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## 模型-机器学习-聚类-DBSCAN算法与密度聚类

### 1. 模型名称

Density-Based Spatial Clustering of Applications with Noise, DBSCAN

代表性密度聚类 (Density-Based Clustering)

### 2. 模型评价

#### 2.1 优点

- DBSCAN不需要事先知道要形成的簇类的数量
- DBSCAN可以发现任意形状的簇类
- DBSCAN能够识别出噪声点
- DBSCAN对于数据库中样本的顺序不敏感，即Pattern的输入顺序对结果的影响不大。但是，对于处于簇类之间边界样本，可能会根据哪个簇类优先被探测到而其归属有所摆动

#### 2.2 缺点

- DBSCAN不能很好反映高维数据
- DBSCAN不能很好反映数据集以变化的密度
- 如果样本集的密度不均匀、聚类间距差相差很大时，聚类质量较差

### 3. 基本算法

1. 将所有点标记为**核心点**、**边界点**或**噪声点**

**核心点**：在半径Eps内含有超过MinPts数目的点

**边界点**：在半径Eps内点的数量小于MinPts，但是落在核心点的邻域内

**噪音点**：既不是核心点也不是边界点的点

2. 删除噪声点

3. 为距离在Eps之内的所有核心点之间赋予一条边

4. 每组连通的核心点形成一个簇

5. 将每个边界点指派到一个与之关联的核心点点簇中（哪一个核心点的半径范围之内）

4. 实例

4.1 数据介绍

现有大学校园网的日志数据，290条大学生的校园网使用情况数据，数据包括用户ID，设备的MAC地址，IP地址，开始上网时间，停止上网时间，上网时长，校园网套餐等。

学生上网日志（单条数据格式）	
记录编号	2c929293466b97a6014754607e457d68
学生编号	U201215025
MAC地址	A417314EEA7B
IP地址	10.12.49.26
开始上网时间	2014-07-20 22:44:18.540000000
停止上网时间	2014-07-20 23:10:16.540000000
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2c929293466b97a601475464e56e0203,U201115384,D4BED93AB2D7,218.197.218.20,2014-07-20  
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2c929293466b97a601475464f2cd0212,M201371953,2089842613A6,222.20.108.208,2014-07-20  
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2c929293466b97a601475464f5740217,I201320086,485D60B37168,10.10.29.242,2014-07-20  
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月,internet  
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21:53:11.143000000,2014-07-20 23:15:10.143000000,4919,15,研究生动态IP模版,20元包  
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07-21 08:13:40.690000000,2014-07-21 08:13:53.690000000,13,1,研究生动态IP模版,20元包  
月,internet  
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2c929293466b97a6014756443a2049bb,U201210207,3C970EFDD303,218.197.226.28,2014-07-20  
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2c929293466b97a6014756451ba84a9b,U201115486,7845C4A427DB,218.197.232.9,2014-07-21  
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08:01:45.867000000,2014-07-21 08:14:35.867000000,770,15,研究生动态IP模版,20元包月,internet



2c929293466b97a6014756451faa4aa4,D201177612,58A2B59C9235,10.12.23.220,2014-07-21  
08:05:58.457000000,2014-07-21 08:14:35.457000000,517,15,研究生动态IP模版,100元包半  
年,internet

2c929293466b97a601475645210c4aa6,U201116686,101C0C7ED999,10.12.78.31,2014-07-21  
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2c929293466b97a60147564527494ab1,U201316012,E0DB55C218D5,222.20.66.155,2014-07-20  
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月,internet

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2c929293466b97a601475647c6914df7,U201314149,D022BED42F3F,10.10.196.146,2014-07-21  
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月,internet

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年,internet

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月,internet

2c929293466b97a60147564507874a88,U201213753,5CF9DD6337CC,222.20.31.42,2014-07-21  
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月,internet

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月,internet  
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2c929293466b97a601475645b36c4b7f,U201114112,786A89D2ED41,10.12.52.139,2014-07-21  
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08:14:29.287000000,2014-07-21 08:14:49.287000000,20,1,本科生态IP模版,100元每半年,internet

## 4.2 实验目的

通过DBSCAN聚类，分析学生上网时间和上网时长的模式

## 4.3 代码实现

[internet.py](#)

代码：

```
# 导入sklearn相关包
import numpy as np
import sklearn.cluster as skc
from sklearn import metrics
# 导入matplotlib相关包
import matplotlib.pyplot as plt

# 读入数据并进行处理
# mac2id是一个字典：key是mac地址，value是对应mac地址的上网时长以及开始上网时间在onlinetimes中的索引
mac2id = dict()
# 用onlinetimes存 (onlinetime, starttime)
onlinetimes = []
# 打开文件
f = open('/Users/xinyuanhe/Desktop/working/2021美赛/模型/模型-机器学习-聚类-DBSCAN算法与密度聚类【hxy】/internet.txt')
for line in f:
    # 获取一行中以','分割的第三个字符串，即mac地址
    mac = line.split(',')[2]
    # 获取上网时长
    onlinetime = int(line.split(',')[6])
    # 获取开始上网时间
    starttime = int(line.split(',')[4].split(' ')[1].split(':')[0])
    # 将每一条记录放到onlinetimes中，并将其索引作为value赋给对应mac地址
    if mac not in mac2id:
        mac2id[mac] = len(onlinetimes)
        onlinetimes.append((starttime, onlinetime))
    else:
        onlinetimes[mac2id[mac]] = (starttime, onlinetime)
# 固定列数为2列，行数由系统自行确定
real_X = np.array(onlinetimes).reshape((-1, 2))

# 上网时间聚类，创建DBSCAN算法实例，并进行训练，获得标签
# 上网时间数列
X = real_X[:, 0:1]
# 调用DBSCAN方法进行训练
db = skc.DBSCAN(eps=0.01, min_samples=20).fit(X)
# labels为每个数据的簇标签
labels = db.labels_
print('Labels:')
```

```

print(labels)
# 计算标签为-1，即噪声数据的比例
ratio = len(labels[labels[:] == -1]) / len(labels)
print('Noise ratio:',format(ratio, '.2%'))
# 打印簇的个数并打印，评价聚类效果
n_clusters_ = len(set(labels)) - (1 if -1 in labels else 0)
print('Estimated number of clusters: %d' % n_clusters_)
print('Silhouette Coefficient: %0.3f' % metrics.silhouette_score(X, labels))
# 打印各簇标号以及各簇内数据
for i in range(n_clusters_):
    print('Cluster ',i,':')
    print(list(X[labels == i].flatten()))
# 画直方图，分析实验结果
plt.hist(X,24)
plt.show()

# 分割线
print(' ')
print('----- 分割线 -----')
print(' ')

# 上网时长聚类，创建DBSCAN算法实例，并进行训练，获得标签
# 上网时长数列（由于原数据不适合聚类分析，故取对数运算）
X = np.log(1+real_X[:,1:])
# 调用DBSCAN方法进行训练
db = skc.DBSCAN(eps=0.14,min_samples=10).fit(X)
# labels为每个数据的簇标签
labels = db.labels_
print('Labels:')
print(labels)
# 计算标签为-1，即噪声数据的比例
ratio = len(labels[labels[:]==-1]) /len(labels)
print('Noise ratio:',format(ratio, '.2%'))
# 打印簇的个数并打印，评价聚类效果
n_clusters_ = len(set(labels)) - (1 if -1 in labels else 0)
print('Estimated number of clusters: %d' % n_clusters_)
print('Silhouette Coefficient: %0.3f' % metrics.silhouette_score(X, labels))
# 统计每一个簇内的样本个数，均值，标准差
for i in range(n_clusters_):
    print('Cluster ',i,':')
    # 个数
    count = len(X[labels==i])
    print('\t number of sample: ',count)
    # 均值
    mean = np.mean(real_X[labels==i][:,1])
    print('\t mean of sample : ',format(mean, '.1f'))
    # 标准差
    std = np.std(real_X[labels==i][:,1])
    print('\t std of sample :',format(std, '.1f'))

```

上网时间聚类结果：

```
= RESTART: /Users/xinyuanhe/Desktop/working/2021美赛/模型/模型-机器学习-聚类-DBSCAN  
算法与密度聚类【hxy】/internet.py
```

```
Labels:
```

```
[ 0 -1  0  1 -1  1  0  1  2 -1  1  0  1  1  3 -1 -1  3 -1  1  1 -1  1  3  
 4 -1  1  1  2  0  2  2 -1  0  1  0  0  0  1  3 -1  0  1  1  0  0  2 -1  
 1  3  1 -1  3 -1  3  0  1  1  2  3  3 -1 -1 -1  0  1  2  1 -1  3  1  1  
 2  3  0  1 -1  2  0  0  3  2  0  1 -1  1  3 -1  4  2 -1 -1  0 -1  3 -1  
 0  2  1 -1 -1  2  1  1  2  0  2  1  1  3  3  0  1  2  0  1  0 -1  1  1  
 3 -1  2  1  3  1  1  1  2 -1  5 -1  1  3 -1  0  1  0  0  1 -1 -1 -1  2  
 2  0  1  1  3  0  0  0  1  4  4 -1 -1 -1 -1  4 -1  4  4 -1  4 -1  1  2  
 2  3  0  1  0 -1  1  0  0  1 -1 -1  0  2  1  0  2 -1  1  1 -1 -1  0  1  
 1 -1  3  1  1 -1  1  1  0  0 -1  0 -1  0  0  2 -1  1 -1  1  0 -1  2  1  
 3  1  1 -1  1  0  0 -1  0  0  3  2  0  0  5 -1  3  2 -1  5  4  4  4 -1  
 5  5 -1  4  0  4  4  4  5  4  4  5  5  0  5  4 -1  4  5  5  5  1  5  5  
 0  5  4  4 -1  4  4  5  4  0  5  4 -1  0  5  5  5 -1  4  5  5  5  5  4  
 4]
```

```
Noise ratio: 22.15%
```

```
Estimated number of clusters: 6
```

```
Silhouette Coefficient: 0.710
```

```
Cluster 0 :
```

```
[22, 22, 22, 22, 22, 22, 22, 22, 22, 22, 22, 22, 22, 22, 22, 22, 22, 22, 22, 22, 22, 22,  
 22, 22, 22, 22, 22, 22, 22, 22, 22, 22, 22, 22, 22, 22, 22, 22, 22, 22, 22, 22, 22,  
 22, 22, 22, 22, 22, 22, 22, 22, 22, 22, 22, 22, 22, 22, 22, 22, 22]
```

```
Cluster 1 :
```

```
[23, 23, 23, 23, 23, 23, 23, 23, 23, 23, 23, 23, 23, 23, 23, 23, 23, 23, 23, 23, 23, 23,  
 23, 23, 23, 23, 23, 23, 23, 23, 23, 23, 23, 23, 23, 23, 23, 23, 23, 23, 23, 23, 23,  
 23, 23, 23, 23, 23, 23, 23, 23, 23, 23, 23, 23, 23, 23, 23, 23, 23, 23, 23, 23, 23,  
 23, 23, 23, 23, 23]
```

```
Cluster 2 :
```

```
[20, 20, 20, 20, 20, 20, 20, 20, 20, 20, 20, 20, 20, 20, 20, 20, 20, 20, 20, 20, 20, 20,  
 20, 20, 20, 20, 20, 20, 20, 20]
```

```
Cluster 3 :
```

```
[21, 21, 21, 21, 21, 21, 21, 21, 21, 21, 21, 21, 21, 21, 21, 21, 21, 21, 21, 21, 21, 21,  
 21, 21, 21, 21, 21]
```

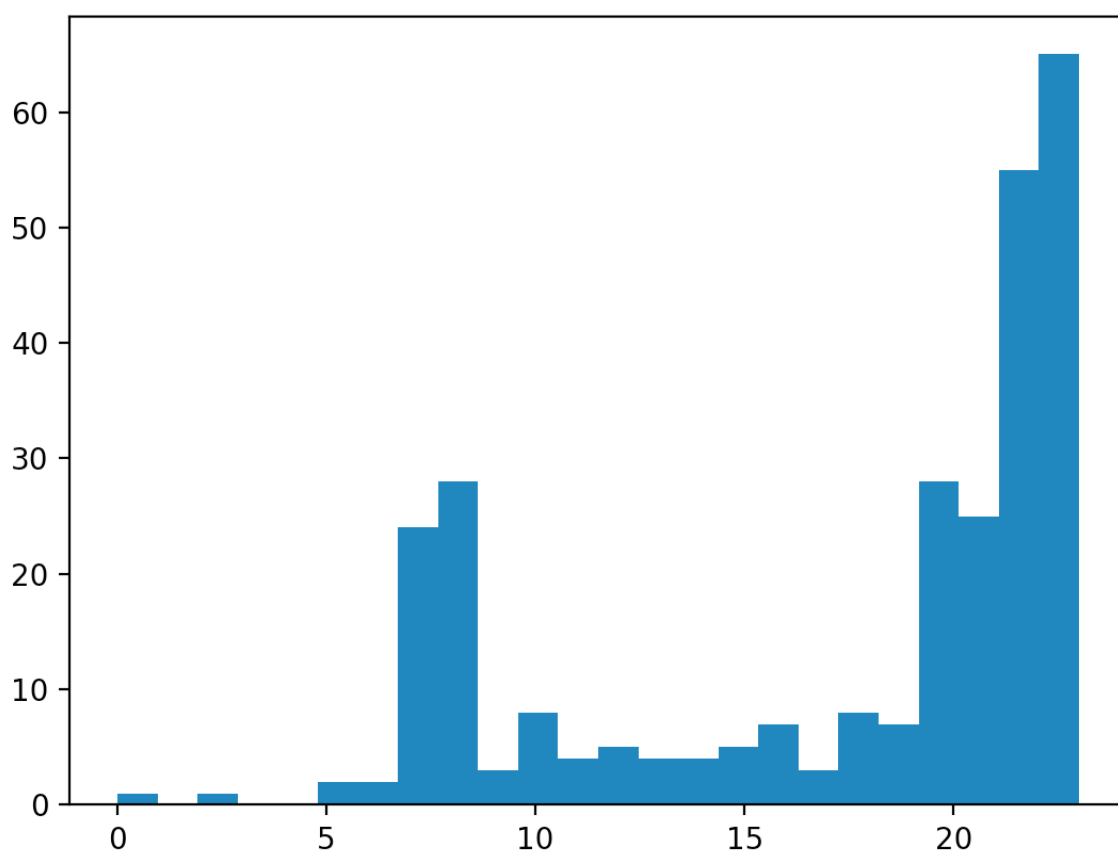
```
Cluster 4 :
```

```
[8, 8, 8, 8, 8, 8, 8, 8, 8, 8, 8, 8, 8, 8, 8, 8, 8, 8, 8, 8, 8, 8, 8, 8, 8, 8,  
 8]
```

```
Cluster 5 :
```

```
[7, 7, 7, 7, 7, 7, 7, 7, 7, 7, 7, 7, 7, 7, 7, 7, 7, 7, 7, 7, 7, 7, 7, 7, 7]
```

由下图得，上网时间大多聚集在22:00到23:00之间：



上网时长聚类结果：



```

Labels:
[ 0  1  0  4  1  2  0  2  0  3 -1  0 -1 -1  0  3  1  0  3  2  2  1  2  0
  1  1 -1 -1  0  0  0  0  1  0 -1  0  0  0  2  0  1  0 -1 -1  0  0  0  3
  2  0 -1  1  0  1  0  0 -1  2  0  0  0  1  3  3  0  2  0 -1  3  0  0  2
  0  0  0  2  1 -1  0  0  0  0  0  0  1 -1  0  3  1  0  1  1  0  1  0  1
  0  0 -1  1  1  0  0  2  0  0  0  2  2  0  0  0 -1  0  0  4  0  1  2 -1
  0  1  0  2  0 -1 -1 -1  0  1  1  3 -1  0  1  0  2  0  0  2  1  1  0  0
  0  0  4 -1  0  0  0  0  2  0  0  0  0 -1  2  0  0  0  0  4  0  0 -1  0
  2  0  0 -1  0  1  4  0  0 -1  1  1  0  0  2  0  0  3 -1 -1 -1  1  0  0
  2  1  0 -1 -1  3  2  2  0  0  3  0  1  0  0  0  3  2  0 -1  0  1 -1 -1
  0  2  2  1  4  0  0  1  0  2  0  0  0  0  1  1  0  0  1  0  4 -1 -1  0
  0  0 -1 -1  1 -1  4 -1  0  2  2 -1  2  1  2 -1  0 -1  0  2  2  1 -1  0
  1  2 -1 -1  1 -1  2 -1 -1  1  4  2  3  1  0  4  0  0  4  2  4  0  0  2
 -1]
Noise ratio: 16.96%
Estimated number of clusters: 5
Silhouette Coefficient: 0.227
Cluster 0 :
    number of sample: 128
    mean of sample   : 5864.3
    std of sample    : 3498.1
Cluster 1 :
    number of sample: 46
    mean of sample   : 36835.1
    std of sample    : 11314.1
Cluster 2 :
    number of sample: 40
    mean of sample   : 843.2
    std of sample    : 242.9
Cluster 3 :
    number of sample: 14
    mean of sample   : 16581.6
    std of sample    : 1186.7
Cluster 4 :
    number of sample: 12
    mean of sample   : 338.4
    std of sample    : 31.9

```

## 5. 参考资料

1. [Mooc机器学习DBSCAN](#)
2. 高老师第三次培训PPT: P75-P77
3. [matplotlib文档](#)