worksheet_07-Copy2

February 23, 2024

1 Worksheet 07

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1.0.1 Topics

- Density-Based Clustering

1.0.2 Density-Based Clustering

Follow along with the live coding of the DBScan algorithm.

[1]:
```
import numpy as np
import matplotlib.pyplot as plt
import sklearn.datasets as datasets

centers = [[1, 1], [-1, -1], [1, -1]]
X, _ = datasets.make_blobs(n_samples=750, centers=centers, cluster_std=0.4,
random_state=0)
plt.scatter(X[:, 0], X[:, 1], s=10, alpha=0.8)
plt.show()

class DBC():

    def __init__(self, dataset, min_pts, epsilon):
        self.dataset = dataset
        self.min_pts = min_pts
        self.epsilon = epsilon
        self.assignments = [-1 for _ in range(len(self.dataset))]

    def distance(self, i, j):
        return np.linalg.norm(self.dataset[i] - self.dataset[j])

    def is_core(self, i):
        return len(self.get_nbhd(i)) >= self.min_pts

    def get_nbhd(self, i):
        nbhd = []
        for j in range(len(self.dataset)):
```

```
            if i != j and self.distance(i, j) <= self.epsilon:
                nbhd.append(j)
        return nbhd


    def is_unassigned(self, i):
        return self.assignments[i]==-1


    def get_unassigned_nbhd(self, i):
        nbhd = self.get_nbhd(i)
        return [pt for pt in nbhd if self.is_unassigned(pt)]

    def make_cluster(self, i, cluster_num):
        self.assignments[i] = cluster_num
        nbhd_q = self.get_unassigned_nbhd(i)

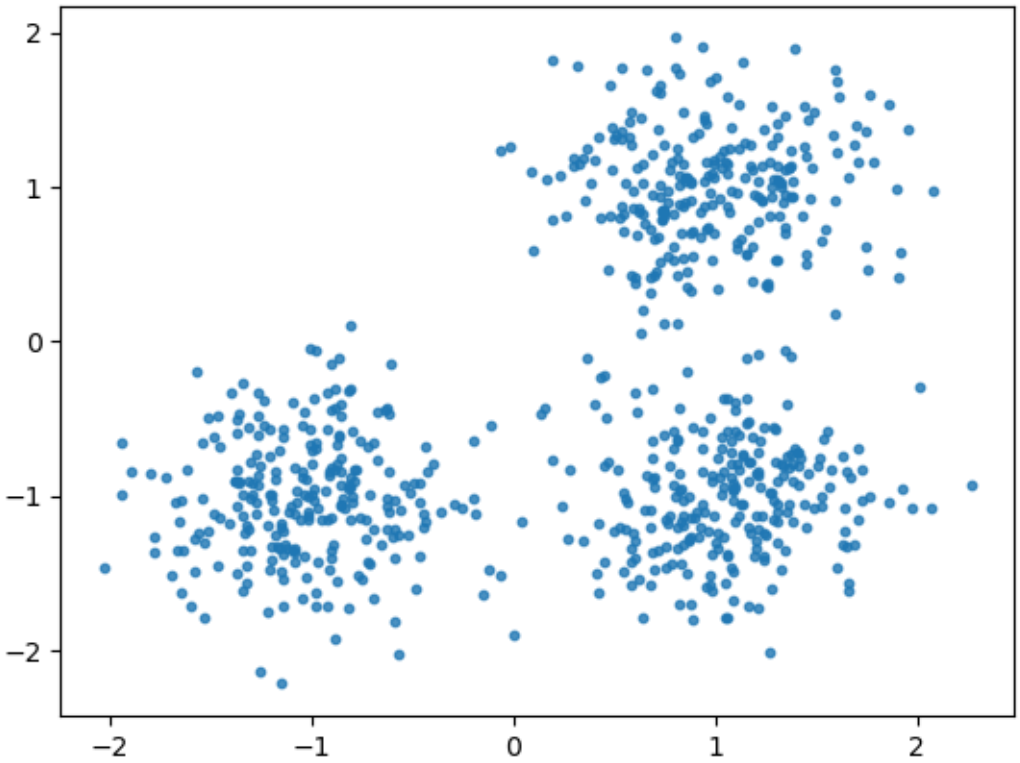
        while nbhd_q:
            next_pt = nbhd_q.pop()
            if not self.is_unassigned(next_pt):
                continue
            self.assignments[next_pt] = cluster_num
            #self.snap()
            if self.is_core(next_pt):
                nbhd_q += self.get_unassigned_nbhd(next_pt)

    def dbscan(self):
        cluster_num = 0

        for i in range(len(self.dataset)):
            if self.assignments[i] != -1:
                continue
            if self.is_core(i):
                self.make_cluster(i, cluster_num)
                cluster_num += 1

        return self.assignments

clustering = DBC(X, 5, 0.3).dbscan()
colors = np.array([x for x in 'bgrcmykbgrcmykbgrcmykbgrcmyk'])
colors = np.hstack([colors] * 100)
plt.scatter(X[:, 0], X[:, 1], color=colors[clustering].tolist(), s=10, alpha=0.
 ↪8)
plt.show()
```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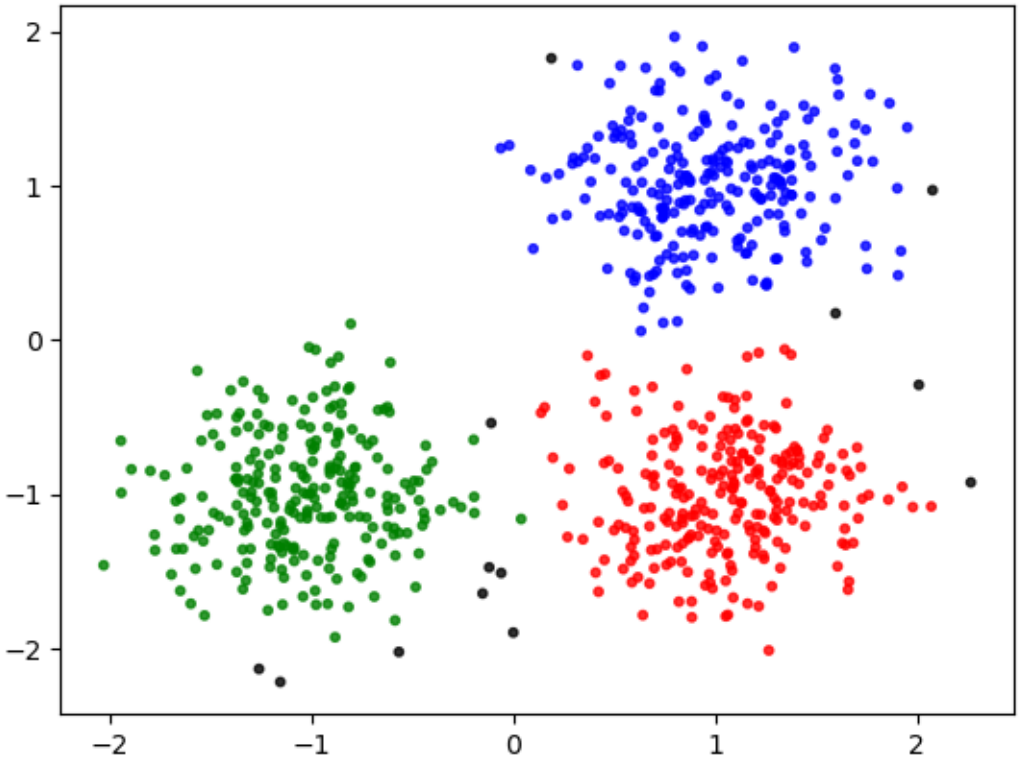
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[5]:
```
# Challenge part 1 - animation of DBScan algorithm, result is in 'dbscan2.gif'


import numpy as np
import matplotlib.pyplot as plt
import sklearn.datasets as datasets
from matplotlib.patches import Circle
from PIL import Image as im

centers = [[1, 1], [-1, -1], [1, -1]]
X, _ = datasets.make_blobs(n_samples=750, centers=centers, cluster_std=0.4,␣
 ↪random_state=0)
plt.scatter(X[:, 0], X[:, 1], s=10, alpha=0.8)
plt.show()
TEMPFILE = 'temp.png'


class DBC():

    def __init__(self, dataset, min_pts, epsilon):
        self.dataset = dataset
        self.min_pts = min_pts
        self.epsilon = epsilon
        self.assignments = [-1 for _ in range(len(self.dataset))]
        self.snaps = []

    def distance(self, i, j):
        return np.linalg.norm(self.dataset[i] - self.dataset[j])

    def is_core(self, i):
        return len(self.get_nbhd(i)) >= self.min_pts

    def get_nbhd(self, i):
        nbhd = []
        for j in range(len(self.dataset)):
            if i != j and self.distance(i, j) <= self.epsilon:
                nbhd.append(j)
        return nbhd

    def is_unassigned(self, i):
        return self.assignments[i] == -1

    def get_unassigned_nbhd(self, i):
        nbhd = self.get_nbhd(i)
        return [pt for pt in nbhd if self.is_unassigned(pt)]
```

```
    def make_cluster(self, i, cluster_num):
        self.assignments[i] = cluster_num
        nbhd_q = self.get_unassigned_nbhd(i)

        while nbhd_q:
            next_pt = nbhd_q.pop()
            if not self.is_unassigned(next_pt):
                continue
            self.assignments[next_pt] = cluster_num
            print("Taking a snapshot...")
            self.snapshot(next_pt)  # Take a snapshot when a point is assigned
            if self.is_core(next_pt):
                nbhd_q += self.get_unassigned_nbhd(next_pt)

    def snapshot(self, assigned_point):
        fig, ax = plt.subplots()
        colors = np.array([x for x in 'bgrcmykbgrcmykbgrcmykbgrcmyk'])
        colors = np.hstack([colors] * 100)

        ax.scatter(self.dataset[:, 0], self.dataset[:, 1], color=colors[self.
↪assignments].tolist(), s=10, alpha=0.8)

        for i, assignment in enumerate(self.assignments):
            if assignment != -1 and i == assigned_point:
                cir = Circle((self.dataset[i, 0], self.dataset[i, 1]), self.
↪epsilon, fill=False, color='black')
                ax.add_patch(cir)

        ax.set_xlim(np.min(self.dataset[:, 0]) - 1, np.max(self.dataset[:, 0])␣
↪+ 1)
        ax.set_ylim(np.min(self.dataset[:, 1]) - 1, np.max(self.dataset[:, 1])␣
↪+ 1)
        ax.set_aspect('equal')  # necessary or else the circles appear to be␣
↪oval shaped

        temp_file = 'temp1.png'
        fig.savefig(temp_file)
        plt.close()

        with im.open(temp_file) as img:
            img_copy = img.copy()
        self.snaps.append(img_copy)


    def dbscan(self):
        cluster_num = 0
```

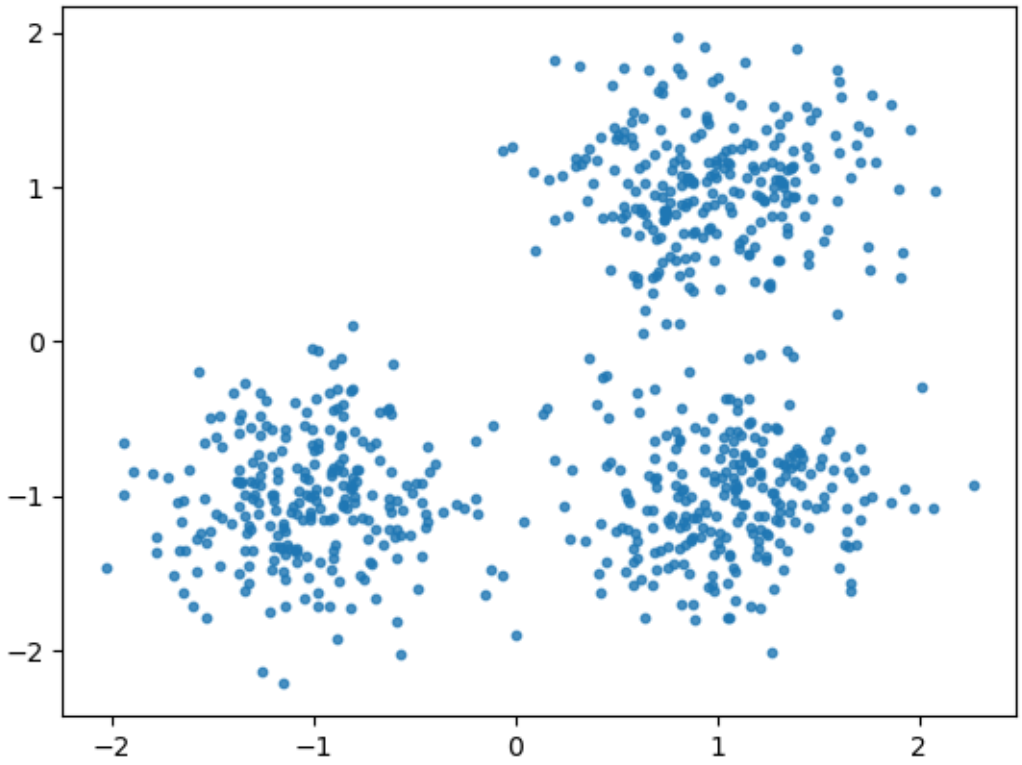
```
        for i in range(len(self.dataset)):
            if self.assignments[i] != -1:
                continue
            if self.is_core(i):
                self.make_cluster(i, cluster_num)
                cluster_num += 1

        return self.assignments


dbc = DBC(X, 5, 0.3)
clustering = dbc.dbscan()

dbc.snaps[0].save(
    'dbscan2.gif',
    optimize=False,
    save_all=True,
    append_images=dbc.snaps[1:],
    loop=0,
    duration=25
)


#########
```

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[ ]:

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[6]:

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```

1.1 Challenge Problem

Using the code above and the template provided below, create the animation below of the DBScan algorithm.

[7]:
```
from IPython.display import Image
Image(filename="dbscan_2.gif", width=500, height=500)
```

[7]:
```
<IPython.core.display.Image object>
```

Hints:

- First animate the dbscan algorithm for the dataset used in class (before trying to create the above dataset)
- Take a snapshot of the assignments when the point gets assigned to a cluster
- Confirm that the snapshot works by saving it to a file
- Don't forget to close the matplotlib plot after saving the figure
- Gather the snapshots in a list of images that you can then save as a gif using the code below
- Use `ax.set_aspect('equal')` so that the circles don't appear to be oval shaped
- To create the above dataset you need two blobs for the eyes. For the mouth you can use the following process to generate (x, y) pairs:
  - Pick an x at random in an interval that makes sense given where the eyes are positioned
  - For that x generate y that is 0.2 * x^2 plus a small amount of randomness
  - `zip` the x's and y's together and append them to the dataset containing the blobs

[20]:
```
# Challenge part 2 - animation of Smiley face, result is in 'dbscan_smile4.gif'


import numpy as np
import matplotlib.pyplot as plt
import sklearn.datasets as datasets
from matplotlib.patches import Circle
from PIL import Image as im

# centers = [[1, 1], [-1, -1], [1, -1]]
# X, _ = datasets.make_blobs(n_samples=750, centers=centers, cluster_std=0.4,␣
 ↪random_state=0)
# plt.scatter(X[:, 0], X[:, 1], s=10, alpha=0.8)
# plt.show()
# TEMPFILE = 'temp.png'


class DBC():

    def __init__(self, dataset, min_pts, epsilon):
        self.dataset = dataset
        self.min_pts = min_pts
        self.epsilon = epsilon
        self.assignments = [-1 for _ in range(len(self.dataset))]
```

```
        self.snaps = []

    def distance(self, i, j):
        return np.linalg.norm(self.dataset[i] - self.dataset[j])

    def is_core(self, i):
        return len(self.get_nbhd(i)) >= self.min_pts

    def get_nbhd(self, i):
        nbhd = []
        for j in range(len(self.dataset)):
            if i != j and self.distance(i, j) <= self.epsilon:
                nbhd.append(j)
        return nbhd

    def is_unassigned(self, i):
        return self.assignments[i] == -1

    def get_unassigned_nbhd(self, i):
        nbhd = self.get_nbhd(i)
        return [pt for pt in nbhd if self.is_unassigned(pt)]

    def make_cluster(self, i, cluster_num):
        self.assignments[i] = cluster_num
        nbhd_q = self.get_unassigned_nbhd(i)

        while nbhd_q:
            next_pt = nbhd_q.pop()
            if not self.is_unassigned(next_pt):
                continue
            self.assignments[next_pt] = cluster_num
            print("Taking a snapshot...")
            self.snapshot(next_pt)  # Take a snapshot when a point is assigned
            if self.is_core(next_pt):
                nbhd_q += self.get_unassigned_nbhd(next_pt)

    def snapshot(self, assigned_point):
        fig, ax = plt.subplots()
        colors = np.array([x for x in 'bgrcmykbgrcmykbgrcmykbgrcmyk'])
        colors = np.hstack([colors] * 100)

        ax.scatter(self.dataset[:, 0], self.dataset[:, 1], color=colors[self.
↪assignments].tolist(), s=10, alpha=0.8)

        for i, assignment in enumerate(self.assignments):
            if assignment != -1 and i == assigned_point:
```

```
                cir = Circle((self.dataset[i, 0], self.dataset[i, 1]), self.
↪epsilon, fill=False, color='black')
                ax.add_patch(cir)

        ax.set_xlim(np.min(self.dataset[:, 0]) - 1, np.max(self.dataset[:, 0])␣
↪+ 1)
        ax.set_ylim(np.min(self.dataset[:, 1]) - 1, np.max(self.dataset[:, 1])␣
↪+ 1)
        ax.set_aspect('equal')  # necessary or else the circles appear to be␣
↪oval shaped

        temp_file = 'temp_smile3.png'
        fig.savefig(temp_file)
        plt.close()

        with im.open(temp_file) as img:
            img_copy = img.copy()
        self.snaps.append(img_copy)


    def dbscan(self):
        cluster_num = 0

        for i in range(len(self.dataset)):
            if self.assignments[i] != -1:
                continue
            if self.is_core(i):
                self.make_cluster(i, cluster_num)
                cluster_num += 1

        return self.assignments


#centers = [[-1.5, 3], [1.5, 3]]
# centers = [[-1, 2], [1, 2]]
# eyes, _ = datasets.make_blobs(n_samples=500, centers=centers, cluster_std=0.
↪4, random_state=0)
centers = [[-1, 2], [1, 2]]
eyes, _ = datasets.make_blobs(n_samples=500, centers=centers, cluster_std=0.2,␣
↪random_state=0)
# eyes, _ = datasets.make_blobs(n_samples=750, centers=centers, cluster_std=0.
↪4, random_state=0)


# mouth_x = 6 * np.random.random(150) - 3  # Random x values in the range [-3,␣
↪3]
```

```
# mouth_y = 0.2 * mouth_x**2 + 0.1 * np.random.randn(150)  # Generate y values␣
 ↪for the smiley face mouth
# mouth_x = 5 * np.random.random(150) - 2.5  # Random x values in the range [-2.
 ↪5, 2.5]
# mouth_y = 0.07 * mouth_x**2 + 0.1 * np.random.randn(150)  # Generate y values␣
 ↪for the smiley face mouth
mouth_x = 4 * np.random.random(250) - 2  # Random x values in the range [-2, 2]
mouth_y = 0.2 * mouth_x**2 + 0.1 * np.random.randn(250)  # Generate y values␣
 ↪for the smiley face mouth



face = np.append(eyes, np.column_stack((mouth_x, mouth_y)), axis=0)

# Run DBSCAN on smiley face dataset
dbc = DBC(face, 5, 0.3)
clustering = dbc.dbscan()


dbc.snaps[0].save(
    'dbscan_smile4.gif',
    optimize=False,
    save_all=True,
    append_images=dbc.snaps[1:],
    loop=0,
    duration=25
)
```

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[ ]:
```
# import numpy as np
# from PIL import Image as im
# import matplotlib.pyplot as plt
# import sklearn.datasets as datasets

# TEMPFILE = 'temp.png'

# class DBC():

#     def __init__(self, dataset, min_pts, epsilon):
#         self.dataset = dataset
#         self.min_pts = min_pts
#         self.epsilon = epsilon
#         self.snaps = []


#     def snapshot(self):
#         fig, ax = plt.subplots()
#         colors = ...

#         ax.scatter(...)
#         cir = plt.Circle(...) # create circle around the point assigned
#         ax.add_patch(cir)
#         ax.set_xlim(...)
#         ax.set_ylim(...)
#         ax.set_aspect('equal') # necessary or else the circles appear to be␣
 ↪oval shaped

#         fig.savefig(TEMPFILE)
#         plt.close()

#         return im.fromarray(np.asarray(im.open(TEMPFILE)))


#     def dbscan(self):
#         ...
#         return
```

```
# centers = [[-2, 2], [2, 2]]
# eyes, _ = datasets.make_blobs(n_samples=750, centers=centers, cluster_std=0.
 ↪4, random_state=0)

# mouth_x = 6 * np.random.random(150) - 3  # Random x values in the range [-3,␣
 ↪3]
# mouth_y = 0.2 * mouth_x**2 + 0.1 * np.random.randn(150)  # Generate y values␣
 ↪for the smiley face mouth

# face = np.append(eyes, np.column_stack((mouth_x, mouth_y)), axis=0)

# # Run DBSCAN on smiley face dataset
# dbc = DBC(face, 5, 0.3)
# clustering = dbc.dbscan()


# dbc.snaps[0].save(
#     'dbscan_smile.gif',
#     optimize=False,
#     save_all=True,
#     append_images=dbc.snaps[1:],
#     loop=0,
#     duration=25
# )
```