Python 数据处理

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1 基本技能

1.0.1 以 openml 中的数据集 diabetes 为例，计算不同 class 分类下，age 的中位数。

[1]:
```
# 导入数据集获取工具
from sklearn.datasets import fetch_openml
```

[2]:
```
# 获取数据
data = fetch_openml(
    data_id=37,
    as_frame=True,
    parser="pandas"
)["frame"]
```

[3]:
```
# 查看数据集的前五行
data.head()
```

[3]:
```
   preg  plas  pres  skin  insu  mass   pedi  age            class
0     6   148    72    35     0  33.6  0.627   50  tested_positive
1     1    85    66    29     0  26.6  0.351   31  tested_negative
2     8   183    64     0     0  23.3  0.672   32  tested_positive
3     1    89    66    23    94  28.1  0.167   21  tested_negative
4     0   137    40    35   168  43.1  2.288   33  tested_positive
```

[4]:
```
# 分组计算平均数
data.groupby(by="class")["age"].agg("median")
```

[4]:
```
class
tested_negative    27.0
tested_positive    36.0
Name: age, dtype: float64
```

1.0.2 以 openml 中的数据集 diabetes 为例，查找第五大的年龄是多少岁。

[1]:
```
# 导入数据集获取工具
from sklearn.datasets import fetch_openml
```

[2]:
```
# 获取数据
data = fetch_openml(
    data_id=37,
    as_frame=True,
    parser="pandas"
)["frame"]
```

[3]:
```
# 查看数据集的前五行
data.head()
```

```
[3]:    preg  plas  pres  skin  insu  mass   pedi  age            class
     0     6   148    72    35     0  33.6  0.627   50  tested_positive
     1     1    85    66    29     0  26.6  0.351   31  tested_negative
     2     8   183    64     0     0  23.3  0.672   32  tested_positive
     3     1    89    66    23    94  28.1  0.167   21  tested_negative
     4     0   137    40    35   168  43.1  2.288   33  tested_positive
```

```
[4]: # 降序排列后取出第四个
     data["age"].sort_values(ascending=False).iloc[3]
```

```
[4]: 69
```

1.0.3 以 **openml** 中的数据集 **diabetes** 为例，新建一个 **id** 列，划分为两个子数据集，两个数据集的样本量是一样的，只是变量不同。

1.0.4 将这两个的子数据集打乱顺序，按照 **id** 合并。

```
[1]: # 导入数据集获取工具
     from sklearn.datasets import fetch_openml
```

```
[2]: # 获取数据
     data = fetch_openml(
         data_id=37,
         as_frame=True,
         parser="pandas"
     )["frame"]
```

```
[3]: # 查看数据集的前五行
     data.head()
```

```
[3]:    preg  plas  pres  skin  insu  mass   pedi  age            class
     0     6   148    72    35     0  33.6  0.627   50  tested_positive
     1     1    85    66    29     0  26.6  0.351   31  tested_negative
     2     8   183    64     0     0  23.3  0.672   32  tested_positive
     3     1    89    66    23    94  28.1  0.167   21  tested_negative
     4     0   137    40    35   168  43.1  2.288   33  tested_positive
```

```
[4]: # 新建一列 id
     data["id"] = range(1,data.shape[0]+1)
```

```
[5]: # 按照 preg 排序，打乱顺序
     data1 = data.loc[:, ["preg", "plas", "pres", "class", "id"]].
      ↪sort_values(by=["preg"])
     # 按照 age 排序，打乱顺序
     data2 = data.loc[:, ["skin", "insu", "mass", "pedi", "age", "id"]].
      ↪sort_values(by=["age"])
```

```
[6]: data1.head()
```

```
[6]:      preg  plas  pres            class   id
467     0    97    64  tested_negative  468
109     0    95    85  tested_positive  110
452     0    91    68  tested_negative  453
449     0   120    74  tested_negative  450
448     0   104    64  tested_positive  449
```

```
[7]: data2.head()
```

```
[7]:      skin  insu  mass   pedi  age   id
255    35     0  33.6  0.543   21  256
60      0     0   0.0  0.304   21   61
102     0     0  22.5  0.262   21  103
182    20    23  27.7  0.299   21  183
623    27   115  43.5  0.347   21  624
```

```
[8]: # 按照 id 合并
newdata = data1.merge(data2, on="id")
# 按照 id 排序
newdata.sort_values(by=["id"], inplace=True)
newdata.head()
```

```
[8]:      preg  plas  pres            class  id  skin  insu  mass   pedi  age
587     6   148    72  tested_positive   1    35     0  33.6  0.627   50
233     1    85    66  tested_negative   2    29     0  26.6  0.351   31
665     8   183    64  tested_positive   3     0     0  23.3  0.672   32
212     1    89    66  tested_negative   4    23    94  28.1  0.167   21
101     0   137    40  tested_positive   5    35   168  43.1  2.288   33
```

1.0.5 以 openml 中的数据集 1StudentPerfromance 为例，求数学分数 math score 的排名

```
[1]: # 导入数据集获取工具
from sklearn.datasets import fetch_openml
```

```
[2]: # 获取数据
data = fetch_openml(
    data_id=43255,
    as_frame=True,
    parser="pandas"
)["frame"]
```

```
[3]: # 查看数据集的前五行
data.head()
```

```
[3]:   gender race/ethnicity parental level of education         lunch  \
0  female        group B           bachelor\'s degree      standard
1  female        group C                 some college      standard
```

```
2  female        group B            master\'s degree      standard
3    male        group A        associate\'s degree  free/reduced
4    male        group C                some college      standard

  test preparation course  math score  reading score  writing score
0                    none          72             72             74
1               completed          69             90             88
2                    none          90             95             93
3                    none          47             57             44
4                    none          76             78             75
```

[4]:
```python
# 按照 max 方法进行排序
res1 = data["math score"].rank(method="max")
res1.sort_values().iloc[:12]
```

[4]:
```
59      1.0
980     2.0
17      3.0
787     4.0
145     5.0
842     6.0
338     7.0
466     8.0
91     10.0
363    10.0
327    11.0
528    14.0
Name: math score, dtype: float64
```

[5]:
```python
# 按照 min 方法进行排序
res2 = data["math score"].rank(method="min")
res2.sort_values().iloc[:12]
```

[5]:
```
59      1.0
980     2.0
17      3.0
787     4.0
145     5.0
842     6.0
338     7.0
466     8.0
91      9.0
363     9.0
327    11.0
528    12.0
Name: math score, dtype: float64
```

[6]:
```
# 按照 dense 方法进行排序
res3 = data["math score"].rank(method="dense")
res3.sort_values().iloc[:12]
```

[6]:
```
59      1.0
980     2.0
17      3.0
787     4.0
145     5.0
842     6.0
338     7.0
466     8.0
91      9.0
363     9.0
327    10.0
528    11.0
Name: math score, dtype: float64
```

1.0.6 以 openml 中的数据集 1StudentPerfromance 为例，求数学分数 math score 连续出现 3 次的分数。

[1]:
```
# 导入数据集获取工具
from sklearn.datasets import fetch_openml
# 导入数据分析库
import pandas as pd
```

[2]:
```
# 获取数据
data = fetch_openml(
    data_id=43255,
    as_frame=True,
    parser="pandas"
)["frame"]
```

[3]:
```
# 查看数据集的前五行
data.head()
```

[3]:
```
   gender race/ethnicity parental level of education         lunch  \
0  female        group B           bachelor\'s degree      standard
1  female        group C                 some college      standard
2  female        group B             master\'s degree      standard
3    male        group A          associate\'s degree  free/reduced
4    male        group C                 some college      standard

  test preparation course  math score  reading score  writing score
0                    none          72             72             74
1               completed          69             90             88
2                    none          90             95             93
```

```
3                   none          47            57            44
4                   none          76            78            75
```

[4]:
```
# 一步差分结果，删除缺失值
diff1 = data["math score"].diff().dropna()
diff1
```

[4]:
```
1       -3.0
2       21.0
3      -43.0
4       29.0
5       -5.0
        …
995     25.0
996    -26.0
997     -3.0
998      9.0
999      9.0
Name: math score, Length: 999, dtype: float64
```

[5]:
```
# 找到为零的那些元素，表示重复两次出现的值
diff1_zero = diff1[diff1==0]
diff1_zero
```

[5]:
```
384    0.0
390    0.0
432    0.0
437    0.0
453    0.0
518    0.0
537    0.0
550    0.0
565    0.0
747    0.0
797    0.0
925    0.0
948    0.0
Name: math score, dtype: float64
```

[6]:
```
# 再对一步差分结果中零的索引进行差分，若为零，则说明是三个连续值
result = pd.Series(diff1_zero.index).diff().dropna()
result[result==0]
```

[6]:
```
Series([], dtype: float64)
```

1.0.7 以 **openml** 中的数据集 **1StudentPerfromance** 为例，求阅读分数 **reading score** 中出现次数大于 **1** 的重复值。

[1]:
```
# 导入数据集获取工具
from sklearn.datasets import fetch_openml
# 导入数据分析库
import pandas as pd
```

[2]:
```
# 获取数据
data = fetch_openml(
    data_id=43255,
    as_frame=True,
    parser="pandas"
)["frame"]
```

[3]:
```
# 查看数据集的前五行
data.head()
```

[3]:
```
  gender race/ethnicity parental level of education         lunch  \
0 female        group B           bachelor\'s degree      standard
1 female        group C                 some college      standard
2 female        group B             master\'s degree      standard
3   male        group A          associate\'s degree  free/reduced
4   male        group C                 some college      standard

  test preparation course  math score  reading score  writing score
0                    none          72             72             74
1               completed          69             90             88
2                    none          90             95             93
3                    none          47             57             44
4                    none          76             78             75
```

[8]:
```
# 找出 reading score 值相同的行
dup_bool = data["reading score"].duplicated()
res = data["reading score"][dup_bool]
res
```

[8]:
```
6      95
13     72
21     75
22     54
26     54
       ..
995    99
996    55
997    71
998    78
```

```
999    86
Name: reading score, Length: 928, dtype: int64
```

1.0.8 以 openml 中的数据集 1StudentPerfromance 为例，求 reading score 中重复值各自出现的次数。

[1]:
```
# 导入数据集获取工具
from sklearn.datasets import fetch_openml
# 导入数据分析库
import pandas as pd
```

[2]:
```
# 获取数据
data = fetch_openml(
    data_id=43255,
    as_frame=True,
    parser="pandas"
)["frame"]
```

[3]:
```
# 查看数据集的前五行
data.head()
```

[3]:
```
   gender race/ethnicity parental level of education        lunch  \
0  female        group B           bachelor\'s degree      standard
1  female        group C                 some college      standard
2  female        group B             master\'s degree      standard
3    male        group A          associate\'s degree  free/reduced
4    male        group C                 some college      standard

  test preparation course  math score  reading score  writing score
0                    none          72             72             74
1               completed          69             90             88
2                    none          90             95             93
3                    none          47             57             44
4                    none          76             78             75
```

[4]:
```
# 频数统计
counts = data["reading score"].value_counts()
# 取出频数大于 1 的值
results = counts[counts > 1]
# 按照 reading score 的数值排序
res_sort = results.sort_index(ascending=False)
res_sort
```

[4]:
```
100    17
99      3
97      5
96      4
```

```
95      8
       ..
37      3
34      4
31      2
29      2
24      2
Name: reading score, Length: 66, dtype: int64
```

1.0.9 以 openml 中的数据集 1StudentPerfromance 为例，求 math score 中分数为零的样本。

[1]:
```
# 导入数据集获取工具
from sklearn.datasets import fetch_openml
# 导入数据分析库
import pandas as pd
```

[2]:
```
# 获取数据
data = fetch_openml(
    data_id=43255,
    as_frame=True,
    parser="pandas"
)["frame"]
```

[3]:
```
# 查看数据集的前五行
data.head()
```

[3]:
```
   gender race/ethnicity parental level of education         lunch  \
0  female        group B           bachelor\'s degree      standard
1  female        group C                 some college      standard
2  female        group B             master\'s degree      standard
3    male        group A          associate\'s degree  free/reduced
4    male        group C                 some college      standard

  test preparation course  math score  reading score  writing score
0                    none          72             72             74
1               completed          69             90             88
2                    none          90             95             93
3                    none          47             57             44
4                    none          76             78             75
```

[4]:
```
# 数学分数为零的样本
data[data["math score"] == 0]
```

[4]:
```
    gender race/ethnicity parental level of education         lunch  \
59  female        group C            some high school  free/reduced
```

```
   test preparation course  math score  reading score  writing score
59                    none           0             17             10
```

1.0.10 以 **openml** 中的数据集 **1StudentPerfromance** 为例，删除 **writing score** 中分数相同的样本。

[1]:
```
# 导入数据集获取工具
from sklearn.datasets import fetch_openml
# 导入数据分析库
import pandas as pd
```

[2]:
```
# 获取数据
data = fetch_openml(
    data_id=43255,
    as_frame=True,
    parser="pandas"
)["frame"]
```

[3]:
```
# 查看数据集的前五行
data.head()
```

[3]:
```
   gender race/ethnicity parental level of education         lunch  \
0  female        group B           bachelor\'s degree      standard
1  female        group C                 some college      standard
2  female        group B             master\'s degree      standard
3    male        group A          associate\'s degree  free/reduced
4    male        group C                 some college      standard

  test preparation course  math score  reading score  writing score
0                    none          72             72             74
1               completed          69             90             88
2                    none          90             95             93
3                    none          47             57             44
4                    none          76             78             75
```

[4]:
```
newdata = data.drop_duplicates(subset=["writing score"])
print("删除 writing score 重复值后的样本量: ", newdata.shape, sep="\n")
newdata.head()
```

```
删除 writing score 重复值后的样本量:
(77, 8)
```

[4]:
```
   gender race/ethnicity parental level of education         lunch  \
0  female        group B           bachelor\'s degree      standard
1  female        group C                 some college      standard
2  female        group B             master\'s degree      standard
3    male        group A          associate\'s degree  free/reduced
```

```
4    male         group C                  some college      standard

  test preparation course  math score  reading score  writing score
0                    none          72             72             74
1               completed          69             90             88
2                    none          90             95             93
3                    none          47             57             44
4                    none          76             78             75
```

1.0.11 以 openml 中的数据集 1StudentPerfromance 为例，找到下一个 math score 分数比上一个高的样本值。

[1]:
```
# 导入数据集获取工具
from sklearn.datasets import fetch_openml
# 导入数据分析库
import pandas as pd
```

[2]:
```
# 获取数据
data = fetch_openml(
    data_id=43255,
    as_frame=True,
    parser="pandas"
)["frame"]
```

[3]:
```
# 查看数据集的前五行
data.head()
```

[3]:
```
   gender race/ethnicity parental level of education         lunch  \
0  female        group B          bachelor\'s degree      standard
1  female        group C                some college      standard
2  female        group B            master\'s degree      standard
3    male        group A          associate\'s degree  free/reduced
4    male        group C                some college      standard

  test preparation course  math score  reading score  writing score
0                    none          72             72             74
1               completed          69             90             88
2                    none          90             95             93
3                    none          47             57             44
4                    none          76             78             75
```

[4]:
```
# 一步差分结果
diff_res = data["math score"].diff().dropna()
# 从一步差分结果的索引找到这些样本
data.loc[diff_res[diff_res > 0].index, ].head()
```

[4]:
```
    gender race/ethnicity parental level of education         lunch  \
2   female        group B             master\'s degree      standard
4     male        group C                 some college      standard
6   female        group B                 some college      standard
8     male        group D                  high school  free/reduced
10    male        group C           associate\'s degree      standard

   test preparation course  math score  reading score  writing score
2                     none          90             95             93
4                     none          76             78             75
6                completed          88             95             92
8                completed          64             64             67
10                    none          58             54             52
```

1.0.12 以 openml 中的数据集 1StudentPerfromance 为例，找到 writing score 中分数大于 90 的样本。

[1]:
```python
# 导入数据集获取工具
from sklearn.datasets import fetch_openml
# 导入数据分析库
import pandas as pd
```

[2]:
```python
# 获取数据
data = fetch_openml(
    data_id=43255,
    as_frame=True,
    parser="pandas"
)["frame"]
```

[3]:
```python
# 查看数据集的前五行
data.head()
```

[3]:
```
   gender race/ethnicity parental level of education         lunch  \
0  female        group B           bachelor\'s degree      standard
1  female        group C                 some college      standard
2  female        group B             master\'s degree      standard
3    male        group A          associate\'s degree  free/reduced
4    male        group C                 some college      standard

  test preparation course  math score  reading score  writing score
0                    none          72             72             74
1               completed          69             90             88
2                    none          90             95             93
3                    none          47             57             44
4                    none          76             78             75
```

[4]:
```python
# 分数大于 90 的样本
data[data["writing score"] > 90].head()
```

[4]:
```
      gender race/ethnicity parental level of education         lunch  \
2     female        group B             master\'s degree      standard
6     female        group B                 some college      standard
94    female        group B                 some college      standard
106   female        group D             master\'s degree      standard
110   female        group D          associate\'s degree  free/reduced

    test preparation course  math score  reading score  writing score
2                      none          90             95             93
6                 completed          88             95             92
94                     none          79             86             92
106                    none          87            100            100
110               completed          77             89             98
```

1.0.13 以 openml 中的数据集 1StudentPerfromance 为例，统计各个民族的人数。

[1]:
```python
# 导入数据集获取工具
from sklearn.datasets import fetch_openml
# 导入数据分析库
import pandas as pd
```

[2]:
```python
# 获取数据
data = fetch_openml(
    data_id=43255,
    as_frame=True,
    parser="pandas"
)["frame"]
```

[3]:
```python
# 查看数据集的前五行
data.head()
```

[3]:
```
  gender race/ethnicity parental level of education         lunch  \
0  female        group B            bachelor\'s degree      standard
1  female        group C                 some college      standard
2  female        group B             master\'s degree      standard
3    male        group A          associate\'s degree  free/reduced
4    male        group C                 some college      standard

  test preparation course  math score  reading score  writing score
0                    none          72             72             74
1               completed          69             90             88
2                    none          90             95             93
3                    none          47             57             44
```

```
4                   none          76            78            75
```

[4]:
```
# 分组统计频数
data["race/ethnicity"].value_counts()
```

[4]:
```
group C    319
group D    262
group B    190
group E    140
group A     89
Name: race/ethnicity, dtype: int64
```

1.0.14 以 openml 中的数据集 1StudentPerfromance 为例，寻找 math score 中只出现一次的最大数值。

[1]:
```
# 导入数据集获取工具
from sklearn.datasets import fetch_openml
# 导入数据分析库
import pandas as pd
```

[2]:
```
# 获取数据
data = fetch_openml(
    data_id=43255,
    as_frame=True,
    parser="pandas"
)["frame"]
```

[3]:
```
# 查看数据集的前五行
data.head()
```

[3]:
```
   gender race/ethnicity parental level of education         lunch  \
0  female        group B          bachelor\'s degree      standard
1  female        group C                some college      standard
2  female        group B            master\'s degree      standard
3    male        group A         associate\'s degree  free/reduced
4    male        group C                some college      standard

  test preparation course  math score  reading score  writing score
0                    none          72             72             74
1               completed          69             90             88
2                    none          90             95             93
3                    none          47             57             44
4                    none          76             78             75
```

[4]:
```
# 寻找唯一值，再从唯一值中求最大值
data["math score"].unique().max()
```

[4]:
```
100
```

1.0.15 以 openml 中的数据集 1StudentPerfromance 为例，将 reading score 中数值为 59 的全部修改为 60。

[1]:
```python
# 导入数据集获取工具
from sklearn.datasets import fetch_openml
# 导入数据分析库
import pandas as pd
```

[2]:
```python
# 获取数据
data = fetch_openml(
    data_id=43255,
    as_frame=True,
    parser="pandas"
)["frame"]
```

[3]:
```python
# 查看数据集的前五行
data.head()
```

[3]:
```
  gender race/ethnicity parental level of education         lunch  \
0  female        group B          bachelor\'s degree      standard
1  female        group C                some college      standard
2  female        group B            master\'s degree      standard
3    male        group A         associate\'s degree  free/reduced
4    male        group C                some college      standard

  test preparation course  math score  reading score  writing score
0                    none          72             72             74
1               completed          69             90             88
2                    none          90             95             93
3                    none          47             57             44
4                    none          76             78             75
```

[4]:
```python
# 将 reading score 为 59 的替换为 60
print("替换之前，数字 60 的个数为：", data["reading score"].value_counts().loc[60,])
data["reading score"].replace(to_replace=59, value=60, inplace=True)
print("替换之后，数字 60 的个数为：", data["reading score"].value_counts().loc[60,])
```

```
替换之前，数字 60 的个数为： 21
替换之后，数字 60 的个数为： 38
```

1.0.16 以 openml 中的数据集 CSM 为例，计算评分 Ratings 前 10 的电影到底有多少人喜欢？

[1]:
```python
# 导入数据集获取工具
from sklearn.datasets import fetch_openml
# 导入数据分析库
import pandas as pd
```

[2]:
```
# 获取数据
data = fetch_openml(
    data_id=42371,
    as_frame=True,
    parser="pandas"
)["frame"]
```

[3]:
```
# 查看数据集的前五行
data.head()
```

[3]:
```
   Year  Ratings  Genre      Gross       Budget  Screens  Sequel  Sentiment  \
0  2014      6.3      8       9130    4000000.0     45.0       1          0
1  2014      7.1      1  192000000   50000000.0   3306.0       2          2
2  2014      6.2      1   30700000   28000000.0   2872.0       1          0
3  2014      6.3      1  106000000  110000000.0   3470.0       2          0
4  2014      4.7      8   17300000    3500000.0   2310.0       2          0

     Views  Likes  Dislikes  Comments  Aggregate.Followers
0  3280543   4632       425       636            1120000.0
1   583289   3465        61       186           12350000.0
2   304861    328        34        47             483000.0
3   452917   2429       132       590             568000.0
4  3145573  12163       610      1082            1923800.0
```

[4]:
```
# 按照 Rating 降序排列，取出前 10 对应的 Likes 数
data.sort_values(by=["Ratings"], ascending=False).iloc[:10, ][["Ratings", "Likes"]]
```

[4]:
```
     Ratings  Likes
55       8.7  16635
166      8.6   4632
155      8.6  17541
174      8.3  13030
175      8.3  12607
158      8.2   1023
45       8.2   1390
212      8.2  18398
46       8.1   8567
129      8.1  11748
```

1.0.17 以 **openml** 中的数据集 **CSM** 为例，将数据集按照评分 **Ratings** 作为第一因子降序排列，**Likes** 作为第二因子升序排列。

[1]:
```
# 导入数据集获取工具
from sklearn.datasets import fetch_openml
# 导入数据分析库
import pandas as pd
```

[2]:
```
# 获取数据
data = fetch_openml(
    data_id=42371,
    as_frame=True,
    parser="pandas"
)["frame"]
```

[3]:
```
# 查看数据集的前五行
data.head()
```

[3]:
```
   Year  Ratings  Genre      Gross       Budget  Screens  Sequel  Sentiment  \
0  2014      6.3      8       9130    4000000.0     45.0       1          0
1  2014      7.1      1  192000000   50000000.0   3306.0       2          2
2  2014      6.2      1   30700000   28000000.0   2872.0       1          0
3  2014      6.3      1  106000000  110000000.0   3470.0       2          0
4  2014      4.7      8   17300000    3500000.0   2310.0       2          0

     Views  Likes  Dislikes  Comments  Aggregate.Followers
0  3280543   4632       425       636            1120000.0
1   583289   3465        61       186           12350000.0
2   304861    328        34        47             483000.0
3   452917   2429       132       590             568000.0
4  3145573  12163       610      1082            1923800.0
```

[4]:
```
# 多字段排序，升降序排列
res = data.sort_values(by=["Ratings", "Likes"], ascending=[False, True])
res.head()
```

[4]:
```
     Year  Ratings  Genre      Gross       Budget  Screens  Sequel  Sentiment  \
55   2014      8.7      2  188000000  165000000.0   3561.0       1          2
166  2015      8.6     12  345000000  175000000.0   3946.0       1          2
155  2014      8.6      3   13100000    3300000.0     42.0       1          2
175  2015      8.3      9  135000000   28000000.0   2757.0       1          5
174  2015      8.3      1  153000000  150000000.0   3702.0       4         -4

       Views  Likes  Dislikes  Comments  Aggregate.Followers
55   5421705  16635       751      4316            1865000.0
166  1438926   4632       262       496             232000.0
155  7750223  17541       631      2760             858000.0
175   848970  12607       237      1560              55618.0
174  2732371  13030       497      1774             768700.0
```

1.0.18 以 **openml** 中的数据集 **CSM** 为例，将数据集的行索引修改为 **Movie{i}**。

[1]:
```
# 导入数据集获取工具
from sklearn.datasets import fetch_openml
# 导入数据分析库
import pandas as pd
```

[2]:
```
# 获取数据
data = fetch_openml(
    data_id=42371,
    as_frame=True,
    parser="pandas"
)["frame"]
```

[3]:
```
# 查看数据集的前五行
data.head()
```

[3]:
```
   Year  Ratings  Genre      Gross       Budget  Screens  Sequel  Sentiment  \
0  2014      6.3      8       9130    4000000.0     45.0       1          0
1  2014      7.1      1  192000000   50000000.0   3306.0       2          2
2  2014      6.2      1   30700000   28000000.0   2872.0       1          0
3  2014      6.3      1  106000000  110000000.0   3470.0       2          0
4  2014      4.7      8   17300000    3500000.0   2310.0       2          0

     Views  Likes  Dislikes  Comments  Aggregate.Followers
0  3280543   4632       425       636            1120000.0
1   583289   3465        61       186           12350000.0
2   304861    328        34        47             483000.0
3   452917   2429       132       590             568000.0
4  3145573  12163       610      1082            1923800.0
```

[4]:
```
# 重新设置行索引
data.index = ["Movie{}".format(i) for i in range(1, data.shape[0]+1)]
data.head()
```

[4]:
```
        Year  Ratings  Genre      Gross       Budget  Screens  Sequel  \
Movie1  2014      6.3      8       9130    4000000.0     45.0       1
Movie2  2014      7.1      1  192000000   50000000.0   3306.0       2
Movie3  2014      6.2      1   30700000   28000000.0   2872.0       1
Movie4  2014      6.3      1  106000000  110000000.0   3470.0       2
Movie5  2014      4.7      8   17300000    3500000.0   2310.0       2

        Sentiment    Views  Likes  Dislikes  Comments  Aggregate.Followers
Movie1          0  3280543   4632       425       636            1120000.0
Movie2          2   583289   3465        61       186           12350000.0
Movie3          0   304861    328        34        47             483000.0
Movie4          0   452917   2429       132       590             568000.0
```

```
Movie5           0   3145573   12163        610       1082             1923800.0
```

1.0.19 以 openml 中的数据集 CSM 为例，将数据集的部分列名进行修改。

[1]:
```
# 导入数据集获取工具
from sklearn.datasets import fetch_openml
# 导入数据分析库
import pandas as pd
```

[2]:
```
# 获取数据
data = fetch_openml(
    data_id=42371,
    as_frame=True,
    parser="pandas"
)["frame"]
```

[3]:
```
# 查看数据集的前五行
data.head()
```

[3]:
```
   Year  Ratings  Genre      Gross       Budget  Screens  Sequel  Sentiment  \
0  2014      6.3      8       9130    4000000.0     45.0       1          0
1  2014      7.1      1  192000000   50000000.0   3306.0       2          2
2  2014      6.2      1   30700000   28000000.0   2872.0       1          0
3  2014      6.3      1  106000000  110000000.0   3470.0       2          0
4  2014      4.7      8   17300000    3500000.0   2310.0       2          0

     Views  Likes  Dislikes  Comments  Aggregate.Followers
0  3280543   4632       425       636            1120000.0
1   583289   3465        61       186           12350000.0
2   304861    328        34        47             483000.0
3   452917   2429       132       590             568000.0
4  3145573  12163       610      1082            1923800.0
```

[4]:
```
# 列重新命名
data.columns = [
    "年份",
    "评分",
    "类型",
    "gross",
    "预算",
    "screens",
    "续集",
    "感情",
    "观看次数",
    "喜欢人数",
    "不喜欢人数",
    "评论数",
    "粉丝数"
]
data.head()
```

```
[4]:      年份   评分   类型        gross           预算   screens   续集   感情      观看次数  ␣
     ↪喜欢人数  \
0  2014  6.3   8       9130    4000000.0     45.0   1   0  3280543   4632
1  2014  7.1   1  192000000   50000000.0   3306.0   2   2   583289   3465
2  2014  6.2   1   30700000   28000000.0   2872.0   1   0   304861    328
3  2014  6.3   1  106000000  110000000.0   3470.0   2   0   452917   2429
4  2014  4.7   8   17300000    3500000.0   2310.0   2   0  3145573  12163

   不喜欢人数   评论数          粉丝数
0     425   636   1120000.0
1      61   186  12350000.0
2      34    47    483000.0
3     132   590    568000.0
4     610  1082   1923800.0
```

1.0.20 以 **openml** 中的数据集 **CSM** 为例，从数据集中无放回地随机抽取 **50** 个样本，计算评分 **Ratings** 的平均值。

```
[1]: # 导入数据集获取工具
     from sklearn.datasets import fetch_openml
     # 导入数据分析库
     import pandas as pd
```

```
[2]: # 获取数据
     data = fetch_openml(
         data_id=42371,
         as_frame=True,
         parser="pandas"
     )["frame"]
```

```
[3]: # 查看数据集的前五行
     data.head()
```

```
[3]:    Year  Ratings  Genre      Gross       Budget  Screens  Sequel  Sentiment  \
0  2014      6.3      8       9130    4000000.0     45.0       1          0
1  2014      7.1      1  192000000   50000000.0   3306.0       2          2
2  2014      6.2      1   30700000   28000000.0   2872.0       1          0
3  2014      6.3      1  106000000  110000000.0   3470.0       2          0
4  2014      4.7      8   17300000    3500000.0   2310.0       2          0

     Views  Likes  Dislikes  Comments  Aggregate.Followers
```

```
0  3280543   4632       425       636            1120000.0
1   583289   3465        61       186           12350000.0
2   304861    328        34        47             483000.0
3   452917   2429       132       590             568000.0
4  3145573  12163       610      1082            1923800.0
```

[4]:
```python
# 随机抽样平均值
data["Ratings"].sample(n=50, replace=False).mean()
```

[4]:
```
6.534
```

1.0.21 以 **openml** 中的数据集 **1StudentPerformance** 为例，计算 **math score** 大于 **60** 且小于 **90** 的人数。

[1]:
```python
# 导入数据集获取工具
from sklearn.datasets import fetch_openml
# 导入数据分析库
import pandas as pd
```

[2]:
```python
# 获取数据
data = fetch_openml(
    data_id=43255,
    as_frame=True,
    parser="pandas"
)["frame"]
```

[3]:
```python
# 查看数据集的前五行
data.head()
```

[3]:
```
  gender race/ethnicity parental level of education         lunch  \
0  female        group B           bachelor\'s degree      standard
1  female        group C                some college      standard
2  female        group B             master\'s degree      standard
3    male        group A          associate\'s degree  free/reduced
4    male        group C                some college      standard

  test preparation course  math score  reading score  writing score
0                    none          72             72             74
1               completed          69             90             88
2                    none          90             95             93
3                    none          47             57             44
4                    none          76             78             75
```

[4]:
```python
# 查找满足条件的样本
res = data[(data["math score"] > 60) & (data["math score"] < 90)]
# 计算样本量
res.shape[0]
```

[4]:
```
603
```

1.0.22 以 openml 中的数据集 1StudentPerformance 为例,找到 math score 小于 reading score 小于 writing score 的人。

[1]:
```python
# 导入数据集获取工具
from sklearn.datasets import fetch_openml
# 导入数据分析库
import pandas as pd
```

[2]:
```python
# 获取数据
data = fetch_openml(
    data_id=43255,
    as_frame=True,
    parser="pandas"
)["frame"]
```

[3]:
```python
# 查看数据集的前五行
data.head()
```

[3]:
```
  gender race/ethnicity parental level of education         lunch  \
0  female        group B          bachelor\'s degree      standard
1  female        group C                some college      standard
2  female        group B            master\'s degree      standard
3    male        group A         associate\'s degree  free/reduced
4    male        group C                some college      standard

  test preparation course  math score  reading score  writing score
0                    none          72             72             74
1               completed          69             90             88
2                    none          90             95             93
3                    none          47             57             44
4                    none          76             78             75
```

[4]:
```python
# 修改列名, 为了使用 query 语法
data.columns = data.columns[:5].to_list() + ["math_score", "reading_score",␣
↪"writing_score"]
# 该查询方法直接是列名表达式
newdata = data.query("math_score < reading_score < writing_score")
newdata.head()
```

[4]:
```
   gender race/ethnicity parental level of education         lunch  \
14  female        group A            master\'s degree      standard
15  female        group C            some high school      standard
19  female        group C         associate\'s degree  free/reduced
27  female        group C          bachelor\'s degree      standard
29  female        group D            master\'s degree      standard
```

```
   test preparation course  math_score  reading_score  writing_score
14                    none          50             53             58
15                    none          69             75             78
19                    none          54             58             61
27                    none          67             69             75
29                    none          62             70             75
```

1.0.23 以 openml 中的数据集 1StudentPerformance 为例，查找 math score 中是否存在零分。

[1]:
```
# 导入数据集获取工具
from sklearn.datasets import fetch_openml
# 导入数据分析库
import pandas as pd
```

[2]:
```
# 获取数据
data = fetch_openml(
    data_id=43255,
    as_frame=True,
    parser="pandas"
)["frame"]
```

[3]:
```
# 查看数据集的前五行
data.head()
```

[3]:
```
   gender race/ethnicity parental level of education         lunch  \
0  female        group B           bachelor\'s degree      standard
1  female        group C                 some college      standard
2  female        group B             master\'s degree      standard
3    male        group A          associate\'s degree  free/reduced
4    male        group C                 some college      standard

  test preparation course  math score  reading score  writing score
0                    none          72             72             74
1               completed          69             90             88
2                    none          90             95             93
3                    none          47             57             44
4                    none          76             78             75
```

[4]:
```
0 in data["math score"]
```

[4]:
```
True
```

1.0.24 以 **openml** 中的数据集 **1StudentPerformance** 为例，查找 **math score** 的数值属于 **reading score** 的样本。

[1]:
```
# 导入数据集获取工具
from sklearn.datasets import fetch_openml
# 导入数据分析库
import pandas as pd
```

[2]:
```
# 获取数据
data = fetch_openml(
    data_id=43255,
    as_frame=True,
    parser="pandas"
)["frame"]
```

[3]:
```
# 查看数据集的前五行
data.head()
```

[3]:
```
   gender race/ethnicity parental level of education         lunch  \
0  female        group B           bachelor\'s degree      standard
1  female        group C                 some college      standard
2  female        group B             master\'s degree      standard
3    male        group A          associate\'s degree  free/reduced
4    male        group C                 some college      standard

  test preparation course  math score  reading score  writing score
0                    none          72             72             74
1               completed          69             90             88
2                    none          90             95             93
3                    none          47             57             44
4                    none          76             78             75
```

[4]:
```
# 修改列名，为了使用 query 语法
data.columns = data.columns[:5].to_list() + ["math", "reading", "writing"]
res = data.query("math in reading")
res.head()
```

[4]:
```
   gender race/ethnicity parental level of education         lunch  \
0  female        group B           bachelor\'s degree      standard
1  female        group C                 some college      standard
2  female        group B             master\'s degree      standard
3    male        group A          associate\'s degree  free/reduced
4    male        group C                 some college      standard

  test preparation course  math  reading  writing
0                    none    72       72       74
1               completed    69       90       88
```

```
2                    none     90        95        93
3                    none     47        57        44
4                    none     76        78        75
```

1.0.25 以 **openml** 中的数据集 **1StudentPerformance** 为例，查找 **race/ethnicity** 为 **groupA** 和 **groupB** 的人。

[1]:
```python
# 导入数据集获取工具
from sklearn.datasets import fetch_openml
# 导入数据分析库
import pandas as pd
```

[2]:
```python
# 获取数据
data = fetch_openml(
    data_id=43255,
    as_frame=True,
    parser="pandas"
)["frame"]
```

[3]:
```python
# 查看数据集的前五行
data.head()
```

[3]:
```
   gender race/ethnicity parental level of education         lunch  \
0  female        group B          bachelor\'s degree      standard
1  female        group C                some college      standard
2  female        group B            master\'s degree      standard
3    male        group A         associate\'s degree  free/reduced
4    male        group C                some college      standard

  test preparation course  math score  reading score  writing score
0                    none          72             72             74
1               completed          69             90             88
2                    none          90             95             93
3                    none          47             57             44
4                    none          76             78             75
```

[4]:
```python
# 修改列名
data["race"] = data["race/ethnicity"].copy()
# 删除原来的列
data.drop(columns=["race/ethnicity"], inplace=True)
res = data.query("race in ['group A', 'group C']")
res.head()
```

[4]:
```
    gender parental level of education         lunch test preparation course  \
1   female                some college      standard               completed
3     male         associate\'s degree  free/reduced                    none
```

```
4     male              some college     standard                completed
10    male          associate\'s degree     standard                     none
13    male              some college     standard                completed
```

```
   math score  reading score  writing score     race
1          69             90             88  group C
3          47             57             44  group A
4          76             78             75  group C
10         58             54             52  group C
13         78             72             70  group A
```

1.0.26 以 **openml** 中的数据集 **1StudentPerformance** 为例，将列名 **math score** 修改为 **MathScore**，将 **reading score** 修改为 **ReadingScore**，将 **writing score** 修改为 **WritingScore**。

[1]:
```
# 导入数据集获取工具
from sklearn.datasets import fetch_openml
# 导入数据分析库
import pandas as pd
```

[2]:
```
# 获取数据
data = fetch_openml(
    data_id=43255,
    as_frame=True,
    parser="pandas"
)["frame"]
```

[ ]:
```
# 查看数据集的前五行
data.head()
```

[ ]:
```
  gender race/ethnicity parental level of education         lunch  \
0  female        group B          bachelor\'s degree      standard
1  female        group C                some college      standard
2  female        group B            master\'s degree      standard
3    male        group A          associate\'s degree  free/reduced
4    male        group C                some college      standard

  test preparation course  math score  reading score  writing score
0                    none          72             72             74
1               completed          69             90             88
2                    none          90             95             93
3                    none          47             57             44
4                    none          76             78             75
```

[ ]:
```
# 修改列名
data.rename(columns={
    "math score": "MathScore",
    "reading score": "ReadingScore",
    "writing score": "WritingScore",
}, inplace=True)
data.head()
```

1.0.27 以 **openml** 中的数据集 **1StudentPerformance** 为例，将数据集随机地拆分为三块，再从三个子集中分别进行重抽样，将所得到的结果按行合并。

[1]:
```
# 导入数据集获取工具
from sklearn.datasets import fetch_openml
# 导入数据分析库
import pandas as pd
```

[2]:
```
# 获取数据
data = fetch_openml(
    data_id=43255,
    as_frame=True,
    parser="pandas"
)["frame"]
```

[3]:
```
# 查看数据集的前五行
data.head()
```

[3]:
```
  gender race/ethnicity parental level of education        lunch  \
0  female        group B           bachelor\'s degree     standard
1  female        group C                some college     standard
2  female        group B             master\'s degree     standard
3    male        group A          associate\'s degree  free/reduced
4    male        group C                some college     standard

  test preparation course  math score  reading score  writing score
0                    none          72             72             74
1               completed          69             90             88
2                    none          90             95             93
3                    none          47             57             44
4                    none          76             78             75
```

[4]:
```
# 数据集划分
from sklearn.model_selection import train_test_split
# 第一次划分
df_train, df_test = train_test_split(data, test_size=0.3, random_state=1)
# 第二次划分
df_train1, df_test1 = train_test_split(df_train, test_size=0.3, random_state=2)
# 重抽样
sample1 = df_train1.sample(n=100, replace=True)
sample2 = df_test1.sample(n=100, replace=True)
```

```
sample3 = df_test.sample(n=100, replace=True)
# 按行合并
newdata = pd.concat([sample1, sample2, sample3], axis=0)
newdata.head()
```

[4]:
```
    gender race/ethnicity parental level of education         lunch  \
497  female        group D                some college  free/reduced
384  female        group A            some high school  free/reduced
487  female        group C          associate\'s degree  free/reduced
273  female        group D                some college      standard
728  female        group D                 high school  free/reduced

   test preparation course  math score  reading score  writing score
497              completed          59             78             76
384                   none          38             43             43
487                   none          60             75             74
273                   none          65             70             71
728                   none          73             92             84
```

1.0.28 以 **openml** 中的数据集 **1StudentPerformance** 为例，将数据集进行三次重抽样，将所得到的结果按行合并（每次重抽样的结果可能有样本值是相同的，合并时需要特别注意，我们这里重新设置行索引）。

[1]:
```
# 导入数据集获取工具
from sklearn.datasets import fetch_openml
# 导入数据分析库
import pandas as pd
```

[2]:
```
# 获取数据
data = fetch_openml(
    data_id=43255,
    as_frame=True,
    parser="pandas"
)["frame"]
```

[3]:
```
# 查看数据集的前五行
data.head()
```

[3]:
```
  gender race/ethnicity parental level of education         lunch  \
0  female        group B          bachelor\'s degree      standard
1  female        group C                some college      standard
2  female        group B            master\'s degree      standard
3    male        group A          associate\'s degree  free/reduced
4    male        group C                some college      standard

  test preparation course  math score  reading score  writing score
```

```
0                      none          72              72              74
1                 completed          69              90              88
2                      none          90              95              93
3                      none          47              57              44
4                      none          76              78              75
```

[8]:
```
# 重抽样
sample1 = data.sample(n=100, replace=True, random_state=1)
sample2 = data.sample(n=100, replace=True, random_state=2)
sample3 = data.sample(n=100, replace=True, random_state=3)
# 按行合并，忽略行索引，重新给定索引
newdata = pd.concat([sample1, sample2, sample3], axis=0, ignore_index=True)
newdata.head()
```

[8]:
```
   gender race/ethnicity parental level of education         lunch  \
0  female        group D            some high school  free/reduced
1    male        group D         associate\'s degree      standard
2  female        group C          bachelor\'s degree  free/reduced
3  female        group A         associate\'s degree  free/reduced
4    male        group B                 high school      standard

  test preparation course  math score  reading score  writing score
0                    none          50             64             59
1                    none          80             75             77
2                    none          67             75             72
3                    none          41             51             48
4               completed          76             62             60
```

1.0.29 以 **openml** 中的数据集 **1StudentPerformance** 为例，将数据集拆分成两个子集（变量拆分），样本是从原数据集中重抽样所得，将这两个子集按列合并，默认键是行索引 **index**。

[1]:
```
# 导入数据集获取工具
from sklearn.datasets import fetch_openml
# 导入数据分析库
import pandas as pd
```

[2]:
```
# 获取数据
data = fetch_openml(
    data_id=43255,
    as_frame=True,
    parser="pandas"
)["frame"]
```

[3]:
```
# 查看数据集的前五行
data.head()
```

```
[3]:   gender race/ethnicity parental level of education         lunch  \
     0  female        group B          bachelor\'s degree      standard
     1  female        group C                some college      standard
     2  female        group B            master\'s degree      standard
     3    male        group A         associate\'s degree  free/reduced
     4    male        group C                some college      standard

       test preparation course  math score  reading score  writing score
     0                    none          72             72             74
     1               completed          69             90             88
     2                    none          90             95             93
     3                    none          47             57             44
     4                    none          76             78             75
```

```
[4]: # 重抽样
     data1 = data.iloc[:, :4].sample(n=50, replace=True, random_state=1)
     data2 = data.iloc[:, 4:].sample(n=50, replace=True, random_state=2)
     # 按列合并，默认的 key 是 Index，取并集，以缺失值填充
     newdata1 = pd.concat([data1, data2], axis=1, join="outer")
     newdata1.head()
```

```
[4]:     gender race/ethnicity parental level of education         lunch  \
     37   female        group D            some high school  free/reduced
     235    male        group D         associate\'s degree      standard
     908  female        group C          bachelor\'s degree  free/reduced
     72   female        group A         associate\'s degree  free/reduced
     767    male        group B                 high school      standard

         test preparation course  math score  reading score  writing score
     37                      NaN         NaN            NaN            NaN
     235                     NaN         NaN            NaN            NaN
     908                     NaN         NaN            NaN            NaN
     72                      NaN         NaN            NaN            NaN
     767                     NaN         NaN            NaN            NaN
```

```
[5]: # 按列合并，默认的 key 是 Index，取交集，无缺失值
     newdata2 = pd.concat([data1, data2], axis=1, join="inner")
     newdata2.head()
```

```
[5]:    gender race/ethnicity parental level of education     lunch  \
     534   male        group B                 high school  standard

         test preparation course  math score  reading score  writing score
     534               completed          73             69             68
```

1.0.30 以 **openml** 中的数据集 **1StudentPerformance** 为例，将列 **gender** 取出来转为 **dataframe** 对象。

[1]:
```
# 导入数据集获取工具
from sklearn.datasets import fetch_openml
# 导入数据分析库
import pandas as pd
```

[2]:
```
# 获取数据
data = fetch_openml(
    data_id=43255,
    as_frame=True,
    parser="pandas"
)["frame"]
```

[3]:
```
# 查看数据集的前五行
data.head()
```

[3]:
```
   gender race/ethnicity parental level of education         lunch  \
0  female        group B           bachelor\'s degree      standard
1  female        group C                 some college      standard
2  female        group B             master\'s degree      standard
3    male        group A          associate\'s degree  free/reduced
4    male        group C                 some college      standard

  test preparation course  math score  reading score  writing score
0                    none          72             72             74
1               completed          69             90             88
2                    none          90             95             93
3                    none          47             57             44
4                    none          76             78             75
```

[4]:
```
# Series 转 Dataframe
data["gender"].to_frame()
```

[4]:
```
     gender
0    female
1    female
2    female
3      male
4      male
..      …
995  female
996    male
997  female
998  female
999  female
```

```
[1000 rows x 1 columns]
```

1.0.31 以 **openml** 中的数据集 **1StudentPerformance** 为例，统计不同 **race** 和不同性别下数学成绩的平均值。

[1]:
```
# 导入数据集获取工具
from sklearn.datasets import fetch_openml
# 导入数据分析库
import pandas as pd
```

[2]:
```
# 获取数据
data = fetch_openml(
    data_id=43255,
    as_frame=True,
    parser="pandas"
)["frame"]
```

[3]:
```
# 查看数据集的前五行
data.head()
```

[3]:
```
   gender race/ethnicity parental level of education        lunch  \
0  female        group B           bachelor\'s degree      standard
1  female        group C                 some college      standard
2  female        group B             master\'s degree      standard
3    male        group A          associate\'s degree  free/reduced
4    male        group C                 some college      standard

  test preparation course  math score  reading score  writing score
0                    none          72             72             74
1               completed          69             90             88
2                    none          90             95             93
3                    none          47             57             44
4                    none          76             78             75
```

[4]:
```
# 在不同的分组下，计算数学成绩平均值
data.groupby(by=["gender", "race/ethnicity"])["math score"].agg("mean")
```

[4]:
```
gender  race/ethnicity
female  group A           58.527778
        group B           61.403846
        group C           62.033333
        group D           65.248062
        group E           70.811594
male    group A           63.735849
        group B           65.930233
        group C           67.611511
        group D          69.413534
        group E          76.746479
Name: math score, dtype: float64
```

1.0.32 以 openml 中的数据集 1StudentPerformance 为例，统计不同 race 和不同性别下阅读成绩的中位数。

[1]:
```python
# 导入数据集获取工具
from sklearn.datasets import fetch_openml
# 导入数据分析库
import pandas as pd
```

[2]:
```python
# 获取数据
data = fetch_openml(
    data_id=43255,
    as_frame=True,
    parser="pandas"
)["frame"]
```

[3]:
```python
# 查看数据集的前五行
data.head()
```

[3]:
```
  gender race/ethnicity parental level of education         lunch  \
0  female        group B          bachelor\'s degree      standard
1  female        group C                some college      standard
2  female        group B            master\'s degree      standard
3    male        group A         associate\'s degree  free/reduced
4    male        group C                some college      standard

  test preparation course  math score  reading score  writing score
0                    none          72             72             74
1               completed          69             90             88
2                    none          90             95             93
3                    none          47             57             44
4                    none          76             78             75
```

[4]:
```python
# 数据透视表
pd.pivot_table(
    data,
    values="reading score",
    index="gender",
    columns="race/ethnicity",
    aggfunc="median"
)
```

[4]:
```
race/ethnicity  group A  group B  group C  group D  group E
gender
female             67.5     71.5     73.0     74.0     76.0
male               61.0     62.0     66.0     68.0     73.0
```

1.0.33 以 openml 中的数据集 1StudentPerformance 为例，统计不同 race 和不同性别，不同的 parental level of education 下，写作成绩的方差。

[1]:
```python
# 导入数据集获取工具
from sklearn.datasets import fetch_openml
# 导入数据分析库
import pandas as pd
```

[2]:
```python
# 获取数据
data = fetch_openml(
    data_id=43255,
    as_frame=True,
    parser="pandas"
)["frame"]
```

[3]:
```python
# 查看数据集的前五行
data.head()
```

[3]:
```
  gender race/ethnicity parental level of education         lunch  \
0  female        group B           bachelor\'s degree      standard
1  female        group C                some college      standard
2  female        group B             master\'s degree      standard
3    male        group A          associate\'s degree  free/reduced
4    male        group C                some college      standard

  test preparation course  math score  reading score  writing score
0                    none          72             72             74
1               completed          69             90             88
2                    none          90             95             93
3                    none          47             57             44
4                    none          76             78             75
```

[4]:
```python
# 数据透视表
pd.pivot_table(
    data,
    values="writing score",
    index=["gender", "parental level of education"],
    columns="race/ethnicity",
    aggfunc="var"
)
```

[4]:
```
race/ethnicity                       group A     group B     group C  \
gender parental level of education
female associate\'s degree        260.966667  152.221344  144.846465
       bachelor\'s degree          94.333333   59.290909  158.426154
       high school                219.476190  231.485450  210.171264
       master\'s degree            112.500000  171.200000  157.571429
       some college               167.696429  236.352381  220.390592
       some high school           358.711111  284.874459  314.109788
male   associate\'s degree        244.125000  217.911765  211.751894
       bachelor\'s degree         161.527778  180.777778  223.170330
       high school                120.654545  234.892105  129.466132
       master\'s degree                  NaN         NaN  126.060606
       some college               396.722222  233.922078  262.640000
       some high school           150.131868  186.495833   85.447619

race/ethnicity                       group D     group E
gender parental level of education
female associate\'s degree        215.449275  192.970588
       bachelor\'s degree         214.858974  387.333333
       high school                181.441176  207.659091
       master\'s degree           228.780952  306.666667
       some college               110.063866  152.229167
       some high school           232.090000  387.766667
male   associate\'s degree        149.435385  226.147619
       bachelor\'s degree         203.095238  141.267857
       high school                158.396011  109.833333
       master\'s degree            47.071429         NaN
       some college               163.741935  144.368421
       some high school           173.156667  276.931818
```

1.0.34 以 **openml** 中的数据集 **1StudentPerformance** 为例，统计不同 **race** 和不同性别，不同的 **parental level of education** 下，样本的数量，并给出边际值（也是数量）。

[1]:
```python
# 导入数据集获取工具
from sklearn.datasets import fetch_openml
# 导入数据分析库
import pandas as pd
```

[2]:
```python
# 获取数据
data = fetch_openml(
    data_id=43255,
    as_frame=True,
    parser="pandas"
)["frame"]
```

```
[3]: # 查看数据集的前五行
     data.head()
```

```
[3]:    gender race/ethnicity parental level of education         lunch  \
     0  female        group B           bachelor\'s degree      standard
     1  female        group C                some college      standard
     2  female        group B             master\'s degree      standard
     3    male        group A          associate\'s degree  free/reduced
     4    male        group C                some college      standard

       test preparation course  math score  reading score  writing score
     0                    none          72             72             74
     1               completed          69             90             88
     2                    none          90             95             93
     3                    none          47             57             44
     4                    none          76             78             75
```

```
[4]: # 数据透视表
     pd.pivot_table(
         data,
         values="writing score",
         index=["gender", "parental level of education"],
         columns="race/ethnicity",
         aggfunc="count",
         margins=True,
         margins_name="样本总数"
     )
```

```
[4]: race/ethnicity                     group A  group B  group C  group D  \
     gender parental level of education
     female associate\'s degree               6       23       45       24
            bachelor\'s degree                3       11       26       13
            high school                      7       28       30       17
            master\'s degree                  2        5        7       15
            some college                     8       15       44       35
            some high school                10       22       28       25
     male   associate\'s degree               8       18       33       26
            bachelor\'s degree                9        9       14       15
            high school                     11       20       34       27
            master\'s degree                  1        1       12        8
            some college                    10       22       25       32
            some high school                14       16       21       25
     样本总数                                    89      190      319      262

     race/ethnicity                     group E  样本总数
     gender parental level of education
```

```
female associate\'s degree          18   116
       bachelor\'s degree           10    63
       high school                  12    94
       master\'s degree              7    36
       some college                 16   118
       some high school              6    91
male   associate\'s degree          21   106
       bachelor\'s degree            8    55
       high school                  10   102
       master\'s degree              1    23
       some college                 19   108
       some high school             12    88
样本总数                               140  1000
```

1.0.35 以 **openml** 中的数据集 **1StudentPerformance** 为例，计算 **gender** 和 **race/ethnicity** 的二维列联表。

[1]:
```
# 导入数据集获取工具
from sklearn.datasets import fetch_openml
# 导入数据分析库
import pandas as pd
```

[2]:
```
# 获取数据
data = fetch_openml(
    data_id=43255,
    as_frame=True,
    parser="pandas"
)["frame"]
```

[3]:
```
# 查看数据集的前五行
data.head()
```

[3]:
```
   gender race/ethnicity parental level of education         lunch  \
0  female        group B          bachelor\'s degree      standard
1  female        group C                some college      standard
2  female        group B            master\'s degree      standard
3    male        group A         associate\'s degree  free/reduced
4    male        group C                some college      standard

  test preparation course  math score  reading score  writing score
0                    none          72             72             74
1               completed          69             90             88
2                    none          90             95             93
3                    none          47             57             44
4                    none          76             78             75
```

[4]:
```
# 列联表
pd.crosstab(
    index=data["gender"],
    columns=data["race/ethnicity"]
)
```

[4]:
```
race/ethnicity  group A  group B  group C  group D  group E
gender
female               36      104      180      129       69
male                 53       86      139      133       71
```

1.0.36 以 **openml** 中的数据集 **1StudentPerformance** 为例，计算 **gender** 和 **race/ethnicity** 和 **lunch** 的三维频率列联表，并给出边际值。

[1]:
```
# 导入数据集获取工具
from sklearn.datasets import fetch_openml
# 导入数据分析库
import pandas as pd
```

[2]:
```
# 获取数据
data = fetch_openml(
    data_id=43255,
    as_frame=True,
    parser="pandas"
)["frame"]
```

[3]:
```
# 查看数据集的前五行
data.head()
```

[3]:
```
  gender race/ethnicity parental level of education         lunch  \
0  female        group B           bachelor\'s degree      standard
1  female        group C                some college      standard
2  female        group B             master\'s degree      standard
3    male        group A          associate\'s degree  free/reduced
4    male        group C                some college      standard

  test preparation course  math score  reading score  writing score
0                    none          72             72             74
1               completed          69             90             88
2                    none          90             95             93
3                    none          47             57             44
4                    none          76             78             75
```

[4]:
```
# 列联表
pd.crosstab(
    index=[data["gender"], data["lunch"]], # 必须是列表形式
    columns=data["race/ethnicity"],
    normalize=True,
    margins=True,
    margins_name="合计比例"
)
```

[4]:
```
race/ethnicity       group A  group B  group C  group D  group E   合计比例
gender lunch
female free/reduced    0.014    0.039    0.062    0.051    0.023  0.189
       standard        0.022    0.065    0.118    0.078    0.046  0.329
male   free/reduced    0.022    0.030    0.052    0.044    0.018  0.166
       standard        0.031    0.056    0.087    0.089    0.053  0.316
合计比例                   0.089    0.190    0.319    0.262    0.140  1.000
```

1.0.37 以 **openml** 中的数据集 **1StudentPerformance** 为例，对数学成绩 **math score** 离散化分组。

[1]:
```python
# 导入数据集获取工具
from sklearn.datasets import fetch_openml
# 导入数据分析库
import pandas as pd
```

[2]:
```python
# 获取数据
data = fetch_openml(
    data_id=43255,
    as_frame=True,
    parser="pandas"
)["frame"]
```

[3]:
```python
# 查看数据集的前五行
data.head()
```

[3]:
```
   gender race/ethnicity parental level of education         lunch  \
0  female        group B          bachelor\'s degree      standard
1  female        group C                some college      standard
2  female        group B            master\'s degree      standard
3    male        group A         associate\'s degree  free/reduced
4    male        group C                some college      standard

  test preparation course  math score  reading score  writing score
0                    none          72             72             74
1               completed          69             90             88
2                    none          90             95             93
3                    none          47             57             44
4                    none          76             78             75
```

[4]:
```python
# 离散变量分组
pd.cut(data["math score"], bins=10)
```

```
[4]: 0       (70.0, 80.0]
     1       (60.0, 70.0]
     2       (80.0, 90.0]
     3       (40.0, 50.0]
     4       (70.0, 80.0]
                 …
     995     (80.0, 90.0]
     996     (60.0, 70.0]
     997     (50.0, 60.0]
     998     (60.0, 70.0]
     999     (70.0, 80.0]
     Name: math score, Length: 1000, dtype: category
     Categories (10, interval[float64, right]): [(-0.1, 10.0] < (10.0, 20.0] < (20.0,
     30.0] < (30.0, 40.0] … (60.0, 70.0] < (70.0, 80.0] < (80.0, 90.0] < (90.0,
     100.0]]
```

1.0.38 以 openml 中的数据集 1StudentPerformance 为例，对 gender 进行虚拟变量化。

```
[1]: # 导入数据集获取工具
     from sklearn.datasets import fetch_openml
     # 导入数据分析库
     import pandas as pd
```

```
[2]: # 获取数据
     data = fetch_openml(
         data_id=43255,
         as_frame=True,
         parser="pandas"
     )["frame"]
```

```
[3]: # 查看数据集的前五行
     data.head()
```

```
[3]:    gender race/ethnicity parental level of education         lunch  \
     0  female        group B           bachelor\'s degree      standard
     1  female        group C                 some college      standard
     2  female        group B             master\'s degree      standard
     3    male        group A          associate\'s degree  free/reduced
     4    male        group C                 some college      standard

       test preparation course  math score  reading score  writing score
     0                    none          72             72             74
     1               completed          69             90             88
     2                    none          90             95             93
     3                    none          47             57             44
     4                    none          76             78             75
```

[4]:
```
# 生成虚拟变量
dummy = pd.get_dummies(data["gender"], prefix="性别")
dummy
```

[4]:
```
     性别_female  性别_male
0             1        0
1             1        0
2             1        0
3             0        1
4             0        1
..          …        …
995           1        0
996           0        1
997           1        0
998           1        0
999           1        0

[1000 rows x 2 columns]
```

[5]:
```
# 从虚拟变量的 dataframe 转为正常的一列 dataframe
newdata = pd.from_dummies(dummy)
newdata
```

[5]:
```

0    性别_female
1    性别_female
2    性别_female
3      性别_male
4      性别_male
..          …
995  性别_female
996    性别_male
997  性别_female
998  性别_female
999  性别_female

[1000 rows x 1 columns]
```

1.0.39 以 openml 中的数据集 1StudentPerformance 为例，对 gender 转为因子类型。

[1]:
```
# 导入数据集获取工具
from sklearn.datasets import fetch_openml
# 导入数据分析库
import pandas as pd
```

[2]:
```
# 获取数据
data = fetch_openml(
    data_id=43255,
    as_frame=True,
    parser="pandas"
)["frame"]
```

[3]:
```
# 查看数据集的前五行
data.head()
```

[3]:
```
   gender race/ethnicity parental level of education         lunch  \
0  female        group B           bachelor\'s degree      standard
1  female        group C                 some college      standard
2  female        group B             master\'s degree      standard
3    male        group A          associate\'s degree  free/reduced
4    male        group C                 some college      standard

  test preparation course  math score  reading score  writing score
0                    none          72             72             74
1               completed          69             90             88
2                    none          90             95             93
3                    none          47             57             44
4                    none          76             78             75
```

[4]:
```
# 变量因子化
newdata, index = pd.factorize(data["gender"])
newdata[:10]
```

[4]:
```
array([0, 0, 0, 1, 1, 0, 0, 1, 1, 0], dtype=int64)
```

[5]:
```
index
```

[5]:
```
CategoricalIndex(['female', 'male'], categories=['female', 'male'],
ordered=False, dtype='category')
```

1.0.40 以 **openml** 中的数据集 **1StudentPerformance** 为例，将宽数据转为长数据。

[1]:
```
# 导入数据集获取工具
from sklearn.datasets import fetch_openml
# 导入数据分析库
import pandas as pd
```

[2]:
```
# 获取数据
data = fetch_openml(
    data_id=43255,
    as_frame=True,
    parser="pandas"
)["frame"]
```

[3]:
```
# 查看数据集的前五行
data.head()
```

[3]:
```
  gender race/ethnicity parental level of education         lunch  \
0 female        group B           bachelor\'s degree      standard
1 female        group C                 some college      standard
2 female        group B             master\'s degree      standard
3   male        group A           associate\'s degree  free/reduced
4   male        group C                 some college      standard

  test preparation course  math score  reading score  writing score
0                    none          72             72             74
1               completed          69             90             88
2                    none          90             95             93
3                    none          47             57             44
4                    none          76             78             75
```

[4]:
```
# 宽数据转为长数据
data.iloc[:5, [0,1,5,6]].melt(id_vars=["gender", "race/ethnicity"])
```

[4]:
```
  gender race/ethnicity       variable  value
0 female        group B     math score     72
1 female        group C     math score     69
2 female        group B     math score     90
3   male        group A     math score     47
4   male        group C     math score     76
5 female        group B  reading score     72
6 female        group C  reading score     90
7 female        group B  reading score     95
8   male        group A  reading score     57
9   male        group C  reading score     78
```

1.0.41 以 openml 中的数据集 1StudentPerformance 为例，将 gender 的字符串全部大写，将 race/ethnicity 的字符串全部小写。

[1]:
```
# 导入数据集获取工具
from sklearn.datasets import fetch_openml
# 导入数据分析库
import pandas as pd
```

[2]:
```
# 获取数据
data = fetch_openml(
    data_id=43255,
    as_frame=True,
    parser="pandas"
)["frame"]
```

[3]:
```
# 查看数据集的前五行
data.head()
```

[3]:
```
   gender race/ethnicity parental level of education         lunch  \
0  female        group B          bachelor\'s degree      standard
1  female        group C                some college      standard
2  female        group B            master\'s degree      standard
3    male        group A         associate\'s degree  free/reduced
4    male        group C                some college      standard

  test preparation course  math score  reading score  writing score
0                    none          72             72             74
1               completed          69             90             88
2                    none          90             95             93
3                    none          47             57             44
4                    none          76             78             75
```

[4]:
```
# 字符串大小写
data["gender"].str.upper()
```

[4]:
```
0      FEMALE
1      FEMALE
2      FEMALE
3        MALE
4        MALE
        …
995    FEMALE
996      MALE
997    FEMALE
998    FEMALE
999    FEMALE
Name: gender, Length: 1000, dtype: object
```

[5]:
```
data["race/ethnicity"].str.lower()
```

[5]:
```
0      group b
1      group c
2      group b
3      group a
4      group c
        …
995    group e
996    group c
997    group c
```

```
998     group d
999     group d
Name: race/ethnicity, Length: 1000, dtype: object
```

1.0.42 以 **openml** 中的数据集 **1StudentPerformance** 为例，计算 **lunch** 列字符串中字符的个数。

[1]:
```
# 导入数据集获取工具
from sklearn.datasets import fetch_openml
# 导入数据分析库
import pandas as pd
```

[2]:
```
# 获取数据
data = fetch_openml(
    data_id=43255,
    as_frame=True,
    parser="pandas"
)["frame"]
```

[3]:
```
# 查看数据集的前五行
data.head()
```

[3]:
```
   gender race/ethnicity parental level of education         lunch  \
0  female        group B          bachelor\'s degree      standard
1  female        group C                some college      standard
2  female        group B            master\'s degree      standard
3    male        group A         associate\'s degree  free/reduced
4    male        group C                some college      standard

  test preparation course  math score  reading score  writing score
0                    none          72             72             74
1               completed          69             90             88
2                    none          90             95             93
3                    none          47             57             44
4                    none          76             78             75
```

[4]:
```
# 字符个数
data["lunch"].str.len()
```

[4]:
```
0       8
1       8
2       8
3      12
4       8
       ..
995     8
996    12
```

```
997     12
998      8
999     12
Name: lunch, Length: 1000, dtype: int64
```

1.0.43 以 **openml** 中的数据集 **1StudentPerformance** 为例，将 **race/ethnicity** 中的字符串空格去除。

[1]:
```python
# 导入数据集获取工具
from sklearn.datasets import fetch_openml
# 导入数据分析库
import pandas as pd
```

[2]:
```python
# 获取数据
data = fetch_openml(
    data_id=43255,
    as_frame=True,
    parser="pandas"
)["frame"]
```

[3]:
```python
# 查看数据集的前五行
data.head()
```

[3]:
```
  gender race/ethnicity parental level of education         lunch  \
0 female        group B          bachelor\'s degree      standard
1 female        group C                some college      standard
2 female        group B            master\'s degree      standard
3   male        group A         associate\'s degree  free/reduced
4   male        group C                some college      standard

  test preparation course  math score  reading score  writing score
0                    none          72             72             74
1               completed          69             90             88
2                    none          90             95             93
3                    none          47             57             44
4                    none          76             78             75
```

[4]:
```python
# 去除空格
data["race/ethnicity"].str.replace(" ", "")
```

[4]:
```
0       groupB
1       groupC
2       groupB
3       groupA
4       groupC
         …
995     groupE
```

```
996     groupC
997     groupC
998     groupD
999     groupD
Name: race/ethnicity, Length: 1000, dtype: object
```

1.0.44 以 **openml** 中的数据集 **1StudentPerformance** 为例，将 **race/ethnicity** 的字符串按照空格分割成列表。

[1]:
```
# 导入数据集获取工具
from sklearn.datasets import fetch_openml
# 导入数据分析库
import pandas as pd
```

[2]:
```
# 获取数据
data = fetch_openml(
    data_id=43255,
    as_frame=True,
    parser="pandas"
)["frame"]
```

[3]:
```
# 查看数据集的前五行
data.head()
```

[3]:
```
  gender race/ethnicity parental level of education         lunch  \
0 female        group B          bachelor\'s degree      standard
1 female        group C                some college      standard
2 female        group B            master\'s degree      standard
3   male        group A         associate\'s degree  free/reduced
4   male        group C                some college      standard

  test preparation course  math score  reading score  writing score
0                    none          72             72             74
1               completed          69             90             88
2                    none          90             95             93
3                    none          47             57             44
4                    none          76             78             75
```

[4]:
```
# 分割为列表
strlist = data["race/ethnicity"].str.split(" ")
strlist
```

[4]:
```
0       [group, B]
1       [group, C]
2       [group, B]
3       [group, A]
```

```
4       [group, C]
           …
995     [group, E]
996     [group, C]
997     [group, C]
998     [group, D]
999     [group, D]
Name: race/ethnicity, Length: 1000, dtype: object
```

[5]:
```
# 获取分割的列表的第二个元素
strlist.str[1]
```

[5]:
```
0      B
1      C
2      B
3      A
4      C
      ..
995    E
996    C
997    C
998    D
999    D
Name: race/ethnicity, Length: 1000, dtype: object
```

1.0.45 以 **openml** 中的数据集 **1StudentPerformance** 为例，将 **race/ethnicity** 的字符串按照空格分割成列表，并将列表中的各个元素作为列加入到 **dataframe** 中。

[1]:
```
# 导入数据集获取工具
from sklearn.datasets import fetch_openml
# 导入数据分析库
import pandas as pd
```

[2]:
```
# 获取数据
data = fetch_openml(
    data_id=43255,
    as_frame=True,
    parser="pandas"
)["frame"]
```

[3]:
```
# 查看数据集的前五行
data.head()
```

[3]:
```
  gender race/ethnicity parental level of education         lunch  \
0  female        group B           bachelor\'s degree      standard
1  female        group C                 some college      standard
```

```
2  female         group B            master\'s degree      standard
3    male         group A        associate\'s degree  free/reduced
4    male         group C                some college      standard

  test preparation course  math score  reading score  writing score
0                    none          72             72             74
1               completed          69             90             88
2                    none          90             95             93
3                    none          47             57             44
4                    none          76             78             75
```

[4]:
```python
# 分割为列表
strlist = data["race/ethnicity"].str.split(" ", expand=True)
strlist
```

[4]:
```
         0  1
0    group  B
1    group  C
2    group  B
3    group  A
4    group  C
..     … ..
995  group  E
996  group  C
997  group  C
998  group  D
999  group  D

[1000 rows x 2 columns]
```

1.0.46 以 **openml** 中的数据集 **1StudentPerformance** 为例，将 **parental level of education** 的字符串中的反斜杠去掉。

[1]:
```python
# 导入数据集获取工具
from sklearn.datasets import fetch_openml
# 导入数据分析库
import pandas as pd
```

[2]:
```python
# 获取数据
data = fetch_openml(
    data_id=43255,
    as_frame=True,
    parser="pandas"
)["frame"]
```

```
[3]: # 查看数据集的前五行
     data.head()
```

```
[3]:   gender race/ethnicity parental level of education         lunch  \
     0  female        group B           bachelor\'s degree      standard
     1  female        group C                 some college      standard
     2  female        group B             master\'s degree      standard
     3    male        group A          associate\'s degree  free/reduced
     4    male        group C                 some college      standard

       test preparation course  math score  reading score  writing score
     0                    none          72             72             74
     1               completed          69             90             88
     2                    none          90             95             93
     3                    none          47             57             44
     4                    none          76             78             75
```

```
[4]: # 去掉反斜杠，使用替换
     data["parental level of education"].iloc[0]
```

```
[4]: "bachelor\\'s degree"
```

```
[5]: # 使用正则表达式替换
     data["parental level of education"].str.replace("\\", "", regex=True)
```

```
[5]: 0       bachelor's degree
     1            some college
     2         master's degree
     3      associate's degree
     4            some college
                   …
     995       master's degree
     996           high school
     997           high school
     998          some college
     999          some college
     Name: parental level of education, Length: 1000, dtype: object
```

1.0.47 以 **openml** 中的数据集 **1StudentPerformance** 为例，将 **math score**，**reading score** 和 **writing score** 三列合并为一列，以逗号分隔。

```
[1]: # 导入数据集获取工具
     from sklearn.datasets import fetch_openml
     # 导入数据分析库
     import pandas as pd
```

[2]:
```
# 获取数据
data = fetch_openml(
    data_id=43255,
    as_frame=True,
    parser="pandas"
)["frame"]
```

[3]:
```
# 查看数据集的前五行
data.head()
```

[3]:
```
  gender race/ethnicity parental level of education         lunch  \
0  female        group B           bachelor\'s degree      standard
1  female        group C                 some college      standard
2  female        group B             master\'s degree      standard
3    male        group A          associate\'s degree  free/reduced
4    male        group C                 some college      standard

  test preparation course  math score  reading score  writing score
0                    none          72             72             74
1               completed          69             90             88
2                    none          90             95             93
3                    none          47             57             44
4                    none          76             78             75
```

[4]:
```
# 列之间的合并
newS = data["math score"].astype("string").str.cat(data["reading score"].
 ↪astype("string"), sep=",").str.cat(data["writing score"].astype("string"),␣
 ↪sep=",")
newS
```

[4]:
```
0      72,72,74
1      69,90,88
2      90,95,93
3      47,57,44
4      76,78,75
         …
995    88,99,95
996    62,55,55
997    59,71,65
998    68,78,77
999    77,86,86
Name: math score, Length: 1000, dtype: string
```

1.0.48 对含有缺失值的列进行求和和求乘积，看看结果如何

[1]:
```
import pandas as pd
import numpy as np
```

[2]:
```
# 生成 dataframe
df = pd.DataFrame(
    np.random.randn(5, 3),
    index=["a", "c", "e", "f", "h"],
    columns=["one", "two", "three"],
)
df["four"] = "bar"
df["five"] = df["one"] > 0
df = df.reindex(["a", "b", "c", "d", "e", "f", "g", "h"])
df
```

[2]:
```
        one       two     three four   five
a  0.271842 -0.350975  0.194960  bar   True
b       NaN       NaN       NaN  NaN    NaN
c -0.104840 -0.469391 -0.410844  bar  False
d       NaN       NaN       NaN  NaN    NaN
e -0.059557  0.436472 -0.792940  bar  False
f  0.575772 -0.903377  0.192159  bar   True
g       NaN       NaN       NaN  NaN    NaN
h -1.555696  0.607744 -0.759766  bar  False
```

[3]:
```
# 计算含有缺失值的列的和，默认是跳过缺失值
df["one"].sum()
```

[3]:
```
-0.8724777568039623
```

[4]:
```
# 不跳过缺失值，那么得到的和就是 NaN
df["two"].sum(skipna=False)
```

[4]:
```
nan
```

[5]:
```
# 计算含有缺失值的列的积，默认是跳过缺失值
df["one"].prod()
```

[5]:
```
-0.0015203634461877212
```

[6]:
```
# 不跳过缺失值，那么得到的积就是 NaN
df["two"].prod(skipna=False)
```

[6]:
```
nan
```

1.0.49 对含有缺失值的列进行填充，将缺失值以其他的值替换

[1]:
```
import pandas as pd
import numpy as np
```

[2]:
```
# 生成 dataframe
df = pd.DataFrame(
    np.random.randn(5, 3),
    index=["a", "c", "e", "f", "h"],
    columns=["one", "two", "three"],
)
df["four"] = "bar"
df["five"] = df["one"] > 0
df = df.reindex(["a", "b", "c", "d", "e", "f", "g", "h"])
df
```

[2]:
```
        one       two     three four   five
a  1.010471  1.775946  0.116074  bar   True
b       NaN       NaN       NaN  NaN    NaN
c -0.709978  0.945866  1.369733  bar  False
d       NaN       NaN       NaN  NaN    NaN
e  0.010790  0.209315  1.177950  bar   True
f  0.028884  1.194446 -0.041722  bar   True
g       NaN       NaN       NaN  NaN    NaN
h  1.731725  0.499953 -0.015604  bar   True
```

[3]:
```
# 以均值替换
df["one"].fillna(df["one"].mean())
```

[3]:
```
a    1.010471
b    0.414378
c   -0.709978
d    0.414378
e    0.010790
f    0.028884
g    0.414378
h    1.731725
Name: one, dtype: float64
```

1.0.50 对含有缺失值的列或者行删除。

[1]:
```
import pandas as pd
import numpy as np
```

[2]:
```
# 生成 dataframe
df = pd.DataFrame(
    np.random.randn(5, 3),
    index=["a", "c", "e", "f", "h"],
    columns=["one", "two", "three"],
)
df["four"] = "bar"
df["five"] = df["one"] > 0
df = df.reindex(["a", "b", "c", "d", "e", "f", "g", "h"])
df
```

[2]:

```
        one       two     three four   five
a  1.105184  0.696500  1.024294  bar   True
b       NaN       NaN       NaN  NaN    NaN
c  0.286259 -1.286451  1.746801  bar   True
d       NaN       NaN       NaN  NaN    NaN
e  0.283374 -0.699082  1.299307  bar   True
f -0.698294  0.484663  1.120755  bar  False
g       NaN       NaN       NaN  NaN    NaN
h -2.119560  0.173416  0.700130  bar  False
```

[3]:

```
# 删除含有缺失值的行，存在缺失值就删除
df.dropna(axis=0, how="any")
```

[3]:

```
        one       two     three four   five
a  1.105184  0.696500  1.024294  bar   True
c  0.286259 -1.286451  1.746801  bar   True
e  0.283374 -0.699082  1.299307  bar   True
f -0.698294  0.484663  1.120755  bar  False
h -2.119560  0.173416  0.700130  bar  False
```

[4]:

```
# 删除含有缺失值的列，全部都是缺失值才删除
df.dropna(axis=1, how="all")
```

[4]:

```
        one       two     three four   five
a  1.105184  0.696500  1.024294  bar   True
b       NaN       NaN       NaN  NaN    NaN
c  0.286259 -1.286451  1.746801  bar   True
d       NaN       NaN       NaN  NaN    NaN
e  0.283374 -0.699082  1.299307  bar   True
f -0.698294  0.484663  1.120755  bar  False
g       NaN       NaN       NaN  NaN    NaN
h -2.119560  0.173416  0.700130  bar  False
```

1.0.51 对含有缺失值的列进行计数，求非缺失值的个数。

[1]:

```
import pandas as pd
import numpy as np
```

[2]:
```
# 生成 dataframe
df = pd.DataFrame(
    np.random.randn(5, 3),
    index=["a", "c", "e", "f", "h"],
    columns=["one", "two", "three"],
)
df["four"] = "bar"
df["five"] = df["one"] > 0
df = df.reindex(["a", "b", "c", "d", "e", "f", "g", "h"])
df
```

[2]:
```
        one       two     three four   five
a -0.126636 -1.491391  0.700825  bar  False
b       NaN       NaN       NaN  NaN    NaN
c  0.981905 -1.506363  0.082841  bar   True
d       NaN       NaN       NaN  NaN    NaN
e -0.383442  1.491860 -0.551062  bar  False
f -0.182666  0.236521  0.678531  bar  False
g       NaN       NaN       NaN  NaN    NaN
h  0.984269 -0.652942 -1.957255  bar   True
```

[3]:
```
# 求非缺失值的个数
df["one"].count()
```

[3]:
```
5
```

1.0.52 对含有缺失值的列进行插值。

[1]:
```
import pandas as pd
import numpy as np
```

[2]:
```
# 生成 dataframe
df = pd.DataFrame(
    np.random.randn(5, 3),
    index=["a", "c", "e", "f", "h"],
    columns=["one", "two", "three"],
)
df["four"] = "bar"
df["five"] = df["one"] > 0
df = df.reindex(["a", "b", "c", "d", "e", "f", "g", "h"])
df
```

[2]:
```
        one       two     three four   five
a  0.957477  0.356867  1.238439  bar   True
b       NaN       NaN       NaN  NaN    NaN
c -1.194969 -0.859723 -2.106189  bar  False
d       NaN       NaN       NaN  NaN    NaN
```

```
e  0.327321  0.633526 -0.024933  bar   True
f  1.027312  0.586582  0.242355  bar   True
g       NaN       NaN       NaN  NaN    NaN
h  0.095649  0.213300  0.137504  bar   True
```

[3]:
```
# 线性插值
df["one"].interpolate()
```

[3]:
```
a    0.957477
b   -0.118746
c   -1.194969
d   -0.433824
e    0.327321
f    1.027312
g    0.561480
h    0.095649
Name: one, dtype: float64
```

1.0.53 以 **openml** 中的数据集 **1StudentPerformance** 为例，将 **gender** 变量变为 **category** 类型。

[1]:
```
# 导入数据集获取工具
from sklearn.datasets import fetch_openml
# 导入数据分析库
import pandas as pd
```

[2]:
```
# 获取数据
data = fetch_openml(
    data_id=43255,
    as_frame=True,
    parser="pandas"
)["frame"]
```

[3]:
```
# 查看数据集的前五行
data.head()
```

[3]:
```
  gender race/ethnicity parental level of education         lunch  \
0  female        group B           bachelor\'s degree      standard
1  female        group C                 some college      standard
2  female        group B             master\'s degree      standard
3    male        group A          associate\'s degree  free/reduced
4    male        group C                 some college      standard

 test preparation course  math score  reading score  writing score
0                    none          72             72             74
1               completed          69             90             88
2                    none          90             95             93
```

```
3                   none          47             57             44
4                   none          76             78             75
```

[4]:
```
# 将字符串变量 category 化
data["gender"].astype("category")
```

[4]:
```
0      female
1      female
2      female
3        male
4        male
        …
995    female
996      male
997    female
998    female
999    female
Name: gender, Length: 1000, dtype: category
Categories (2, object): ['female', 'male']
```

1.0.54 以 openml 中的数据集 1StudentPerformance 为例，将 gender 变量变为 category 类型并修改类别名称为”男性”和”女性”。

[1]:
```
# 导入数据集获取工具
from sklearn.datasets import fetch_openml
# 导入数据分析库
import pandas as pd
```

[2]:
```
# 获取数据
data = fetch_openml(
    data_id=43255,
    as_frame=True,
    parser="pandas"
)["frame"]
```

[3]:
```
# 查看数据集的前五行
data.head()
```

[3]:
```
   gender race/ethnicity parental level of education         lunch  \
0  female        group B          bachelor\'s degree      standard
1  female        group C                some college      standard
2  female        group B            master\'s degree      standard
3    male        group A         associate\'s degree  free/reduced
4    male        group C                some college      standard

  test preparation course  math score  reading score  writing score
```

```
0                 none        72          72          74
1            completed        69          90          88
2                 none        90          95          93
3                 none        47          57          44
4                 none        76          78          75
```

[4]:
```
# 将 gender 修改为分类变量
newvar = data["gender"].astype("category")
newvar.head()
```

[4]:
```
0    female
1    female
2    female
3      male
4      male
Name: gender, dtype: category
Categories (2, object): ['female', 'male']
```

[5]:
```
# 查看分类变量的类别名称
print(newvar.cat.categories)
```

```
Index(['female', 'male'], dtype='object')
```

[6]:
```
# 修改分类变量的类别名称
new_categories = ["女性", "男性"]
newvar = newvar.cat.rename_categories(new_categories)
newvar.head()
```

[6]:
```
0    女性
1    女性
2    女性
3    男性
4    男性
Name: gender, dtype: category
Categories (2, object): ['女性', '男性']
```

1.0.55 以 openml 中的数据集 1StudentPerformance 为例，将 gender 变量变为 category 类型并添加一个类别”Unknown”。

[1]:
```
# 导入数据集获取工具
from sklearn.datasets import fetch_openml
# 导入数据分析库
import pandas as pd
```

[2]:
```
# 获取数据
data = fetch_openml(
    data_id=43255,
    as_frame=True,
    parser="pandas"
)["frame"]
```

[3]:
```
# 查看数据集的前五行
data.head()
```

[3]:
```
   gender race/ethnicity parental level of education         lunch  \
0  female        group B           bachelor\'s degree      standard
1  female        group C                 some college      standard
2  female        group B             master\'s degree      standard
3    male        group A          associate\'s degree  free/reduced
4    male        group C                 some college      standard

  test preparation course  math score  reading score  writing score
0                    none          72             72             74
1               completed          69             90             88
2                    none          90             95             93
3                    none          47             57             44
4                    none          76             78             75
```

[4]:
```
# 将 gender 修改为分类变量
newvar = data["gender"].astype("category")
newvar.head()
```

[4]:
```
0    female
1    female
2    female
3      male
4      male
Name: gender, dtype: category
Categories (2, object): ['female', 'male']
```

[5]:
```
# 添加一个类别
newvar = newvar.cat.add_categories(["Unknown"])
newvar.head()
```

[5]:
```
0    female
1    female
2    female
3      male
4      male
Name: gender, dtype: category
Categories (3, object): ['female', 'male', 'Unknown']
```

1.0.56 以 **openml** 中的数据集 **1StudentPerformance** 为例，将 **gender** 变量变为 **category** 类型并添加一个类别 **”Unknown”**，然后删除该类别。

[1]:
```python
# 导入数据集获取工具
from sklearn.datasets import fetch_openml
# 导入数据分析库
import pandas as pd
```

[2]:
```python
# 获取数据
data = fetch_openml(
    data_id=43255,
    as_frame=True,
    parser="pandas"
)["frame"]
```

[3]:
```python
# 查看数据集的前五行
data.head()
```

[3]:
```
   gender race/ethnicity parental level of education         lunch  \
0  female        group B           bachelor\'s degree      standard
1  female        group C                 some college      standard
2  female        group B             master\'s degree      standard
3    male        group A          associate\'s degree  free/reduced
4    male        group C                 some college      standard

  test preparation course  math score  reading score  writing score
0                    none          72             72             74
1               completed          69             90             88
2                    none          90             95             93
3                    none          47             57             44
4                    none          76             78             75
```

[4]:
```python
# 将 gender 修改为分类变量
newvar = data["gender"].astype("category")
newvar.head()
```

[4]:
```
0    female
1    female
2    female
3      male
4      male
Name: gender, dtype: category
Categories (2, object): ['female', 'male']
```

[5]:
```python
# 添加一个类别
newvar = newvar.cat.add_categories(["Unknown"])
newvar.head()
```

```
[5]: 0    female
     1    female
     2    female
     3      male
     4      male
     Name: gender, dtype: category
     Categories (3, object): ['female', 'male', 'Unknown']
```

```
[6]: newvar.cat.remove_categories(["Unknown"])
```

```
[6]: 0      female
     1      female
     2      female
     3        male
     4        male
             …
     995    female
     996      male
     997    female
     998    female
     999    female
     Name: gender, Length: 1000, dtype: category
     Categories (2, object): ['female', 'male']
```

```
[7]: newvar.cat.remove_categories(["Unknown", "female"])
```

```
[7]: 0       NaN
     1       NaN
     2       NaN
     3      male
     4      male
            …
     995     NaN
     996    male
     997     NaN
     998     NaN
     999     NaN
     Name: gender, Length: 1000, dtype: category
     Categories (1, object): ['male']
```

1.0.57 以 **openml** 中的数据集 **1StudentPerformance** 为例，将 **gender** 变量变为 **category** 类型并添加一个类别”**Unknown**”，然后删除没用的类别（类别无变量值对应）。

[1]:
```
# 导入数据集获取工具
from sklearn.datasets import fetch_openml
# 导入数据分析库
import pandas as pd
```

[2]:
```
# 获取数据
data = fetch_openml(
    data_id=43255,
    as_frame=True,
    parser="pandas"
)["frame"]
```

[3]:
```
# 查看数据集的前五行
data.head()
```

[3]:
```
  gender race/ethnicity parental level of education         lunch  \
0 female        group B           bachelor\'s degree      standard
1 female        group C                 some college      standard
2 female        group B             master\'s degree      standard
3   male        group A          associate\'s degree  free/reduced
4   male        group C                 some college      standard

  test preparation course  math score  reading score  writing score
0                    none          72             72             74
1               completed          69             90             88
2                    none          90             95             93
3                    none          47             57             44
4                    none          76             78             75
```

[4]:
```
# 将 gender 修改为分类变量
newvar = data["gender"].astype("category")
newvar.head()
```

[4]:
```
0    female
1    female
2    female
3      male
4      male
Name: gender, dtype: category
Categories (2, object): ['female', 'male']
```

[5]:
```
# 添加一个类别
newvar = newvar.cat.add_categories(["Unknown"])
newvar.head()
```

[5]:
```
0    female
1    female
2    female
3      male
4      male
Name: gender, dtype: category
Categories (3, object): ['female', 'male', 'Unknown']
```

[6]:
```
# 删除无用类别
newvar = newvar.cat.remove_unused_categories()
newvar
```

[6]:
```
0      female
1      female
2      female
3        male
4        male
        …
995    female
996      male
997    female
998    female
999    female
Name: gender, Length: 1000, dtype: category
Categories (2, object): ['female', 'male']
```

1.0.58 以 **openml** 中的数据集 **1StudentPerformance** 为例，将变量 **parental level of education** 变为有序的 **category** 类型。

[1]:
```
# 导入数据集获取工具
from sklearn.datasets import fetch_openml
# 导入数据分析库
import pandas as pd
```

[2]:
```
# 获取数据
data = fetch_openml(
    data_id=43255,
    as_frame=True,
    parser="pandas"
)["frame"]
```

[3]:
```
# 查看数据集的前五行
data.head()
```

[3]:
```
   gender race/ethnicity parental level of education        lunch  \
0  female        group B           bachelor\'s degree     standard
1  female        group C                 some college     standard
```

```
2  female        group B           master\'s degree      standard
3    male        group A        associate\'s degree  free/reduced
4    male        group C               some college      standard

  test preparation course  math score  reading score  writing score
0                    none          72             72             74
1               completed          69             90             88
2                    none          90             95             93
3                    none          47             57             44
4                    none          76             78             75
```

[4]:
```python
# 将 gender 修改为分类变量
t = pd.CategoricalDtype([
    "some high school","high school","some college",
    "associate\\'s degree","bachelor\\'s degree","master\\'s degree"
    ],
    ordered=True # 从小打到排序
)
newvar = data["parental level of education"].astype(t)
newvar.head()
```

[4]:
```
0     bachelor\'s degree
1           some college
2       master\'s degree
3    associate\'s degree
4           some college
Name: parental level of education, dtype: category
Categories (6, object): ['some high school' < 'high school' < 'some college' <
'associate\'s degree' < 'bachelor\'s degree' < 'master\'s degree']
```

1.0.59 以 **openml** 中的数据集 **1StudentPerformance** 为例，将变量 **parental level of education** 变为有序的 **category** 类型并且修改类别之间的顺序。

[1]:
```python
# 导入数据集获取工具
from sklearn.datasets import fetch_openml
# 导入数据分析库
import pandas as pd
```

[2]:
```python
# 获取数据
data = fetch_openml(
    data_id=43255,
    as_frame=True,
    parser="pandas"
)["frame"]
```

[3]:
```
# 查看数据集的前五行
data.head()
```

[3]:
```
   gender race/ethnicity parental level of education         lunch  \
0  female        group B           bachelor\'s degree      standard
1  female        group C                 some college      standard
2  female        group B             master\'s degree      standard
3    male        group A          associate\'s degree  free/reduced
4    male        group C                 some college      standard

  test preparation course  math score  reading score  writing score
0                    none          72             72             74
1               completed          69             90             88
2                    none          90             95             93
3                    none          47             57             44
4                    none          76             78             75
```

[4]:
```
# 将 gender 修改为分类变量
t = pd.CategoricalDtype([
    "some high school","high school","some college",
    "associate\\'s degree","bachelor\\'s degree","master\\'s degree"
    ],
    ordered=True # 从小打到排序
)
newvar = data["parental level of education"].astype(t)
newvar.head()
```

[4]:
```
0     bachelor\'s degree
1           some college
2       master\'s degree
3    associate\'s degree
4           some college
Name: parental level of education, dtype: category
Categories (6, object): ['some high school' < 'high school' < 'some college' <
'associate\'s degree' < 'bachelor\'s degree' < 'master\'s degree']
```

[6]:
```
newvar = data["parental level of education"].cat.reorder_categories([
    "high school","some high school","associate\\'s degree",
    "some college","bachelor\\'s degree","master\\'s degree"
    ],
    ordered=True # 从小打到排序
)
newvar.head()
```

[6]:
```
0     bachelor\'s degree
1           some college
```

```
2       master\'s degree
3    associate\'s degree
4           some college
Name: parental level of education, dtype: category
Categories (6, object): ['high school' < 'some high school' < 'associate\'s
degree' < 'some college' < 'bachelor\'s degree' < 'master\'s degree']
```

1.0.60 以 **openml** 中的数据集 **1StudentPerformance** 为例，将变量 **parental level of education** 变为有序的 **category** 类型并且对该列和 **math score** 作为因子排序。

[1]:
```
# 导入数据集获取工具
from sklearn.datasets import fetch_openml
# 导入数据分析库
import pandas as pd
```

[2]:
```
# 获取数据
data = fetch_openml(
    data_id=43255,
    as_frame=True,
    parser="pandas"
)["frame"]
```

[3]:
```
# 查看数据集的前五行
data.head()
```

[3]:
```
   gender race/ethnicity parental level of education         lunch  \
0  female        group B          bachelor\'s degree      standard
1  female        group C                some college      standard
2  female        group B            master\'s degree      standard
3    male        group A         associate\'s degree  free/reduced
4    male        group C                some college      standard

  test preparation course  math score  reading score  writing score
0                    none          72             72             74
1               completed          69             90             88
2                    none          90             95             93
3                    none          47             57             44
4                    none          76             78             75
```

[4]:
```
# 将 gender 修改为分类变量
t = pd.CategoricalDtype([
    "some high school","high school","some college",
    "associate\\'s degree","bachelor\\'s degree","master\\'s degree"
    ],
    ordered=True # 从小打到排序
)
```

```
data["parental level of education"] = data["parental level of education"].astype(t)
data["parental level of education"].head()
```

[4]:
```
0     bachelor\'s degree
1           some college
2       master\'s degree
3    associate\'s degree
4           some college
Name: parental level of education, dtype: category
Categories (6, object): ['some high school' < 'high school' < 'some college' <
'associate\'s degree' < 'bachelor\'s degree' < 'master\'s degree']
```

[5]:
```
# 排序
data.sort_values(by=["parental level of education", "math score"], ascending=False)
```

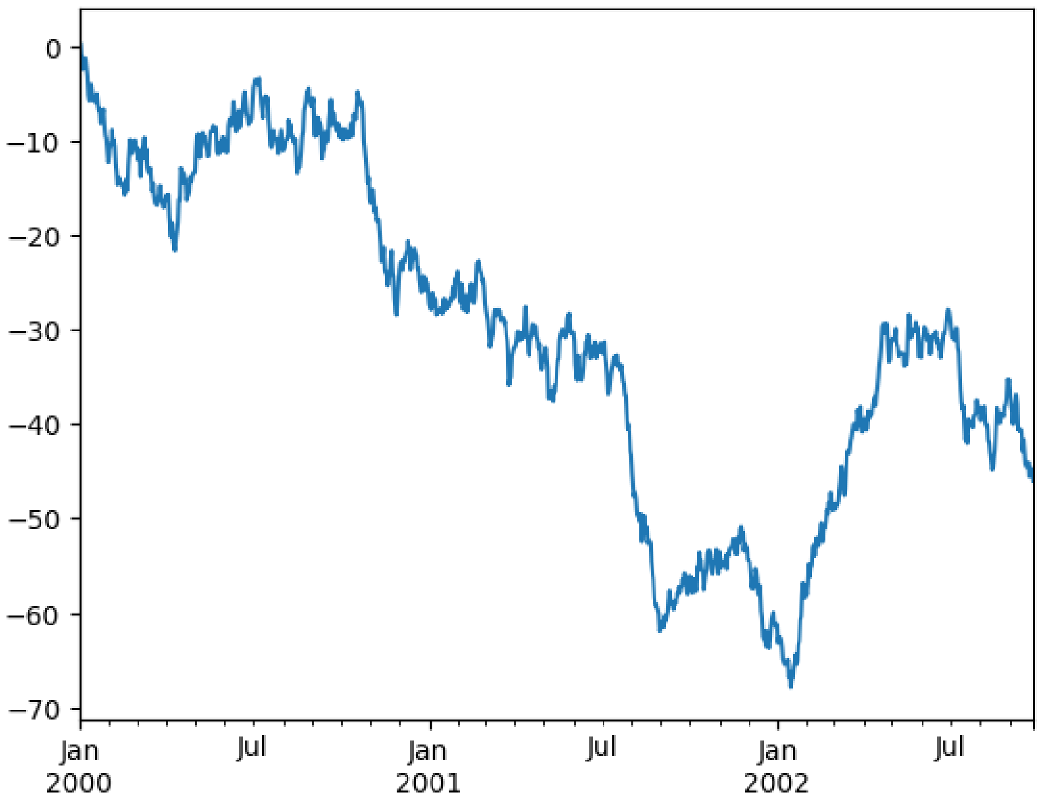
[5]:
```
     gender race/ethnicity parental level of education         lunch  \
618    male        group D            master\'s degree      standard
685  female        group E            master\'s degree      standard
957  female        group D            master\'s degree      standard
846    male        group C            master\'s degree      standard
2    female        group B            master\'s degree      standard
..      …            …                          …            …
683  female        group C            some high school  free/reduced
363  female        group D            some high school  free/reduced
338  female        group B            some high school  free/reduced
17   female        group B            some high school  free/reduced
59   female        group C            some high school  free/reduced

    test preparation course  math score  reading score  writing score
618                    none          95             81             84
685               completed          94             99            100
957                    none          92            100            100
846               completed          91             85             85
2                      none          90             95             93
..                      …          …             …             …
683               completed          29             40             44
363                    none          27             34             32
338                    none          24             38             27
17                     none          18             32             28
59                     none           0             17             10

[1000 rows x 8 columns]
```

1.0.61 绘制线图

[1]:
```
# 导入基础计算库
import numpy as np
# 导入数据分析库
import pandas as pd
```

[2]:
```
# 设置随机数种子
np.random.seed(123456)
# 生成数据
ts = pd.Series(
    np.random.randn(1000), # 数字
    index=pd.date_range("1/1/2000", periods=1000) # 时间
)
# 累加
ts = ts.cumsum()
ts.plot()
```

[2]:
```
<Axes: >
```

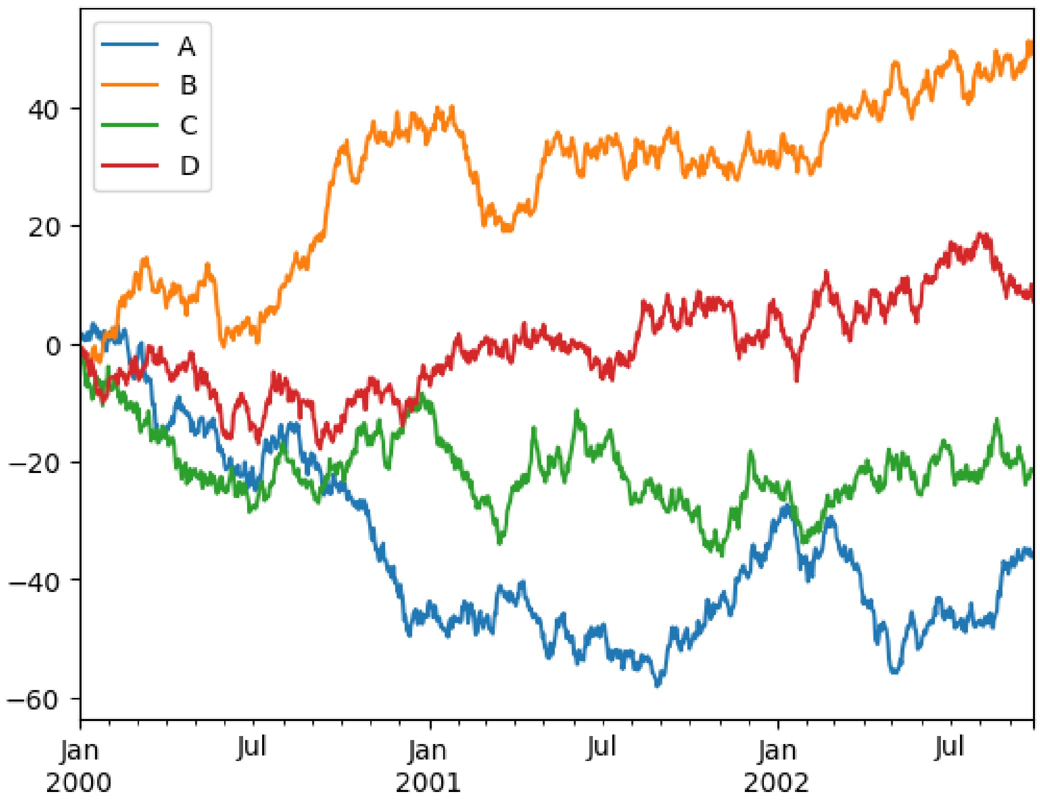


1.0.62 绘制多列数据的线图

[1]:
```
# 导入基础计算库
import numpy as np
# 导入数据分析库
import pandas as pd
```

[3]:
```
# 设置随机数种子
np.random.seed(123456)
# 生成数据
df = pd.DataFrame(
    np.random.randn(1000, 4),
    index=pd.date_range("1/1/2000", periods=1000),
    columns=list("ABCD")
)
# 累加
df = df.cumsum()
df.plot()
```

[3]:
```
<Axes: >
```

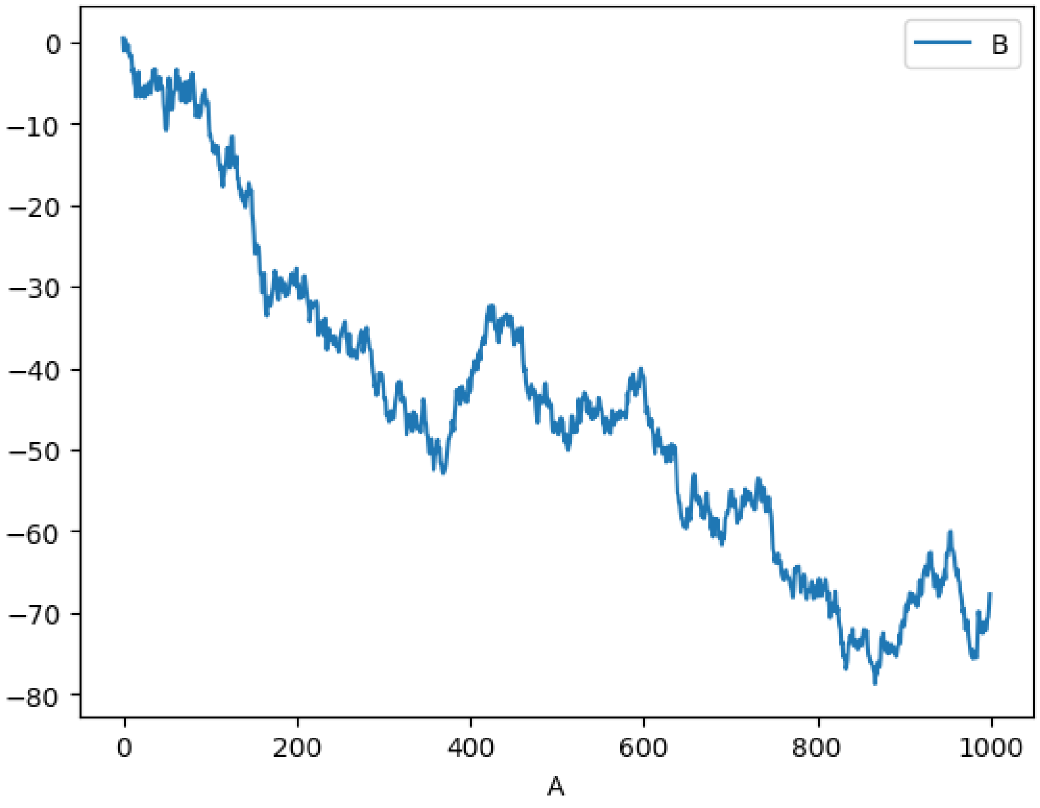


1.0.63 绘制多列数据中某两列的线图

[1]:
```
# 导入基础计算库
import numpy as np
# 导入数据分析库
import pandas as pd
```

[2]:
```
# 设置随机数种子
np.random.seed(123456)
# 生成数据
df = pd.DataFrame(np.random.randn(1000, 2), columns=["B", "C"]).cumsum()
# 修改 A 列的值
df["A"] = pd.Series(list(range(len(df))))
df.plot(x="A", y="B")
```

[2]:
```
<Axes: xlabel='A'>
```

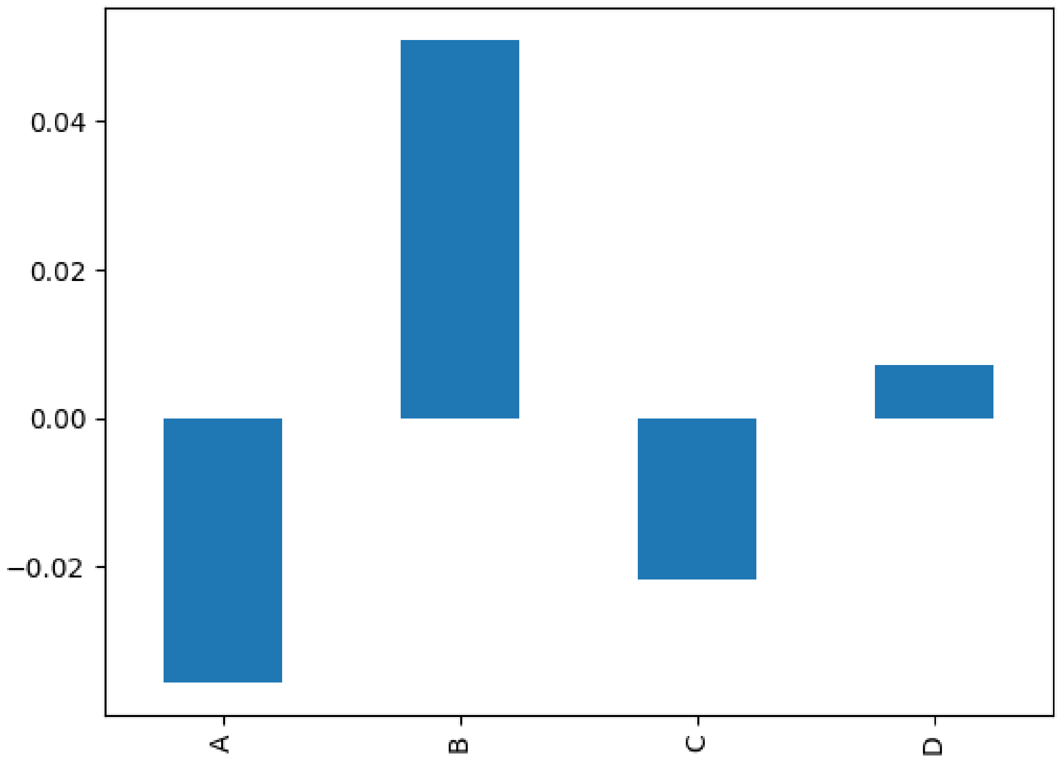


1.0.64 绘制多列数据的均值柱状图

[1]:
```
# 导入基础计算库
import numpy as np
# 导入数据分析库
import pandas as pd
```

[2]:
```
# 设置随机数种子
np.random.seed(123456)
# 生成数据
df = pd.DataFrame(
    np.random.randn(1000, 4),
    index=pd.date_range("1/1/2000", periods=1000),
    columns=list("ABCD")
)
# 累加
df = df.mean()
df.plot(kind="bar")
```

[2]:
```
<Axes: >
```



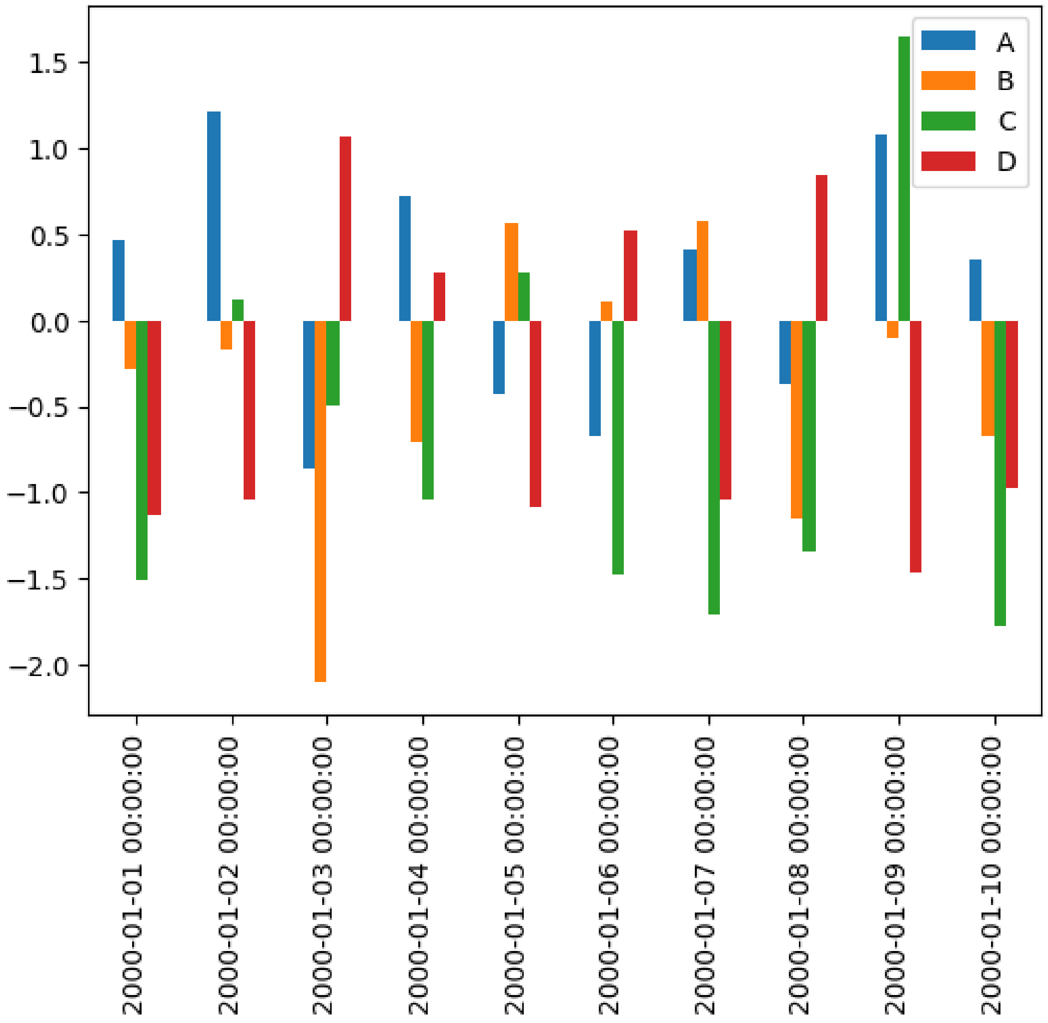
1.0.65 绘制多列数据的柱状图，分组柱状图

[1]:
```
# 导入基础计算库
import numpy as np
# 导入数据分析库
import pandas as pd
```

[3]:
```
# 设置随机数种子
np.random.seed(123456)
# 生成数据
```

```
df = pd.DataFrame(
    np.random.randn(10, 4),
    index=pd.date_range("1/1/2000", periods=10),
    columns=list("ABCD")
)
df.plot(kind="bar")
```

[3]:
```
<Axes: >
```

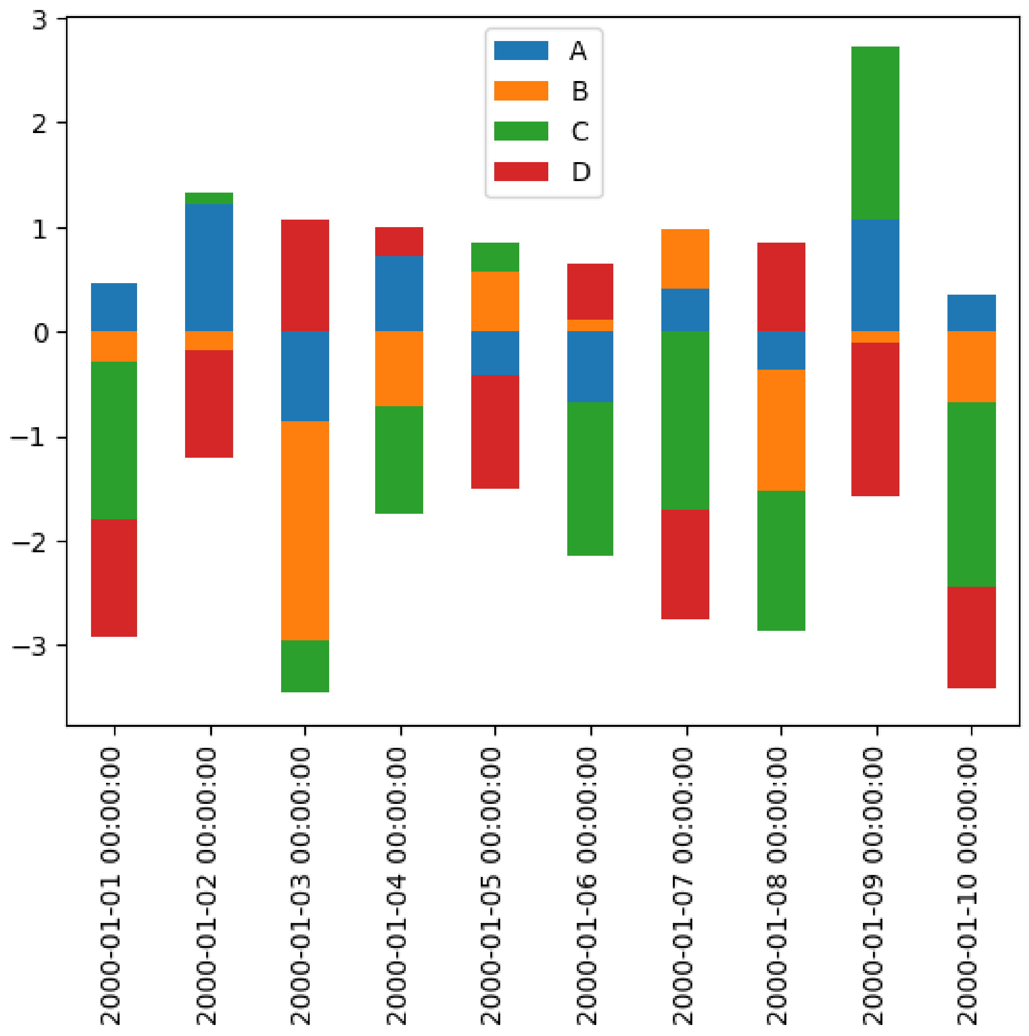


1.0.66 绘制多列数据的柱状图，堆叠柱状图

[1]:
```
# 导入基础计算库
import numpy as np
# 导入数据分析库
import pandas as pd
```

[2]:
```
# 设置随机数种子
np.random.seed(123456)
# 生成数据
df = pd.DataFrame(
    np.random.randn(10, 4),
    index=pd.date_range("1/1/2000", periods=10),
    columns=list("ABCD")
)
df.plot(kind="bar", stacked=True)
```

[2]:
```
<Axes: >
```

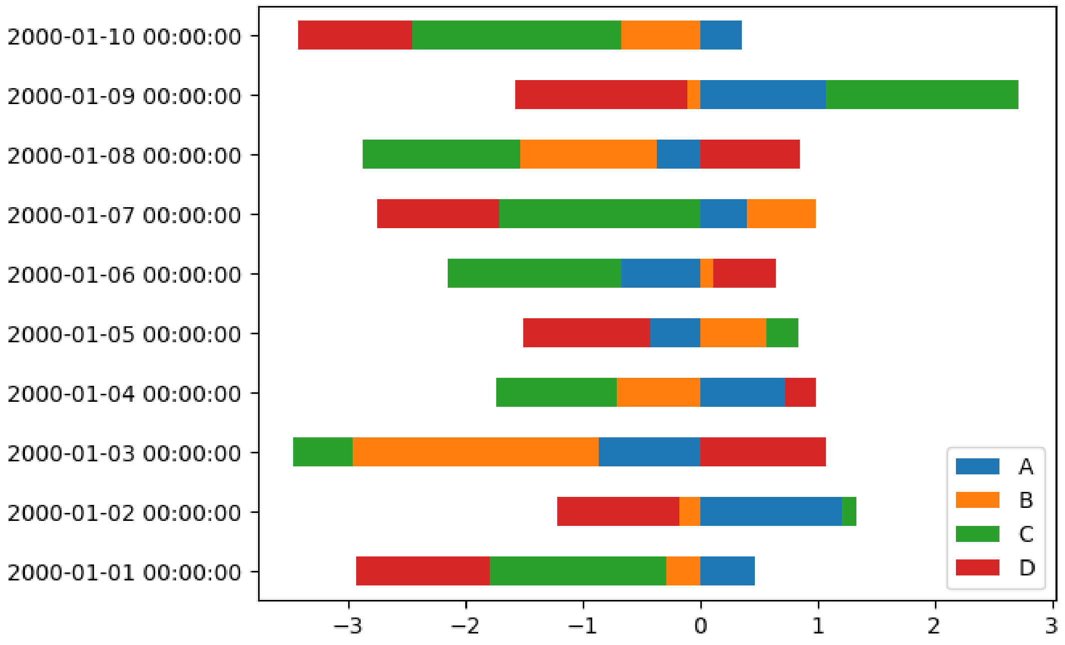


1.0.67 绘制多列数据的水平柱状图，堆叠柱状图

[1]:
```
# 导入基础计算库
import numpy as np
# 导入数据分析库
import pandas as pd
```

[2]:
```
# 设置随机数种子
np.random.seed(123456)
# 生成数据
df = pd.DataFrame(
    np.random.randn(10, 4),
    index=pd.date_range("1/1/2000", periods=10),
    columns=list("ABCD")
)
df.plot(kind="barh", stacked=True)
```

[2]:
```
<Axes: >
```

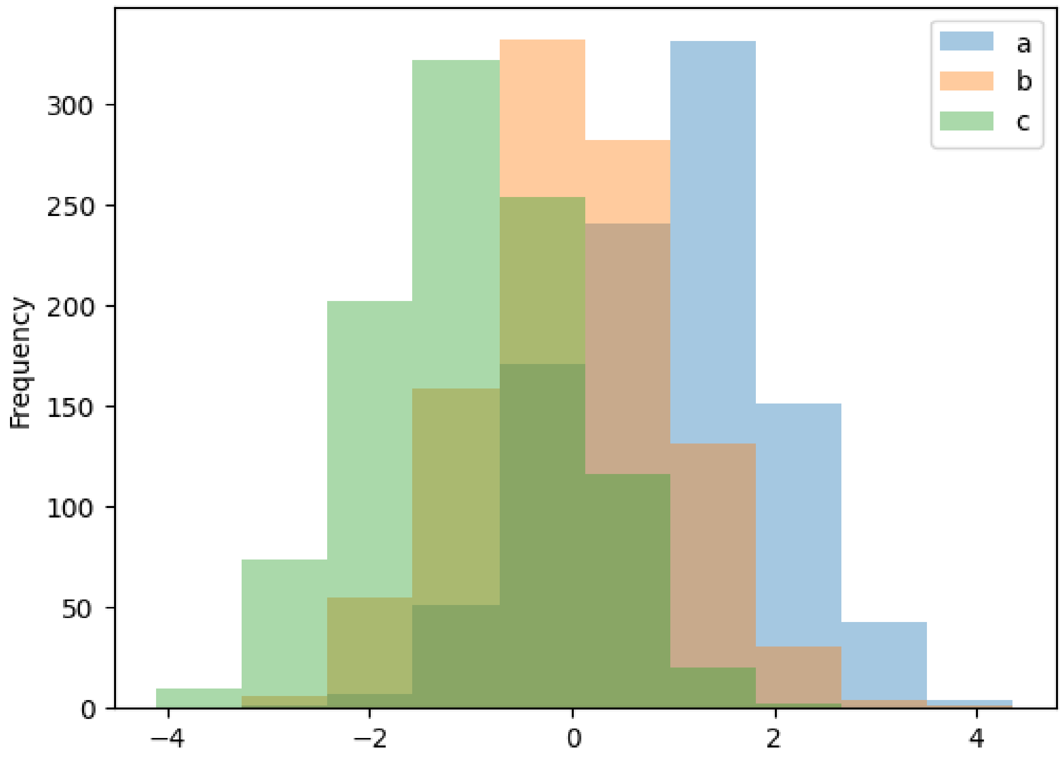


1.0.68 绘制多列数据的直方图

[1]:
```
# 导入基础计算库
import numpy as np
# 导入数据分析库
import pandas as pd
```

[2]:
```
# 设置随机数种子
np.random.seed(123456)
# 生成数据
df = pd.DataFrame(
    {
        "a": np.random.randn(1000) + 1,
        "b": np.random.randn(1000),
        "c": np.random.randn(1000) - 1,
    },
    columns=["a", "b", "c"]
)
df.plot(kind="hist", alpha=0.4)
```

[2]:
```
<Axes: ylabel='Frequency'>
```

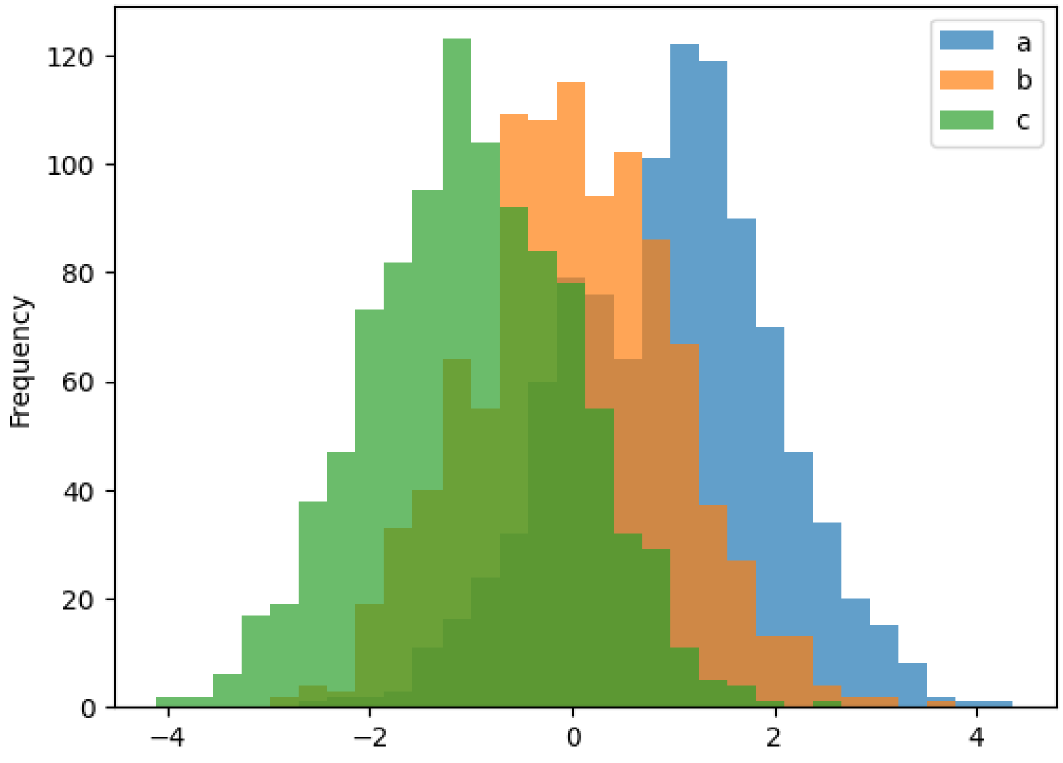


1.0.69 绘制多列数据的直方图，指定组数为 30

[1]:
```
# 导入基础计算库
import numpy as np
# 导入数据分析库
import pandas as pd
```

[2]:
```
# 设置随机数种子
np.random.seed(123456)
# 生成数据
df = pd.DataFrame(
    {
        "a": np.random.randn(1000) + 1,
        "b": np.random.randn(1000),
        "c": np.random.randn(1000) - 1,
    },
    columns=["a", "b", "c"]
)
df.plot(kind="hist", alpha=0.7, bins=30)
```

[2]:
```
<Axes: ylabel='Frequency'>
```

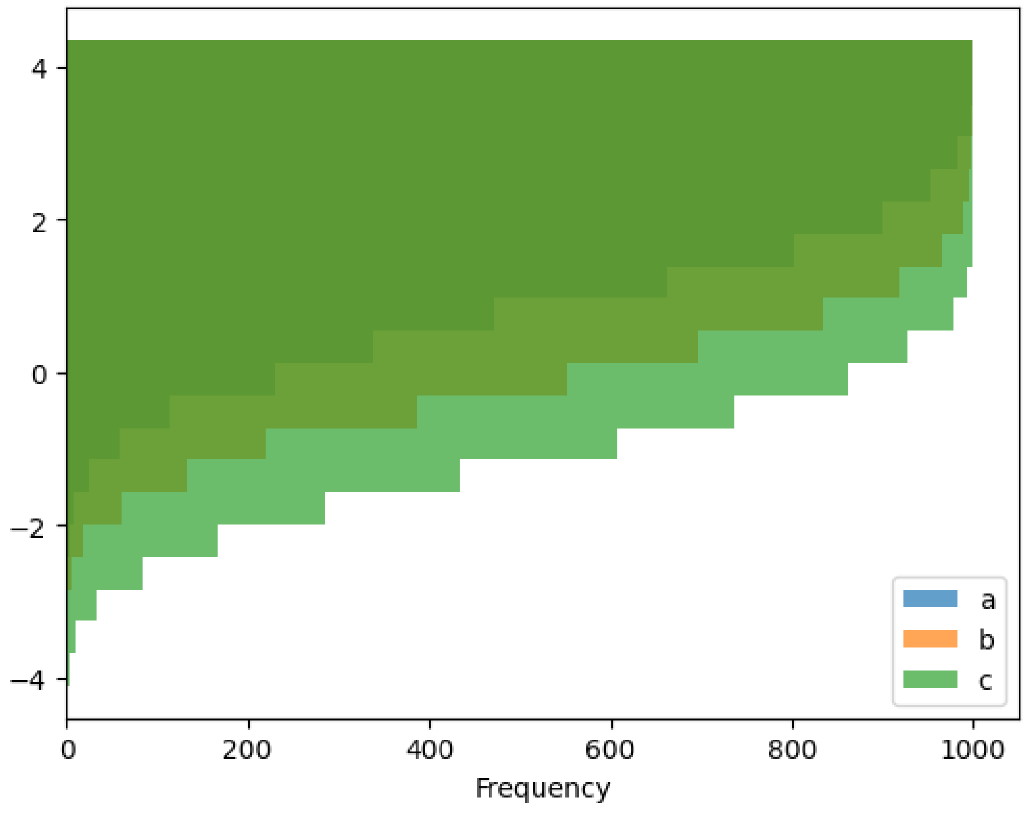


1.0.70 绘制多列数据的水平累积直方图，组数为 **20**

[1]:
```
# 导入基础计算库
import numpy as np
# 导入数据分析库
import pandas as pd
```

[2]:
```
# 设置随机数种子
np.random.seed(123456)
# 生成数据
df = pd.DataFrame(
    {
        "a": np.random.randn(1000) + 1,
        "b": np.random.randn(1000),
        "c": np.random.randn(1000) - 1,
    },
    columns=["a", "b", "c"]
)
df.plot(kind="hist", alpha=0.7, bins=20, orientation="horizontal", cumulative=True)
```

[2]:
```
<Axes: xlabel='Frequency'>
```

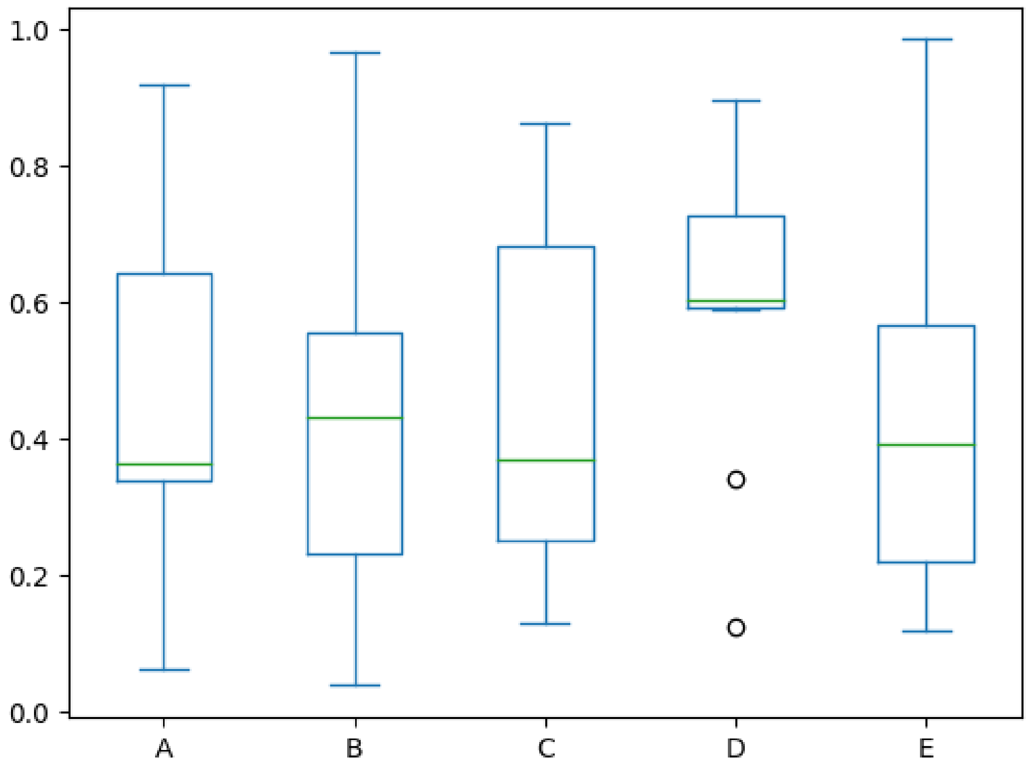


1.0.71 绘制多列数据的箱线图

[1]:
```
# 导入基础计算库
import numpy as np
# 导入数据分析库
import pandas as pd
```

[3]:
```python
# 设置随机数种子
np.random.seed(123456)
# 生成数据
df = pd.DataFrame(np.random.rand(10, 5), columns=["A", "B", "C", "D", "E"])
df.plot(kind="box")
```

[3]:
```
<Axes: >
```

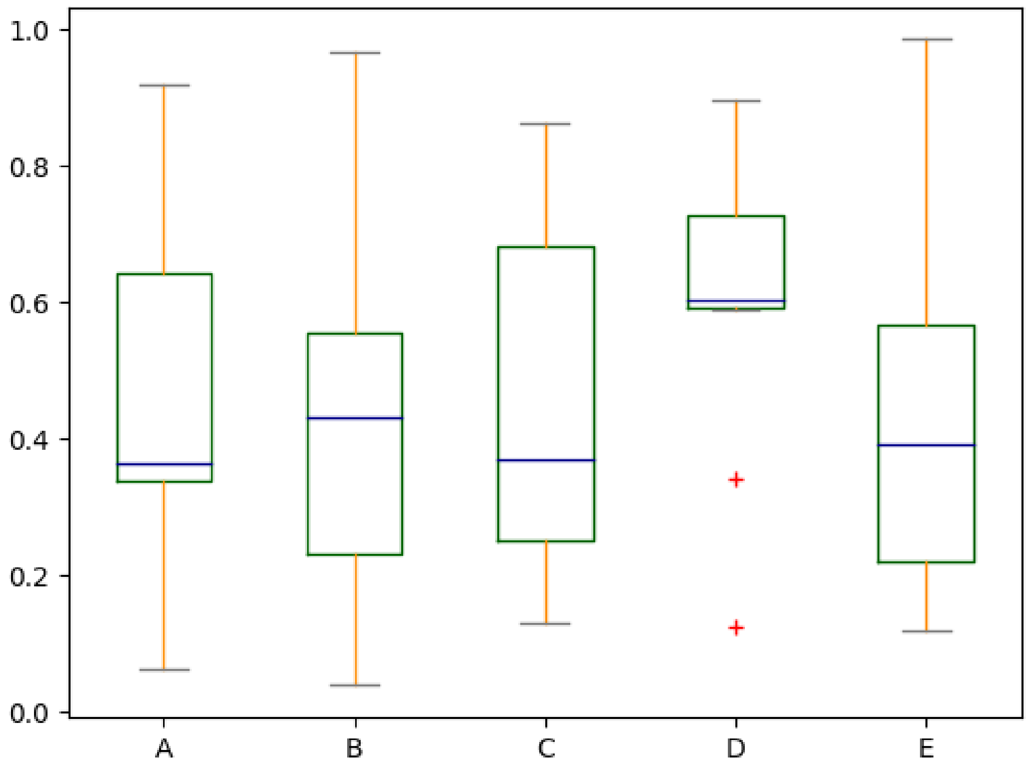


1.0.72 绘制多列数据的箱线图，给点外观颜色

[1]:
```python
# 导入基础计算库
import numpy as np
# 导入数据分析库
import pandas as pd
```

[2]:
```python
# 设置随机数种子
np.random.seed(123456)
# 生成数据
df = pd.DataFrame(np.random.rand(10, 5), columns=["A", "B", "C", "D", "E"])
# 设置相关颜色
color = {
    "boxes": "DarkGreen",
    "whiskers": "DarkOrange",
    "medians": "DarkBlue",
    "caps": "Gray",
}
df.plot(kind="box",color=color, sym="r+")
```

[2]: <Axes: >

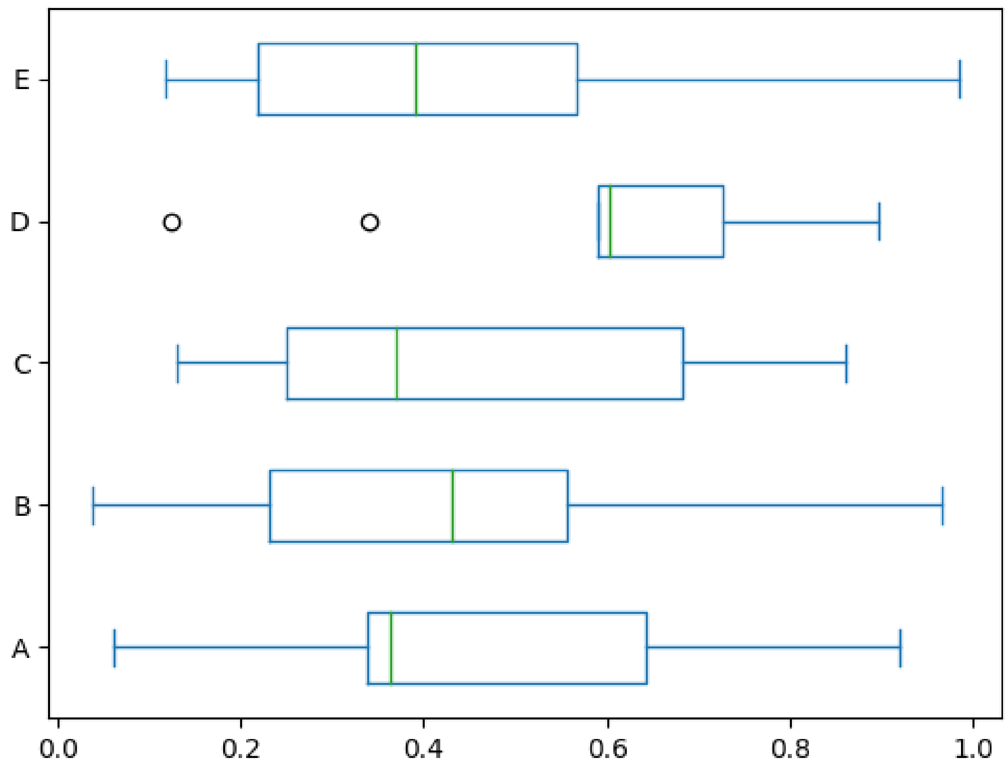


1.0.73 绘制多列数据的水平箱线图

[1]:
```
# 导入基础计算库
import numpy as np
# 导入数据分析库
import pandas as pd
```

[2]:
```
# 设置随机数种子
np.random.seed(123456)
# 生成数据
df = pd.DataFrame(np.random.rand(10, 5), columns=["A", "B", "C", "D", "E"])
df.plot(kind="box",vert=False)
```

[2]: <Axes: >

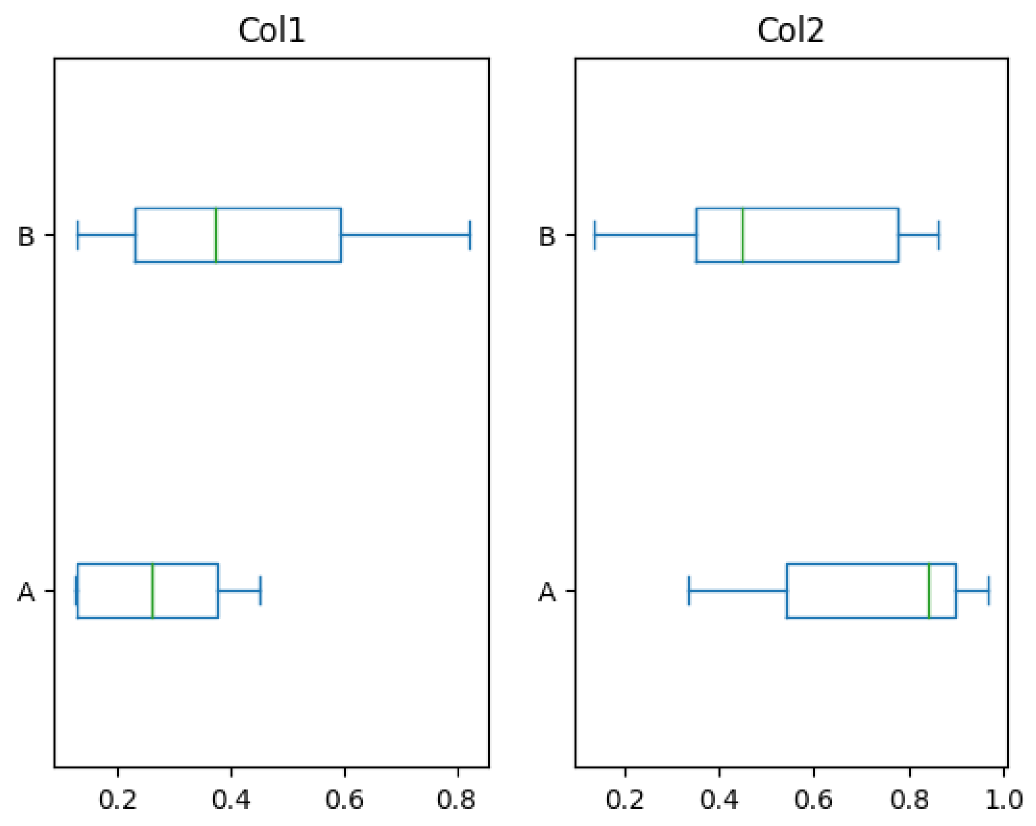


1.0.74 绘制数据的分组箱线图

[1]:
```
# 导入基础计算库
import numpy as np
# 导入数据分析库
import pandas as pd
```

[2]:
```
# 设置随机数种子
np.random.seed(123456)
# 生成数据
df = pd.DataFrame(np.random.rand(10, 2), columns=["Col1", "Col2"])
# 添加一列字符串, 可以作为分类变量
df["X"] = pd.Series(["A", "A", "A", "A", "A", "B", "B", "B", "B", "B"])
df.plot(kind="box",vert=False, by="X")
```

[2]:
```
Col1        Axes(0.125,0.11;0.352273x0.77)
Col2     Axes(0.547727,0.11;0.352273x0.77)
dtype: object
```



1.0.75 绘制数据的分组箱线图，多个分组变量

[1]:
```
# 导入基础计算库
import numpy as np
# 导入数据分析库
import pandas as pd
```

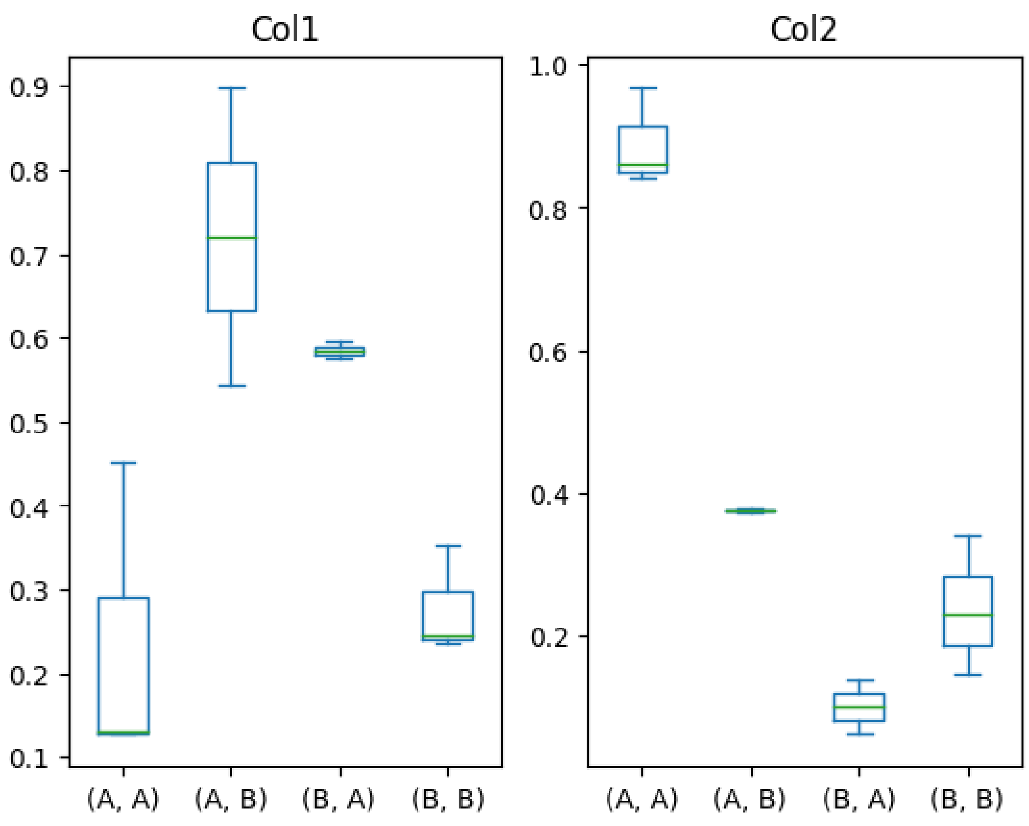
[2]:
```
# 设置随机数种子
np.random.seed(123456)
# 生成数据
df = pd.DataFrame(np.random.rand(10, 3), columns=["Col1", "Col2", "Col3"])
# 添加一列
df["X"] = pd.Series(["A", "A", "A", "A", "A", "B", "B", "B", "B", "B"])
# 添加一列
df["Y"] = pd.Series(["A", "B", "A", "B", "A", "B", "A", "B", "A", "B"])
df.head()
```

[2]:
```
       Col1      Col2      Col3  X  Y
0  0.126970  0.966718  0.260476  A  A
1  0.897237  0.376750  0.336222  A  B
2  0.451376  0.840255  0.123102  A  A
3  0.543026  0.373012  0.447997  A  B
```

```
4  0.129441  0.859879  0.820388  A  A
```

[3]:
```
df.plot(kind="box",column=["Col1", "Col2"], by=["X", "Y"])
```

[3]:
```
Col1        Axes(0.125,0.11;0.352273x0.77)
Col2    Axes(0.547727,0.11;0.352273x0.77)
dtype: object
```

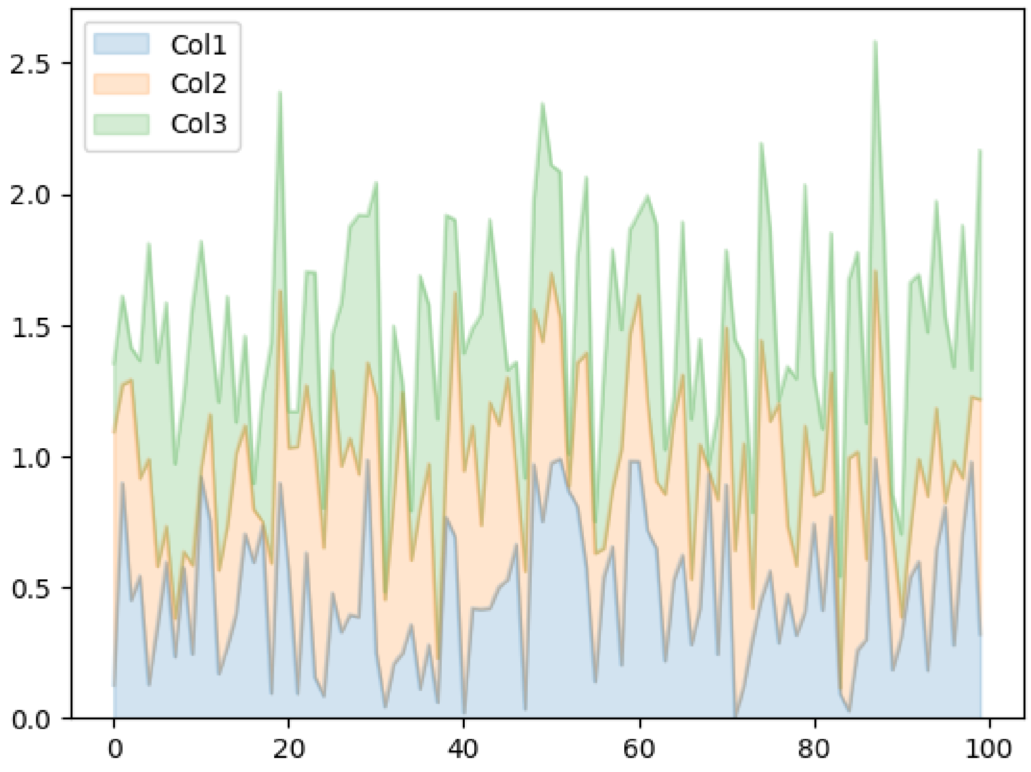


1.0.76 绘制多列数据的面积填充图

[1]:
```
# 导入基础计算库
import numpy as np
# 导入数据分析库
import pandas as pd
```

[2]:
```
# 设置随机数种子
np.random.seed(123456)
# 生成数据
df = pd.DataFrame(np.random.rand(100, 3), columns=["Col1", "Col2", "Col3"])
df.plot(kind="area",alpha=0.2)
```

[2]:
```
<Axes: >
```

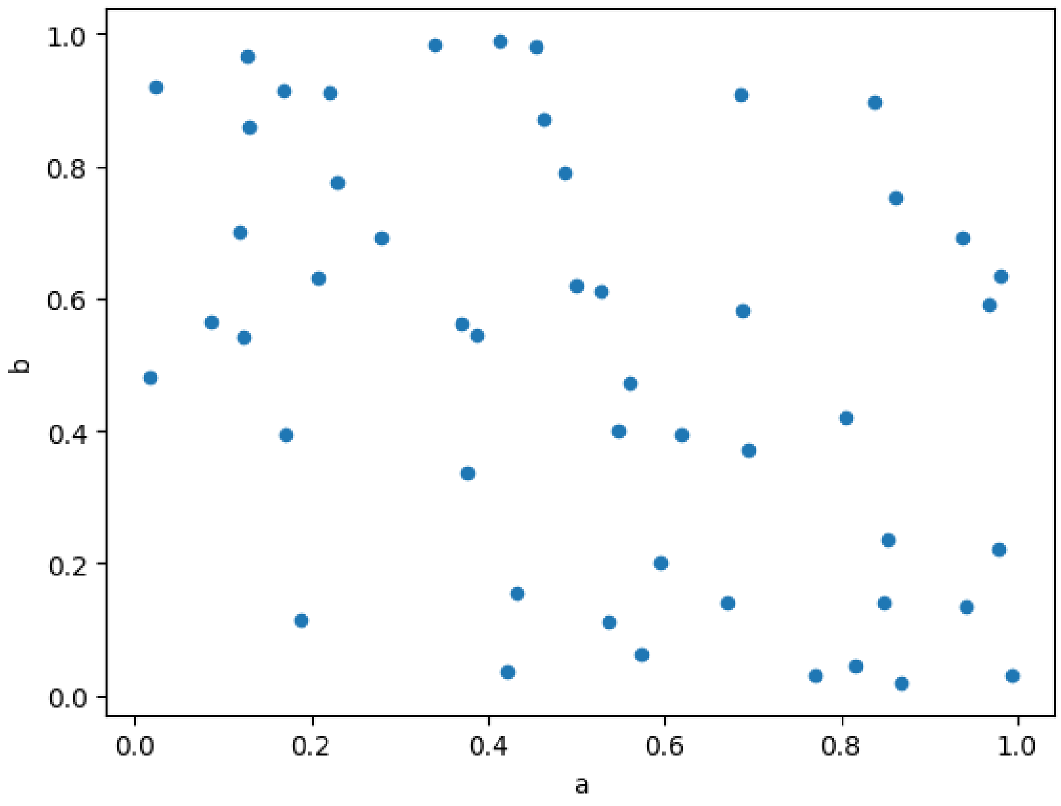


1.0.77 绘制两列数据的散点图

[1]:
```
# 导入基础计算库
import numpy as np
# 导入数据分析库
import pandas as pd
```

[2]:
```
# 设置随机数种子
np.random.seed(123456)
# 生成数据
df = pd.DataFrame(np.random.rand(50, 4), columns=["a", "b", "c", "d"])
# 新增一列
df["species"] = pd.Categorical(
    ["setosa"] * 20 + ["versicolor"] * 20 + ["virginica"] * 10
)
df.plot.scatter(x="a", y="b")
```

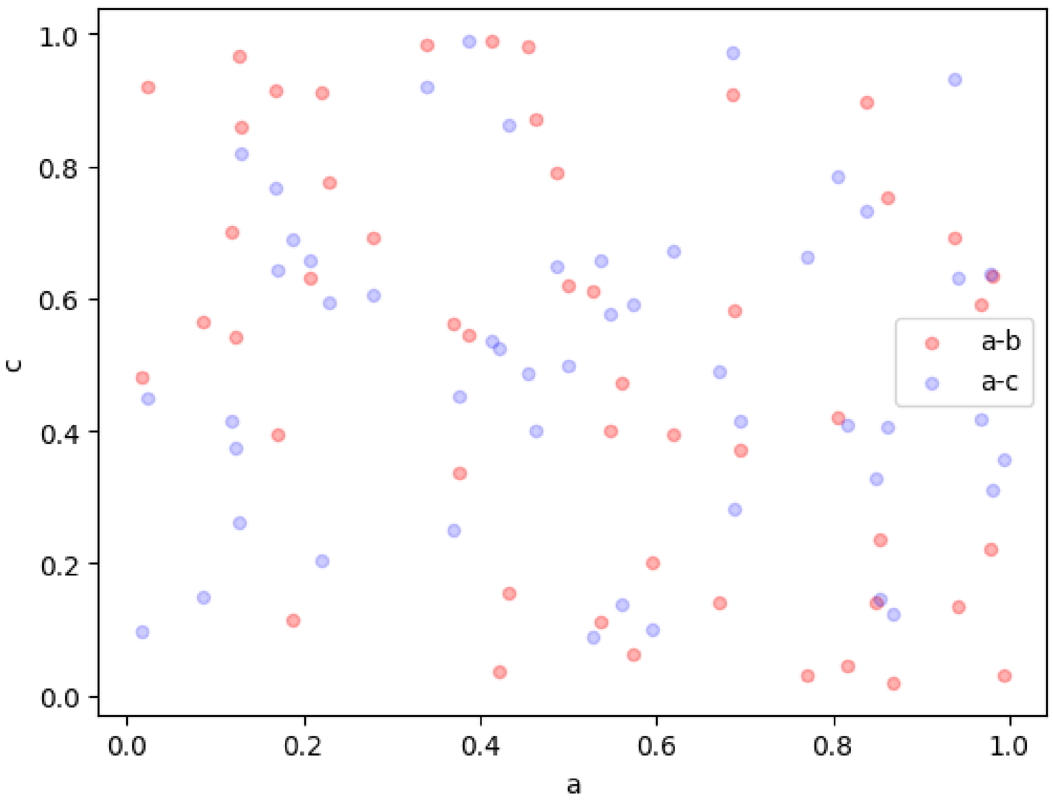
[2]:
```
<Axes: xlabel='a', ylabel='b'>
```



1.0.78 绘制多对散点关系的数据到同一张图

[1]:
```
# 导入基础计算库
import numpy as np
# 导入数据分析库
import pandas as pd
```

[2]:
```
# 设置随机数种子
np.random.seed(123456)
# 生成数据
df = pd.DataFrame(np.random.rand(50, 4), columns=["a", "b", "c", "d"])
# 新增一列
df["species"] = pd.Categorical(
    ["setosa"] * 20 + ["versicolor"] * 20 + ["virginica"] * 10
)
ax = df.plot.scatter(x="a", y="b",color="red", alpha=0.3,label="a-b")
ax = df.plot.scatter(x="a", y="c",ax=ax, color="blue", alpha=0.2,label="a-c")
```

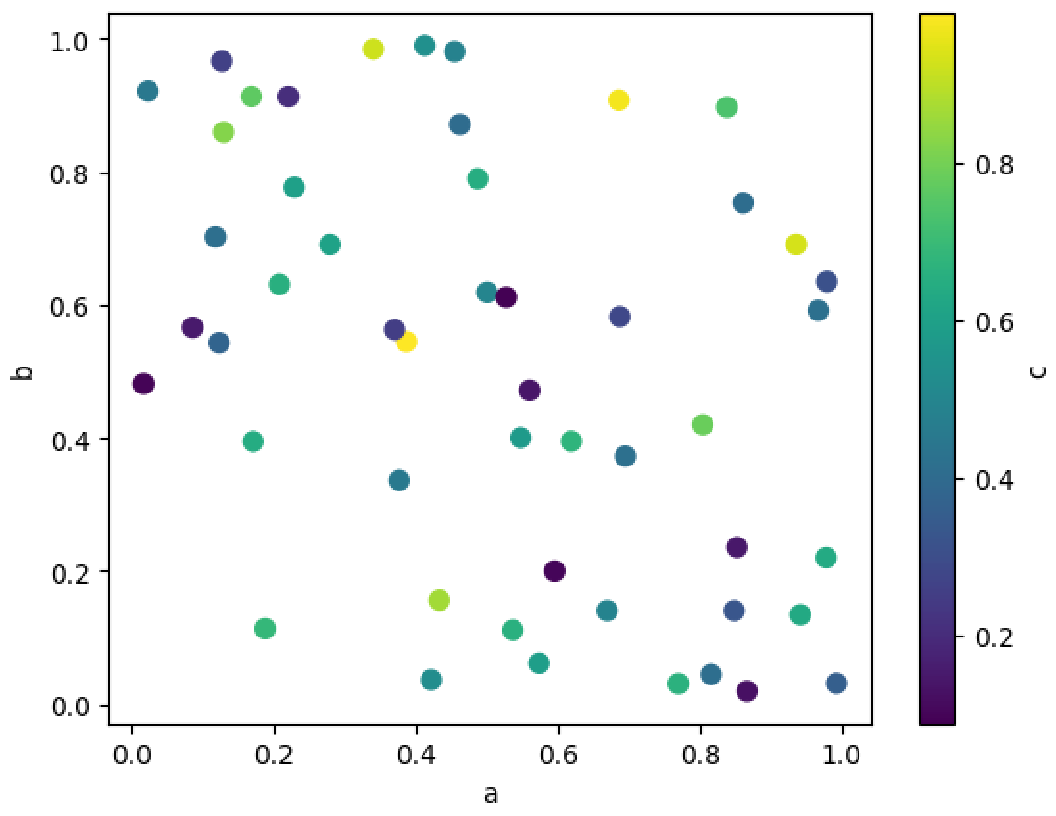


1.0.79 绘制数据的散点图，将颜色映射到另一个数值变量上

[1]:
```
# 导入基础计算库
import numpy as np
# 导入数据分析库
import pandas as pd
```

[2]:
```
# 设置随机数种子
np.random.seed(123456)
# 生成数据
df = pd.DataFrame(np.random.rand(50, 4), columns=["a", "b", "c", "d"])
# 新增一列
df["species"] = pd.Categorical(
    ["setosa"] * 20 + ["versicolor"] * 20 + ["virginica"] * 10
)
df.plot.scatter(x="a", y="b",c="c",s=50)
```

[2]:
```
<Axes: xlabel='a', ylabel='b'>
```

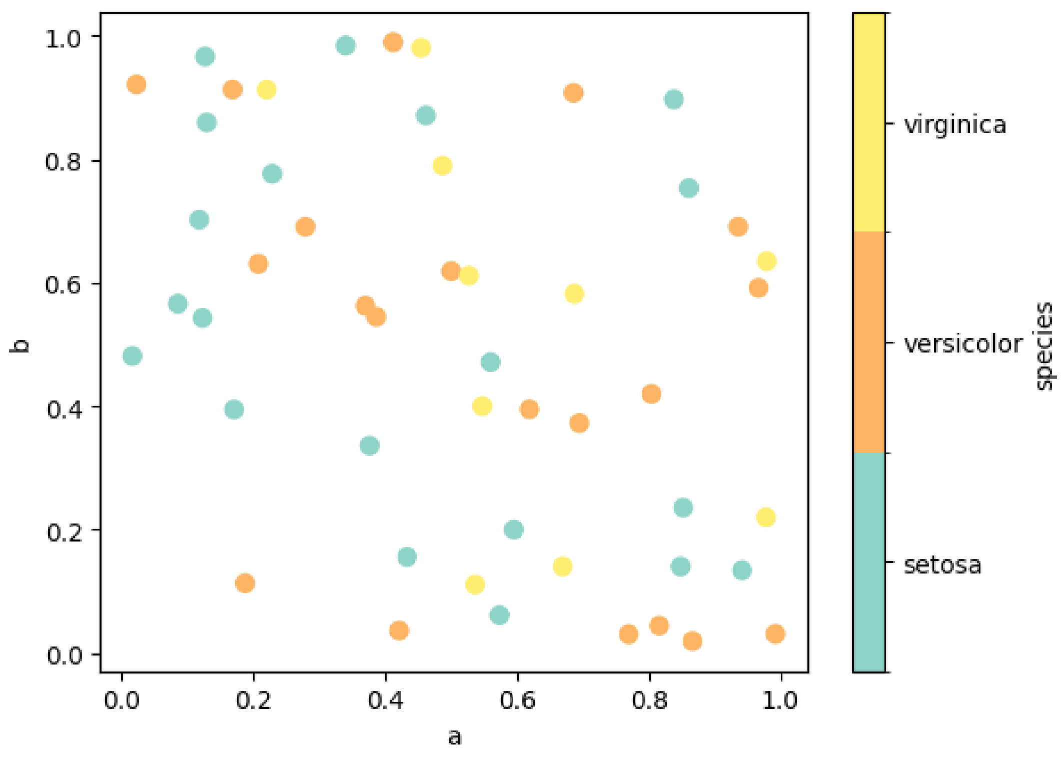


1.0.80 绘制数据的散点图，将颜色映射到另一个分类变量上

```
[1]: # 导入基础计算库
     import numpy as np
     # 导入数据分析库
     import pandas as pd
```

```
[2]: # 设置随机数种子
     np.random.seed(123456)
     # 生成数据
     df = pd.DataFrame(np.random.rand(50, 4), columns=["a", "b", "c", "d"])
     # 新增一列
     df["species"] = pd.Categorical(
         ["setosa"] * 20 + ["versicolor"] * 20 + ["virginica"] * 10
     )
     df.plot.scatter(x="a", y="b",c="species",cmap="Set3", s=50)
```

```
[2]: <Axes: xlabel='a', ylabel='b'>
```

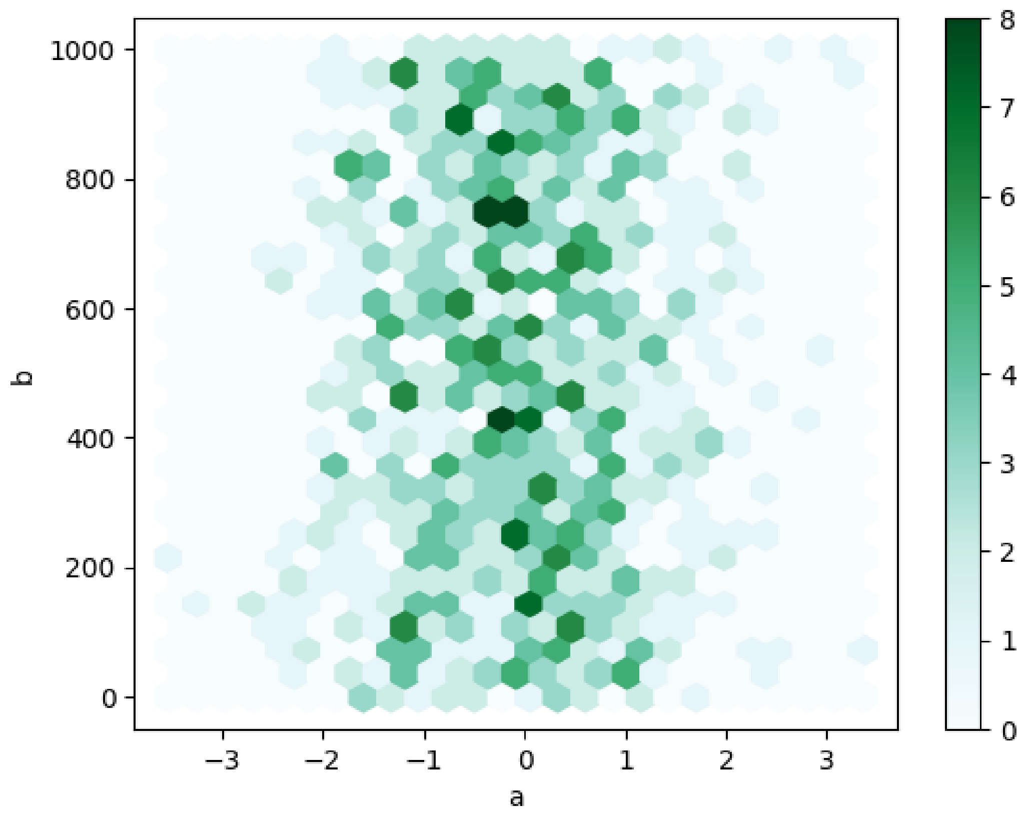


1.0.81 绘制数据的六边形箱图，针对散点过于密集的情况

[1]:
```
# 导入基础计算库
import numpy as np
# 导入数据分析库
import pandas as pd
```

[2]:
```
# 设置随机数种子
np.random.seed(123456)
# 生成数据
df = pd.DataFrame(np.random.randn(1000, 2), columns=["a", "b"])
# 修改这一列的值
df["b"] = df["b"] + np.arange(1000)
df.plot.hexbin(
    x="a", y="b",
    gridsize=25 # 六边形的大小，数值越大，面积越小
)
```

[2]:
```
<Axes: xlabel='a', ylabel='b'>
```

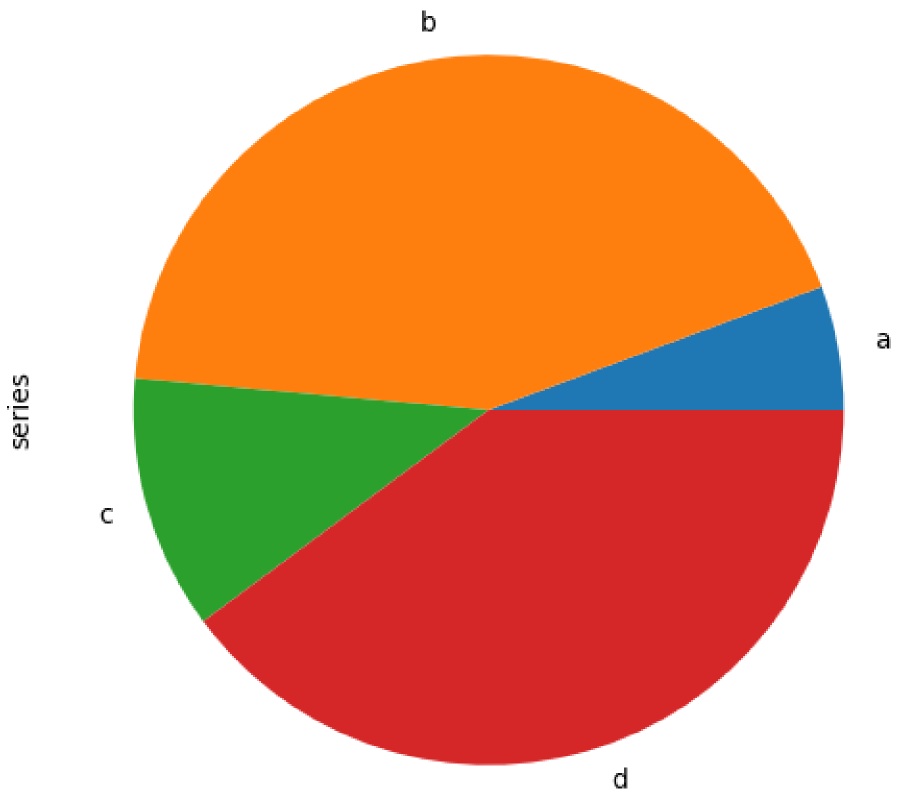


1.0.82 绘制饼图

```
[1]: # 导入基础计算库
     import numpy as np
     # 导入数据分析库
     import pandas as pd
```

```
[2]: # 设置随机数种子
     np.random.seed(123456)
     # 生成数据
     series = pd.Series(3 * np.random.rand(4), index=["a", "b", "c", "d"], name="series")
     series.plot.pie(figsize=(6, 6))
```

```
[2]: <Axes: ylabel='series'>
```

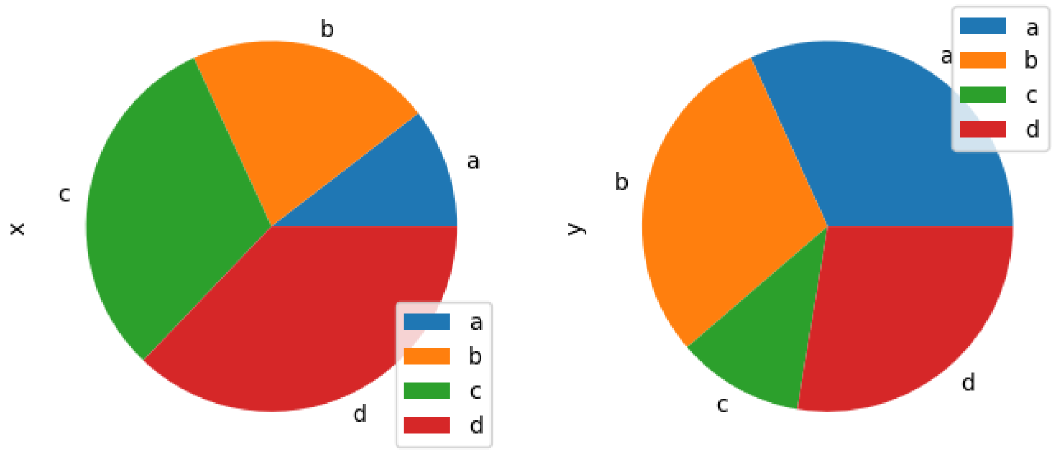


1.0.83 绘制多列数据的饼图

[1]:
```
# 导入基础计算库
import numpy as np
# 导入数据分析库
import pandas as pd
```

[2]:
```
# 设置随机数种子
np.random.seed(123456)
# 生成数据
df = pd.DataFrame(
    3 * np.random.rand(4, 2), index=["a", "b", "c", "d"], columns=["x", "y"]
)
# 以子图形式
df.plot.pie(subplots=True, figsize=(8, 4))
```

[2]:
```
array([<Axes: ylabel='x'>, <Axes: ylabel='y'>], dtype=object)
```



1.0.84 各类绘图对缺失值的处理方式如下

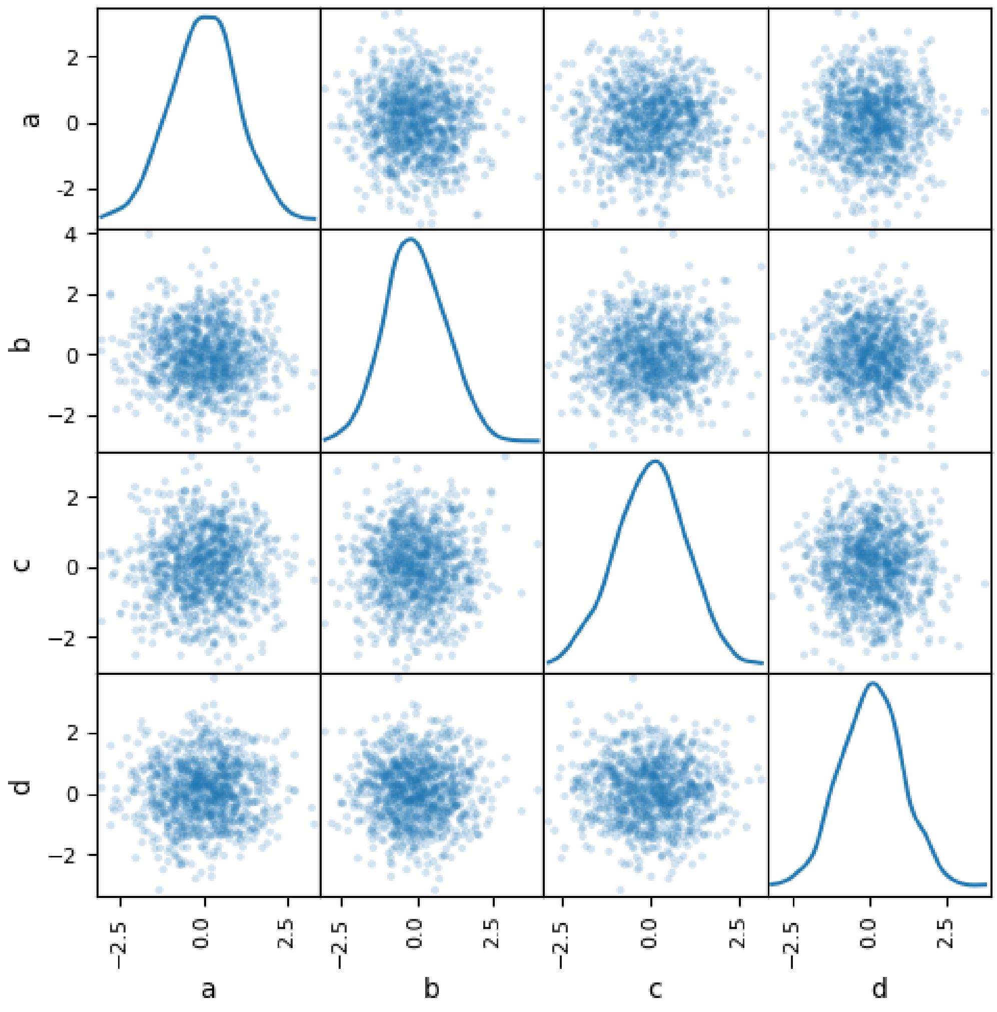
Plot Type	NaN Handling
Line	Leave gaps at NaNs
Line	(stacked) Fill 0’s
Bar	Fill 0’s
Scatter	Drop NaNs
Histogram	Drop NaNs (column-wise)
Box	Drop NaNs (column-wise)
Area	Fill 0’s
KDE	Drop NaNs (column-wise)
Hexbin	Drop NaNs
Pie	Fill 0’s

1.0.85 绘制多个变量之间的散点图矩阵

[1]:
```
# 导入基础计算库
import numpy as np
# 导入数据分析库
import pandas as pd
```

[2]:
```
# 导入散点矩阵绘图工具
from pandas.plotting import scatter_matrix
# 设置随机数种子
np.random.seed(1)
# 生成数据
df = pd.DataFrame(np.random.randn(1000, 4), columns=["a", "b", "c", "d"])
scatter_matrix(df, alpha=0.2, figsize=(6, 6), diagonal="kde")
```

[2]:
```
array([[<Axes: xlabel='a', ylabel='a'>, <Axes: xlabel='b', ylabel='a'>,
        <Axes: xlabel='c', ylabel='a'>, <Axes: xlabel='d', ylabel='a'>],
       [<Axes: xlabel='a', ylabel='b'>, <Axes: xlabel='b', ylabel='b'>,
        <Axes: xlabel='c', ylabel='b'>, <Axes: xlabel='d', ylabel='b'>],
       [<Axes: xlabel='a', ylabel='c'>, <Axes: xlabel='b', ylabel='c'>,
        <Axes: xlabel='c', ylabel='c'>, <Axes: xlabel='d', ylabel='c'>],
       [<Axes: xlabel='a', ylabel='d'>, <Axes: xlabel='b', ylabel='d'>,
        <Axes: xlabel='c', ylabel='d'>, <Axes: xlabel='d', ylabel='d'>]],
      dtype=object)
```

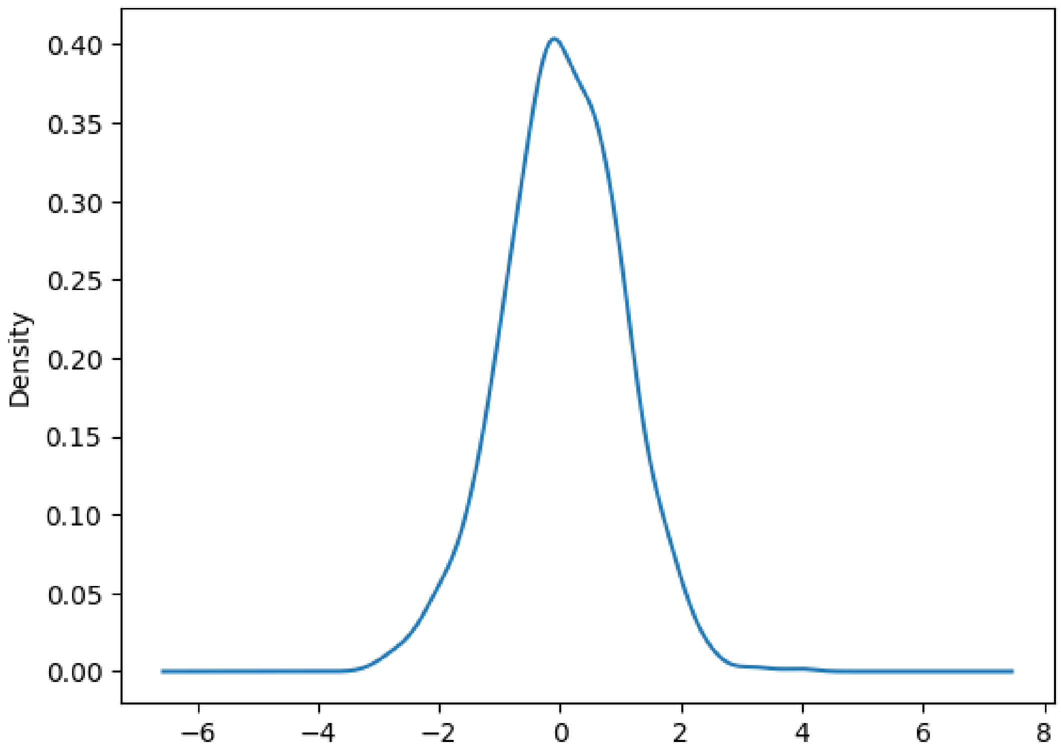


1.0.86 绘制核密度估计曲线

[1]:
```
# 导入基础计算库
import numpy as np
# 导入数据分析库
import pandas as pd
```

[2]:
```
# 设置随机数种子
np.random.seed(1)
ser = pd.Series(np.random.randn(1000))
ser.plot.kde()
```

[2]:
```
<Axes: ylabel='Density'>
```



1.0.87 绘制安德鲁曲线，多元分析中的一种图形

[1]:
```
# 导入基础计算库
import numpy as np
# 导入数据分析库
import pandas as pd
# 导入数据集获取工具
from sklearn.datasets import fetch_openml
```

[2]:
```
# 导入安德鲁曲线绘图工具
from pandas.plotting import andrews_curves
# 获取数据
data = fetch_openml(
    data_id=61,
    as_frame=True,
    parser="pandas"
)["frame"]
```

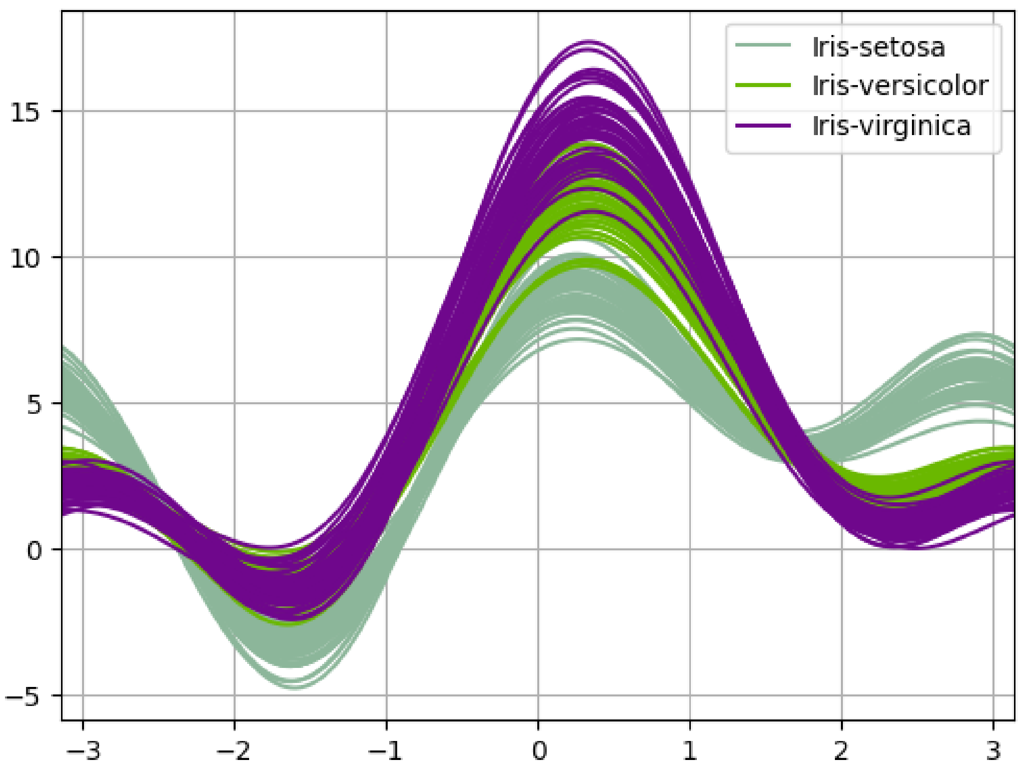
```
data.head()
```

[2]:

```
   sepallength  sepalwidth  petallength  petalwidth        class
0          5.1         3.5          1.4         0.2  Iris-setosa
1          4.9         3.0          1.4         0.2  Iris-setosa
2          4.7         3.2          1.3         0.2  Iris-setosa
3          4.6         3.1          1.5         0.2  Iris-setosa
4          5.0         3.6          1.4         0.2  Iris-setosa
```

[3]:
```
andrews_curves(data, "class")
```

[3]:
```
<Axes: >
```



1.0.88 绘制平行坐标曲线，多元分析中的一种图形

[1]:
```
# 导入基础计算库
import numpy as np
# 导入数据分析库
import pandas as pd
# 导入数据集获取工具
from sklearn.datasets import fetch_openml
```

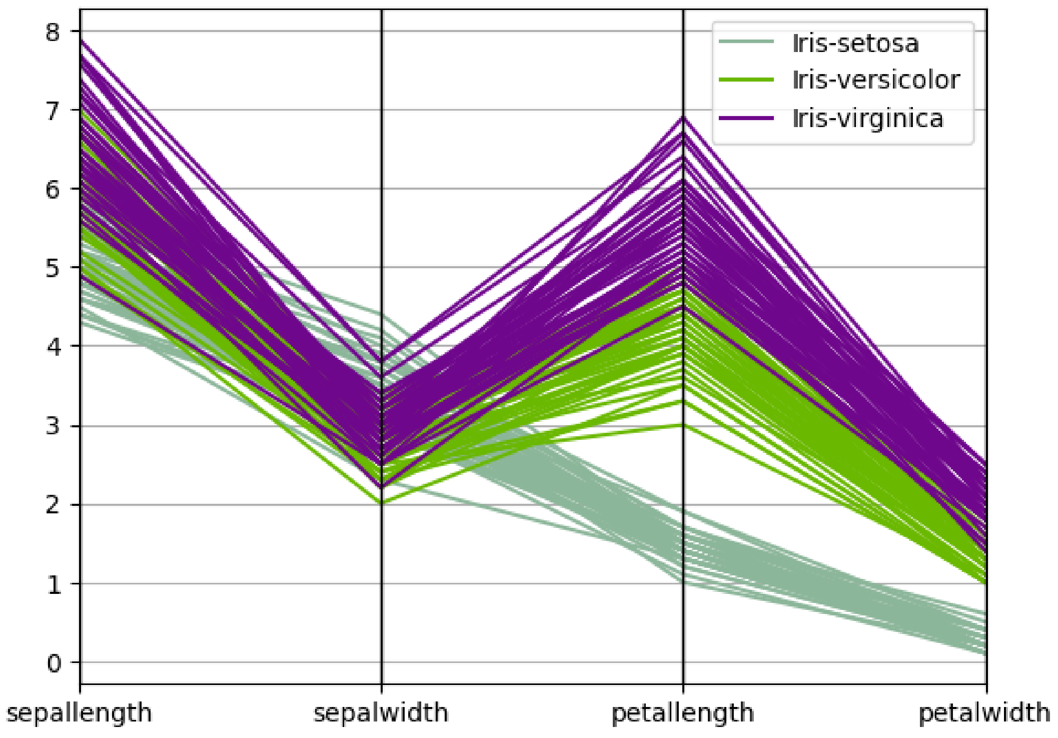
[2]:
```
# 导入安德鲁曲线绘图工具
from pandas.plotting import parallel_coordinates
```

```
# 获取数据
data = fetch_openml(
    data_id=61,
    as_frame=True,
    parser="pandas"
)["frame"]
data.head()
```

[2]:
```
   sepallength  sepalwidth  petallength  petalwidth        class
0          5.1         3.5          1.4         0.2  Iris-setosa
1          4.9         3.0          1.4         0.2  Iris-setosa
2          4.7         3.2          1.3         0.2  Iris-setosa
3          4.6         3.1          1.5         0.2  Iris-setosa
4          5.0         3.6          1.4         0.2  Iris-setosa
```

[3]:
```
parallel_coordinates(data, "class")
```

[3]:
```
<Axes: >
```

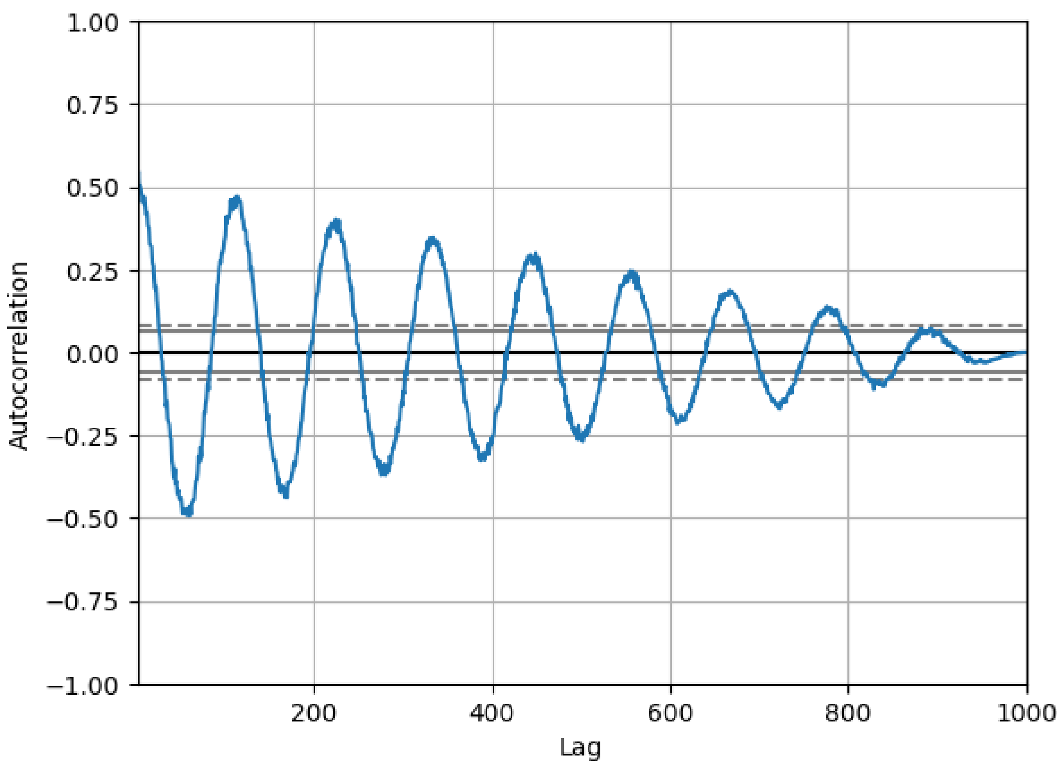


1.0.89 绘制自相关图

[1]:
```
# 导入基础计算库
import numpy as np
# 导入数据分析库
import pandas as pd
```

[2]:
```
# 导入自相关系数绘图工具
from pandas.plotting import autocorrelation_plot
spacing = np.linspace(-9 * np.pi, 9 * np.pi, num=1000)
# 设置随机数种子
np.random.seed(1)
# 生成数据
data = pd.Series(0.7 * np.random.rand(1000) + 0.3 * np.sin(spacing))
autocorrelation_plot(data)
```

[2]:
```
<Axes: xlabel='Lag', ylabel='Autocorrelation'>
```



1.0.90 调整数据的显示精度

[1]:
```
# 导入基础计算库
import numpy as np
# 导入数据分析库
import pandas as pd
# 导入 matplotlib 包
import matplotlib as mpl
```

[2]:
```
# 生成数据
df = pd.DataFrame({
    "strings": ["Adam", "Mike"],
    "ints": [1, 3],
    "floats": [1.123, 1000.23]
})
df.head()
```

[2]:

```
  strings  ints     floats
0    Adam     1      1.123
1    Mike     3   1000.230
```

[3]:

```
# 格式化输出
df.style.format(
    precision=3, thousands=".", decimal="," # 将千分位的点替换为,
).format_index(
    str.upper, axis=1 # 将列名全部大写
).relabel_index(
    ["row 1", "row 2"], axis=0 # 修改行名
)
```

[3]:

```
<pandas.io.formats.style.Styler at 0x20649a5e5f0>
```

1.0.91 自定义高亮显示数据

[1]:

```
# 导入基础计算库
import numpy as np
# 导入数据分析库
import pandas as pd
# 导入 matplotlib 包
import matplotlib as mpl
```

[2]:

```
# 设置随机数种子
np.random.seed(1)
# 生成数据
weather_df = pd.DataFrame(
    np.random.rand(10,2)*5,
    index=pd.date_range(start="2021-01-01", periods=10),
    columns=["Tokyo", "Beijing"]
)
# 自定义函数
def rain_condition(v):
    if v < 1.75:
        return "Dry"
    elif v < 2.75:
        return "Rain"
    return "Heavy Rain"
# 高亮显示
def make_pretty(styler):
    styler.set_caption("Weather Conditions") # 设置数据表的标题
    styler.format(rain_condition) # 设置数据格式，调用自定义函数
    styler.format_index(lambda v: v.strftime("%A")) # 修改行名
    # 背景颜色
    styler.background_gradient(axis=None, vmin=1, vmax=5, cmap="YlGnBu")
    return styler

weather_df
```

[2]:
```
                Tokyo   Beijing
2021-01-01  2.085110  3.601622
2021-01-02  0.000572  1.511663
2021-01-03  0.733779  0.461693
2021-01-04  0.931301  1.727804
2021-01-05  1.983837  2.694084
2021-01-06  2.095973  3.426098
2021-01-07  1.022261  4.390587
2021-01-08  0.136938  3.352338
2021-01-09  2.086524  2.793449
2021-01-10  0.701935  0.990507
```

[3]:
```
# 高亮显示，调用 make_pretty 函数
weather_df.loc["2021-01-04":"2021-01-08"].style.pipe(make_pretty)
```

[3]:
```
<pandas.io.formats.style.Styler at 0x287e35be0e0>
```

1.0.92 隐藏行名和列名

[1]:
```
# 导入基础计算库
import numpy as np
# 导入数据分析库
import pandas as pd
# 导入 matplotlib 包
import matplotlib as mpl
```

[2]:
```
# 设置随机数种子
np.random.seed(1)
# 生成数据
df = pd.DataFrame(np.random.randn(5, 5))
df
```

[2]:
```
          0         1         2         3         4
0  1.624345 -0.611756 -0.528172 -1.072969  0.865408
1 -2.301539  1.744812 -0.761207  0.319039 -0.249370
2  1.462108 -2.060141 -0.322417 -0.384054  1.133769
3 -1.099891 -0.172428 -0.877858  0.042214  0.582815
4 -1.100619  1.144724  0.901591  0.502494  0.900856
```

```
[3]: df.style.hide(
         subset=[0, 2, 4], axis=0 # 隐藏第一, 三, 五行
     ).hide(
         subset=[0, 2, 4], axis=1 # 隐藏第一, 三, 五列
     )
```

```
[3]: <pandas.io.formats.style.Styler at 0x241561cfac0>
```

```
[4]: # 需要显示的行列
     show = [0, 2, 4]
     df.style.hide(
         [row for row in df.index if row not in show], axis=0 # 隐藏 show 列表之外的行
     ).hide(
         [col for col in df.columns if col not in show], axis=1 # 隐藏 show 列表之外的列
     )
```

```
[4]: <pandas.io.formats.style.Styler at 0x2415f52fd30>
```

1.0.93 连接数据

```
[1]: # 导入基础计算库
     import numpy as np
     # 导入数据分析库
     import pandas as pd
     # 导入 matplotlib 包
     import matplotlib as mpl
```

```
[2]: # 设置随机数种子
     np.random.seed(1)
     # 生成数据
     df = pd.DataFrame(np.random.randn(5, 5))
     df
```

```
[2]:           0         1         2         3         4
     0  1.624345 -0.611756 -0.528172 -1.072969  0.865408
     1 -2.301539  1.744812 -0.761207  0.319039 -0.249370
     2  1.462108 -2.060141 -0.322417 -0.384054  1.133769
     3 -1.099891 -0.172428 -0.877858  0.042214  0.582815
     4 -1.100619  1.144724  0.901591  0.502494  0.900856
```

```
[3]: summary_styler = df.agg(["sum", "mean"]).style.format(
         precision=3
     ).relabel_index(["Sum", "Average"]) # 中心修改行名
     summary_styler
```

```
[3]: <pandas.io.formats.style.Styler at 0x1caeaefda50>
```

```
[4]: df.style.format(precision=1).concat(summary_styler)
```

```
[4]: <pandas.io.formats.style.Styler at 0x1caed690bb0>
```

1.0.94 将数据单元格进行格式转换

```
[1]: # 导入基础计算库
import numpy as np
# 导入数据分析库
import pandas as pd
# 导入 matplotlib 包
import matplotlib as mpl
```

```
[2]: # 设置随机数种子
np.random.seed(0)
# 生成数据
df = pd.DataFrame(np.random.randn(10,4), columns=["A","B","C","D"])
df.style
```

```
[2]: <pandas.io.formats.style.Styler at 0x22964ffda50>
```

```
[3]: # 对负数进行格式转换
def style_negative(v, props=''):
    return props if v < 0 else None
s = df.style.applymap(
    style_negative, props="color:red;"
).applymap(
    lambda v: "opacity: 20%;" if (v < 0.3) and (v > -0.3) else None
)
s
```

```
[3]: <pandas.io.formats.style.Styler at 0x2295ec329b0>
```

1.0.95 对每一列的最大值进行高亮显示

```
[1]: # 导入基础计算库
import numpy as np
# 导入数据分析库
import pandas as pd
# 导入 matplotlib 包
import matplotlib as mpl
```

```
[2]: # 设置随机数种子
np.random.seed(0)
# 生成数据
df = pd.DataFrame(np.random.randn(10,4), columns=["A","B","C","D"])
df.style
```

```
[2]: <pandas.io.formats.style.Styler at 0x145f5ac1e10>
```

[3]:
```
# 对最大值进行高亮显示
def highlight_max(s, props=""):
    return np.where(s == np.nanmax(s.values), props, "")
df.style.apply(
    highlight_max, props="color:white;background-color:darkblue",
    axis=0
)
```

[3]:
```
<pandas.io.formats.style.Styler at 0x145ef7b0670>
```

1.0.96 对每一行以及整个 dataframe 的最大值进行高亮显示

[1]:
```
# 导入基础计算库
import numpy as np
# 导入数据分析库
import pandas as pd
# 导入 matplotlib 包
import matplotlib as mpl
```

[2]:
```
# 设置随机数种子
np.random.seed(0)
# 生成数据
df = pd.DataFrame(np.random.randn(10,4), columns=["A","B","C","D"])
df.style
```

[2]:
```
<pandas.io.formats.style.Styler at 0x14caa885ea0>
```

[3]:
```
# 对最大值进行高亮显示
def highlight_max(s, props=""):
    return np.where(s == np.nanmax(s.values), props, "")
```

[4]:
```
df.style.apply(
    highlight_max, props="color:white;background-color:pink;",
    axis=1
)
```

[4]:
```
<pandas.io.formats.style.Styler at 0x14ca452c310>
```

[5]:
```
df.style.apply(
    highlight_max, props="color:white;background-color:purple",
    axis=None
)
```

[5]:
```
<pandas.io.formats.style.Styler at 0x14cad00ceb0>
```

1.0.97 对行名和列名进行格式变换

[1]:
```
# 导入基础计算库
import numpy as np
# 导入数据分析库
import pandas as pd
# 导入 matplotlib 包
import matplotlib as mpl
```

[2]:
```
# 设置随机数种子
np.random.seed(0)
# 生成数据
df = pd.DataFrame(np.random.randn(10,4), columns=["A","B","C","D"])
df.style
```

[2]:
```
<pandas.io.formats.style.Styler at 0x2461ce5da50>
```

[3]:
```
df.style.applymap_index(
    lambda v: "color:pink;" if v>4 else "color:darkblue;",
    axis=0 # 对行名进行变换
)
```

[3]:
```
<pandas.io.formats.style.Styler at 0x24616a92980>
```

[4]:
```
df.style.apply_index(
    lambda s: np.where(
        s.isin(["A", "B"]), "color:pink;", "color:darkblue;"
    ),
    axis=1 # 对列名进行转换
)
```

[4]:
```
<pandas.io.formats.style.Styler at 0x24616a93b20>
```

1.0.98 对行名和列名指定子集进行格式变换

[1]:
```
# 导入基础计算库
import numpy as np
# 导入数据分析库
import pandas as pd
# 导入 matplotlib 包
import matplotlib as mpl
```

[2]:
```
# 设置随机数种子
np.random.seed(0)
# 生成数据
df = pd.DataFrame(np.random.randn(10,4), columns=["A","B","C","D"])
df.style
```

```
[2]: <pandas.io.formats.style.Styler at 0x19a12e95e10>
```

```
[3]: # 对最大值进行高亮显示
     def highlight_max(s, props=""):
         return np.where(s == np.nanmax(s.values), props, "")

     slice_ = ["C", "D"]
     df.style.apply(
         highlight_max, props="color:red;",
         axis=0, subset=slice_
     ).set_properties(
         **{"background-color": "#ffffb3"},
         subset=slice_
     )
```

```
[3]: <pandas.io.formats.style.Styler at 0x19a15e839d0>
```

1.0.99 对缺失值进行高亮显示（内置函数）

```
[1]: # 导入基础计算库
     import numpy as np
     # 导入数据分析库
     import pandas as pd
     # 导入 matplotlib 包
     import matplotlib as mpl
```

```
[2]: # 设置随机数种子
     np.random.seed(0)
     # 生成数据
     df = pd.DataFrame(np.random.randn(10,4), columns=["A","B","C","D"])
     df.style
```

```
[2]: <pandas.io.formats.style.Styler at 0x1763425da50>
```

```
[3]: df.iloc[0,2] = np.nan
     df.iloc[4,3] = np.nan
```

```
[4]: df.style.highlight_null(color="yellow")
```

```
[4]: <pandas.io.formats.style.Styler at 0x176369e8d90>
```

1.0.100 对最大值和最小值进行高亮显示（内置函数）

```
[1]: # 导入基础计算库
     import numpy as np
     # 导入数据分析库
     import pandas as pd
     # 导入 matplotlib 包
```

```
import matplotlib as mpl
```

[2]:
```
# 设置随机数种子
np.random.seed(0)
# 生成数据
df = pd.DataFrame(np.random.randn(10,4), columns=["A","B","C","D"])
df.style
```

[2]:
```
<pandas.io.formats.style.Styler at 0x26e697b5ea0>
```

[3]:
```
# 最大值高亮显示
df.style.highlight_max(
    axis=1, # 行最大值
    props="color:white; font-weight:bold; background-color:darkblue;"
)
```

[3]:
```
<pandas.io.formats.style.Styler at 0x26e6bf3cd60>
```

[4]:
```
# 最大值高亮显示
df.style.highlight_max(
    axis=0, # 列最大值
    props="color:white; font-weight:bold; background-color:darkblue;"
)
```

[4]:
```
<pandas.io.formats.style.Styler at 0x26e6bf3d270>
```

[5]:
```
# 最大值高亮显示
df.style.highlight_max(
    axis=None, # 整个 dataframe 最大值
    props="color:white; font-weight:bold; background-color:darkblue;"
)
```

[5]:
```
<pandas.io.formats.style.Styler at 0x26e6c79f910>
```

[6]:
```
# 最小值高亮显示
df.style.highlight_min(
    axis=1, # 行最小值
    props="color:white; font-weight:bold; background-color:darkblue;"
)
```

[6]:
```
<pandas.io.formats.style.Styler at 0x26e6c79f3a0>
```

[7]:
```
# 最小值高亮显示
df.style.highlight_min(
    axis=0, # 列最小值
    props="color:white; font-weight:bold; background-color:darkblue;"
)
```

[7]:
```
<pandas.io.formats.style.Styler at 0x26e6c79fc40>
```

[8]:
```
# 最小值高亮显示
df.style.highlight_min(
    axis=None, # 整个 dataframe 最小值
    props="color:white; font-weight:bold; background-color:darkblue;"
)
```

[8]:
```
<pandas.io.formats.style.Styler at 0x26e6c79f6d0>
```

1.0.101 对介于某两个数值之间的数据进行高亮显示（内置函数）

[1]:
```
# 导入基础计算库
import numpy as np
# 导入数据分析库
import pandas as pd
# 导入 matplotlib 包
import matplotlib as mpl
```

[2]:
```
# 设置随机数种子
np.random.seed(0)
# 生成数据
df = pd.DataFrame(np.random.randn(10,4), columns=["A","B","C","D"])
df.style
```

[2]:
```
<pandas.io.formats.style.Styler at 0x24b751a5ea0>
```

[3]:
```
left = pd.Series([1.0, 0.0, 1.0], index=["A", "B", "D"])
df.style.highlight_between(
    left=left, right=1.5,
    axis=1, # 对列进行操作
    props="color:white; background-color:purple;"
)
```

[3]:
```
<pandas.io.formats.style.Styler at 0x24b7792cfd0>
```

[4]:
```
left = pd.Series([0, 0, 0, 0, 0], index=[0,2,3,5,8])
df.style.highlight_between(
    left=left, right=2.5,
    axis=0, # 对行进行操作
    props="color:white; background-color:purple;"
)
```

[4]:
```
<pandas.io.formats.style.Styler at 0x24b6ee4fa60>
```

1.0.102 对分位数进行高亮显示（内置函数）

[1]:
```
# 导入基础计算库
import numpy as np
# 导入数据分析库
import pandas as pd
# 导入 matplotlib 包
import matplotlib as mpl
```

[2]:
```
# 设置随机数种子
np.random.seed(0)
# 生成数据
df = pd.DataFrame(np.random.randn(10,4), columns=["A","B","C","D"])
df.style
```

[2]:
```
<pandas.io.formats.style.Styler at 0x1b9f30f9ea0>
```

[3]:
```
# 将 0.85 到 1 的分位数高亮显示
df.style.highlight_quantile(
    q_left=0.85, axis=0, color="yellow" # 列
)
```

[3]:
```
<pandas.io.formats.style.Styler at 0x1b9f587cd60>
```

[4]:
```
df.style.highlight_quantile(
    q_left=0.85, axis=1, color="yellow" # 行
)
```

[4]:
```
<pandas.io.formats.style.Styler at 0x1b9f587d4e0>
```

[5]:
```
df.style.highlight_quantile(
    q_left=0.85, axis=None, color="yellow" # 整个 dataframe
)
```

[5]:
```
<pandas.io.formats.style.Styler at 0x1b9f60df580>
```

1.0.103 对 dataframe 添加背景色（内置函数）

[1]:
```
# 导入基础计算库
import numpy as np
# 导入数据分析库
import pandas as pd
# 导入 matplotlib 包
import matplotlib as mpl
```

[2]:
```
# 设置随机数种子
np.random.seed(0)
# 生成数据
df = pd.DataFrame(np.random.randn(10,4), columns=["A","B","C","D"])
```

```
df.style
```

[2]:
```
<pandas.io.formats.style.Styler at 0x21c7ec7da50>
```

[3]:
```
import seaborn as sns
cm = sns.light_palette("green", as_cmap=True)
df.style.background_gradient(cmap=cm)
```

[3]:
```
<pandas.io.formats.style.Styler at 0x21c788b0bb0>
```

1.0.104 对 dataframe 添加文字前景色（内置函数）

[1]:
```
# 导入基础计算库
import numpy as np
# 导入数据分析库
import pandas as pd
# 导入 matplotlib 包
import matplotlib as mpl
```

[2]:
```
# 设置随机数种子
np.random.seed(0)
# 生成数据
df = pd.DataFrame(np.random.randn(10,4), columns=["A","B","C","D"])
df.style
```

[2]:
```
<pandas.io.formats.style.Styler at 0x293c5b7da50>
```

[3]:
```
import seaborn as sns
cm = sns.light_palette("green", as_cmap=True)
df.style.text_gradient(cmap=cm)
```

[3]:
```
<pandas.io.formats.style.Styler at 0x293bf82f850>
```

1.0.105 对整个 dataframe 设置背景色和前景色（内置函数）

[1]:
```
# 导入基础计算库
import numpy as np
# 导入数据分析库
import pandas as pd
# 导入 matplotlib 包
import matplotlib as mpl
```

[2]:
```
# 设置随机数种子
np.random.seed(0)
# 生成数据
df = pd.DataFrame(np.random.randn(10,4), columns=["A","B","C","D"])
df.style
```

```
[2]: <pandas.io.formats.style.Styler at 0x231dabd5e10>
```

```
[3]: # 对 style 设置属性
df.style.set_properties(
    **{
        "background-color": "black",
        "color": "lawngreen",
        "border-color": "white"
      }
)
```

```
[3]: <pandas.io.formats.style.Styler at 0x231dd36d210>
```

1.0.106 在 dataframe 上添加柱状图（内置函数）

```
[1]: # 导入基础计算库
import numpy as np
# 导入数据分析库
import pandas as pd
# 导入 matplotlib 包
import matplotlib as mpl
```

```
[2]: # 设置随机数种子
np.random.seed(0)
# 生成数据
df = pd.DataFrame(np.random.randn(10,4), columns=["A","B","C","D"])
df.style
```

```
[2]: <pandas.io.formats.style.Styler at 0x1711ec3da50>
```

```
[3]: df.style.bar(subset=["A", "D"], color='#d65f5f')
```

```
[3]: <pandas.io.formats.style.Styler at 0x171213d0ca0>
```

1.0.107 在 dataframe 上添加柱状图，不遮挡数值（内置函数）

```
[1]: # 导入基础计算库
import numpy as np
# 导入数据分析库
import pandas as pd
# 导入 matplotlib 包
import matplotlib as mpl
```

```
[2]: # 设置随机数种子
np.random.seed(0)
# 生成数据
df = pd.DataFrame(np.random.randn(10,4), columns=["A","B","C","D"])
```

```
df.style
```

[2]:
```
<pandas.io.formats.style.Styler at 0x20dad88da50>
```

[3]:
```
df.style.format(
    "{:.3f}", na_rep=""
).bar(
    align=0, vmin=-2.5, vmax=2.5, cmap="bwr", height=50,
    width=60, props="width: 120px; border-right: 1px solid black;"
).text_gradient(cmap="bwr", vmin=-2.5, vmax=2.5)
```

[3]:
```
<pandas.io.formats.style.Styler at 0x20da74c6980>
```

1.0.108 在 dataframe 上使用鼠标互动

[1]:
```
# 导入基础计算库
import numpy as np
# 导入数据分析库
import pandas as pd
# 导入 matplotlib 包
import matplotlib as mpl
```

[2]:
```
# 设置随机数种子
np.random.seed(0)
# 生成数据
df = pd.DataFrame(np.random.randn(10,4), columns=["A","B","C","D"])
df.style
```

[2]:
```
<pandas.io.formats.style.Styler at 0x204dabc1ea0>
```

[3]:
```
# 鼠标停留时，行高和列宽增大的函数
def magnify():
    return [dict(selector="th",
                 props=[("font-size", "10pt")]),
            dict(selector="td",
                 props=[('padding', "8em 8em")]),
            dict(selector="th:hover",
                 props=[("font-size", "10pt")]),
            dict(selector="tr:hover td:hover",
                 props=[('max-width', '5px'),
                        ('font-size', '5pt')])
]
```

[4]:
```
np.random.seed(25)
import seaborn as sns
cmap = sns.diverging_palette(5, 250, as_cmap=True)
df.style.background_gradient(
    cmap, axis=1
).set_properties(
    **{
        "max-width": "80px", "font-size": "1pt"
    }
).set_caption(
    "Hover to magnify"
).format(
    precision=2
).set_table_styles(magnify())
```

[4]:

```
<pandas.io.formats.style.Styler at 0x204ddbaf880>
```

1.0.109 固定 dataframe 的行名（列名不需要固定）

[1]:

```
# 导入基础计算库
import numpy as np
# 导入数据分析库
import pandas as pd
# 导入 matplotlib 包
import matplotlib as mpl
```

[2]:

```
# 设置随机数种子
np.random.seed(0)
# 生成数据
df = pd.DataFrame(np.random.randn(16, 100), columns=["A{}".format(i) for i in␣
 ↪range(1, 101)])
df.style
```

[2]:

```
<pandas.io.formats.style.Styler at 0x14fdbbede10>
```

[3]:

```
# 固定行名
df.style.set_sticky(axis="index")
```

[3]:

```
<pandas.io.formats.style.Styler at 0x14fdebdf2e0>
```

1.0.110 分组求和

[1]:

```
# 导入基础计算库
import numpy as np
# 导入数据分析库
import pandas as pd
# 导入 matplotlib 包
import matplotlib as mpl
```

[2]:

```
df = pd.DataFrame({"X": ["B", "B", "A", "A"], "Y": [1, 2, 3, 4]})
df
```

```
[2]:    X  Y
     0  B  1
     1  B  2
     2  A  3
     3  A  4
```

```
[3]: # 按照变量 X 来分组，对剩下的变量求和
     df.groupby(["X"]).sum()
```

```
[3]:    Y
     X
     A  7
     B  3
```

```
[4]: # 分组求和后，排序
     df.groupby(["X"], sort=False).sum()
```

```
[4]:    Y
     X
     B  3
     A  7
```

1.0.111 分组后查看分组数据

```
[1]: # 导入基础计算库
     import numpy as np
     # 导入数据分析库
     import pandas as pd
     # 导入 matplotlib 包
     import matplotlib as mpl
```

```
[2]: df = pd.DataFrame({"X": ["B", "B", "A", "A"], "Y": [1, 2, 3, 4]})
     df
```

```
[2]:    X  Y
     0  B  1
     1  B  2
     2  A  3
     3  A  4
```

```
[3]: # 获取 A 组别
     df.groupby(["X"]).get_group("A")
```

```
[3]:    X  Y
     2  A  3
     3  A  4
```

[4]:
```
# 获取 B 组别
df.groupby(["X"]).get_group("B")
```

[4]:
```
   X  Y
0  B  1
1  B  2
```

1.0.112 按照行名分组，针对多水平索引的情况

[1]:
```
# 导入基础计算库
import numpy as np
# 导入数据分析库
import pandas as pd
# 导入 matplotlib 包
import matplotlib as mpl
```

[2]:
```
df = pd.DataFrame(
    {
        "A": ["foo", "bar", "foo", "bar", "foo", "bar", "foo", "foo"],
        "B": ["one", "one", "two", "three", "two", "two", "one", "three"],
        "C": np.random.randn(8),
        "D": np.random.randn(8),
    }
)
df
```

[2]:
```
     A      B         C         D
0  foo    one -0.827937 -1.798664
1  bar    one  0.762386 -0.411717
2  foo    two -0.313361  0.071818
3  bar  three  1.199653  1.508659
4  foo    two  0.919133  0.012376
5  bar    two -0.033925  1.043274
6  foo    one  1.581738 -0.798991
7  foo  three  0.652731 -0.568396
```

[3]:
```
# 重新设置索引，将索引设置为 A，B 列的值
df2 = df.set_index(["A", "B"])
df2
```

[3]:
```
                  C         D
A   B
foo one   -0.827937 -1.798664
bar one    0.762386 -0.411717
foo two   -0.313361  0.071818
bar three  1.199653  1.508659
foo two    0.919133  0.012376
```

```
bar two   -0.033925  1.043274
foo one    1.581738 -0.798991
    three  0.652731 -0.568396
```

[4]:
```
# 按照 index 的 A 进行分组
grouped = df2.groupby(level=df2.index.names.difference(["B"]))
# 对分组后的数据求和
grouped.sum()
```

[4]:
```
            C         D
A
bar  1.928113  2.140216
foo  2.012304 -3.081857
```

1.0.113 同时按照行名和列名分组，针对多水平索引的情况

[1]:
```
# 导入基础计算库
import numpy as np
# 导入数据分析库
import pandas as pd
# 导入 matplotlib 包
import matplotlib as mpl
```

[2]:
```
# 生成数据
arrays = [
    ["bar", "bar", "baz", "baz", "foo", "foo", "qux", "qux"],
    ["one", "two", "one", "two", "one", "two", "one", "two"],
]
# 生成多水平索引
index = pd.MultiIndex.from_arrays(arrays, names=["first", "second"])
# 生成数据
df = pd.DataFrame({"A": [1, 1, 1, 1, 2, 2, 3, 3], "B": np.arange(8)}, index=index)
df
```

[2]:
```
              A  B
first second
bar   one     1  0
      two     1  1
baz   one     1  2
      two     1  3
foo   one     2  4
      two     2  5
qux   one     3  6
      two     3  7
```

[3]:
```
# 按照第二水平索引（second）和 A 列进行分组，再求和
df.groupby([pd.Grouper(level=1), "A"]).sum()
```

[3]:
```
          B
second A
one    1  2
       2  4
       3  6
two    1  4
       2  5
       3  7
```

1.0.114 迭代循环输出分组的组别名和分组数据

[1]:
```
# 导入基础计算库
import numpy as np
# 导入数据分析库
import pandas as pd
# 导入 matplotlib 包
import matplotlib as mpl
```

[2]:
```
# 设置随机数种子
np.random.seed(10)
# 生成数据
df = pd.DataFrame(
    {
        "A": ["foo", "bar", "foo", "bar", "foo", "bar", "foo", "foo"],
        "B": ["one", "one", "two", "three", "two", "two", "one", "three"],
        "C": np.random.randn(8),
        "D": np.random.randn(8),
    }
)
df
```

[2]:
```
     A      B         C         D
0  foo    one  1.331587  0.004291
1  bar    one  0.715279 -0.174600
2  foo    two -1.545400  0.433026
3  bar  three -0.008384  1.203037
4  foo    two  0.621336 -0.965066
5  bar    two -0.720086  1.028274
6  foo    one  0.265512  0.228630
7  foo  three  0.108549  0.445138
```

[3]:
```
# 分组
grouped = df.groupby("A")
```

```
# 迭代循环
for name, group in grouped:
    print(name)
    print(group)
```

```
bar
     A      B         C         D
1  bar    one  0.715279 -0.174600
3  bar  three -0.008384  1.203037
5  bar    two -0.720086  1.028274
foo
     A      B         C         D
0  foo    one  1.331587  0.004291
2  foo    two -1.545400  0.433026
4  foo    two  0.621336 -0.965066
6  foo    one  0.265512  0.228630
7  foo  three  0.108549  0.445138
```

1.0.115 分组求和

[1]:
```
# 导入基础计算库
import numpy as np
# 导入数据分析库
import pandas as pd
# 导入 matplotlib 包
import matplotlib as mpl
```

[2]:
```
# 设置随机数种子
np.random.seed(1)
# 生成数据
df = pd.DataFrame(
    {
        "A": ["foo", "bar", "foo", "bar", "foo", "bar", "foo", "foo"],
        "B": ["one", "one", "two", "three", "two", "two", "one", "three"],
        "C": np.random.randn(8),
        "D": np.random.randn(8),
    }
)
df
```

[2]:
```
     A      B         C         D
0  foo    one  1.624345  0.319039
1  bar    one -0.611756 -0.249370
2  foo    two -0.528172  1.462108
3  bar  three -1.072969 -2.060141
4  foo    two  0.865408 -0.322417
```

```
5  bar    two -2.301539 -0.384054
6  foo    one  1.744812  1.133769
7  foo  three -0.761207 -1.099891
```

[3]:
```python
# 以 A 分组
grouped = df.groupby("A")
# 对 C D 求和
grouped[["C", "D"]].aggregate("sum")
```

[3]:
```
            C         D
A
bar -3.986264 -2.693565
foo  2.945186  1.492608
```

1.0.116 分组求平均数

[1]:
```python
# 导入基础计算库
import numpy as np
# 导入数据分析库
import pandas as pd
# 导入 matplotlib 包
import matplotlib as mpl
```

[2]:
```python
# 设置随机数种子
np.random.seed(1)
# 生成数据
df = pd.DataFrame(
    {
        "A": ["foo", "bar", "foo", "bar", "foo", "bar", "foo", "foo"],
        "B": ["one", "one", "two", "three", "two", "two", "one", "three"],
        "C": np.random.randn(8),
        "D": np.random.randn(8),
    }
)
df
```

[2]:
```
     A      B         C         D
0  foo    one  1.624345  0.319039
1  bar    one -0.611756 -0.249370
2  foo    two -0.528172  1.462108
3  bar  three -1.072969 -2.060141
4  foo    two  0.865408 -0.322417
5  bar    two -2.301539 -0.384054
6  foo    one  1.744812  1.133769
7  foo  three -0.761207 -1.099891
```

[3]:
```
# 以 A 分组
grouped = df.groupby("A")
# 对 C D 求平均数
grouped[["C", "D"]].aggregate("mean")
```

[3]:
```
            C         D
A
bar -1.328755 -0.897855
foo  0.589037  0.298522
```

1.0.117 分组计数

[1]:
```
# 导入基础计算库
import numpy as np
# 导入数据分析库
import pandas as pd
# 导入 matplotlib 包
import matplotlib as mpl
```

[2]:
```
# 设置随机数种子
np.random.seed(1)
# 生成数据
df = pd.DataFrame(
    {
        "A": ["foo", "bar", "foo", "bar", "foo", "bar", "foo", "foo"],
        "B": ["one", "one", "two", "three", "two", "two", "one", "three"],
        "C": np.random.randn(8),
        "D": np.random.randn(8),
    }
)
df
```

[2]:
```
     A      B         C         D
0  foo    one  1.624345  0.319039
1  bar    one -0.611756 -0.249370
2  foo    two -0.528172  1.462108
3  bar  three -1.072969 -2.060141
4  foo    two  0.865408 -0.322417
5  bar    two -2.301539 -0.384054
6  foo    one  1.744812  1.133769
7  foo  three -0.761207 -1.099891
```

[3]:
```
# 以 A 分组
grouped = df.groupby("A")
# 对 C D 求平均数
grouped[["C", "D"]].aggregate("count")
```

[3]:
```
     C  D
A
bar  3  3
foo  5  5
```

1.0.118 分组计算剩下的组别之间的协方差

[1]:
```
# 导入基础计算库
import numpy as np
# 导入数据分析库
import pandas as pd
# 导入 matplotlib 包
import matplotlib as mpl
```

[2]:
```
# 设置随机数种子
np.random.seed(1)
# 生成数据
df = pd.DataFrame(
    {
        "A": ["foo", "bar", "foo", "bar", "foo", "bar", "foo", "foo"],
        "B": ["one", "one", "two", "three", "two", "two", "one", "three"],
        "C": np.random.randn(8),
        "D": np.random.randn(8),
    }
)
df
```

[2]:
```
     A      B         C         D
0  foo    one  1.624345  0.319039
1  bar    one -0.611756 -0.249370
2  foo    two -0.528172  1.462108
3  bar  three -1.072969 -2.060141
4  foo    two  0.865408 -0.322417
5  bar    two -2.301539 -0.384054
6  foo    one  1.744812  1.133769
7  foo  three -0.761207 -1.099891
```

[3]:
```
# 以 A 分组
grouped = df.groupby("A")
# 对 C D 求平均数
grouped[["C", "D"]].aggregate("cov")
```

[3]:
```
              C         D
A
bar C  0.762911 -0.166076
    D -0.166076  1.017716
```

```
foo C  1.388843  0.350805
    D  0.350805  1.098279
```

1.0.119 分组计算每一列的最大值的下标

[1]:
```
# 导入基础计算库
import numpy as np
# 导入数据分析库
import pandas as pd
# 导入 matplotlib 包
import matplotlib as mpl
```

[2]:
```
# 设置随机数种子
np.random.seed(1)
# 生成数据
df = pd.DataFrame(
    {
        "A": ["foo", "bar", "foo", "bar", "foo", "bar", "foo", "foo"],
        "B": ["one", "one", "two", "three", "two", "two", "one", "three"],
        "C": np.random.randn(8),
        "D": np.random.randn(8),
    }
)
df
```

[2]:
```
     A      B         C         D
0  foo    one  1.624345  0.319039
1  bar    one -0.611756 -0.249370
2  foo    two -0.528172  1.462108
3  bar  three -1.072969 -2.060141
4  foo    two  0.865408 -0.322417
5  bar    two -2.301539 -0.384054
6  foo    one  1.744812  1.133769
7  foo  three -0.761207 -1.099891
```

[3]:
```
# 以 A 分组
grouped = df.groupby("A")
# 对 C D 求最大值的下标
grouped[["C", "D"]].aggregate("idxmax")
```

[3]:
```
     C  D
A
bar  1  1
foo  6  2
```

1.0.120 分组计算每一列的最小值的下标

[1]:
```
# 导入基础计算库
import numpy as np
# 导入数据分析库
import pandas as pd
# 导入 matplotlib 包
import matplotlib as mpl
```

[2]:
```
# 设置随机数种子
np.random.seed(1)
# 生成数据
df = pd.DataFrame(
    {
        "A": ["foo", "bar", "foo", "bar", "foo", "bar", "foo", "foo"],
        "B": ["one", "one", "two", "three", "two", "two", "one", "three"],
        "C": np.random.randn(8),
        "D": np.random.randn(8),
    }
)
df
```

[2]:
```
     A      B         C         D
0  foo    one  1.624345  0.319039
1  bar    one -0.611756 -0.249370
2  foo    two -0.528172  1.462108
3  bar  three -1.072969 -2.060141
4  foo    two  0.865408 -0.322417
5  bar    two -2.301539 -0.384054
6  foo    one  1.744812  1.133769
7  foo  three -0.761207 -1.099891
```

[3]:
```
# 以 A 分组
grouped = df.groupby("A")
# 对 C D 求最大值的下标
grouped[["C", "D"]].aggregate("idxmin")
```

[3]:
```
     C  D
A
bar  5  3
foo  7  7
```

1.0.121 分组计算每一列的最大值

[1]:
```
# 导入基础计算库
import numpy as np
# 导入数据分析库
import pandas as pd
# 导入 matplotlib 包
import matplotlib as mpl
```

[2]:
```
# 设置随机数种子
np.random.seed(1)
# 生成数据
df = pd.DataFrame(
    {
        "A": ["foo", "bar", "foo", "bar", "foo", "bar", "foo", "foo"],
        "B": ["one", "one", "two", "three", "two", "two", "one", "three"],
        "C": np.random.randn(8),
        "D": np.random.randn(8),
    }
)
df
```

[2]:
```
     A      B         C         D
0  foo    one  1.624345  0.319039
1  bar    one -0.611756 -0.249370
2  foo    two -0.528172  1.462108
3  bar  three -1.072969 -2.060141
4  foo    two  0.865408 -0.322417
5  bar    two -2.301539 -0.384054
6  foo    one  1.744812  1.133769
7  foo  three -0.761207 -1.099891
```

[3]:
```
# 以 A 分组
grouped = df.groupby("A")
# 对 C D 求最大值的下标
grouped[["C", "D"]].aggregate("max")
```

[3]:
```
            C         D
A
bar -0.611756 -0.249370
foo  1.744812  1.462108
```

1.0.122 分组计算每一列的最小值

[1]:
```
# 导入基础计算库
import numpy as np
# 导入数据分析库
import pandas as pd
# 导入 matplotlib 包
import matplotlib as mpl
```

[2]:
```
# 设置随机数种子
np.random.seed(1)
# 生成数据
df = pd.DataFrame(
    {
        "A": ["foo", "bar", "foo", "bar", "foo", "bar", "foo", "foo"],
        "B": ["one", "one", "two", "three", "two", "two", "one", "three"],
        "C": np.random.randn(8),
        "D": np.random.randn(8),
    }
)
df
```

[2]:
```
     A      B         C         D
0  foo    one  1.624345  0.319039
1  bar    one -0.611756 -0.249370
2  foo    two -0.528172  1.462108
3  bar  three -1.072969 -2.060141
4  foo    two  0.865408 -0.322417
5  bar    two -2.301539 -0.384054
6  foo    one  1.744812  1.133769
7  foo  three -0.761207 -1.099891
```

[3]:
```
# 以 A 分组
grouped = df.groupby("A")
# 对 C D 求最大值的下标
grouped[["C", "D"]].aggregate("min")
```

[3]:
```
            C         D
A
bar -2.301539 -2.060141
foo -0.761207 -1.099891
```

1.0.123 分组计算每一列的中位数

[1]:
```
# 导入基础计算库
import numpy as np
# 导入数据分析库
import pandas as pd
# 导入 matplotlib 包
import matplotlib as mpl
```

[2]:
```
# 设置随机数种子
np.random.seed(1)
# 生成数据
df = pd.DataFrame(
    {
        "A": ["foo", "bar", "foo", "bar", "foo", "bar", "foo", "foo"],
        "B": ["one", "one", "two", "three", "two", "two", "one", "three"],
        "C": np.random.randn(8),
        "D": np.random.randn(8),
    }
)
df
```

[2]:
```
     A      B         C         D
0  foo    one  1.624345  0.319039
1  bar    one -0.611756 -0.249370
2  foo    two -0.528172  1.462108
3  bar  three -1.072969 -2.060141
4  foo    two  0.865408 -0.322417
5  bar    two -2.301539 -0.384054
6  foo    one  1.744812  1.133769
7  foo  three -0.761207 -1.099891
```

[3]:
```
# 以 A 分组
grouped = df.groupby("A")
# 对 C D 求最大值的下标
grouped[["C", "D"]].aggregate("median")
```

[3]:
```
            C         D
A
bar -1.072969 -0.384054
foo  0.865408  0.319039
```

1.0.124 分组计算每一列中唯一值的数量

[1]:
```
# 导入基础计算库
import numpy as np
# 导入数据分析库
import pandas as pd
# 导入 matplotlib 包
import matplotlib as mpl
```

[2]:
```
# 设置随机数种子
np.random.seed(1)
# 生成数据
df = pd.DataFrame(
    {
        "A": ["foo", "bar", "foo", "bar", "foo", "bar", "foo", "foo"],
        "B": ["one", "one", "two", "three", "two", "two", "one", "three"],
        "C": np.random.randn(8),
        "D": np.random.randn(8),
    }
)
df
```

[2]:
```
     A      B         C         D
0  foo    one  1.624345  0.319039
1  bar    one -0.611756 -0.249370
2  foo    two -0.528172  1.462108
3  bar  three -1.072969 -2.060141
4  foo    two  0.865408 -0.322417
5  bar    two -2.301539 -0.384054
6  foo    one  1.744812  1.133769
7  foo  three -0.761207 -1.099891
```

[3]:
```
# 以 A 分组
grouped = df.groupby("A")
# 对 C D 求最大值的下标
grouped[["C", "D"]].aggregate("nunique")
```

[3]:
```
     C  D
A
bar  3  3
foo  5  5
```

1.0.125 分组计算每一列的连乘

[1]:
```
# 导入基础计算库
import numpy as np
# 导入数据分析库
import pandas as pd
# 导入 matplotlib 包
import matplotlib as mpl
```

[2]:
```
# 设置随机数种子
np.random.seed(1)
# 生成数据
df = pd.DataFrame(
    {
        "A": ["foo", "bar", "foo", "bar", "foo", "bar", "foo", "foo"],
        "B": ["one", "one", "two", "three", "two", "two", "one", "three"],
        "C": np.random.randn(8),
        "D": np.random.randn(8),
    }
)
df
```

[2]:
```
     A      B         C         D
0  foo    one  1.624345  0.319039
1  bar    one -0.611756 -0.249370
2  foo    two -0.528172  1.462108
3  bar  three -1.072969 -2.060141
4  foo    two  0.865408 -0.322417
5  bar    two -2.301539 -0.384054
6  foo    one  1.744812  1.133769
7  foo  three -0.761207 -1.099891
```

[3]:
```
# 以 A 分组
grouped = df.groupby("A")
# 对 C D 求最大值的下标
grouped[["C", "D"]].aggregate("prod")
```

[3]:
```
            C         D
A
bar -1.510719 -0.197303
foo  0.986110  0.187550
```

1.0.126 分组计算每一列的分位数

[1]:
```
# 导入基础计算库
import numpy as np
# 导入数据分析库
import pandas as pd
# 导入 matplotlib 包
import matplotlib as mpl
```

[2]:
```
# 设置随机数种子
np.random.seed(1)
# 生成数据
df = pd.DataFrame(
    {
        "A": ["foo", "bar", "foo", "bar", "foo", "bar", "foo", "foo"],
        "B": ["one", "one", "two", "three", "two", "two", "one", "three"],
        "C": np.random.randn(8),
        "D": np.random.randn(8),
    }
)
df
```

[2]:
```
     A      B         C         D
0  foo    one  1.624345  0.319039
1  bar    one -0.611756 -0.249370
2  foo    two -0.528172  1.462108
3  bar  three -1.072969 -2.060141
4  foo    two  0.865408 -0.322417
5  bar    two -2.301539 -0.384054
6  foo    one  1.744812  1.133769
7  foo  three -0.761207 -1.099891
```

[3]:
```
# 以 A 分组
grouped = df.groupby("A")
# 对 C D 求最大值的下标
grouped[["C", "D"]].aggregate("quantile", q=0.75)
```

[3]:
```
            C         D
A
bar -0.842363 -0.316712
foo  1.624345  1.133769
```

1.0.127 分组计算每一列的均值标准误

[1]:
```
# 导入基础计算库
import numpy as np
# 导入数据分析库
import pandas as pd
# 导入 matplotlib 包
import matplotlib as mpl
```

[2]:
```
# 设置随机数种子
np.random.seed(1)
# 生成数据
df = pd.DataFrame(
    {
        "A": ["foo", "bar", "foo", "bar", "foo", "bar", "foo", "foo"],
        "B": ["one", "one", "two", "three", "two", "two", "one", "three"],
        "C": np.random.randn(8),
        "D": np.random.randn(8),
    }
)
df
```

[2]:
```
     A      B         C         D
0  foo    one  1.624345  0.319039
1  bar    one -0.611756 -0.249370
2  foo    two -0.528172  1.462108
3  bar  three -1.072969 -2.060141
4  foo    two  0.865408 -0.322417
5  bar    two -2.301539 -0.384054
6  foo    one  1.744812  1.133769
7  foo  three -0.761207 -1.099891
```

[3]:
```
# 以 A 分组
grouped = df.groupby("A")
# 对 C D 求最大值的下标
grouped[["C", "D"]].aggregate("sem")
```

[3]:
```
            C         D
A
bar  0.504285  0.582442
foo  0.527038  0.468675
```

1.0.128 分组计算样本量

[1]:
```
# 导入基础计算库
import numpy as np
# 导入数据分析库
import pandas as pd
# 导入 matplotlib 包
import matplotlib as mpl
```

[2]:
```
# 设置随机数种子
np.random.seed(1)
# 生成数据
df = pd.DataFrame(
    {
        "A": ["foo", "bar", "foo", "bar", "foo", "bar", "foo", "foo"],
        "B": ["one", "one", "two", "three", "two", "two", "one", "three"],
        "C": np.random.randn(8),
        "D": np.random.randn(8),
    }
)
df
```

[2]:
```
     A      B         C         D
0  foo    one  1.624345  0.319039
1  bar    one -0.611756 -0.249370
2  foo    two -0.528172  1.462108
3  bar  three -1.072969 -2.060141
4  foo    two  0.865408 -0.322417
5  bar    two -2.301539 -0.384054
6  foo    one  1.744812  1.133769
7  foo  three -0.761207 -1.099891
```

[3]:
```
# 以 A 分组
grouped = df.groupby("A")
# 对 C D 求最大值的下标
grouped[["C", "D"]].aggregate("size")
```

[3]:
```
A
bar    3
foo    5
dtype: int64
```

1.0.129 分组计算每一列的标准差

[1]:
```
# 导入基础计算库
import numpy as np
# 导入数据分析库
import pandas as pd
# 导入 matplotlib 包
import matplotlib as mpl
```

[2]:
```
# 设置随机数种子
np.random.seed(1)
# 生成数据
df = pd.DataFrame(
    {
        "A": ["foo", "bar", "foo", "bar", "foo", "bar", "foo", "foo"],
        "B": ["one", "one", "two", "three", "two", "two", "one", "three"],
        "C": np.random.randn(8),
        "D": np.random.randn(8),
    }
)
df
```

[2]:
```
     A      B         C         D
0  foo    one  1.624345  0.319039
1  bar    one -0.611756 -0.249370
2  foo    two -0.528172  1.462108
3  bar  three -1.072969 -2.060141
4  foo    two  0.865408 -0.322417
5  bar    two -2.301539 -0.384054
6  foo    one  1.744812  1.133769
7  foo  three -0.761207 -1.099891
```

[3]:
```
# 以 A 分组
grouped = df.groupby("A")
# 对 C D 求最大值的下标
grouped[["C", "D"]].aggregate("std")
```

[3]:
```
            C         D
A
bar  0.873448  1.008819
foo  1.178492  1.047988
```

1.0.130 分组计算每一列的方差

[1]:
```
# 导入基础计算库
import numpy as np
# 导入数据分析库
import pandas as pd
# 导入 matplotlib 包
import matplotlib as mpl
```

[2]:
```
# 设置随机数种子
np.random.seed(1)
# 生成数据
df = pd.DataFrame(
    {
        "A": ["foo", "bar", "foo", "bar", "foo", "bar", "foo", "foo"],
        "B": ["one", "one", "two", "three", "two", "two", "one", "three"],
        "C": np.random.randn(8),
        "D": np.random.randn(8),
    }
)
df
```

[2]:
```
     A      B         C         D
0  foo    one  1.624345  0.319039
1  bar    one -0.611756 -0.249370
2  foo    two -0.528172  1.462108
3  bar  three -1.072969 -2.060141
4  foo    two  0.865408 -0.322417
5  bar    two -2.301539 -0.384054
6  foo    one  1.744812  1.133769
7  foo  three -0.761207 -1.099891
```

[3]:
```
# 以 A 分组
grouped = df.groupby("A")
# 对 C D 求最大值的下标
grouped[["C", "D"]].aggregate("var")
```

[3]:
```
            C         D
A
bar  0.762911  1.017716
foo  1.388843  1.098279
```

1.0.131 分组计算每一列的极差（自定义函数）

[1]:
```
# 导入基础计算库
import numpy as np
# 导入数据分析库
import pandas as pd
# 导入 matplotlib 包
import matplotlib as mpl
```

[2]:
```
# 设置随机数种子
np.random.seed(1)
# 生成数据
df = pd.DataFrame(
    {
        "A": ["foo", "bar", "foo", "bar", "foo", "bar", "foo", "foo"],
        "B": ["one", "one", "two", "three", "two", "two", "one", "three"],
        "C": np.random.randn(8),
        "D": np.random.randn(8),
    }
)
df
```

[2]:
```
     A      B         C         D
0  foo    one  1.624345  0.319039
1  bar    one -0.611756 -0.249370
2  foo    two -0.528172  1.462108
3  bar  three -1.072969 -2.060141
4  foo    two  0.865408 -0.322417
5  bar    two -2.301539 -0.384054
6  foo    one  1.744812  1.133769
7  foo  three -0.761207 -1.099891
```

[3]:
```
# 定义计算极差的函数
def f(x):
    """
    x 是 Series 对象
    """
    res = x.max()-x.min()
    return res
```

[4]:
```
# 以 A 分组
grouped = df.groupby("A")
# 对 C D 求最大值的下标
grouped[["C", "D"]].aggregate(f)
```

[4]:
```
            C         D
A
```

```
bar   1.689782  1.810770
foo   2.506019  2.561999
```

1.0.132 分组计算每一列的多个统计量（同时计算）

[1]:
```
# 导入基础计算库
import numpy as np
# 导入数据分析库
import pandas as pd
# 导入 matplotlib 包
import matplotlib as mpl
```

[2]:
```
# 设置随机数种子
np.random.seed(1)
# 生成数据
df = pd.DataFrame(
    {
        "A": ["foo", "bar", "foo", "bar", "foo", "bar", "foo", "foo"],
        "B": ["one", "one", "two", "three", "two", "two", "one", "three"],
        "C": np.random.randn(8),
        "D": np.random.randn(8),
    }
)
df
```

[2]:
```
     A      B         C         D
0  foo    one  1.624345  0.319039
1  bar    one -0.611756 -0.249370
2  foo    two -0.528172  1.462108
3  bar  three -1.072969 -2.060141
4  foo    two  0.865408 -0.322417
5  bar    two -2.301539 -0.384054
6  foo    one  1.744812  1.133769
7  foo  three -0.761207 -1.099891
```

[3]:
```
# 定义计算极差的函数
def f(x):
    """
    x 是 Series 对象
    """
    res = x.max()-x.min()
    return res
```

[4]:
```
# 以 A 分组
grouped = df.groupby("A")
# 对 C D 求最大值的下标
```

```
grouped[["C", "D"]].aggregate([f, "mean", "max", "var"])
```

[4]:
```
            C                                           D                          \
            f      mean       max       var         f      mean       max
A
bar  1.689782 -1.328755 -0.611756  0.762911  1.810770 -0.897855 -0.249370
foo  2.506019  0.589037  1.744812  1.388843  2.561999  0.298522  1.462108


          var
A
bar  1.017716
foo  1.098279
```

1.0.133 分组计算每一列的多个统计量（同时计算，修改 Agg 的函数名）

[1]:
```
# 导入基础计算库
import numpy as np
# 导入数据分析库
import pandas as pd
# 导入 matplotlib 包
import matplotlib as mpl
```

[2]:
```
# 设置随机数种子
np.random.seed(1)
# 生成数据
df = pd.DataFrame(
    {
        "A": ["foo", "bar", "foo", "bar", "foo", "bar", "foo", "foo"],
        "B": ["one", "one", "two", "three", "two", "two", "one", "three"],
        "C": np.random.randn(8),
        "D": np.random.randn(8),
    }
)
df
```

[2]:
```
     A      B         C         D
0  foo    one  1.624345  0.319039
1  bar    one -0.611756 -0.249370
2  foo    two -0.528172  1.462108
3  bar  three -1.072969 -2.060141
4  foo    two  0.865408 -0.322417
5  bar    two -2.301539 -0.384054
6  foo    one  1.744812  1.133769
7  foo  three -0.761207 -1.099891
```

[3]:
```
# 定义计算极差的函数
def f(x):
    """
    x 是 Series 对象
    """
    res = x.max()-x.min()
    return res
```

[4]:
```
# 以 A 分组
grouped = df.groupby("A")
# 对 C D 求最大值的下标
grouped.agg(
    C 列最小值=pd.NamedAgg(column="C", aggfunc="min"),
    C 列极差=pd.NamedAgg(column="C", aggfunc=f),
    C 列平均值=pd.NamedAgg(column="C", aggfunc="mean"),
    D 列最小值=pd.NamedAgg(column="D", aggfunc="min"),
    D 列极差=pd.NamedAgg(column="D", aggfunc=f),
    D 列平均值=pd.NamedAgg(column="D", aggfunc="mean"),
)
```

[4]:
```
        C 列最小值     C 列极差     C 列平均值     D 列最小值     D 列极差     D 列
平均值
A
bar -2.301539  1.689782 -1.328755 -2.060141  1.810770 -0.897855
foo -0.761207  2.506019  0.589037 -1.099891  2.561999  0.298522
```

1.0.134 分组计算每一列的多个统计量（同时计算，不同的列应用不同的函数）

[1]:
```
# 导入基础计算库
import numpy as np
# 导入数据分析库
import pandas as pd
# 导入 matplotlib 包
import matplotlib as mpl
```

[2]:
```
# 设置随机数种子
np.random.seed(1)
# 生成数据
df = pd.DataFrame(
    {
        "A": ["foo", "bar", "foo", "bar", "foo", "bar", "foo", "foo"],
        "B": ["one", "one", "two", "three", "two", "two", "one", "three"],
        "C": np.random.randn(8),
        "D": np.random.randn(8),
    }
)
```

```
df
```

[2]:
```
       A      B         C         D
0  foo    one  1.624345  0.319039
1  bar    one -0.611756 -0.249370
2  foo    two -0.528172  1.462108
3  bar  three -1.072969 -2.060141
4  foo    two  0.865408 -0.322417
5  bar    two -2.301539 -0.384054
6  foo    one  1.744812  1.133769
7  foo  three -0.761207 -1.099891
```

[3]:
```
# 定义计算极差的函数
def f(x):
    """
    x 是 Series 对象
    """
    res = x.max()-x.min()
    return res
```

[4]:
```
# 以 A 分组
grouped = df.groupby("A")
grouped.agg({"C": "sum", "D": "std"})
```

[4]:
```
            C         D
A
bar -3.986264  1.008819
foo  2.945186  1.047988
```

1.0.135 分组计算每一列的累积计数

[1]:
```
# 导入基础计算库
import numpy as np
# 导入数据分析库
import pandas as pd
# 导入 matplotlib 包
import matplotlib as mpl
```

[2]:
```
# 设置随机数种子
np.random.seed(1)
# 生成数据
df = pd.DataFrame(
    {
        "A": ["foo", "bar", "foo", "bar", "foo", "bar", "foo", "foo"],
        "B": ["one", "one", "two", "three", "two", "two", "one", "three"],
        "C": np.random.randn(8),
        "D": np.random.randn(8),
    }
)
df
```

[2]:
```
     A      B         C         D
0  foo    one  1.624345  0.319039
1  bar    one -0.611756 -0.249370
2  foo    two -0.528172  1.462108
3  bar  three -1.072969 -2.060141
4  foo    two  0.865408 -0.322417
5  bar    two -2.301539 -0.384054
6  foo    one  1.744812  1.133769
7  foo  three -0.761207 -1.099891
```

[3]:
```
# 以 A 分组
grouped = df.groupby("A")
grouped[["C", "D"]].transform("cumsum")
```

[3]:
```
          C         D
0  1.624345  0.319039
1 -0.611756 -0.249370
2  1.096174  1.781147
3 -1.684725 -2.309511
4  1.961581  1.458730
5 -3.986264 -2.693565
6  3.706393  2.592499
7  2.945186  1.492608
```

1.0.136 分组计算每一列的累积最大值

[1]:
```
# 导入基础计算库
import numpy as np
# 导入数据分析库
import pandas as pd
# 导入 matplotlib 包
import matplotlib as mpl
```

[2]:
```
# 设置随机数种子
np.random.seed(1)
# 生成数据
df = pd.DataFrame(
    {
        "A": ["foo", "bar", "foo", "bar", "foo", "bar", "foo", "foo"],
        "B": ["one", "one", "two", "three", "two", "two", "one", "three"],
        "C": np.random.randn(8),
        "D": np.random.randn(8),
    }
)
df
```

[2]:
```
     A      B         C         D
0  foo    one  1.624345  0.319039
1  bar    one -0.611756 -0.249370
2  foo    two -0.528172  1.462108
3  bar  three -1.072969 -2.060141
4  foo    two  0.865408 -0.322417
5  bar    two -2.301539 -0.384054
6  foo    one  1.744812  1.133769
7  foo  three -0.761207 -1.099891
```

[3]:
```
# 以 A 分组
grouped = df.groupby("A")
grouped[["C", "D"]].transform("cummax")
```

[3]:
```
          C         D
0  1.624345  0.319039
1 -0.611756 -0.249370
2  1.624345  1.462108
3 -0.611756 -0.249370
4  1.624345  1.462108
5 -0.611756 -0.249370
6  1.744812  1.462108
7  1.744812  1.462108
```

1.0.137 分组计算每一列的累积最小值

[1]:
```
# 导入基础计算库
import numpy as np
# 导入数据分析库
import pandas as pd
# 导入 matplotlib 包
import matplotlib as mpl
```

[2]:
```
# 设置随机数种子
np.random.seed(1)
# 生成数据
df = pd.DataFrame(
    {
        "A": ["foo", "bar", "foo", "bar", "foo", "bar", "foo", "foo"],
        "B": ["one", "one", "two", "three", "two", "two", "one", "three"],
        "C": np.random.randn(8),
        "D": np.random.randn(8),
    }
)
df
```

[2]:
```
     A      B         C         D
0  foo    one  1.624345  0.319039
1  bar    one -0.611756 -0.249370
2  foo    two -0.528172  1.462108
3  bar  three -1.072969 -2.060141
4  foo    two  0.865408 -0.322417
5  bar    two -2.301539 -0.384054
6  foo    one  1.744812  1.133769
7  foo  three -0.761207 -1.099891
```

[3]:
```
# 以 A 分组
grouped = df.groupby("A")
grouped[["C", "D"]].transform("cummin")
```

[3]:
```
          C         D
0  1.624345  0.319039
1 -0.611756 -0.249370
2 -0.528172  0.319039
3 -1.072969 -2.060141
4 -0.528172 -0.322417
5 -2.301539 -2.060141
6 -0.528172 -0.322417
7 -0.761207 -1.099891
```

1.0.138 分组计算每一列的累乘

[1]:
```
# 导入基础计算库
import numpy as np
# 导入数据分析库
import pandas as pd
# 导入 matplotlib 包
import matplotlib as mpl
```

[2]:
```
# 设置随机数种子
np.random.seed(1)
# 生成数据
df = pd.DataFrame(
    {
        "A": ["foo", "bar", "foo", "bar", "foo", "bar", "foo", "foo"],
        "B": ["one", "one", "two", "three", "two", "two", "one", "three"],
        "C": np.random.randn(8),
        "D": np.random.randn(8),
    }
)
df
```

[2]:

```
     A      B         C         D
0  foo    one  1.624345  0.319039
1  bar    one -0.611756 -0.249370
2  foo    two -0.528172  1.462108
3  bar  three -1.072969 -2.060141
4  foo    two  0.865408 -0.322417
5  bar    two -2.301539 -0.384054
6  foo    one  1.744812  1.133769
7  foo  three -0.761207 -1.099891
```

[3]:

```
# 以 A 分组
grouped = df.groupby("A")
grouped[["C", "D"]].transform("cumprod")
```

[3]:

```
          C         D
0  1.624345  0.319039
1 -0.611756 -0.249370
2 -0.857933  0.466470
3  0.656395  0.513738
4 -0.742462 -0.150398
5 -1.510719 -0.197303
6 -1.295457 -0.170516
7  0.986110  0.187550
```

1.0.139 分组计算每一列的累积求和

[1]:

```
# 导入基础计算库
import numpy as np
# 导入数据分析库
import pandas as pd
# 导入 matplotlib 包
import matplotlib as mpl
```

[2]:

```
# 设置随机数种子
np.random.seed(1)
# 生成数据
df = pd.DataFrame(
    {
        "A": ["foo", "bar", "foo", "bar", "foo", "bar", "foo", "foo"],
        "B": ["one", "one", "two", "three", "two", "two", "one", "three"],
        "C": np.random.randn(8),
        "D": np.random.randn(8),
    }
)
df
```

[2]:
```
     A      B         C         D
0  foo    one  1.624345  0.319039
1  bar    one -0.611756 -0.249370
2  foo    two -0.528172  1.462108
3  bar  three -1.072969 -2.060141
4  foo    two  0.865408 -0.322417
5  bar    two -2.301539 -0.384054
6  foo    one  1.744812  1.133769
7  foo  three -0.761207 -1.099891
```

[3]:
```
# 以 A 分组
grouped = df.groupby("A")
grouped[["C", "D"]].transform("cumsum")
```

[3]:
```
          C         D
0  1.624345  0.319039
1 -0.611756 -0.249370
2  1.096174  1.781147
3 -1.684725 -2.309511
4  1.961581  1.458730
5 -3.986264 -2.693565
6  3.706393  2.592499
7  2.945186  1.492608
```

1.0.140 分组计算每一列的差分

[1]:
```
# 导入基础计算库
import numpy as np
# 导入数据分析库
import pandas as pd
# 导入 matplotlib 包
import matplotlib as mpl
```

[2]:
```
# 设置随机数种子
np.random.seed(1)
# 生成数据
df = pd.DataFrame(
    {
        "A": ["foo", "bar", "foo", "bar", "foo", "bar", "foo", "foo"],
        "B": ["one", "one", "two", "three", "two", "two", "one", "three"],
        "C": np.random.randn(8),
        "D": np.random.randn(8),
    }
)
df
```

[2]:
```
     A      B         C         D
0  foo    one  1.624345  0.319039
1  bar    one -0.611756 -0.249370
2  foo    two -0.528172  1.462108
3  bar  three -1.072969 -2.060141
4  foo    two  0.865408 -0.322417
5  bar    two -2.301539 -0.384054
6  foo    one  1.744812  1.133769
7  foo  three -0.761207 -1.099891
```

[3]:
```
# 以 A 分组
grouped = df.groupby("A")
grouped[["C", "D"]].transform("diff")
```

[3]:
```
          C         D
0       NaN       NaN
1       NaN       NaN
2 -2.152517  1.143069
3 -0.461212 -1.810770
4  1.393579 -1.784525
5 -1.228570  1.676086
6  0.879404  1.456187
7 -2.506019 -2.233661
```

1.0.141 移动求和

[1]:
```
import numpy as np
import pandas as pd
```

[2]:
```
times = ['2020-01-01', '2020-01-03', '2020-01-04', '2020-01-05', '2020-01-29']
# 生成一个时间序列
s = pd.Series(range(5), index=pd.DatetimeIndex(times))
s
```

[2]:
```
2020-01-01    0
2020-01-03    1
2020-01-04    2
2020-01-05    3
2020-01-29    4
dtype: int64
```

[3]:
```
# 移动两期，求和
s.rolling(window=2).sum()
```

[3]:
```
2020-01-01    NaN
2020-01-03    1.0
2020-01-04    3.0
2020-01-05    5.0
2020-01-29    7.0
dtype: float64
```

[4]:
```
# 移动两天，求和
s.rolling(window='2D').sum()
```

[4]:
```
2020-01-01    0.0
2020-01-03    1.0
2020-01-04    3.0
2020-01-05    5.0
2020-01-29    4.0
dtype: float64
```

1.0.142 移动平均，中心化

[1]:
```
import numpy as np
import pandas as pd
```

[2]:
```
times = ['2020-01-01', '2020-01-03', '2020-01-04', '2020-01-05', '2020-01-29']
# 生成一个时间序列
s = pd.Series(range(5), index=pd.DatetimeIndex(times))
s
```

[2]:
```
2020-01-01    0
2020-01-03    1
2020-01-04    2
2020-01-05    3
2020-01-29    4
dtype: int64
```

[3]:
```
s.rolling(window=5).mean()
```

[3]:
```
2020-01-01    NaN
2020-01-03    NaN
2020-01-04    NaN
2020-01-05    NaN
2020-01-29    2.0
dtype: float64
```

[4]:
```
s.rolling(window=5, center=True).mean()
```

```
[4]: 2020-01-01    NaN
     2020-01-03    NaN
     2020-01-04    2.0
     2020-01-05    NaN
     2020-01-29    NaN
     dtype: float64
```

1.0.143 生成时间戳和事件跨度

```
[1]: import numpy as np
     import pandas as pd
```

```
[2]: pd.Timestamp("2012-05-01")
```

```
[2]: Timestamp('2012-05-01 00:00:00')
```

```
[3]: pd.Timestamp(2012, 5, 1)
```

```
[3]: Timestamp('2012-05-01 00:00:00')
```

```
[4]: pd.Period("2011-01")
```

```
[4]: Period('2011-01', 'M')
```

```
[5]: pd.Period("2012-05", freq="D")
```

```
[5]: Period('2012-05-01', 'D')
```

1.0.144 生成一个时间序列

```
[1]: import numpy as np
     import pandas as pd
```

```
[2]: dates = [
         pd.Timestamp("2012-05-01"),
         pd.Timestamp("2012-05-02"),
         pd.Timestamp("2012-05-03"),
     ]
     # 创建时间序列
     ts = pd.Series(np.random.randn(3), dates)
```

```
[3]: # 这个时间序列的索引是 DatetimeIndex 类型
     type(ts.index)
```

```
[3]: pandas.core.indexes.datetimes.DatetimeIndex
```

```
[4]: ts.index
```

```
[4]: DatetimeIndex(['2012-05-01', '2012-05-02', '2012-05-03'],
     dtype='datetime64[ns]', freq=None)
```

```
[5]: ts
```

```
[5]: 2012-05-01    0.573656
     2012-05-02    1.003672
     2012-05-03    0.026830
     dtype: float64
```

```
[6]: # 创建一个时间跨度
     periods = [pd.Period("2012-01"), pd.Period("2012-02"), pd.Period("2012-03")]
     # 创建时间序列
     ts = pd.Series(np.random.randn(3), periods)
```

```
[7]: # 改时间序列的索引是 PeriodIndex 类型
     type(ts.index)
```

```
[7]: pandas.core.indexes.period.PeriodIndex
```

```
[8]: ts.index
```

```
[8]: PeriodIndex(['2012-01', '2012-02', '2012-03'], dtype='period[M]')
```

```
[9]: ts
```

```
[9]: 2012-01    0.124377
     2012-02    0.244281
     2012-03    1.218229
     Freq: M, dtype: float64
```

1.0.145 将字符串日期转为时间戳

```
[1]: import numpy as np
     import pandas as pd
```

```
[2]: pd.to_datetime(pd.Series(["Jul 31, 2009", "Jan 10, 2010", None]))
```

```
[2]: 0   2009-07-31
     1   2010-01-10
     2          NaT
     dtype: datetime64[ns]
```

```
[3]: pd.to_datetime(["2005/11/23", "2010/12/31"])
```

```
[3]: DatetimeIndex(['2005-11-23', '2010-12-31'], dtype='datetime64[ns]', freq=None)
```

```
[4]: pd.to_datetime("2010/11/12")
```

```
[4]: Timestamp('2010-11-12 00:00:00')
```

```
[5]: pd.Timestamp("2010/11/12")
```

```
[5]: Timestamp('2010-11-12 00:00:00')
```

```
[6]: pd.DatetimeIndex(["2018-01-01", "2018-01-03", "2018-01-05"])
```

```
[6]: DatetimeIndex(['2018-01-01', '2018-01-03', '2018-01-05'],
     dtype='datetime64[ns]', freq=None)
```

1.0.146 将字符串日期转为时间戳，指定格式

```
[1]: import numpy as np
     import pandas as pd
```

```
[2]: pd.to_datetime("2010/11/12", format="%Y/%m/%d")
```

```
[2]: Timestamp('2010-11-12 00:00:00')
```

```
[3]: pd.to_datetime("12-11-2010 00:00", format="%d-%m-%Y %H:%M")
```

```
[3]: Timestamp('2010-11-12 00:00:00')
```

```
[4]: df = pd.DataFrame(
         {"year": [2015, 2016], "month": [2, 3], "day": [4, 5], "hour": [2, 3]}
     )
     df
```

```
[4]:    year  month  day  hour
     0  2015      2    4     2
     1  2016      3    5     3
```

```
[5]: pd.to_datetime(df)
```

```
[5]: 0   2015-02-04 02:00:00
     1   2016-03-05 03:00:00
     dtype: datetime64[ns]
```

1.0.147 将秒数 (毫秒，纳秒，微秒) 转为时间戳

这些秒是从 origin 参数指定的时间计算的，默认是 1970 年 1 月 1 日零时

```
[1]: import numpy as np
     import pandas as pd
```

```
[2]: pd.to_datetime(
         [1349720105, 1349806505, 1349892905, 1349979305, 1350065705], unit="s" # 秒
     )
```

```
[2]: DatetimeIndex(['2012-10-08 18:15:05', '2012-10-09 18:15:05',
                    '2012-10-10 18:15:05', '2012-10-11 18:15:05',
                    '2012-10-12 18:15:05'],
                   dtype='datetime64[ns]', freq=None)
```

[3]:
```
pd.to_datetime(
    [1349720105100, 1349720105200, 1349720105300, 1349720105400, 1349720105500],
    unit="ms", # 毫秒
)
```

[3]:
```
DatetimeIndex(['2012-10-08 18:15:05.100000', '2012-10-08 18:15:05.200000',
               '2012-10-08 18:15:05.300000', '2012-10-08 18:15:05.400000',
               '2012-10-08 18:15:05.500000'],
              dtype='datetime64[ns]', freq=None)
```

[4]:
```
pd.Timestamp(1262347200000000000)
```

[4]:
```
Timestamp('2010-01-01 12:00:00')
```

[5]:
```
pd.DatetimeIndex([1262347200000000000])
```

[5]:
```
DatetimeIndex(['2010-01-01 12:00:00'], dtype='datetime64[ns]', freq=None)
```

[6]:
```
pd.to_datetime([1490195805.433, 1490195805.433502912], unit="s")
```

[6]:
```
DatetimeIndex(['2017-03-22 15:16:45.433000088', '2017-03-22
15:16:45.433502913'], dtype='datetime64[ns]', freq=None)
```

[7]:
```
pd.to_datetime(1490195805433502912, unit="ns")
```

[7]:
```
Timestamp('2017-03-22 15:16:45.433502912')
```

1.0.148 将时间戳转为秒数 (毫秒，纳秒，微秒)

这些秒是从 origin 参数指定的时间计算的，默认是 1970 年 1 月 1 日零时

[1]:
```
import numpy as np
import pandas as pd
```

[2]:
```
stamps = pd.date_range("2012-10-08 18:15:05", periods=4, freq="D")
stamps
```

[2]:
```
DatetimeIndex(['2012-10-08 18:15:05', '2012-10-09 18:15:05',
               '2012-10-10 18:15:05', '2012-10-11 18:15:05'],
              dtype='datetime64[ns]', freq='D')
```

[3]:
```
(stamps - pd.Timestamp("1970-01-01")) // pd.Timedelta("1s")
```

[3]:
```
Int64Index([1349720105, 1349806505, 1349892905, 1349979305], dtype='int64')
```

1.0.149 生成一个时间戳序列 (date_range)

[1]:
```
import numpy as np
import pandas as pd
```

[2]:
```
import datetime
start = datetime.datetime(2011, 1, 1)
end = datetime.datetime(2012, 1, 1)
index = pd.date_range(start, end)
index
```

[2]:
```
DatetimeIndex(['2011-01-01', '2011-01-02', '2011-01-03', '2011-01-04',
               '2011-01-05', '2011-01-06', '2011-01-07', '2011-01-08',
               '2011-01-09', '2011-01-10',
               …
               '2011-12-23', '2011-12-24', '2011-12-25', '2011-12-26',
               '2011-12-27', '2011-12-28', '2011-12-29', '2011-12-30',
               '2011-12-31', '2012-01-01'],
              dtype='datetime64[ns]', length=366, freq='D')
```

[3]:
```
# 工作日时间
index = pd.bdate_range(start, end)
index
```

[3]:
```
DatetimeIndex(['2011-01-03', '2011-01-04', '2011-01-05', '2011-01-06',
               '2011-01-07', '2011-01-10', '2011-01-11', '2011-01-12',
               '2011-01-13', '2011-01-14',
               …
               '2011-12-19', '2011-12-20', '2011-12-21', '2011-12-22',
               '2011-12-23', '2011-12-26', '2011-12-27', '2011-12-28',
               '2011-12-29', '2011-12-30'],
              dtype='datetime64[ns]', length=260, freq='B')
```

[4]:
```
# 月份为间隔
pd.date_range(start, periods=1000, freq="M")
```

[4]:
```
DatetimeIndex(['2011-01-31', '2011-02-28', '2011-03-31', '2011-04-30',
               '2011-05-31', '2011-06-30', '2011-07-31', '2011-08-31',
               '2011-09-30', '2011-10-31',
               …
               '2093-07-31', '2093-08-31', '2093-09-30', '2093-10-31',
               '2093-11-30', '2093-12-31', '2094-01-31', '2094-02-28',
               '2094-03-31', '2094-04-30'],
              dtype='datetime64[ns]', length=1000, freq='M')
```

[5]:
```
# 季节为间隔，工作日
pd.bdate_range(start, periods=250, freq="BQS")
```

```
[5]: DatetimeIndex(['2011-01-03', '2011-04-01', '2011-07-01', '2011-10-03',
                    '2012-01-02', '2012-04-02', '2012-07-02', '2012-10-01',
                    '2013-01-01', '2013-04-01',
                    …
                    '2071-01-01', '2071-04-01', '2071-07-01', '2071-10-01',
                    '2072-01-01', '2072-04-01', '2072-07-01', '2072-10-03',
                    '2073-01-02', '2073-04-03'],
                   dtype='datetime64[ns]', length=250, freq='BQS-JAN')
```

```
[6]: # 月份间隔
     pd.date_range(start, end, freq="BM")
```

```
[6]: DatetimeIndex(['2011-01-31', '2011-02-28', '2011-03-31', '2011-04-29',
                    '2011-05-31', '2011-06-30', '2011-07-29', '2011-08-31',
                    '2011-09-30', '2011-10-31', '2011-11-30', '2011-12-30'],
                   dtype='datetime64[ns]', freq='BM')
```

```
[7]: # 星期为间隔
     pd.date_range(start, end, freq="W")
```

```
[7]: DatetimeIndex(['2011-01-02', '2011-01-09', '2011-01-16', '2011-01-23',
                    '2011-01-30', '2011-02-06', '2011-02-13', '2011-02-20',
                    '2011-02-27', '2011-03-06', '2011-03-13', '2011-03-20',
                    '2011-03-27', '2011-04-03', '2011-04-10', '2011-04-17',
                    '2011-04-24', '2011-05-01', '2011-05-08', '2011-05-15',
                    '2011-05-22', '2011-05-29', '2011-06-05', '2011-06-12',
                    '2011-06-19', '2011-06-26', '2011-07-03', '2011-07-10',
                    '2011-07-17', '2011-07-24', '2011-07-31', '2011-08-07',
                    '2011-08-14', '2011-08-21', '2011-08-28', '2011-09-04',
                    '2011-09-11', '2011-09-18', '2011-09-25', '2011-10-02',
                    '2011-10-09', '2011-10-16', '2011-10-23', '2011-10-30',
                    '2011-11-06', '2011-11-13', '2011-11-20', '2011-11-27',
                    '2011-12-04', '2011-12-11', '2011-12-18', '2011-12-25',
                    '2012-01-01'],
                   dtype='datetime64[ns]', freq='W-SUN')
```

```
[8]: # 指定序列的长度，从结尾日期开始
     pd.bdate_range(end=end, periods=20)
```

```
[8]: DatetimeIndex(['2011-12-05', '2011-12-06', '2011-12-07', '2011-12-08',
                    '2011-12-09', '2011-12-12', '2011-12-13', '2011-12-14',
                    '2011-12-15', '2011-12-16', '2011-12-19', '2011-12-20',
                    '2011-12-21', '2011-12-22', '2011-12-23', '2011-12-26',
                    '2011-12-27', '2011-12-28', '2011-12-29', '2011-12-30'],
                   dtype='datetime64[ns]', freq='B')
```

[9]:
```
# 指定序列的长度，从开始日期开始
pd.bdate_range(start=start, periods=20)
```

[9]:
```
DatetimeIndex(['2011-01-03', '2011-01-04', '2011-01-05', '2011-01-06',
               '2011-01-07', '2011-01-10', '2011-01-11', '2011-01-12',
               '2011-01-13', '2011-01-14', '2011-01-17', '2011-01-18',
               '2011-01-19', '2011-01-20', '2011-01-21', '2011-01-24',
               '2011-01-25', '2011-01-26', '2011-01-27', '2011-01-28'],
              dtype='datetime64[ns]', freq='B')
```

[10]:
```
# 字符串日期指定起始
pd.date_range("2018-01-01", "2018-01-05", periods=5)
```

[10]:
```
DatetimeIndex(['2018-01-01', '2018-01-02', '2018-01-03', '2018-01-04',
               '2018-01-05'],
              dtype='datetime64[ns]', freq=None)
```

[11]:
```
pd.date_range("2018-01-01", "2018-01-05", periods=10)
```

[11]:
```
DatetimeIndex(['2018-01-01 00:00:00', '2018-01-01 10:40:00',
               '2018-01-01 21:20:00', '2018-01-02 08:00:00',
               '2018-01-02 18:40:00', '2018-01-03 05:20:00',
               '2018-01-03 16:00:00', '2018-01-04 02:40:00',
               '2018-01-04 13:20:00', '2018-01-05 00:00:00'],
              dtype='datetime64[ns]', freq=None)
```

1.0.150 按照时间索引提取元素

[1]:
```
import numpy as np
import pandas as pd
```

[2]:
```
start="2010-01-01"
end="2011-12-31"
rng = pd.date_range(start, end, freq="BM")
ts = pd.Series(np.random.randn(len(rng)), index=rng)
ts.index
```

[2]:
```
DatetimeIndex(['2010-01-29', '2010-02-26', '2010-03-31', '2010-04-30',
               '2010-05-31', '2010-06-30', '2010-07-30', '2010-08-31',
               '2010-09-30', '2010-10-29', '2010-11-30', '2010-12-31',
               '2011-01-31', '2011-02-28', '2011-03-31', '2011-04-29',
               '2011-05-31', '2011-06-30', '2011-07-29', '2011-08-31',
               '2011-09-30', '2011-10-31', '2011-11-30', '2011-12-30'],
              dtype='datetime64[ns]', freq='BM')
```

[3]:
```
# 以字符串索引
ts["1/31/2011"]
```

[3]:
```
-0.5482838196964798
```

[4]:
```
import datetime
ts[datetime.datetime(2011, 12, 25):]
```

[4]:
```
2011-12-30    0.615083
Freq: BM, dtype: float64
```

[5]:
```
# 日期字符串切片
ts["10/31/2011":"12/31/2011"]
```

[5]:
```
2011-10-31    0.094092
2011-11-30   -1.676836
2011-12-30    0.615083
Freq: BM, dtype: float64
```

[6]:
```
# 提取月份，2011 年的所有月份
ts["2011"]
```

[6]:
```
2011-01-31   -0.548284
2011-02-28   -1.238285
2011-03-31   -1.445370
2011-04-29   -1.405894
2011-05-31   -1.149388
2011-06-30    0.077598
2011-07-29   -1.874590
2011-08-31   -0.026948
2011-09-30   -0.110488
2011-10-31    0.094092
2011-11-30   -1.676836
2011-12-30    0.615083
Freq: BM, dtype: float64
```

[7]:
```
# 提取 6 月份的最后一天
ts["2011-6"]
```

[7]:
```
2011-06-30    0.077598
Freq: BM, dtype: float64
```

1.0.151 获取时间的年月日时分秒

[1]:
```
import numpy as np
import pandas as pd
```

[2]:
```
idx = pd.date_range(start="2019-12-29 12:13:14", freq="s", periods=4000000)
# 转为 Series 对象
idx = pd.Series(idx)
idx
```

[2]:
```
0          2019-12-29 12:13:14
1          2019-12-29 12:13:15
2          2019-12-29 12:13:16
3          2019-12-29 12:13:17
4          2019-12-29 12:13:18
                   …
3999995    2020-02-13 19:19:49
3999996    2020-02-13 19:19:50
3999997    2020-02-13 19:19:51
3999998    2020-02-13 19:19:52
3999999    2020-02-13 19:19:53
Length: 4000000, dtype: datetime64[ns]
```

[3]:
```
# 年份
idx.dt.year
```

[3]:
```
0           2019
1           2019
2           2019
3           2019
4           2019
            …
3999995     2020
3999996     2020
3999997     2020
3999998     2020
3999999     2020
Length: 4000000, dtype: int64
```

[4]:
```
# 月份
idx.dt.month
```

[4]:
```
0           12
1           12
2           12
3           12
4           12
            ..
3999995      2
3999996      2
3999997      2
3999998      2
3999999      2
Length: 4000000, dtype: int64
```

[5]:
```
# 日子
idx.dt.day
```

[5]:
```
0          29
1          29
2          29
3          29
4          29
           ..
3999995    13
3999996    13
3999997    13
3999998    13
3999999    13
Length: 4000000, dtype: int64
```

[6]:
```
# 小时
idx.dt.hour
```

[6]:
```
0          12
1          12
2          12
3          12
4          12
           ..
3999995    19
3999996    19
3999997    19
3999998    19
3999999    19
Length: 4000000, dtype: int64
```

[7]:
```
# 分钟
idx.dt.minute
```

[7]:
```
0          13
1          13
2          13
3          13
4          13
           ..
3999995    19
3999996    19
3999997    19
3999998    19
3999999    19
Length: 4000000, dtype: int64
```

[8]:
```
# 秒
idx.dt.second
```

[8]:
```
0          14
1          15
2          16
3          17
4          18
           ..
3999995    49
3999996    50
3999997    51
3999998    52
3999999    53
Length: 4000000, dtype: int64
```

[9]:
```
# 日期
idx.dt.date
```

[9]:
```
0          2019-12-29
1          2019-12-29
2          2019-12-29
3          2019-12-29
4          2019-12-29
              …
3999995    2020-02-13
3999996    2020-02-13
3999997    2020-02-13
3999998    2020-02-13
3999999    2020-02-13
Length: 4000000, dtype: object
```

[10]:
```
# 时间
idx.dt.time
```

[10]:
```
0          12:13:14
1          12:13:15
2          12:13:16
3          12:13:17
4          12:13:18
             …
3999995    19:19:49
3999996    19:19:50
3999997    19:19:51
3999998    19:19:52
3999999    19:19:53
Length: 4000000, dtype: object
```

2 强化技能

2.0.1 以 **openml** 中的数据集 **1StudentPerformance** 为例，新建一列 **id** 表示不同学生的编号，创建一个矩阵，矩阵的第 i 行第 j 列是第 i 个学生的数学成绩 **math score** 减去第 j 个学生的数学成绩的结果。使用 **for** 循环对 **dataframe** 的元素一个一个赋值，赋值方式使用 **loc** 和 **at**，对比时间消耗。为了节省时间，限制 $1 <= i, j <= 200$。

[1]:
```
# 导入数据集获取工具
from sklearn.datasets import fetch_openml
# 导入数据分析库
import pandas as pd
```

[2]:
```
# 获取数据
data = fetch_openml(
    data_id=43255,
    as_frame=True,
    parser="pandas"
)["frame"]
```

[3]:
```
# 查看数据集的前五行
data.head()
```

[3]:
```
   gender race/ethnicity parental level of education         lunch  \
0  female        group B           bachelor\'s degree      standard
1  female        group C                 some college      standard
2  female        group B             master\'s degree      standard
3    male        group A          associate\'s degree  free/reduced
4    male        group C                 some college      standard

  test preparation course  math score  reading score  writing score
0                    none          72             72             74
1               completed          69             90             88
2                    none          90             95             93
3                    none          47             57             44
4                    none          76             78             75
```

[4]:
```
# 新建 id 列
data["id"] = ["ID{}".format(i) for i in range(1, data.shape[0]+1)]
```

[5]:
```
%%timeit
# 新建一个 dataframe
resdf1 = pd.DataFrame(columns=data["id"], index=data["id"])
for i in range(1, 201):
    for j in range(1, 201):
        resdf1.at["ID{}".format(i), "ID{}".format(j)] = data.at[i-1, "math score"]␣
↪- data.at[j-1, "math score"]
```

```
2.66 s ± 95.1 ms per loop (mean ± std. dev. of 7 runs, 1 loop each)
```

[6]:
```
%%timeit
# 新建一个 dataframe
resdf2 = pd.DataFrame(columns=data["id"], index=data["id"])
for i in range(1, 201):
    for j in range(1, 201):
        resdf2.loc["ID{}".format(i), "ID{}".format(j)] = data.loc[i-1, "math␣
↪score"] - data.loc[j-1, "math score"]
```

```
6.97 s ± 270 ms per loop (mean ± std. dev. of 7 runs, 1 loop each)
```

2.0.2 计算 DataFrame 每一列的均值，对于 for 循环和 apply 方法

[1]:
```
# 导入数据分析库
import pandas as pd
# 导入基础计算库
import numpy as np
```

[2]:
```
# 行列数
row=20
col=10
np.random.seed(1)
df = pd.DataFrame(np.random.randn(row, col))
```

[3]:
```
%%timeit
df.apply("mean", axis=0)
```

```
792 µs ± 38.7 µs per loop (mean ± std. dev. of 7 runs, 1,000 loops each)
```

[4]:
```
%%timeit
# 存储结果的列表
lst = []
for i in range(df.shape[1]):
    lst.append(np.mean(df.iloc[:, i]))
```

```
2.78 ms ± 133 µs per loop (mean ± std. dev. of 7 runs, 100 loops each)
```

apply 方法完胜 for 循环。

2.0.3 计算 DataFrame 每一列的均值，对于 for 循环和 apply 方法，改变行数

[1]:
```
# 导入数据分析库
import pandas as pd
# 导入基础计算库
import numpy as np
```

[2]:
```
def generate_data(row, col):
    np.random.seed(1)
    df = pd.DataFrame(np.random.randn(row, col))
    return df
```

[3]:
```
df = generate_data(20, 10)
```

[4]:
```
%%timeit
df.apply("mean", axis=0)
```

```
757 µs ± 42 µs per loop (mean ± std. dev. of 7 runs, 1,000 loops each)
```

[5]:
```
%%timeit
# 存储结果的列表
lst = []
for i in range(df.shape[1]):
    lst.append(np.mean(df.iloc[:, i]))
```

```
2.84 ms ± 142 µs per loop (mean ± std. dev. of 7 runs, 100 loops each)
```

[6]:
```
df = generate_data(200, 10)
```

[7]:
```
%%timeit
df.apply("mean", axis=0)
```

```
803 µs ± 30.6 µs per loop (mean ± std. dev. of 7 runs, 1,000 loops each)
```

[8]:
```
%%timeit
# 存储结果的列表
lst = []
for i in range(df.shape[1]):
    lst.append(np.mean(df.iloc[:, i]))
```

```
2.74 ms ± 78.5 µs per loop (mean ± std. dev. of 7 runs, 100 loops each)
```

[9]:
```
df = generate_data(2000, 10)
```

[10]:
```
%%timeit
df.apply("mean", axis=0)
```

```
1.01 ms ± 45.3 µs per loop (mean ± std. dev. of 7 runs, 1,000 loops each)
```

[11]:
```
%%timeit
# 存储结果的列表
lst = []
```

```
for i in range(df.shape[1]):
    lst.append(np.mean(df.iloc[:, i]))
```

```
3 ms ± 333 µs per loop (mean ± std. dev. of 7 runs, 100 loops each)
```

[12]:
```
df = generate_data(20000, 10)
```

[13]:
```
%%timeit
df.apply("mean", axis=0)
```

```
3.69 ms ± 329 µs per loop (mean ± std. dev. of 7 runs, 100 loops each)
```

[14]:
```
%%timeit
# 存储结果的列表
lst = []
for i in range(df.shape[1]):
    lst.append(np.mean(df.iloc[:, i]))
```

```
4.74 ms ± 603 µs per loop (mean ± std. dev. of 7 runs, 100 loops each)
```

[15]:
```
df = generate_data(200000, 10)
```

[16]:
```
%%timeit
df.apply("mean", axis=0)
```

```
30.5 ms ± 818 µs per loop (mean ± std. dev. of 7 runs, 10 loops each)
```

[17]:
```
%%timeit
# 存储结果的列表
lst = []
for i in range(df.shape[1]):
    lst.append(np.mean(df.iloc[:, i]))
```

```
60.3 ms ± 915 µs per loop (mean ± std. dev. of 7 runs, 10 loops each)
```

apply 方法完胜 for 循环

2.0.4 计算 DataFrame 每一列的均值，对于 for 循环和 apply 方法，改变列数

[1]:
```
# 导入数据分析库
import pandas as pd
# 导入基础计算库
import numpy as np
```

[2]:
```
def generate_data(row, col):
    np.random.seed(1)
    df = pd.DataFrame(np.random.randn(row, col))
    return df
```

[3]:
```
df = generate_data(10, 20)
```

[4]:
```
%%timeit
df.apply("mean", axis=0)
```

```
720 µs ± 13.2 µs per loop (mean ± std. dev. of 7 runs, 1,000 loops each)
```

[5]:
```
%%timeit
# 存储结果的列表
lst = []
for i in range(df.shape[1]):
    lst.append(np.mean(df.iloc[:, i]))
```

```
5.38 ms ± 283 µs per loop (mean ± std. dev. of 7 runs, 100 loops each)
```

[6]:
```
df = generate_data(10, 200)
```

[7]:
```
%%timeit
df.apply("mean", axis=0)
```

```
768 µs ± 23 µs per loop (mean ± std. dev. of 7 runs, 1,000 loops each)
```

[8]:
```
%%timeit
# 存储结果的列表
lst = []
for i in range(df.shape[1]):
    lst.append(np.mean(df.iloc[:, i]))
```

```
52.3 ms ± 1.87 ms per loop (mean ± std. dev. of 7 runs, 10 loops each)
```

[9]:
```
df = generate_data(10, 2000)
```

[10]:
```
%%timeit
df.apply("mean", axis=0)
```

```
953 µs ± 25.3 µs per loop (mean ± std. dev. of 7 runs, 1,000 loops each)
```

[11]:
```
%%timeit
# 存储结果的列表
lst = []
```

```
for i in range(df.shape[1]):
    lst.append(np.mean(df.iloc[:, i]))
```

```
571 ms ± 33.3 ms per loop (mean ± std. dev. of 7 runs, 1 loop each)
```

[12]:
```
df = generate_data(10, 20000)
```

[13]:
```
%%timeit
df.apply("mean", axis=0)
```

```
3.45 ms ± 128 μs per loop (mean ± std. dev. of 7 runs, 100 loops each)
```

[14]:
```
%%timeit
# 存储结果的列表
lst = []
for i in range(df.shape[1]):
    lst.append(np.mean(df.iloc[:, i]))
```

```
5.23 s ± 93.1 ms per loop (mean ± std. dev. of 7 runs, 1 loop each)
```

[15]:
```
df = generate_data(10, 200000)
```

[16]:
```
%%timeit
df.apply("mean", axis=0)
```

```
41.1 ms ± 1.76 ms per loop (mean ± std. dev. of 7 runs, 10 loops each)
```

[17]:
```
%%timeit
# 存储结果的列表
lst = []
for i in range(df.shape[1]):
    lst.append(np.mean(df.iloc[:, i]))
```

```
56.5 s ± 2.74 s per loop (mean ± std. dev. of 7 runs, 1 loop each)
```

apply 方法完胜 for 循环

2.0.5 计算 DataFrame 每一行的均值，对于 for 循环和 apply 方法

[1]:
```
# 导入数据分析库
import pandas as pd
# 导入基础计算库
import numpy as np
```

[2]:
```
# 行列数
row=20
col=10
np.random.seed(1)
df = pd.DataFrame(np.random.randn(row, col))
```

[3]:
```
%%timeit
df.apply("mean", axis=1)
```

```
505 µs ± 34.3 µs per loop (mean ± std. dev. of 7 runs, 1,000 loops each)
```

[4]:
```
%%timeit
# 存储结果的列表
lst = []
for i in range(df.shape[0]):
    lst.append(np.mean(df.iloc[i, :]))
```

```
6.07 ms ± 609 µs per loop (mean ± std. dev. of 7 runs, 100 loops each)
```

apply 方法完胜 for 循环。

2.0.6 计算 DataFrame 每一行的均值，对于 for 循环和 apply 方法，改变行数

[1]:
```
# 导入数据分析库
import pandas as pd
# 导入基础计算库
import numpy as np
```

[2]:
```
def generate_data(row, col):
    np.random.seed(1)
    df = pd.DataFrame(np.random.randn(row, col))
    return df
```

[3]:
```
df = generate_data(20, 10)
```

[4]:
```
%%timeit
df.apply("mean", axis=1)
```

```
474 µs ± 21.4 µs per loop (mean ± std. dev. of 7 runs, 1,000 loops each)
```

[5]:
```
%%timeit
# 存储结果的列表
lst = []
for i in range(df.shape[0]):
    lst.append(np.mean(df.iloc[i, :]))
```

```
6.44 ms ± 538 µs per loop (mean ± std. dev. of 7 runs, 100 loops each)
```

```
[6]: df = generate_data(200, 10)
```

```
[7]: %%timeit
     df.apply("mean", axis=1)
```

```
493 µs ± 25.5 µs per loop (mean ± std. dev. of 7 runs, 1,000 loops each)
```

```
[8]: %%timeit
     # 存储结果的列表
     lst = []
     for i in range(df.shape[0]):
         lst.append(np.mean(df.iloc[i, :]))
```

```
61.4 ms ± 2.09 ms per loop (mean ± std. dev. of 7 runs, 10 loops each)
```

```
[9]: df = generate_data(2000, 10)
```

```
[10]: %%timeit
      df.apply("mean", axis=1)
```

```
756 µs ± 54.1 µs per loop (mean ± std. dev. of 7 runs, 1,000 loops each)
```

```
[11]: %%timeit
      # 存储结果的列表
      lst = []
      for i in range(df.shape[0]):
          lst.append(np.mean(df.iloc[i, :]))
```

```
616 ms ± 26.3 ms per loop (mean ± std. dev. of 7 runs, 1 loop each)
```

```
[12]: df = generate_data(20000, 10)
```

```
[13]: %%timeit
      df.apply("mean", axis=1)
```

```
3.2 ms ± 113 µs per loop (mean ± std. dev. of 7 runs, 100 loops each)
```

```
[14]: %%timeit
      # 存储结果的列表
      lst = []
      for i in range(df.shape[0]):
          lst.append(np.mean(df.iloc[i, :]))
```

```
6.24 s ± 226 ms per loop (mean ± std. dev. of 7 runs, 1 loop each)
```

```
[15]: df = generate_data(200000, 10)
```

```
[16]: %%timeit
df.apply("mean", axis=1)
```

```
33.1 ms ± 1.61 ms per loop (mean ± std. dev. of 7 runs, 10 loops each)
```

```
[17]: %%timeit
# 存储结果的列表
lst = []
for i in range(df.shape[0]):
    lst.append(np.mean(df.iloc[i, :]))
```

```
1min 4s ± 4.6 s per loop (mean ± std. dev. of 7 runs, 1 loop each)
```

apply 方法完胜 for 循环

2.0.7 计算 DataFrame 每一行的均值，对于 for 循环和 apply 方法，改变列数

```
[1]: # 导入数据分析库
import pandas as pd
# 导入基础计算库
import numpy as np
```

```
[2]: def generate_data(row, col):
    np.random.seed(1)
    df = pd.DataFrame(np.random.randn(row, col))
    return df
```

```
[3]: df = generate_data(10, 20)
```

```
[4]: %%timeit
df.apply("mean", axis=1)
```

```
471 µs ± 23.9 µs per loop (mean ± std. dev. of 7 runs, 1,000 loops each)
```

```
[5]: %%timeit
# 存储结果的列表
lst = []
for i in range(df.shape[0]):
    lst.append(np.mean(df.iloc[i, :]))
```

```
3.01 ms ± 160 µs per loop (mean ± std. dev. of 7 runs, 100 loops each)
```

```
[6]: df = generate_data(10, 200)
```

[7]:
```
%%timeit
df.apply("mean", axis=1)
```

```
475 µs ± 11.5 µs per loop (mean ± std. dev. of 7 runs, 1,000 loops each)
```

[8]:
```
%%timeit
# 存储结果的列表
lst = []
for i in range(df.shape[0]):
    lst.append(np.mean(df.iloc[i, :]))
```

```
3.29 ms ± 192 µs per loop (mean ± std. dev. of 7 runs, 100 loops each)
```

[9]:
```
df = generate_data(10, 2000)
```

[10]:
```
%%timeit
df.apply("mean", axis=1)
```

```
595 µs ± 45.3 µs per loop (mean ± std. dev. of 7 runs, 1,000 loops each)
```

[11]:
```
%%timeit
# 存储结果的列表
lst = []
for i in range(df.shape[0]):
    lst.append(np.mean(df.iloc[i, :]))
```

```
3.4 ms ± 323 µs per loop (mean ± std. dev. of 7 runs, 100 loops each)
```

[12]:
```
df = generate_data(10, 20000)
```

[13]:
```
%%timeit
df.apply("mean", axis=1)
```

```
2.01 ms ± 418 µs per loop (mean ± std. dev. of 7 runs, 100 loops each)
```

[14]:
```
%%timeit
# 存储结果的列表
lst = []
for i in range(df.shape[0]):
    lst.append(np.mean(df.iloc[i, :]))
```

```
4.13 ms ± 144 µs per loop (mean ± std. dev. of 7 runs, 100 loops each)
```

[15]:
```
df = generate_data(10, 200000)
```

[16]:
```
%%timeit
df.apply("mean", axis=1)
```

```
17.4 ms ± 558 µs per loop (mean ± std. dev. of 7 runs, 100 loops each)
```

[17]:
```
%%timeit
# 存储结果的列表
lst = []
for i in range(df.shape[0]):
    lst.append(np.mean(df.iloc[i, ]))
```

```
18.9 ms ± 1.84 ms per loop (mean ± std. dev. of 7 runs, 10 loops each)
```

apply 方法完胜 for 循环

2.0.8 计算 ndarray 每一列的均值，对于 for 循环和 apply 方法

[1]:
```
# 导入基础计算库
import numpy as np
```

[2]:
```
# 行列数
row=20
col=10
np.random.seed(1)
df = np.random.randn(row, col)
```

[3]:
```
%%timeit
np.apply_along_axis(np.mean, 0, df)
```

```
364 µs ± 6.64 µs per loop (mean ± std. dev. of 7 runs, 1,000 loops each)
```

[4]:
```
%%timeit
# 存储结果的列表
lst = []
for i in range(df.shape[1]):
    lst.append(np.mean(df[:, i]))
```

```
244 µs ± 27.6 µs per loop (mean ± std. dev. of 7 runs, 1,000 loops each)
```

for 循环完胜 apply 循环。

2.0.9 计算 ndarray 每一列的均值，对于 for 循环和 apply 方法，改变行数

[1]:
```
# 导入基础计算库
import numpy as np
```

[2]:
```
def generate_data(row, col):
    np.random.seed(1)
    df = np.random.randn(row, col)
    return df
```

[3]:
```
df = generate_data(20, 10)
```

[4]:
```
%%timeit
np.apply_along_axis(np.mean, 0, df)
```

```
388 µs ± 25.1 µs per loop (mean ± std. dev. of 7 runs, 1,000 loops each)
```

[5]:
```
%%timeit
# 存储结果的列表
lst = []
for i in range(df.shape[1]):
    lst.append(np.mean(df[:, i]))
```

```
253 µs ± 19.7 µs per loop (mean ± std. dev. of 7 runs, 1,000 loops each)
```

[6]:
```
df = generate_data(200, 10)
```

[7]:
```
%%timeit
np.apply_along_axis(np.mean, 0, df)
```

```
385 µs ± 11.1 µs per loop (mean ± std. dev. of 7 runs, 1,000 loops each)
```

[8]:
```
%%timeit
# 存储结果的列表
lst = []
for i in range(df.shape[1]):
    lst.append(np.mean(df[:, i]))
```

```
263 µs ± 12.7 µs per loop (mean ± std. dev. of 7 runs, 1,000 loops each)
```

[9]:
```
df = generate_data(2000, 10)
```

[10]:
```
%%timeit
np.apply_along_axis(np.mean, 0, df)
```

```
432 µs ± 10.4 µs per loop (mean ± std. dev. of 7 runs, 1,000 loops each)
```

[11]:
```
%%timeit
# 存储结果的列表
lst = []
```

```
for i in range(df.shape[1]):
    lst.append(np.mean(df[:, i]))
```

```
295 µs ± 10.6 µs per loop (mean ± std. dev. of 7 runs, 1,000 loops each)
```

```
[12]: df = generate_data(20000, 10)
```

```
[13]: %%timeit
np.apply_along_axis(np.mean, 0, df)
```

```
831 µs ± 23.7 µs per loop (mean ± std. dev. of 7 runs, 1,000 loops each)
```

```
[14]: %%timeit
# 存储结果的列表
lst = []
for i in range(df.shape[1]):
    lst.append(np.mean(df[:, i]))
```

```
672 µs ± 40.3 µs per loop (mean ± std. dev. of 7 runs, 1,000 loops each)
```

```
[15]: df = generate_data(200000, 10)
```

```
[16]: %%timeit
np.apply_along_axis(np.mean, 0, df)
```

```
26.4 ms ± 1.51 ms per loop (mean ± std. dev. of 7 runs, 10 loops each)
```

```
[17]: %%timeit
# 存储结果的列表
lst = []
for i in range(df.shape[1]):
    lst.append(np.mean(df[:, i]))
```

```
26.5 ms ± 1.07 ms per loop (mean ± std. dev. of 7 runs, 10 loops each)
```

for 循环完胜 apply 方法

2.0.10 计算 ndarray 每一列的均值，对于 for 循环和 apply 方法，改变列数

```
[1]: # 导入基础计算库
import numpy as np
```

```
[2]: def generate_data(row, col):
    np.random.seed(1)
    df = np.random.randn(row, col)
    return df
```

[3]:
```
df = generate_data(10, 20)
```

[4]:
```
%%timeit
np.apply_along_axis(np.mean, 0, df)
```

```
672 µs ± 35.7 µs per loop (mean ± std. dev. of 7 runs, 1,000 loops each)
```

[5]:
```
%%timeit
# 存储结果的列表
lst = []
for i in range(df.shape[1]):
    lst.append(np.mean(df[:, i]))
```

```
484 µs ± 26.9 µs per loop (mean ± std. dev. of 7 runs, 1,000 loops each)
```

[6]:
```
df = generate_data(10, 200)
```

[7]:
```
%%timeit
np.apply_along_axis(np.mean, 0, df)
```

```
6.09 ms ± 480 µs per loop (mean ± std. dev. of 7 runs, 100 loops each)
```

[8]:
```
%%timeit
# 存储结果的列表
lst = []
for i in range(df.shape[1]):
    lst.append(np.mean(df[:, i]))
```

```
4.86 ms ± 252 µs per loop (mean ± std. dev. of 7 runs, 100 loops each)
```

[9]:
```
df = generate_data(10, 2000)
```

[10]:
```
%%timeit
np.apply_along_axis(np.mean, 0, df)
```

```
58.3 ms ± 2.98 ms per loop (mean ± std. dev. of 7 runs, 10 loops each)
```

[11]:
```
%%timeit
# 存储结果的列表
lst = []
for i in range(df.shape[1]):
    lst.append(np.mean(df[:, i]))
```

```
46.2 ms ± 1.47 ms per loop (mean ± std. dev. of 7 runs, 10 loops each)
```

[12]:
```
df = generate_data(10, 20000)
```

[13]:
```
%%timeit
np.apply_along_axis(np.mean, 0, df)
```

```
581 ms ± 21.4 ms per loop (mean ± std. dev. of 7 runs, 1 loop each)
```

[14]:
```
%%timeit
# 存储结果的列表
lst = []
for i in range(df.shape[1]):
    lst.append(np.mean(df[:, i]))
```

```
486 ms ± 21.8 ms per loop (mean ± std. dev. of 7 runs, 1 loop each)
```

[15]:
```
df = generate_data(10, 200000)
```

[16]:
```
%%timeit
np.apply_along_axis(np.mean, 0, df)
```

```
5.7 s ± 154 ms per loop (mean ± std. dev. of 7 runs, 1 loop each)
```

[17]:
```
%%timeit
# 存储结果的列表
lst = []
for i in range(df.shape[1]):
    lst.append(np.mean(df[:, i]))
```

```
4.71 s ± 371 ms per loop (mean ± std. dev. of 7 runs, 1 loop each)
```

for 循环完胜 apply 方法

2.0.11 计算 ndarray 每一行的均值，对于 for 循环和 apply 方法

[1]:
```
# 导入基础计算库
import numpy as np
```

[2]:
```
# 行列数
row=20
col=10
np.random.seed(1)
df = np.random.randn(row, col)
```

[3]:
```
%%timeit
np.apply_along_axis(np.mean, 1, df)
```

```
668 µs ± 17.5 µs per loop (mean ± std. dev. of 7 runs, 1,000 loops each)
```

[4]:
```
%%timeit
# 存储结果的列表
lst = []
for i in range(df.shape[0]):
    lst.append(np.mean(df[i, :]))
```

```
461 µs ± 11 µs per loop (mean ± std. dev. of 7 runs, 1,000 loops each)
```

for 循环完胜 apply 方法

2.0.12 计算 ndarray 每一行的均值，对于 for 循环和 apply 方法，改变行数

[1]:
```
# 导入基础计算库
import numpy as np
```

[2]:
```
def generate_data(row, col):
    np.random.seed(1)
    df = np.random.randn(row, col)
    return df
```

[3]:
```
df = generate_data(20, 10)
```

[4]:
```
%%timeit
np.apply_along_axis(np.mean, 1, df)
```

```
742 µs ± 76.6 µs per loop (mean ± std. dev. of 7 runs, 1,000 loops each)
```

[5]:
```
%%timeit
# 存储结果的列表
lst = []
for i in range(df.shape[0]):
    lst.append(np.mean(df[i, :]))
```

```
485 µs ± 24.8 µs per loop (mean ± std. dev. of 7 runs, 1,000 loops each)
```

[6]:
```
df = generate_data(200, 10)
```

[7]:
```
%%timeit
np.apply_along_axis(np.mean, 1, df)
```

```
6.06 ms ± 313 µs per loop (mean ± std. dev. of 7 runs, 100 loops each)
```

[8]:
```
%%timeit
# 存储结果的列表
lst = []
for i in range(df.shape[0]):
    lst.append(np.mean(df[i, :]))
```

```
4.8 ms ± 345 µs per loop (mean ± std. dev. of 7 runs, 100 loops each)
```

[9]:
```
df = generate_data(2000, 10)
```

[10]:
```
%%timeit
np.apply_along_axis(np.mean, 1, df)
```

```
60.1 ms ± 2.6 ms per loop (mean ± std. dev. of 7 runs, 10 loops each)
```

[11]:
```
%%timeit
# 存储结果的列表
lst = []
for i in range(df.shape[0]):
    lst.append(np.mean(df[i, :]))
```

```
48.8 ms ± 3.11 ms per loop (mean ± std. dev. of 7 runs, 10 loops each)
```

[12]:
```
df = generate_data(20000, 10)
```

[13]:
```
%%timeit
np.apply_along_axis(np.mean, 1, df)
```

```
602 ms ± 18.4 ms per loop (mean ± std. dev. of 7 runs, 1 loop each)
```

[14]:
```
%%timeit
# 存储结果的列表
lst = []
for i in range(df.shape[0]):
    lst.append(np.mean(df[i, :]))
```

```
512 ms ± 50.3 ms per loop (mean ± std. dev. of 7 runs, 1 loop each)
```

[15]:
```
df = generate_data(200000, 10)
```

[16]:
```
%%timeit
np.apply_along_axis(np.mean, 1, df)
```

```
6.33 s ± 226 ms per loop (mean ± std. dev. of 7 runs, 1 loop each)
```

[17]:
```
%%timeit
# 存储结果的列表
lst = []
```

```
for i in range(df.shape[0]):
    lst.append(np.mean(df[i, :]))
```

```
4.96 s ± 299 ms per loop (mean ± std. dev. of 7 runs, 1 loop each)
```

for 循环完胜 apply 方法

2.0.13 计算 ndarray 每一行的均值，对于 for 循环和 apply 方法，改变列数

[1]:
```
# 导入基础计算库
import numpy as np
```

[2]:
```
def generate_data(row, col):
    np.random.seed(1)
    df = np.random.randn(row, col)
    return df
```

[3]:
```
df = generate_data(10, 20)
```

[4]:
```
%%timeit
np.apply_along_axis(np.mean, 1, df)
```

```
405 µs ± 21.5 µs per loop (mean ± std. dev. of 7 runs, 1,000 loops each)
```

[5]:
```
%%timeit
# 存储结果的列表
lst = []
for i in range(df.shape[0]):
    lst.append(np.mean(df[i, :]))
```

```
266 µs ± 6.46 µs per loop (mean ± std. dev. of 7 runs, 1,000 loops each)
```

[6]:
```
df = generate_data(10, 200)
```

[7]:
```
%%timeit
np.apply_along_axis(np.mean, 1, df)
```

```
389 µs ± 7.44 µs per loop (mean ± std. dev. of 7 runs, 1,000 loops each)
```

[8]:
```
%%timeit
# 存储结果的列表
lst = []
for i in range(df.shape[0]):
    lst.append(np.mean(df[i, :]))
```

```
263 µs ± 11.3 µs per loop (mean ± std. dev. of 7 runs, 1,000 loops each)
```

```
[9]: df = generate_data(10, 2000)
```

```
[10]: %%timeit
np.apply_along_axis(np.mean, 1, df)
```

```
416 µs ± 9.57 µs per loop (mean ± std. dev. of 7 runs, 1,000 loops each)
```

```
[11]: %%timeit
# 存储结果的列表
lst = []
for i in range(df.shape[0]):
    lst.append(np.mean(df[i, :]))
```

```
289 µs ± 8.98 µs per loop (mean ± std. dev. of 7 runs, 1,000 loops each)
```

```
[12]: df = generate_data(10, 20000)
```

```
[13]: %%timeit
np.apply_along_axis(np.mean, 1, df)
```

```
703 µs ± 98.5 µs per loop (mean ± std. dev. of 7 runs, 1,000 loops each)
```

```
[14]: %%timeit
# 存储结果的列表
lst = []
for i in range(df.shape[0]):
    lst.append(np.mean(df[i, :]))
```

```
608 µs ± 104 µs per loop (mean ± std. dev. of 7 runs, 1,000 loops each)
```

```
[15]: df = generate_data(10, 200000)
```

```
[16]: %%timeit
np.apply_along_axis(np.mean, 1, df)
```

```
8.08 ms ± 696 µs per loop (mean ± std. dev. of 7 runs, 100 loops each)
```

```
[17]: %%timeit
# 存储结果的列表
lst = []
for i in range(df.shape[0]):
    lst.append(np.mean(df[i, ]))
```

```
8.55 ms ± 819 µs per loop (mean ± std. dev. of 7 runs, 100 loops each)
```

for 循环完胜 apply 方法