
[t-SNE] Iteration 277: error = 0.8329975, gradient norm = 0.0002682
[t-SNE] Iteration 278: error = 0.8323492, gradient norm = 0.0002541
[t-SNE] Iteration 279: error = 0.8316989, gradient norm = 0.0002379
[t-SNE] Iteration 280: error = 0.8310487, gradient norm = 0.0002587
[t-SNE] Iteration 281: error = 0.8303950, gradient norm = 0.0002574
[t-SNE] Iteration 282: error = 0.8297363, gradient norm = 0.0002271
[t-SNE] Iteration 283: error = 0.8290767, gradient norm = 0.0002415
[t-SNE] Iteration 284: error = 0.8284113, gradient norm = 0.0002514
[t-SNE] Iteration 285: error = 0.8277363, gradient norm = 0.0002339
[t-SNE] Iteration 286: error = 0.8270549, gradient norm = 0.0002429
[t-SNE] Iteration 287: error = 0.8263635, gradient norm = 0.0002426
[t-SNE] Iteration 288: error = 0.8256629, gradient norm = 0.0002548
[t-SNE] Iteration 289: error = 0.8249530, gradient norm = 0.0002589
[t-SNE] Iteration 290: error = 0.8242399, gradient norm = 0.0002591
[t-SNE] Iteration 291: error = 0.8235460, gradient norm = 0.0002428
[t-SNE] Iteration 292: error = 0.8229181, gradient norm = 0.0002773
[t-SNE] Iteration 293: error = 0.8223466, gradient norm = 0.0003461
[t-SNE] Iteration 294: error = 0.8216908, gradient norm = 0.0003185
[t-SNE] Iteration 295: error = 0.8210448, gradient norm = 0.0003140
[t-SNE] Iteration 296: error = 0.8204181, gradient norm = 0.0003205
[t-SNE] Iteration 297: error = 0.8198280, gradient norm = 0.0003280
[t-SNE] Iteration 298: error = 0.8192587, gradient norm = 0.0003486
[t-SNE] Iteration 299: error = 0.8186148, gradient norm = 0.0003036
[t-SNE] Iteration 300: error = 0.8179635, gradient norm = 0.0002719
[t-SNE] Iteration 301: error = 0.8173556, gradient norm = 0.0002742
[t-SNE] Iteration 302: error = 0.8167377, gradient norm = 0.0002695
[t-SNE] Iteration 303: error = 0.8160967, gradient norm = 0.0002647
[t-SNE] Iteration 304: error = 0.8154441, gradient norm = 0.0002622
[t-SNE] Iteration 305: error = 0.8147622, gradient norm = 0.0002693
[t-SNE] Iteration 306: error = 0.8140359, gradient norm = 0.0002859
[t-SNE] Iteration 307: error = 0.8132517, gradient norm = 0.0002948
[t-SNE] Iteration 308: error = 0.8124592, gradient norm = 0.0003026
[t-SNE] Iteration 309: error = 0.8117590, gradient norm = 0.0003350
[t-SNE] Iteration 310: error = 0.8109096, gradient norm = 0.0002690
[t-SNE] Iteration 311: error = 0.8101824, gradient norm = 0.0003230
[t-SNE] Iteration 312: error = 0.8093770, gradient norm = 0.0003015
[t-SNE] Iteration 313: error = 0.8085640, gradient norm = 0.0002942
[t-SNE] Iteration 314: error = 0.8078397, gradient norm = 0.0003035
```

```
[t-SNE] Iteration 315: error = 0.8071638, gradient norm = 0.0003069
[t-SNE] Iteration 316: error = 0.8064676, gradient norm = 0.0002758
[t-SNE] Iteration 317: error = 0.8057855, gradient norm = 0.0002868
[t-SNE] Iteration 318: error = 0.8051087, gradient norm = 0.0003018
[t-SNE] Iteration 319: error = 0.8044215, gradient norm = 0.0002883
[t-SNE] Iteration 320: error = 0.8037108, gradient norm = 0.0002955
[t-SNE] Iteration 321: error = 0.8029815, gradient norm = 0.0002872
[t-SNE] Iteration 322: error = 0.8022519, gradient norm = 0.0002698
[t-SNE] Iteration 323: error = 0.8015320, gradient norm = 0.0002929
[t-SNE] Iteration 324: error = 0.8008175, gradient norm = 0.0003100
[t-SNE] Iteration 325: error = 0.8001126, gradient norm = 0.0003492
[t-SNE] Iteration 326: error = 0.7994005, gradient norm = 0.0003376
[t-SNE] Iteration 327: error = 0.7986730, gradient norm = 0.0002905
[t-SNE] Iteration 328: error = 0.7979816, gradient norm = 0.0003033
[t-SNE] Iteration 329: error = 0.7973076, gradient norm = 0.0002938
[t-SNE] Iteration 330: error = 0.7966471, gradient norm = 0.0002578
[t-SNE] Iteration 331: error = 0.7959969, gradient norm = 0.0002641
[t-SNE] Iteration 332: error = 0.7953701, gradient norm = 0.0002397
[t-SNE] Iteration 333: error = 0.7947899, gradient norm = 0.0002527
[t-SNE] Iteration 334: error = 0.7942329, gradient norm = 0.0002507
[t-SNE] Iteration 335: error = 0.7937185, gradient norm = 0.0002543
[t-SNE] Iteration 336: error = 0.7932370, gradient norm = 0.0002607
[t-SNE] Iteration 337: error = 0.7927831, gradient norm = 0.0002626
[t-SNE] Iteration 338: error = 0.7923564, gradient norm = 0.0002742
[t-SNE] Iteration 339: error = 0.7919459, gradient norm = 0.0003151
[t-SNE] Iteration 340: error = 0.7915389, gradient norm = 0.0003493
[t-SNE] Iteration 341: error = 0.7911299, gradient norm = 0.0003143
[t-SNE] Iteration 342: error = 0.7907251, gradient norm = 0.0002050
[t-SNE] Iteration 343: error = 0.7903437, gradient norm = 0.0002727
[t-SNE] Iteration 344: error = 0.7899621, gradient norm = 0.0002689
[t-SNE] Iteration 345: error = 0.7895763, gradient norm = 0.0002279
[t-SNE] Iteration 346: error = 0.7891932, gradient norm = 0.0002816
[t-SNE] Iteration 347: error = 0.7888023, gradient norm = 0.0002258
[t-SNE] Iteration 348: error = 0.7884355, gradient norm = 0.0002361
[t-SNE] Iteration 349: error = 0.7880784, gradient norm = 0.0002444
[t-SNE] Iteration 350: error = 0.7877196, gradient norm = 0.0002314
[t-SNE] Iteration 351: error = 0.7873630, gradient norm = 0.0002243
[t-SNE] Iteration 352: error = 0.7870145, gradient norm = 0.0001990
[t-SNE] Iteration 353: error = 0.7866751, gradient norm = 0.0002116
[t-SNE] Iteration 354: error = 0.7863359, gradient norm = 0.0001951
[t-SNE] Iteration 355: error = 0.7859985, gradient norm = 0.0002032
[t-SNE] Iteration 356: error = 0.7856613, gradient norm = 0.0001941
[t-SNE] Iteration 357: error = 0.7853279, gradient norm = 0.0001833
[t-SNE] Iteration 358: error = 0.7849980, gradient norm = 0.0001799
[t-SNE] Iteration 359: error = 0.7846704, gradient norm = 0.0001817
[t-SNE] Iteration 360: error = 0.7843446, gradient norm = 0.0001877
[t-SNE] Iteration 361: error = 0.7840186, gradient norm = 0.0001743
[t-SNE] Iteration 362: error = 0.7836942, gradient norm = 0.0001707
[t-SNE] Iteration 363: error = 0.7833716, gradient norm = 0.0001746
[t-SNE] Iteration 364: error = 0.7830502, gradient norm = 0.0001847
[t-SNE] Iteration 365: error = 0.7827296, gradient norm = 0.0001924
[t-SNE] Iteration 366: error = 0.7824117, gradient norm = 0.0002239
[t-SNE] Iteration 367: error = 0.7820941, gradient norm = 0.0002475
[t-SNE] Iteration 368: error = 0.7817733, gradient norm = 0.0002098
[t-SNE] Iteration 369: error = 0.7814526, gradient norm = 0.0001674
[t-SNE] Iteration 370: error = 0.7811352, gradient norm = 0.0002084
[t-SNE] Iteration 371: error = 0.7808151, gradient norm = 0.0002169
[t-SNE] Iteration 372: error = 0.7804900, gradient norm = 0.0001917
[t-SNE] Iteration 373: error = 0.7801610, gradient norm = 0.0002024
[t-SNE] Iteration 374: error = 0.7798226, gradient norm = 0.0001930
[t-SNE] Iteration 375: error = 0.7794738, gradient norm = 0.0001994
[t-SNE] Iteration 376: error = 0.7791202, gradient norm = 0.0002022
[t-SNE] Iteration 377: error = 0.7787791, gradient norm = 0.0001744
[t-SNE] Iteration 378: error = 0.7784564, gradient norm = 0.0002054
[t-SNE] Iteration 379: error = 0.7781297, gradient norm = 0.0001926
```

```
[t-SNE] Iteration 380: error = 0.7778002, gradient norm = 0.0001886
[t-SNE] Iteration 381: error = 0.7774725, gradient norm = 0.0001895
[t-SNE] Iteration 382: error = 0.7771449, gradient norm = 0.0001838
[t-SNE] Iteration 383: error = 0.7768190, gradient norm = 0.0001814
[t-SNE] Iteration 384: error = 0.7764984, gradient norm = 0.0001651
[t-SNE] Iteration 385: error = 0.7761881, gradient norm = 0.0001661
[t-SNE] Iteration 386: error = 0.7758910, gradient norm = 0.0001628
[t-SNE] Iteration 387: error = 0.7756106, gradient norm = 0.0001531
[t-SNE] Iteration 388: error = 0.7753484, gradient norm = 0.0001548
[t-SNE] Iteration 389: error = 0.7750994, gradient norm = 0.0001516
[t-SNE] Iteration 390: error = 0.7748574, gradient norm = 0.0001605
[t-SNE] Iteration 391: error = 0.7746158, gradient norm = 0.0001649
[t-SNE] Iteration 392: error = 0.7743710, gradient norm = 0.0001621
[t-SNE] Iteration 393: error = 0.7741251, gradient norm = 0.0001565
[t-SNE] Iteration 394: error = 0.7738813, gradient norm = 0.0001564
[t-SNE] Iteration 395: error = 0.7736394, gradient norm = 0.0001593
[t-SNE] Iteration 396: error = 0.7733985, gradient norm = 0.0001609
[t-SNE] Iteration 397: error = 0.7731637, gradient norm = 0.0001626
[t-SNE] Iteration 398: error = 0.7729324, gradient norm = 0.0001879
[t-SNE] Iteration 399: error = 0.7726971, gradient norm = 0.0002055
[t-SNE] Iteration 400: error = 0.7724586, gradient norm = 0.0002042
[t-SNE] Iteration 401: error = 0.7722216, gradient norm = 0.0001674
[t-SNE] Iteration 402: error = 0.7719898, gradient norm = 0.0001453
[t-SNE] Iteration 403: error = 0.7717637, gradient norm = 0.0001684
[t-SNE] Iteration 404: error = 0.7715397, gradient norm = 0.0001673
[t-SNE] Iteration 405: error = 0.7713176, gradient norm = 0.0001491
[t-SNE] Iteration 406: error = 0.7710982, gradient norm = 0.0001693
[t-SNE] Iteration 407: error = 0.7708795, gradient norm = 0.0001644
[t-SNE] Iteration 408: error = 0.7706621, gradient norm = 0.0001471
[t-SNE] Iteration 409: error = 0.7704469, gradient norm = 0.0001467
[t-SNE] Iteration 410: error = 0.7702335, gradient norm = 0.0001525
[t-SNE] Iteration 411: error = 0.7700210, gradient norm = 0.0001501
[t-SNE] Iteration 412: error = 0.7698095, gradient norm = 0.0001378
[t-SNE] Iteration 413: error = 0.7695991, gradient norm = 0.0001458
[t-SNE] Iteration 414: error = 0.7693876, gradient norm = 0.0001484
[t-SNE] Iteration 415: error = 0.7691731, gradient norm = 0.0001426
[t-SNE] Iteration 416: error = 0.7689557, gradient norm = 0.0001441
[t-SNE] Iteration 417: error = 0.7687409, gradient norm = 0.0001418
[t-SNE] Iteration 418: error = 0.7685332, gradient norm = 0.0001487
[t-SNE] Iteration 419: error = 0.7683282, gradient norm = 0.0001449
[t-SNE] Iteration 420: error = 0.7681240, gradient norm = 0.0001464
[t-SNE] Iteration 421: error = 0.7679204, gradient norm = 0.0001527
[t-SNE] Iteration 422: error = 0.7677159, gradient norm = 0.0001536
[t-SNE] Iteration 423: error = 0.7675113, gradient norm = 0.0001386
[t-SNE] Iteration 424: error = 0.7673090, gradient norm = 0.0001404
[t-SNE] Iteration 425: error = 0.7671083, gradient norm = 0.0001572
[t-SNE] Iteration 426: error = 0.7669080, gradient norm = 0.0001625
[t-SNE] Iteration 427: error = 0.7667097, gradient norm = 0.0001676
[t-SNE] Iteration 428: error = 0.7665132, gradient norm = 0.0001766
[t-SNE] Iteration 429: error = 0.7663135, gradient norm = 0.0001759
[t-SNE] Iteration 430: error = 0.7661107, gradient norm = 0.0001366
[t-SNE] Iteration 431: error = 0.7659166, gradient norm = 0.0001486
[t-SNE] Iteration 432: error = 0.7657226, gradient norm = 0.0001636
[t-SNE] Iteration 433: error = 0.7655261, gradient norm = 0.0001426
[t-SNE] Iteration 434: error = 0.7653369, gradient norm = 0.0001784
[t-SNE] Iteration 435: error = 0.7651460, gradient norm = 0.0002044
[t-SNE] Iteration 436: error = 0.7649581, gradient norm = 0.0002189
[t-SNE] Iteration 437: error = 0.7647678, gradient norm = 0.0001708
[t-SNE] Iteration 438: error = 0.7645820, gradient norm = 0.0001451
[t-SNE] Iteration 439: error = 0.7643991, gradient norm = 0.0001780
[t-SNE] Iteration 440: error = 0.7642171, gradient norm = 0.0001527
[t-SNE] Iteration 441: error = 0.7640363, gradient norm = 0.0001345
[t-SNE] Iteration 442: error = 0.7638596, gradient norm = 0.0001504
[t-SNE] Iteration 443: error = 0.7636834, gradient norm = 0.0001426
[t-SNE] Iteration 444: error = 0.7635097, gradient norm = 0.0001506
```

```
[t-SNE] Iteration 445: error = 0.7633369, gradient norm = 0.0001367
[t-SNE] Iteration 446: error = 0.7631669, gradient norm = 0.0001404
[t-SNE] Iteration 447: error = 0.7629991, gradient norm = 0.0001347
[t-SNE] Iteration 448: error = 0.7628330, gradient norm = 0.0001315
[t-SNE] Iteration 449: error = 0.7626699, gradient norm = 0.0001472
[t-SNE] Iteration 450: error = 0.7625080, gradient norm = 0.0001518
[t-SNE] Iteration 451: error = 0.7623475, gradient norm = 0.0001353
[t-SNE] Iteration 452: error = 0.7621893, gradient norm = 0.0001125
[t-SNE] Iteration 453: error = 0.7620342, gradient norm = 0.0001331
[t-SNE] Iteration 454: error = 0.7618803, gradient norm = 0.0001245
[t-SNE] Iteration 455: error = 0.7617283, gradient norm = 0.0001170
[t-SNE] Iteration 456: error = 0.7615785, gradient norm = 0.0001227
[t-SNE] Iteration 457: error = 0.7614301, gradient norm = 0.0001188
[t-SNE] Iteration 458: error = 0.7612834, gradient norm = 0.0001074
[t-SNE] Iteration 459: error = 0.7611386, gradient norm = 0.0001161
[t-SNE] Iteration 460: error = 0.7609949, gradient norm = 0.0001108
[t-SNE] Iteration 461: error = 0.7608525, gradient norm = 0.0001111
[t-SNE] Iteration 462: error = 0.7607112, gradient norm = 0.0001098
[t-SNE] Iteration 463: error = 0.7605706, gradient norm = 0.0001048
[t-SNE] Iteration 464: error = 0.7604313, gradient norm = 0.0001103
[t-SNE] Iteration 465: error = 0.7602924, gradient norm = 0.0001030
[t-SNE] Iteration 466: error = 0.7601546, gradient norm = 0.0001076
[t-SNE] Iteration 467: error = 0.7600175, gradient norm = 0.0001021
[t-SNE] Iteration 468: error = 0.7598814, gradient norm = 0.0000987
[t-SNE] Iteration 469: error = 0.7597462, gradient norm = 0.0001017
[t-SNE] Iteration 470: error = 0.7596116, gradient norm = 0.0001022
[t-SNE] Iteration 471: error = 0.7594778, gradient norm = 0.0001035
[t-SNE] Iteration 472: error = 0.7593448, gradient norm = 0.0001096
[t-SNE] Iteration 473: error = 0.7592122, gradient norm = 0.0001099
[t-SNE] Iteration 474: error = 0.7590800, gradient norm = 0.0001007
[t-SNE] Iteration 475: error = 0.7589486, gradient norm = 0.0000981
[t-SNE] Iteration 476: error = 0.7588182, gradient norm = 0.0001075
[t-SNE] Iteration 477: error = 0.7586882, gradient norm = 0.0001144
[t-SNE] Iteration 478: error = 0.7585588, gradient norm = 0.0001142
[t-SNE] Iteration 479: error = 0.7584303, gradient norm = 0.0001233
[t-SNE] Iteration 480: error = 0.7583030, gradient norm = 0.0001432
[t-SNE] Iteration 481: error = 0.7581762, gradient norm = 0.0001517
[t-SNE] Iteration 482: error = 0.7580486, gradient norm = 0.0001230
[t-SNE] Iteration 483: error = 0.7579221, gradient norm = 0.0000925
[t-SNE] Iteration 484: error = 0.7577980, gradient norm = 0.0001234
[t-SNE] Iteration 485: error = 0.7576733, gradient norm = 0.0001028
[t-SNE] Iteration 486: error = 0.7575498, gradient norm = 0.0001046
[t-SNE] Iteration 487: error = 0.7574267, gradient norm = 0.0001050
[t-SNE] Iteration 488: error = 0.7573043, gradient norm = 0.0001019
[t-SNE] Iteration 489: error = 0.7571827, gradient norm = 0.0001028
[t-SNE] Iteration 490: error = 0.7570615, gradient norm = 0.0000928
[t-SNE] Iteration 491: error = 0.7569414, gradient norm = 0.0001014
[t-SNE] Iteration 492: error = 0.7568218, gradient norm = 0.0001033
[t-SNE] Iteration 493: error = 0.7567023, gradient norm = 0.0000946
[t-SNE] Iteration 494: error = 0.7565834, gradient norm = 0.0000972
[t-SNE] Iteration 495: error = 0.7564645, gradient norm = 0.0000911
[t-SNE] Iteration 496: error = 0.7563466, gradient norm = 0.0000971
[t-SNE] Iteration 497: error = 0.7562287, gradient norm = 0.0000939
[t-SNE] Iteration 498: error = 0.7561114, gradient norm = 0.0001034
[t-SNE] Iteration 499: error = 0.7559945, gradient norm = 0.0001237
[t-SNE] Iteration 500: error = 0.7558783, gradient norm = 0.0001429
[t-SNE] Iteration 501: error = 0.7557618, gradient norm = 0.0001528
[t-SNE] Iteration 502: error = 0.7556455, gradient norm = 0.0001590
[t-SNE] Iteration 503: error = 0.7555287, gradient norm = 0.0001359
[t-SNE] Iteration 504: error = 0.7554123, gradient norm = 0.0001203
[t-SNE] Iteration 505: error = 0.7552972, gradient norm = 0.0001270
[t-SNE] Iteration 506: error = 0.7551821, gradient norm = 0.0001135
[t-SNE] Iteration 507: error = 0.7550677, gradient norm = 0.0001134
[t-SNE] Iteration 508: error = 0.7549538, gradient norm = 0.0001100
[t-SNE] Iteration 509: error = 0.7548406, gradient norm = 0.0001094
```

```
[t-SNE] Iteration 510: error = 0.7547277, gradient norm = 0.0001023
[t-SNE] Iteration 511: error = 0.7546155, gradient norm = 0.0001029
[t-SNE] Iteration 512: error = 0.7545036, gradient norm = 0.0001065
[t-SNE] Iteration 513: error = 0.7543917, gradient norm = 0.0000991
[t-SNE] Iteration 514: error = 0.7542800, gradient norm = 0.0000999
[t-SNE] Iteration 515: error = 0.7541684, gradient norm = 0.0001011
[t-SNE] Iteration 516: error = 0.7540564, gradient norm = 0.0000987
[t-SNE] Iteration 517: error = 0.7539447, gradient norm = 0.0001030
[t-SNE] Iteration 518: error = 0.7538325, gradient norm = 0.0000955
[t-SNE] Iteration 519: error = 0.7537205, gradient norm = 0.0001010
[t-SNE] Iteration 520: error = 0.7536083, gradient norm = 0.0001036
[t-SNE] Iteration 521: error = 0.7534961, gradient norm = 0.0001111
[t-SNE] Iteration 522: error = 0.7533835, gradient norm = 0.0001090
[t-SNE] Iteration 523: error = 0.7532715, gradient norm = 0.0001376
[t-SNE] Iteration 524: error = 0.7531617, gradient norm = 0.0002093
[t-SNE] Iteration 525: error = 0.7530531, gradient norm = 0.0002775
[t-SNE] Iteration 526: error = 0.7529388, gradient norm = 0.0002523
[t-SNE] Iteration 527: error = 0.7528209, gradient norm = 0.0001313
[t-SNE] Iteration 528: error = 0.7527105, gradient norm = 0.0001460
[t-SNE] Iteration 529: error = 0.7526022, gradient norm = 0.0001898
[t-SNE] Iteration 530: error = 0.7524905, gradient norm = 0.0000956
[t-SNE] Iteration 531: error = 0.7523855, gradient norm = 0.0001587
[t-SNE] Iteration 532: error = 0.7522776, gradient norm = 0.0001251
[t-SNE] Iteration 533: error = 0.7521723, gradient norm = 0.0001193
[t-SNE] Iteration 534: error = 0.7520683, gradient norm = 0.0001305
[t-SNE] Iteration 535: error = 0.7519642, gradient norm = 0.0001040
[t-SNE] Iteration 536: error = 0.7518622, gradient norm = 0.0001272
[t-SNE] Iteration 537: error = 0.7517599, gradient norm = 0.0001236
[t-SNE] Iteration 538: error = 0.7516582, gradient norm = 0.0001361
[t-SNE] Iteration 539: error = 0.7515551, gradient norm = 0.0001316
[t-SNE] Iteration 540: error = 0.7514491, gradient norm = 0.0000962
[t-SNE] Iteration 541: error = 0.7513468, gradient norm = 0.0001245
[t-SNE] Iteration 542: error = 0.7512455, gradient norm = 0.0001096
[t-SNE] Iteration 543: error = 0.7511431, gradient norm = 0.0001051
[t-SNE] Iteration 544: error = 0.7510449, gradient norm = 0.0001002
[t-SNE] Iteration 545: error = 0.7509473, gradient norm = 0.0001063
[t-SNE] Iteration 546: error = 0.7508504, gradient norm = 0.0000922
[t-SNE] Iteration 547: error = 0.7507561, gradient norm = 0.0001024
[t-SNE] Iteration 548: error = 0.7506610, gradient norm = 0.0000934
[t-SNE] Iteration 549: error = 0.7505662, gradient norm = 0.0000990
[t-SNE] Iteration 550: error = 0.7504720, gradient norm = 0.0000879
[t-SNE] Iteration 551: error = 0.7503786, gradient norm = 0.0000919
[t-SNE] Iteration 552: error = 0.7502851, gradient norm = 0.0000882
[t-SNE] Iteration 553: error = 0.7501919, gradient norm = 0.0000902
[t-SNE] Iteration 554: error = 0.7500991, gradient norm = 0.0000834
[t-SNE] Iteration 555: error = 0.7500070, gradient norm = 0.0000845
[t-SNE] Iteration 556: error = 0.7499153, gradient norm = 0.0000887
[t-SNE] Iteration 557: error = 0.7498235, gradient norm = 0.0000827
[t-SNE] Iteration 558: error = 0.7497321, gradient norm = 0.0000817
[t-SNE] Iteration 559: error = 0.7496410, gradient norm = 0.0000862
[t-SNE] Iteration 560: error = 0.7495502, gradient norm = 0.0000894
[t-SNE] Iteration 561: error = 0.7494597, gradient norm = 0.0000913
[t-SNE] Iteration 562: error = 0.7493693, gradient norm = 0.0000837
[t-SNE] Iteration 563: error = 0.7492795, gradient norm = 0.0000786
[t-SNE] Iteration 564: error = 0.7491900, gradient norm = 0.0000803
[t-SNE] Iteration 565: error = 0.7491007, gradient norm = 0.0000808
[t-SNE] Iteration 566: error = 0.7490114, gradient norm = 0.0000753
[t-SNE] Iteration 567: error = 0.7489224, gradient norm = 0.0000792
[t-SNE] Iteration 568: error = 0.7488338, gradient norm = 0.0000902
[t-SNE] Iteration 569: error = 0.7487461, gradient norm = 0.0001276
[t-SNE] Iteration 570: error = 0.7486597, gradient norm = 0.0001780
[t-SNE] Iteration 571: error = 0.7485723, gradient norm = 0.0002009
[t-SNE] Iteration 572: error = 0.7484816, gradient norm = 0.0001395
[t-SNE] Iteration 573: error = 0.7483925, gradient norm = 0.0000920
[t-SNE] Iteration 574: error = 0.7483070, gradient norm = 0.0001482
```

```
[t-SNE] Iteration 575: error = 0.7482194, gradient norm = 0.0001246
[t-SNE] Iteration 576: error = 0.7481318, gradient norm = 0.0000771
[t-SNE] Iteration 577: error = 0.7480471, gradient norm = 0.0001279
[t-SNE] Iteration 578: error = 0.7479606, gradient norm = 0.0000914
[t-SNE] Iteration 579: error = 0.7478753, gradient norm = 0.0000873
[t-SNE] Iteration 580: error = 0.7477909, gradient norm = 0.0001068
[t-SNE] Iteration 581: error = 0.7477058, gradient norm = 0.0000746
[t-SNE] Iteration 582: error = 0.7476223, gradient norm = 0.0000974
[t-SNE] Iteration 583: error = 0.7475383, gradient norm = 0.0000747
[t-SNE] Iteration 584: error = 0.7474555, gradient norm = 0.0000914
[t-SNE] Iteration 585: error = 0.7473726, gradient norm = 0.0000796
[t-SNE] Iteration 586: error = 0.7472902, gradient norm = 0.0000786
[t-SNE] Iteration 587: error = 0.7472084, gradient norm = 0.0000836
[t-SNE] Iteration 588: error = 0.7471268, gradient norm = 0.0000747
[t-SNE] Iteration 589: error = 0.7470459, gradient norm = 0.0000831
[t-SNE] Iteration 590: error = 0.7469651, gradient norm = 0.0000716
[t-SNE] Iteration 591: error = 0.7468849, gradient norm = 0.0000777
[t-SNE] Iteration 592: error = 0.7468048, gradient norm = 0.0000715
[t-SNE] Iteration 593: error = 0.7467253, gradient norm = 0.0000755
[t-SNE] Iteration 594: error = 0.7466460, gradient norm = 0.0000724
[t-SNE] Iteration 595: error = 0.7465671, gradient norm = 0.0000759
[t-SNE] Iteration 596: error = 0.7464883, gradient norm = 0.0000726
[t-SNE] Iteration 597: error = 0.7464099, gradient norm = 0.0000735
[t-SNE] Iteration 598: error = 0.7463317, gradient norm = 0.0000766
[t-SNE] Iteration 599: error = 0.7462539, gradient norm = 0.0000779
[t-SNE] Iteration 600: error = 0.7461760, gradient norm = 0.0000729
[t-SNE] Iteration 601: error = 0.7460984, gradient norm = 0.0000733
[t-SNE] Iteration 602: error = 0.7460211, gradient norm = 0.0000735
[t-SNE] Iteration 603: error = 0.7459440, gradient norm = 0.0000733
[t-SNE] Iteration 604: error = 0.7458671, gradient norm = 0.0000704
[t-SNE] Iteration 605: error = 0.7457904, gradient norm = 0.0000715
[t-SNE] Iteration 606: error = 0.7457139, gradient norm = 0.0000736
[t-SNE] Iteration 607: error = 0.7456375, gradient norm = 0.0000710
[t-SNE] Iteration 608: error = 0.7455613, gradient norm = 0.0000698
[t-SNE] Iteration 609: error = 0.7454854, gradient norm = 0.0000721
[t-SNE] Iteration 610: error = 0.7454099, gradient norm = 0.0000781
[t-SNE] Iteration 611: error = 0.7453346, gradient norm = 0.0000900
[t-SNE] Iteration 612: error = 0.7452594, gradient norm = 0.0000927
[t-SNE] Iteration 613: error = 0.7451841, gradient norm = 0.0000801
[t-SNE] Iteration 614: error = 0.7451091, gradient norm = 0.0000674
[t-SNE] Iteration 615: error = 0.7450349, gradient norm = 0.0000809
[t-SNE] Iteration 616: error = 0.7449608, gradient norm = 0.0000799
[t-SNE] Iteration 617: error = 0.7448868, gradient norm = 0.0000659
[t-SNE] Iteration 618: error = 0.7448138, gradient norm = 0.0000775
[t-SNE] Iteration 619: error = 0.7447407, gradient norm = 0.0000738
[t-SNE] Iteration 620: error = 0.7446679, gradient norm = 0.0000682
[t-SNE] Iteration 621: error = 0.7445956, gradient norm = 0.0000748
[t-SNE] Iteration 622: error = 0.7445233, gradient norm = 0.0000683
[t-SNE] Iteration 623: error = 0.7444515, gradient norm = 0.0000741
[t-SNE] Iteration 624: error = 0.7443797, gradient norm = 0.0000673
[t-SNE] Iteration 625: error = 0.7443082, gradient norm = 0.0000663
[t-SNE] Iteration 626: error = 0.7442369, gradient norm = 0.0000703
[t-SNE] Iteration 627: error = 0.7441656, gradient norm = 0.0000674
[t-SNE] Iteration 628: error = 0.7440946, gradient norm = 0.0000716
[t-SNE] Iteration 629: error = 0.7440236, gradient norm = 0.0000666
[t-SNE] Iteration 630: error = 0.7439528, gradient norm = 0.0000642
[t-SNE] Iteration 631: error = 0.7438822, gradient norm = 0.0000659
[t-SNE] Iteration 632: error = 0.7438117, gradient norm = 0.0000665
[t-SNE] Iteration 633: error = 0.7437414, gradient norm = 0.0000674
[t-SNE] Iteration 634: error = 0.7436712, gradient norm = 0.0000659
[t-SNE] Iteration 635: error = 0.7436013, gradient norm = 0.0000695
[t-SNE] Iteration 636: error = 0.7435315, gradient norm = 0.0000725
[t-SNE] Iteration 637: error = 0.7434616, gradient norm = 0.0000703
[t-SNE] Iteration 638: error = 0.7433919, gradient norm = 0.0000697
[t-SNE] Iteration 639: error = 0.7433224, gradient norm = 0.0000731
```

```
[t-SNE] Iteration 640: error = 0.7432529, gradient norm = 0.0000671
[t-SNE] Iteration 641: error = 0.7431836, gradient norm = 0.0000633
[t-SNE] Iteration 642: error = 0.7431146, gradient norm = 0.0000680
[t-SNE] Iteration 643: error = 0.7430456, gradient norm = 0.0000709
[t-SNE] Iteration 644: error = 0.7429769, gradient norm = 0.0000666
[t-SNE] Iteration 645: error = 0.7429083, gradient norm = 0.0000672
[t-SNE] Iteration 646: error = 0.7428401, gradient norm = 0.0000668
[t-SNE] Iteration 647: error = 0.7427721, gradient norm = 0.0000657
[t-SNE] Iteration 648: error = 0.7427043, gradient norm = 0.0000636
[t-SNE] Iteration 649: error = 0.7426370, gradient norm = 0.0000684
[t-SNE] Iteration 650: error = 0.7425698, gradient norm = 0.0000687
[t-SNE] Iteration 651: error = 0.7425028, gradient norm = 0.0000622
[t-SNE] Iteration 652: error = 0.7424361, gradient norm = 0.0000617
[t-SNE] Iteration 653: error = 0.7423697, gradient norm = 0.0000650
[t-SNE] Iteration 654: error = 0.7423033, gradient norm = 0.0000672
[t-SNE] Iteration 655: error = 0.7422370, gradient norm = 0.0000628
[t-SNE] Iteration 656: error = 0.7421709, gradient norm = 0.0000613
[t-SNE] Iteration 657: error = 0.7421049, gradient norm = 0.0000612
[t-SNE] Iteration 658: error = 0.7420390, gradient norm = 0.0000611
[t-SNE] Iteration 659: error = 0.7419732, gradient norm = 0.0000609
[t-SNE] Iteration 660: error = 0.7419075, gradient norm = 0.0000616
[t-SNE] Iteration 661: error = 0.7418420, gradient norm = 0.0000699
[t-SNE] Iteration 662: error = 0.7417769, gradient norm = 0.0000864
[t-SNE] Iteration 663: error = 0.7417118, gradient norm = 0.0001051
[t-SNE] Iteration 664: error = 0.7416462, gradient norm = 0.0000958
[t-SNE] Iteration 665: error = 0.7415803, gradient norm = 0.0000643
[t-SNE] Iteration 666: error = 0.7415153, gradient norm = 0.0000713
[t-SNE] Iteration 667: error = 0.7414506, gradient norm = 0.0000811
[t-SNE] Iteration 668: error = 0.7413856, gradient norm = 0.0000627
[t-SNE] Iteration 669: error = 0.7413213, gradient norm = 0.0000747
[t-SNE] Iteration 670: error = 0.7412568, gradient norm = 0.0000641
[t-SNE] Iteration 671: error = 0.7411928, gradient norm = 0.0000677
[t-SNE] Iteration 672: error = 0.7411291, gradient norm = 0.0000682
[t-SNE] Iteration 673: error = 0.7410655, gradient norm = 0.0000631
[t-SNE] Iteration 674: error = 0.7410023, gradient norm = 0.0000639
[t-SNE] Iteration 675: error = 0.7409393, gradient norm = 0.0000630
[t-SNE] Iteration 676: error = 0.7408765, gradient norm = 0.0000647
[t-SNE] Iteration 677: error = 0.7408140, gradient norm = 0.0000691
[t-SNE] Iteration 678: error = 0.7407515, gradient norm = 0.0000624
[t-SNE] Iteration 679: error = 0.7406894, gradient norm = 0.0000636
[t-SNE] Iteration 680: error = 0.7406275, gradient norm = 0.0000628
[t-SNE] Iteration 681: error = 0.7405657, gradient norm = 0.0000694
[t-SNE] Iteration 682: error = 0.7405037, gradient norm = 0.0000623
[t-SNE] Iteration 683: error = 0.7404422, gradient norm = 0.0000637
[t-SNE] Iteration 684: error = 0.7403810, gradient norm = 0.0000618
[t-SNE] Iteration 685: error = 0.7403198, gradient norm = 0.0000603
[t-SNE] Iteration 686: error = 0.7402589, gradient norm = 0.0000612
[t-SNE] Iteration 687: error = 0.7401980, gradient norm = 0.0000600
[t-SNE] Iteration 688: error = 0.7401372, gradient norm = 0.0000601
[t-SNE] Iteration 689: error = 0.7400765, gradient norm = 0.0000597
[t-SNE] Iteration 690: error = 0.7400158, gradient norm = 0.0000581
[t-SNE] Iteration 691: error = 0.7399553, gradient norm = 0.0000601
[t-SNE] Iteration 692: error = 0.7398948, gradient norm = 0.0000606
[t-SNE] Iteration 693: error = 0.7398343, gradient norm = 0.0000613
[t-SNE] Iteration 694: error = 0.7397737, gradient norm = 0.0000606
[t-SNE] Iteration 695: error = 0.7397133, gradient norm = 0.0000583
[t-SNE] Iteration 696: error = 0.7396530, gradient norm = 0.0000582
[t-SNE] Iteration 697: error = 0.7395928, gradient norm = 0.0000587
[t-SNE] Iteration 698: error = 0.7395326, gradient norm = 0.0000591
[t-SNE] Iteration 699: error = 0.7394726, gradient norm = 0.0000610
[t-SNE] Iteration 700: error = 0.7394128, gradient norm = 0.0000705
[t-SNE] Iteration 701: error = 0.7393534, gradient norm = 0.0001024
[t-SNE] Iteration 702: error = 0.7392948, gradient norm = 0.0001391
[t-SNE] Iteration 703: error = 0.7392352, gradient norm = 0.0001477
[t-SNE] Iteration 704: error = 0.7391737, gradient norm = 0.0000903
```

```
[t-SNE] Iteration 705: error = 0.7391135, gradient norm = 0.0000627
[t-SNE] Iteration 706: error = 0.7390552, gradient norm = 0.0001090
[t-SNE] Iteration 707: error = 0.7389951, gradient norm = 0.0000629
[t-SNE] Iteration 708: error = 0.7389364, gradient norm = 0.0000771
[t-SNE] Iteration 709: error = 0.7388776, gradient norm = 0.0000792
[t-SNE] Iteration 710: error = 0.7388189, gradient norm = 0.0000710
[t-SNE] Iteration 711: error = 0.7387605, gradient norm = 0.0000699
[t-SNE] Iteration 712: error = 0.7387022, gradient norm = 0.0000656
[t-SNE] Iteration 713: error = 0.7386442, gradient norm = 0.0000678
[t-SNE] Iteration 714: error = 0.7385865, gradient norm = 0.0000712
[t-SNE] Iteration 715: error = 0.7385287, gradient norm = 0.0000583
[t-SNE] Iteration 716: error = 0.7384715, gradient norm = 0.0000695
[t-SNE] Iteration 717: error = 0.7384140, gradient norm = 0.0000570
[t-SNE] Iteration 718: error = 0.7383571, gradient norm = 0.0000661
[t-SNE] Iteration 719: error = 0.7383002, gradient norm = 0.0000580
[t-SNE] Iteration 720: error = 0.7382436, gradient norm = 0.0000630
[t-SNE] Iteration 721: error = 0.7381869, gradient norm = 0.0000586
[t-SNE] Iteration 722: error = 0.7381307, gradient norm = 0.0000627
[t-SNE] Iteration 723: error = 0.7380744, gradient norm = 0.0000584
[t-SNE] Iteration 724: error = 0.7380184, gradient norm = 0.0000610
[t-SNE] Iteration 725: error = 0.7379623, gradient norm = 0.0000574
[t-SNE] Iteration 726: error = 0.7379063, gradient norm = 0.0000591
[t-SNE] Iteration 727: error = 0.7378503, gradient norm = 0.0000580
[t-SNE] Iteration 728: error = 0.7377944, gradient norm = 0.0000606
[t-SNE] Iteration 729: error = 0.7377385, gradient norm = 0.0000593
[t-SNE] Iteration 730: error = 0.7376825, gradient norm = 0.0000560
[t-SNE] Iteration 731: error = 0.7376265, gradient norm = 0.0000559
[t-SNE] Iteration 732: error = 0.7375704, gradient norm = 0.0000581
[t-SNE] Iteration 733: error = 0.7375143, gradient norm = 0.0000558
[t-SNE] Iteration 734: error = 0.7374582, gradient norm = 0.0000541
[t-SNE] Iteration 735: error = 0.7374021, gradient norm = 0.0000563
[t-SNE] Iteration 736: error = 0.7373460, gradient norm = 0.0000559
[t-SNE] Iteration 737: error = 0.7372898, gradient norm = 0.0000577
[t-SNE] Iteration 738: error = 0.7372336, gradient norm = 0.0000612
[t-SNE] Iteration 739: error = 0.7371775, gradient norm = 0.0000664
[t-SNE] Iteration 740: error = 0.7371215, gradient norm = 0.0000793
[t-SNE] Iteration 741: error = 0.7370655, gradient norm = 0.0000820
[t-SNE] Iteration 742: error = 0.7370094, gradient norm = 0.0000702
[t-SNE] Iteration 743: error = 0.7369536, gradient norm = 0.0000563
[t-SNE] Iteration 744: error = 0.7368984, gradient norm = 0.0000665
[t-SNE] Iteration 745: error = 0.7368433, gradient norm = 0.0000671
[t-SNE] Iteration 746: error = 0.7367882, gradient norm = 0.0000547
[t-SNE] Iteration 747: error = 0.7367336, gradient norm = 0.0000643
[t-SNE] Iteration 748: error = 0.7366790, gradient norm = 0.0000622
[t-SNE] Iteration 749: error = 0.7366245, gradient norm = 0.0000573
[t-SNE] Iteration 750: error = 0.7365703, gradient norm = 0.0000632
[t-SNE] Iteration 751: error = 0.7365159, gradient norm = 0.0000556
[t-SNE] Iteration 752: error = 0.7364619, gradient norm = 0.0000599
[t-SNE] Iteration 753: error = 0.7364078, gradient norm = 0.0000577
[t-SNE] Iteration 754: error = 0.7363539, gradient norm = 0.0000544
[t-SNE] Iteration 755: error = 0.7363001, gradient norm = 0.0000586
[t-SNE] Iteration 756: error = 0.7362463, gradient norm = 0.0000540
[t-SNE] Iteration 757: error = 0.7361927, gradient norm = 0.0000566
[t-SNE] Iteration 758: error = 0.7361391, gradient norm = 0.0000550
[t-SNE] Iteration 759: error = 0.7360857, gradient norm = 0.0000574
[t-SNE] Iteration 760: error = 0.7360322, gradient norm = 0.0000556
[t-SNE] Iteration 761: error = 0.7359788, gradient norm = 0.0000536
[t-SNE] Iteration 762: error = 0.7359255, gradient norm = 0.0000550
[t-SNE] Iteration 763: error = 0.7358722, gradient norm = 0.0000537
[t-SNE] Iteration 764: error = 0.7358190, gradient norm = 0.0000546
[t-SNE] Iteration 765: error = 0.7357658, gradient norm = 0.0000561
[t-SNE] Iteration 766: error = 0.7357125, gradient norm = 0.0000547
[t-SNE] Iteration 767: error = 0.7356593, gradient norm = 0.0000565
[t-SNE] Iteration 768: error = 0.7356062, gradient norm = 0.0000580
[t-SNE] Iteration 769: error = 0.7355529, gradient norm = 0.0000597
```

```
[t-SNE] Iteration 770: error = 0.7354997, gradient norm = 0.0000580
[t-SNE] Iteration 771: error = 0.7354467, gradient norm = 0.0000638
[t-SNE] Iteration 772: error = 0.7353937, gradient norm = 0.0000630
[t-SNE] Iteration 773: error = 0.7353407, gradient norm = 0.0000565
[t-SNE] Iteration 774: error = 0.7352879, gradient norm = 0.0000552
[t-SNE] Iteration 775: error = 0.7352353, gradient norm = 0.0000582
[t-SNE] Iteration 776: error = 0.7351827, gradient norm = 0.0000579
[t-SNE] Iteration 777: error = 0.7351302, gradient norm = 0.0000547
[t-SNE] Iteration 778: error = 0.7350778, gradient norm = 0.0000563
[t-SNE] Iteration 779: error = 0.7350255, gradient norm = 0.0000553
[t-SNE] Iteration 780: error = 0.7349735, gradient norm = 0.0000585
[t-SNE] Iteration 781: error = 0.7349214, gradient norm = 0.0000594
[t-SNE] Iteration 782: error = 0.7348693, gradient norm = 0.0000568
[t-SNE] Iteration 783: error = 0.7348174, gradient norm = 0.0000542
[t-SNE] Iteration 784: error = 0.7347655, gradient norm = 0.0000528
[t-SNE] Iteration 785: error = 0.7347138, gradient norm = 0.0000547
[t-SNE] Iteration 786: error = 0.7346623, gradient norm = 0.0000566
[t-SNE] Iteration 787: error = 0.7346107, gradient norm = 0.0000567
[t-SNE] Iteration 788: error = 0.7345593, gradient norm = 0.0000550
[t-SNE] Iteration 789: error = 0.7345080, gradient norm = 0.0000540
[t-SNE] Iteration 790: error = 0.7344568, gradient norm = 0.0000541
[t-SNE] Iteration 791: error = 0.7344057, gradient norm = 0.0000569
[t-SNE] Iteration 792: error = 0.7343546, gradient norm = 0.0000584
[t-SNE] Iteration 793: error = 0.7343037, gradient norm = 0.0000587
[t-SNE] Iteration 794: error = 0.7342528, gradient norm = 0.0000568
[t-SNE] Iteration 795: error = 0.7342020, gradient norm = 0.0000568
[t-SNE] Iteration 796: error = 0.7341513, gradient norm = 0.0000572
[t-SNE] Iteration 797: error = 0.7341006, gradient norm = 0.0000606
[t-SNE] Iteration 798: error = 0.7340500, gradient norm = 0.0000593
[t-SNE] Iteration 799: error = 0.7339994, gradient norm = 0.0000527
[t-SNE] Iteration 800: error = 0.7339492, gradient norm = 0.0000554
[t-SNE] Iteration 801: error = 0.7338990, gradient norm = 0.0000573
[t-SNE] Iteration 802: error = 0.7338488, gradient norm = 0.0000584
[t-SNE] Iteration 803: error = 0.7337987, gradient norm = 0.0000552
[t-SNE] Iteration 804: error = 0.7337486, gradient norm = 0.0000536
[t-SNE] Iteration 805: error = 0.7336987, gradient norm = 0.0000556
[t-SNE] Iteration 806: error = 0.7336488, gradient norm = 0.0000562
[t-SNE] Iteration 807: error = 0.7335988, gradient norm = 0.0000582
[t-SNE] Iteration 808: error = 0.7335489, gradient norm = 0.0000610
[t-SNE] Iteration 809: error = 0.7334989, gradient norm = 0.0000550
[t-SNE] Iteration 810: error = 0.7334490, gradient norm = 0.0000516
[t-SNE] Iteration 811: error = 0.7333991, gradient norm = 0.0000525
[t-SNE] Iteration 812: error = 0.7333493, gradient norm = 0.0000556
[t-SNE] Iteration 813: error = 0.7332994, gradient norm = 0.0000582
[t-SNE] Iteration 814: error = 0.7332495, gradient norm = 0.0000528
[t-SNE] Iteration 815: error = 0.7331997, gradient norm = 0.0000523
[t-SNE] Iteration 816: error = 0.7331499, gradient norm = 0.0000547
[t-SNE] Iteration 817: error = 0.7331001, gradient norm = 0.0000550
[t-SNE] Iteration 818: error = 0.7330505, gradient norm = 0.0000512
[t-SNE] Iteration 819: error = 0.7330010, gradient norm = 0.0000518
[t-SNE] Iteration 820: error = 0.7329516, gradient norm = 0.0000540
[t-SNE] Iteration 821: error = 0.7329022, gradient norm = 0.0000544
[t-SNE] Iteration 822: error = 0.7328529, gradient norm = 0.0000531
[t-SNE] Iteration 823: error = 0.7328038, gradient norm = 0.0000551
[t-SNE] Iteration 824: error = 0.7327547, gradient norm = 0.0000555
[t-SNE] Iteration 825: error = 0.7327057, gradient norm = 0.0000542
[t-SNE] Iteration 826: error = 0.7326568, gradient norm = 0.0000533
[t-SNE] Iteration 827: error = 0.7326080, gradient norm = 0.0000535
[t-SNE] Iteration 828: error = 0.7325593, gradient norm = 0.0000548
[t-SNE] Iteration 829: error = 0.7325106, gradient norm = 0.0000542
[t-SNE] Iteration 830: error = 0.7324620, gradient norm = 0.0000555
[t-SNE] Iteration 831: error = 0.7324134, gradient norm = 0.0000546
[t-SNE] Iteration 832: error = 0.7323648, gradient norm = 0.0000522
[t-SNE] Iteration 833: error = 0.7323164, gradient norm = 0.0000522
[t-SNE] Iteration 834: error = 0.7322680, gradient norm = 0.0000556
```

```
[t-SNE] Iteration 835: error = 0.7322196, gradient norm = 0.0000560
[t-SNE] Iteration 836: error = 0.7321711, gradient norm = 0.0000519
[t-SNE] Iteration 837: error = 0.7321228, gradient norm = 0.0000505
[t-SNE] Iteration 838: error = 0.7320746, gradient norm = 0.0000527
[t-SNE] Iteration 839: error = 0.7320264, gradient norm = 0.0000536
[t-SNE] Iteration 840: error = 0.7319781, gradient norm = 0.0000525
[t-SNE] Iteration 841: error = 0.7319299, gradient norm = 0.0000506
[t-SNE] Iteration 842: error = 0.7318817, gradient norm = 0.0000511
[t-SNE] Iteration 843: error = 0.7318336, gradient norm = 0.0000532
[t-SNE] Iteration 844: error = 0.7317853, gradient norm = 0.0000537
[t-SNE] Iteration 845: error = 0.7317370, gradient norm = 0.0000497
[t-SNE] Iteration 846: error = 0.7316888, gradient norm = 0.0000511
[t-SNE] Iteration 847: error = 0.7316405, gradient norm = 0.0000522
[t-SNE] Iteration 848: error = 0.7315921, gradient norm = 0.0000528
[t-SNE] Iteration 849: error = 0.7315437, gradient norm = 0.0000514
[t-SNE] Iteration 850: error = 0.7314953, gradient norm = 0.0000496
[t-SNE] Iteration 851: error = 0.7314470, gradient norm = 0.0000514
[t-SNE] Iteration 852: error = 0.7313987, gradient norm = 0.0000547
[t-SNE] Iteration 853: error = 0.7313503, gradient norm = 0.0000569
[t-SNE] Iteration 854: error = 0.7313019, gradient norm = 0.0000530
[t-SNE] Iteration 855: error = 0.7312535, gradient norm = 0.0000506
[t-SNE] Iteration 856: error = 0.7312053, gradient norm = 0.0000535
[t-SNE] Iteration 857: error = 0.7311570, gradient norm = 0.0000533
[t-SNE] Iteration 858: error = 0.7311087, gradient norm = 0.0000532
[t-SNE] Iteration 859: error = 0.7310604, gradient norm = 0.0000517
[t-SNE] Iteration 860: error = 0.7310122, gradient norm = 0.0000553
[t-SNE] Iteration 861: error = 0.7309640, gradient norm = 0.0000572
[t-SNE] Iteration 862: error = 0.7309156, gradient norm = 0.0000542
[t-SNE] Iteration 863: error = 0.7308673, gradient norm = 0.0000507
[t-SNE] Iteration 864: error = 0.7308191, gradient norm = 0.0000526
[t-SNE] Iteration 865: error = 0.7307710, gradient norm = 0.0000529
[t-SNE] Iteration 866: error = 0.7307228, gradient norm = 0.0000507
[t-SNE] Iteration 867: error = 0.7306746, gradient norm = 0.0000528
[t-SNE] Iteration 868: error = 0.7306264, gradient norm = 0.0000497
[t-SNE] Iteration 869: error = 0.7305782, gradient norm = 0.0000503
[t-SNE] Iteration 870: error = 0.7305300, gradient norm = 0.0000519
[t-SNE] Iteration 871: error = 0.7304817, gradient norm = 0.0000512
[t-SNE] Iteration 872: error = 0.7304334, gradient norm = 0.0000540
[t-SNE] Iteration 873: error = 0.7303852, gradient norm = 0.0000662
[t-SNE] Iteration 874: error = 0.7303369, gradient norm = 0.0000765
[t-SNE] Iteration 875: error = 0.7302883, gradient norm = 0.0000716
[t-SNE] Iteration 876: error = 0.7302394, gradient norm = 0.0000516
[t-SNE] Iteration 877: error = 0.7301910, gradient norm = 0.0000554
[t-SNE] Iteration 878: error = 0.7301427, gradient norm = 0.0000637
[t-SNE] Iteration 879: error = 0.7300941, gradient norm = 0.0000510
[t-SNE] Iteration 880: error = 0.7300457, gradient norm = 0.0000546
[t-SNE] Iteration 881: error = 0.7299973, gradient norm = 0.0000608
[t-SNE] Iteration 882: error = 0.7299487, gradient norm = 0.0000537
[t-SNE] Iteration 883: error = 0.7299003, gradient norm = 0.0000576
[t-SNE] Iteration 884: error = 0.7298516, gradient norm = 0.0000532
[t-SNE] Iteration 885: error = 0.7298030, gradient norm = 0.0000541
[t-SNE] Iteration 886: error = 0.7297543, gradient norm = 0.0000550
[t-SNE] Iteration 887: error = 0.7297056, gradient norm = 0.0000505
[t-SNE] Iteration 888: error = 0.7296570, gradient norm = 0.0000561
[t-SNE] Iteration 889: error = 0.7296083, gradient norm = 0.0000545
[t-SNE] Iteration 890: error = 0.7295597, gradient norm = 0.0000620
[t-SNE] Iteration 891: error = 0.7295110, gradient norm = 0.0000651
[t-SNE] Iteration 892: error = 0.7294621, gradient norm = 0.0000574
[t-SNE] Iteration 893: error = 0.7294133, gradient norm = 0.0000524
[t-SNE] Iteration 894: error = 0.7293644, gradient norm = 0.0000555
[t-SNE] Iteration 895: error = 0.7293154, gradient norm = 0.0000555
[t-SNE] Iteration 896: error = 0.7292664, gradient norm = 0.0000527
[t-SNE] Iteration 897: error = 0.7292172, gradient norm = 0.0000552
[t-SNE] Iteration 898: error = 0.7291679, gradient norm = 0.0000540
[t-SNE] Iteration 899: error = 0.7291186, gradient norm = 0.0000539
```

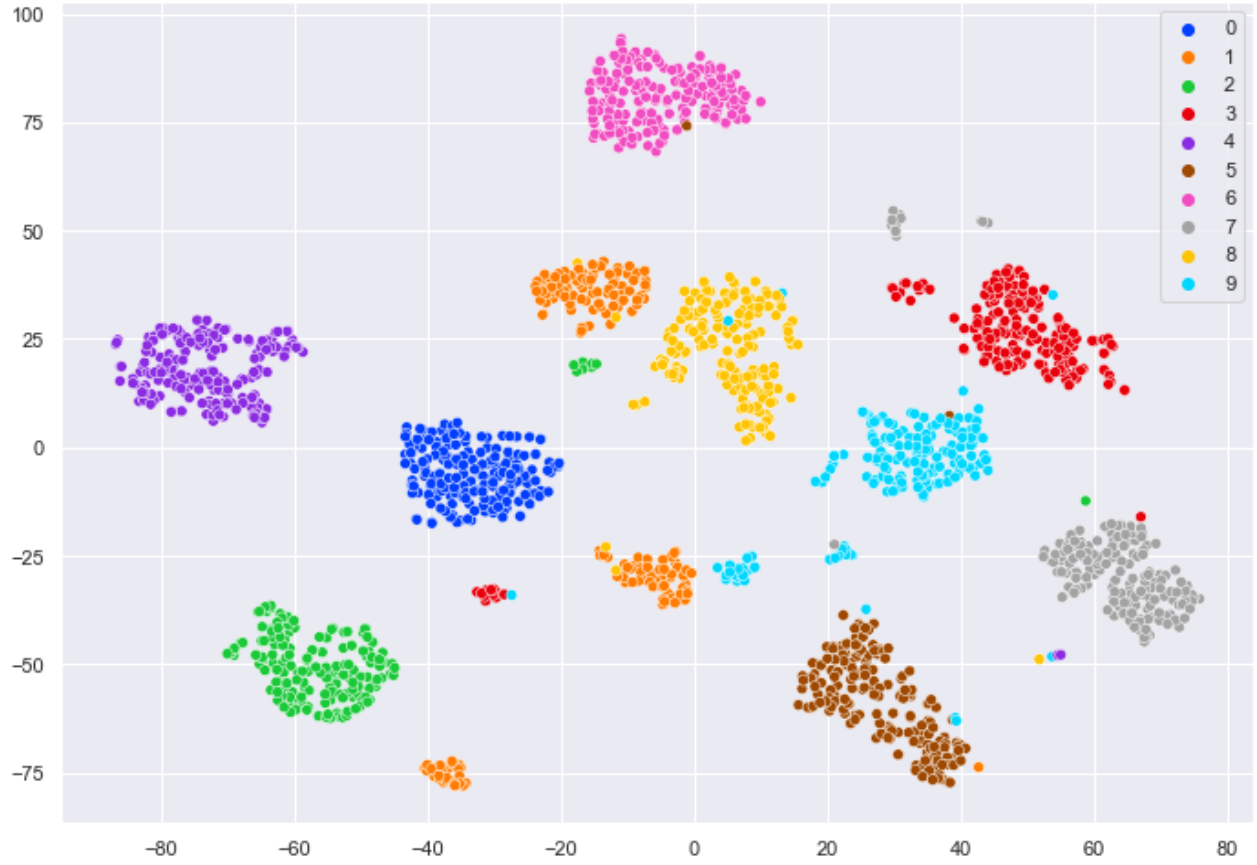
```
[t-SNE] Iteration 900: error = 0.7290692, gradient norm = 0.0000560
[t-SNE] Iteration 901: error = 0.7290196, gradient norm = 0.0000542
[t-SNE] Iteration 902: error = 0.7289701, gradient norm = 0.0000573
[t-SNE] Iteration 903: error = 0.7289205, gradient norm = 0.0000593
[t-SNE] Iteration 904: error = 0.7288708, gradient norm = 0.0000641
[t-SNE] Iteration 905: error = 0.7288210, gradient norm = 0.0000593
[t-SNE] Iteration 906: error = 0.7287713, gradient norm = 0.0000546
[t-SNE] Iteration 907: error = 0.7287218, gradient norm = 0.0000558
[t-SNE] Iteration 908: error = 0.7286723, gradient norm = 0.0000562
[t-SNE] Iteration 909: error = 0.7286227, gradient norm = 0.0000550
[t-SNE] Iteration 910: error = 0.7285732, gradient norm = 0.0000530
[t-SNE] Iteration 911: error = 0.7285237, gradient norm = 0.0000568
[t-SNE] Iteration 912: error = 0.7284742, gradient norm = 0.0000546
[t-SNE] Iteration 913: error = 0.7284245, gradient norm = 0.0000529
[t-SNE] Iteration 914: error = 0.7283749, gradient norm = 0.0000534
[t-SNE] Iteration 915: error = 0.7283252, gradient norm = 0.0000530
[t-SNE] Iteration 916: error = 0.7282754, gradient norm = 0.0000529
[t-SNE] Iteration 917: error = 0.7282256, gradient norm = 0.0000526
[t-SNE] Iteration 918: error = 0.7281756, gradient norm = 0.0000576
[t-SNE] Iteration 919: error = 0.7281256, gradient norm = 0.0000575
[t-SNE] Iteration 920: error = 0.7280753, gradient norm = 0.0000554
[t-SNE] Iteration 921: error = 0.7280249, gradient norm = 0.0000522
[t-SNE] Iteration 922: error = 0.7279744, gradient norm = 0.0000555
[t-SNE] Iteration 923: error = 0.7279239, gradient norm = 0.0000604
[t-SNE] Iteration 924: error = 0.7278731, gradient norm = 0.0000571
[t-SNE] Iteration 925: error = 0.7278222, gradient norm = 0.0000578
[t-SNE] Iteration 926: error = 0.7277711, gradient norm = 0.0000539
[t-SNE] Iteration 927: error = 0.7277202, gradient norm = 0.0000544
[t-SNE] Iteration 928: error = 0.7276694, gradient norm = 0.0000581
[t-SNE] Iteration 929: error = 0.7276184, gradient norm = 0.0000556
[t-SNE] Iteration 930: error = 0.7275675, gradient norm = 0.0000548
[t-SNE] Iteration 931: error = 0.7275167, gradient norm = 0.0000556
[t-SNE] Iteration 932: error = 0.7274659, gradient norm = 0.0000542
[t-SNE] Iteration 933: error = 0.7274152, gradient norm = 0.0000526
[t-SNE] Iteration 934: error = 0.7273647, gradient norm = 0.0000546
[t-SNE] Iteration 935: error = 0.7273143, gradient norm = 0.0000571
[t-SNE] Iteration 936: error = 0.7272638, gradient norm = 0.0000555
[t-SNE] Iteration 937: error = 0.7272134, gradient norm = 0.0000554
[t-SNE] Iteration 938: error = 0.7271629, gradient norm = 0.0000540
[t-SNE] Iteration 939: error = 0.7271127, gradient norm = 0.0000536
[t-SNE] Iteration 940: error = 0.7270627, gradient norm = 0.0000557
[t-SNE] Iteration 941: error = 0.7270128, gradient norm = 0.0000583
[t-SNE] Iteration 942: error = 0.7269630, gradient norm = 0.0000657
[t-SNE] Iteration 943: error = 0.7269134, gradient norm = 0.0000692
[t-SNE] Iteration 944: error = 0.7268638, gradient norm = 0.0000702
[t-SNE] Iteration 945: error = 0.7268143, gradient norm = 0.0000653
[t-SNE] Iteration 946: error = 0.7267650, gradient norm = 0.0000593
[t-SNE] Iteration 947: error = 0.7267158, gradient norm = 0.0000594
[t-SNE] Iteration 948: error = 0.7266668, gradient norm = 0.0000611
[t-SNE] Iteration 949: error = 0.7266179, gradient norm = 0.0000565
[t-SNE] Iteration 950: error = 0.7265691, gradient norm = 0.0000565
[t-SNE] Iteration 951: error = 0.7265205, gradient norm = 0.0000556
[t-SNE] Iteration 952: error = 0.7264720, gradient norm = 0.0000574
[t-SNE] Iteration 953: error = 0.7264235, gradient norm = 0.0000600
[t-SNE] Iteration 954: error = 0.7263751, gradient norm = 0.0000619
[t-SNE] Iteration 955: error = 0.7263268, gradient norm = 0.0000626
[t-SNE] Iteration 956: error = 0.7262785, gradient norm = 0.0000570
[t-SNE] Iteration 957: error = 0.7262303, gradient norm = 0.0000533
[t-SNE] Iteration 958: error = 0.7261822, gradient norm = 0.0000562
[t-SNE] Iteration 959: error = 0.7261341, gradient norm = 0.0000544
[t-SNE] Iteration 960: error = 0.7260861, gradient norm = 0.0000509
[t-SNE] Iteration 961: error = 0.7260381, gradient norm = 0.0000540
[t-SNE] Iteration 962: error = 0.7259901, gradient norm = 0.0000519
[t-SNE] Iteration 963: error = 0.7259421, gradient norm = 0.0000548
[t-SNE] Iteration 964: error = 0.7258939, gradient norm = 0.0000562
```

```
[t-SNE] Iteration 965: error = 0.7258457, gradient norm = 0.0000583
[t-SNE] Iteration 966: error = 0.7257975, gradient norm = 0.0000594
[t-SNE] Iteration 967: error = 0.7257493, gradient norm = 0.0000653
[t-SNE] Iteration 968: error = 0.7257011, gradient norm = 0.0000689
[t-SNE] Iteration 969: error = 0.7256527, gradient norm = 0.0000611
[t-SNE] Iteration 970: error = 0.7256044, gradient norm = 0.0000531
[t-SNE] Iteration 971: error = 0.7255565, gradient norm = 0.0000619
[t-SNE] Iteration 972: error = 0.7255083, gradient norm = 0.0000580
[t-SNE] Iteration 973: error = 0.7254603, gradient norm = 0.0000527
[t-SNE] Iteration 974: error = 0.7254125, gradient norm = 0.0000584
[t-SNE] Iteration 975: error = 0.7253646, gradient norm = 0.0000551
[t-SNE] Iteration 976: error = 0.7253168, gradient norm = 0.0000538
[t-SNE] Iteration 977: error = 0.7252693, gradient norm = 0.0000613
[t-SNE] Iteration 978: error = 0.7252217, gradient norm = 0.0000584
[t-SNE] Iteration 979: error = 0.7251741, gradient norm = 0.0000571
[t-SNE] Iteration 980: error = 0.7251265, gradient norm = 0.0000518
[t-SNE] Iteration 981: error = 0.7250790, gradient norm = 0.0000538
[t-SNE] Iteration 982: error = 0.7250315, gradient norm = 0.0000549
[t-SNE] Iteration 983: error = 0.7249839, gradient norm = 0.0000513
[t-SNE] Iteration 984: error = 0.7249364, gradient norm = 0.0000551
[t-SNE] Iteration 985: error = 0.7248888, gradient norm = 0.0000523
[t-SNE] Iteration 986: error = 0.7248413, gradient norm = 0.0000516
[t-SNE] Iteration 987: error = 0.7247938, gradient norm = 0.0000545
[t-SNE] Iteration 988: error = 0.7247462, gradient norm = 0.0000531
[t-SNE] Iteration 989: error = 0.7246987, gradient norm = 0.0000516
[t-SNE] Iteration 990: error = 0.7246513, gradient norm = 0.0000525
[t-SNE] Iteration 991: error = 0.7246039, gradient norm = 0.0000546
[t-SNE] Iteration 992: error = 0.7245565, gradient norm = 0.0000511
[t-SNE] Iteration 993: error = 0.7245092, gradient norm = 0.0000500
[t-SNE] Iteration 994: error = 0.7244620, gradient norm = 0.0000522
[t-SNE] Iteration 995: error = 0.7244149, gradient norm = 0.0000530
[t-SNE] Iteration 996: error = 0.7243678, gradient norm = 0.0000542
[t-SNE] Iteration 997: error = 0.7243208, gradient norm = 0.0000563
[t-SNE] Iteration 998: error = 0.7242740, gradient norm = 0.0000574
[t-SNE] Iteration 999: error = 0.7242272, gradient norm = 0.0000540
[t-SNE] Iteration 1000: error = 0.7241807, gradient norm = 0.0000552
```

In [39]:
```
sns.scatterplot(X_embedded[:,0], X_embedded[:,1], hue=y, legend='full', palette=palette
```

```
F:\Anaconda\lib\site-packages\seaborn\_decorators.py:36: FutureWarning: Pass the followi
ng variables as keyword args: x, y. From version 0.12, the only valid positional argumen
t will be `data`, and passing other arguments without an explicit keyword will result in
an error or misinterpretation.
  warnings.warn(
```

Out[39]:
```
<AxesSubplot:>
```

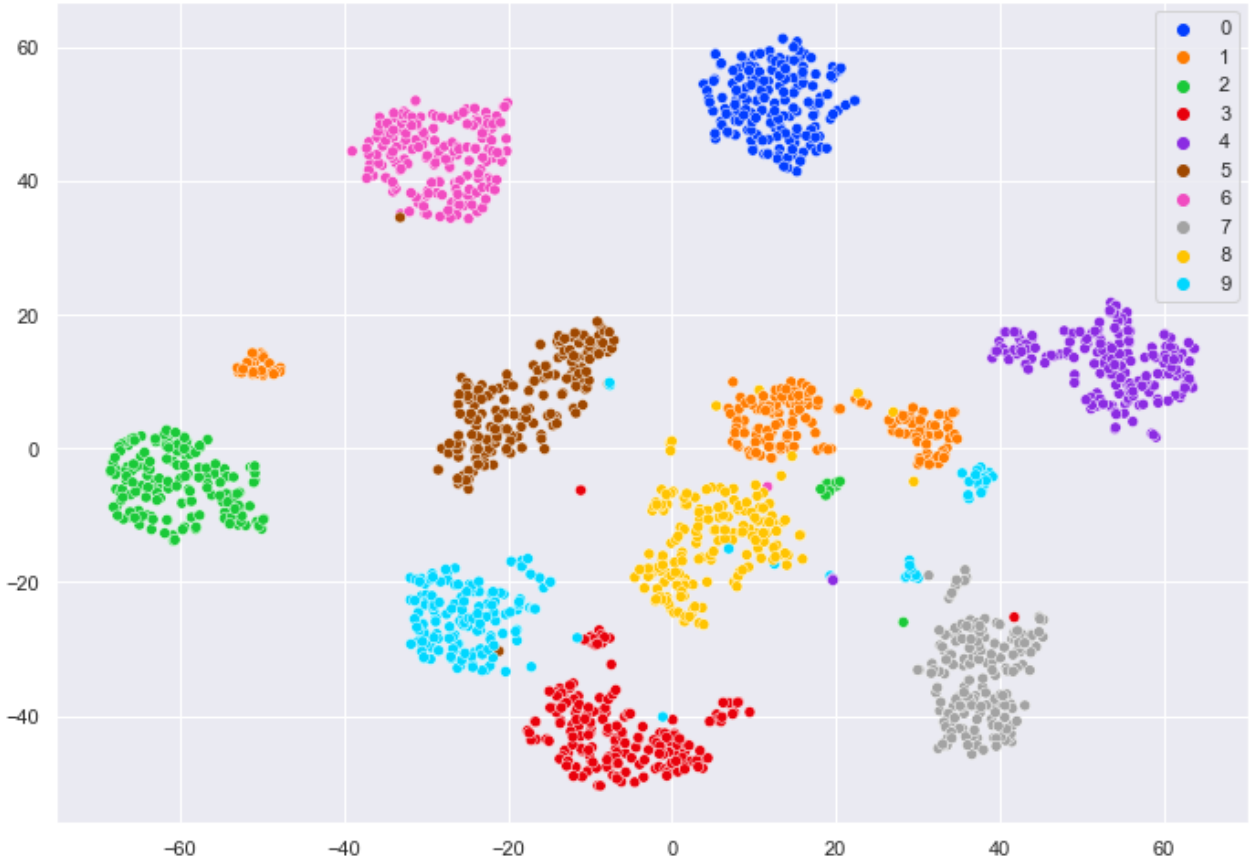


In [40]:
```
tsne = TSNE()
X_embedded = tsne.fit_transform(X)

sns.scatterplot(X_embedded[:,0], X_embedded[:,1], hue=y, legend='full', palette=palette
```

```
F:\Anaconda\lib\site-packages\seaborn\_decorators.py:36: FutureWarning: Pass the followi
ng variables as keyword args: x, y. From version 0.12, the only valid positional argumen
t will be `data`, and passing other arguments without an explicit keyword will result in
an error or misinterpretation.
  warnings.warn(
```

Out[40]: <AxesSubplot:>



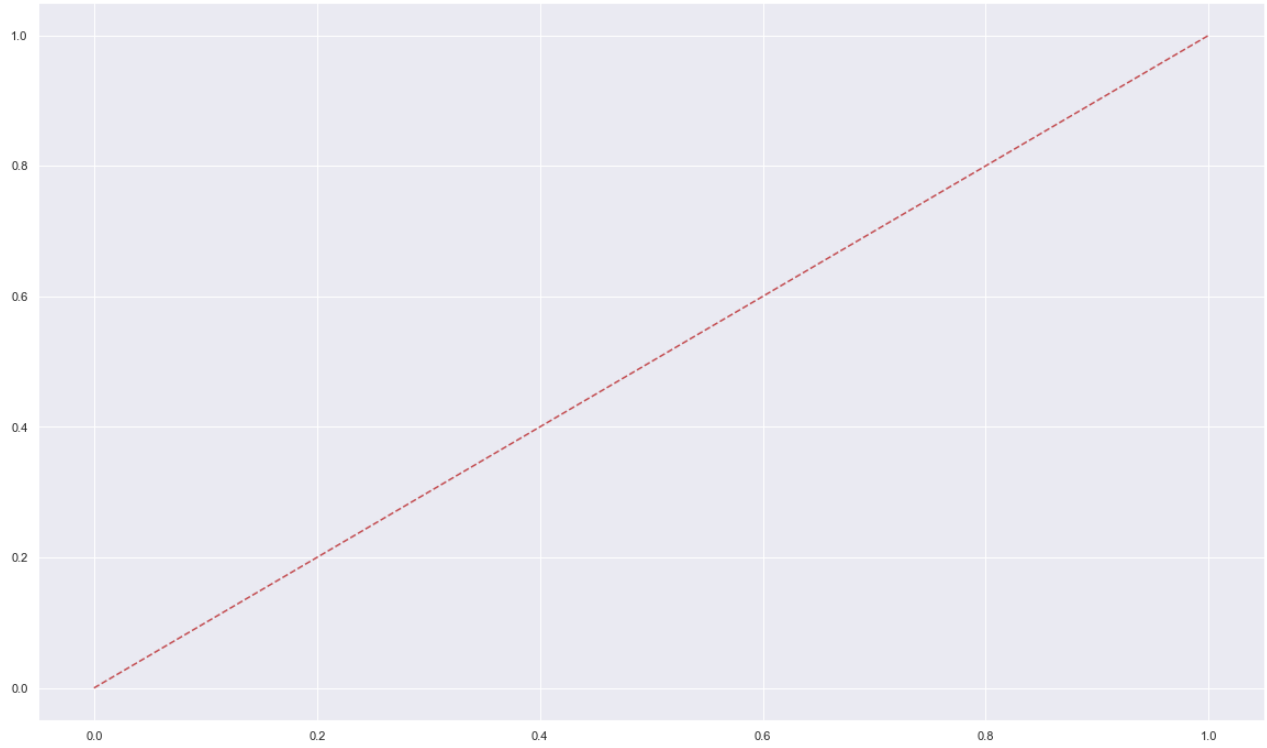
In [43]:
```
from sklearn.metrics import roc_curve, roc_auc_score
from sklearn.model_selection import train_test_split
```

In [52]:
```
from sklearn.metrics import roc_curve, auc

plt.figure(figsize = (20, 12))
plt.plot([0,1], [0,1], 'r--')
probs = supportvectorclassifier.predict_proba(X_test)
probs = probs[:, 1]
fpr, tpr, thresholds = roc_curve(y_test, probs)
roc_auc = auc(fpr, tpr)
label = 'TSNE' + ' {0:.2f}'.format(roc_auc)
plt.plot(fpr, tpr, c = 'g', label = label, linewidth = 4)
plt.xlabel('False Positive Rate', fontsize = 16)
plt.ylabel('True Positive Rate', fontsize = 16)
plt.title('Receiver Operating Characteristic', fontsize = 16)
plt.legend(loc = 'lower right', fontsize = 16)
```

```
---------------------------------------------------------------------------
NameError                                 Traceback (most recent call last)
<ipython-input-52-f49f4e66f60f> in <module>
      3 plt.figure(figsize = (20, 12))
      4 plt.plot([0,1], [0,1], 'r--')
----> 5 probs = supportvectorclassifier.predict_proba(X_test)
      6 probs = probs[:, 1]
      7 fpr, tpr, thresholds = roc_curve(y_test, probs)

NameError: name 'supportvectorclassifier' is not defined
```



In [60]:
```
# ROC curve
fpr_rf, tpr_rf, _ = roc_curve(X_embedded, X)
roc_auc_rf = auc(fpr_rf, tpr_rf)
plt.figure(figsize=(8,8))
plt.xlim([-0.01, 1.00])
plt.ylim([-0.01, 1.01])
plt.plot(fpr_rf, tpr_rf, lw=1, label='{} curve (AUC = {:0.2f})'.format('RF',roc_auc_rf)


plt.xlabel('False Positive Rate', fontsize=16)
plt.ylabel('True Positive Rate', fontsize=16)
plt.title('ROC curve', fontsize=16)
plt.legend(loc='lower right', fontsize=13)
plt.plot([0, 1], [0, 1], color='navy', lw=1, linestyle='--')
plt.axes().set_aspect('equal')
plt.show()
```

```
---------------------------------------------------------------------------
ValueError                                Traceback (most recent call last)
<ipython-input-60-37f4e0548cf4> in <module>
      1 # ROC curve
----> 2 fpr_rf, tpr_rf, _ = roc_curve(X_embedded, X)
      3 roc_auc_rf = auc(fpr_rf, tpr_rf)
      4 plt.figure(figsize=(8,8))
      5 plt.xlim([-0.01, 1.00])

F:\Anaconda\lib\site-packages\sklearn\utils\validation.py in inner_f(*args, **kwargs)
     70                           FutureWarning)
     71         kwargs.update({k: arg for k, arg in zip(sig.parameters, args)})
---> 72         return f(**kwargs)
     73     return inner_f
     74

F:\Anaconda\lib\site-packages\sklearn\metrics\_ranking.py in roc_curve(y_true, y_score,
 pos_label, sample_weight, drop_intermediate)
    773
    774     """
```

```
--> 775     fps, tps, thresholds = _binary_clf_curve(
    776         y_true, y_score, pos__label=pos_label, sample_weight=sample_weight)
    777

F:\Anaconda\lib\site-packages\sklearn\metrics\_ranking.py in _binary_clf_curve(y_true, y
_score, pos_label, sample_weight)
    537     if not (y_type == "binary" or
    538             (y_type == "multiclass" and pos_label is not None)):
--> 539         raise ValueError("{0} format is not supported".format(y_type))
    540
    541     check_consistent_length(y_true, y_score, sample_weight)

ValueError: continuous-multioutput format is not supported
```

In [ ]: