机器学习作业二

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- 专业：信息安全

实验要求

题目：回归模型
实验简介：

- 回归是监督学习的一个重要问题，回归用于预测**输入变量**和**输出变量**之间的关系，特别是当输入变量的值发生变化时，输出变量的值也随之发生变化。
- 回归模型是一种表示从输入变量到输出变量之间映射的函数
- 对连续值的预测
- 可以用合适的曲线揭示样本点随着自变量的变化关系 实验要求：

1. 基本要求：
    - 将数据集winequality-white.csv按照4:1划分为训练集和测试集。
        A. 构造线性回归模型，并采用批量梯度下降和随机梯度下降进行优化；输出训练集和测试集的均方误差（MSE），画出MSE收敛曲线。
        B. 对于批量梯度下降和随机梯度下降，采用不同的学习率并进行MSE曲线展示，分析选择最佳的学习率。
    - 特别需要注意：
        - 划分数据集时尽可能保持数据分布的一致性，保持样本类别比例相似，可采用分层采样的方式。
        - 需要对数据集进行一定的预处理
2. 中级要求：
    - 探究回归模型在机器学习和统计学上的差异。
        - 回归模型在机器学习领域和统计学领域中都十分常用，而且使用方法也相似，但其实际的含义具有本质的区别。我们希望同学们从回归模型的角度更加充分地理解机器学习和统计学的区别。
3. 高级要求：
    - 编程实现岭回归算法，求解训练样本的岭回归模型，平均训练误差和平均测试误差（解析法、批量梯度下降法和随机梯度下降法均可）。

截止日期：10月21日

- 以.ipynb形式的文件提交，输出运行结果，并确保自己的代码能够正确运行
- 发送到邮箱：2120220594@mail.nankai.edu.cn

导入需要的包

In [1]:
```
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
import csv
```

```python
import operator
import random
# from sklearn.model_selection import train_test_split
```

导入数据集 semesion

In [2]:

```python
# 导入数据
# data数据尚未进行预处理
data = pd.read_csv("winequality-white.csv")
data
```

Out[2]:

	fixed acidity	volatile acidity	citric acid	residual sugar	chlorides	free sulfur dioxide	total sulfur dioxide	density	pH	sulphate
0	7.0	0.27	0.36	20.7	0.045	45.0	170.0	1.00100	3.00	0.4
1	6.3	0.30	0.34	1.6	0.049	14.0	132.0	0.99400	3.30	0.4
2	8.1	0.28	0.40	6.9	0.050	30.0	97.0	0.99510	3.26	0.4
3	7.2	0.23	0.32	8.5	0.058	47.0	186.0	0.99560	3.19	0.4
4	7.2	0.23	0.32	8.5	0.058	47.0	186.0	0.99560	3.19	0.4
...	...	...	...	...	...	...	...	...	...	.
4893	6.2	0.21	0.29	1.6	0.039	24.0	92.0	0.99114	3.27	0.5
4894	6.6	0.32	0.36	8.0	0.047	57.0	168.0	0.99490	3.15	0.4
4895	6.5	0.24	0.19	1.2	0.041	30.0	111.0	0.99254	2.99	0.4
4896	5.5	0.29	0.30	1.1	0.022	20.0	110.0	0.98869	3.34	0.3
4897	6.0	0.21	0.38	0.8	0.020	22.0	98.0	0.98941	3.26	0.3

4898 rows × 12 columns

In [3]:

```python
# 数据预处理
# 中心化代码
def Normalization_fun(x):
    # 特征零均值
    x = (x - np.mean(x, 0)) / (np.max(x, 0) - np.min(x, 0))
    return x

# 提取特征和标签
X = data.iloc[:, 0:-1]  # N D
X = Normalization_fun(X)
Y = data.iloc[:, -1]

# 测试X, Y
print(X)
print(Y)
```

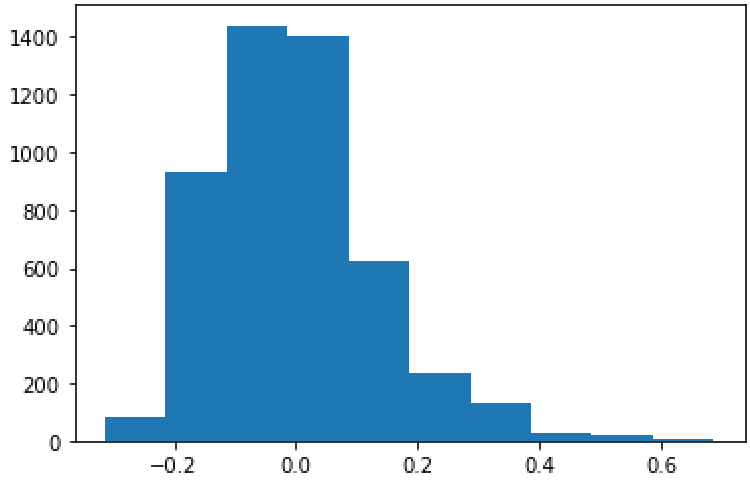
```
      fixed acidity  volatile acidity  citric acid  residual sugar  chloride
s  \
0          0.013963         -0.008080     0.015547        0.219457  -0.00229
2
1         -0.053345          0.021332     0.003499       -0.073488   0.00957
8
2          0.119732          0.001724     0.039644        0.007800   0.01254
5
3          0.033193         -0.047295    -0.008549        0.032340   0.03628
4
4          0.033193         -0.047295    -0.008549        0.032340   0.03628
4
...             ...               ...          ...             ...
...
4893      -0.062960         -0.066903    -0.026621       -0.073488  -0.02009
6
4894      -0.024499          0.040940     0.015547        0.024672   0.00364
3
4895      -0.034114         -0.037491    -0.086862       -0.079623  -0.01416
1
4896      -0.130268          0.011528    -0.020597       -0.081157  -0.07054
1
4897      -0.082191         -0.066903     0.027595       -0.085758  -0.07647
6

      free sulfur dioxide  total sulfur dioxide   density        pH  \
0                0.033770              0.073409  0.134425 -0.171151
1               -0.074244             -0.014758 -0.000528  0.101576
2               -0.018495             -0.095964  0.020679  0.065212
3                0.040738              0.110532  0.030319  0.001576
4                0.040738              0.110532  0.030319  0.001576
...                   ...                   ...       ...       ...
4893            -0.039401             -0.107565 -0.055666  0.074303
4894             0.075582              0.068769  0.016823 -0.034788
4895            -0.018495             -0.063482 -0.028675 -0.180242
4896            -0.053338             -0.065802 -0.102899  0.137939
4897            -0.046370             -0.093644 -0.089018  0.065212

      sulphates   alcohol
0     -0.046334 -0.276495
1      0.000178 -0.163591
2     -0.057961 -0.066817
3     -0.104473 -0.099075
4     -0.104473 -0.099075
...         ...       ...
4893   0.011806  0.110602
4894  -0.034706 -0.147462
4895  -0.034706 -0.179720
4896  -0.127729  0.368667
4897  -0.197496  0.207376

[4898 rows x 11 columns]
0       6
1       6
2       6
3       6
4       6
       ..
4893    6
4894    5
4895    6
4896    7
4897    6
Name: quality, Length: 4898, dtype: int64
```

In [4]:
```python
# 可视化中心化后的sulphates特征
import matplotlib.pyplot as plt
plt.hist(X["sulphates"])
plt.show()
```



In [5]:
```python
# 这里注意一个小trick：回归系数会比特征x多一维，为了向量相乘方便，可以在训练集X左侧添加全
# data0为处理好的所有列
data0 = pd.concat([pd.DataFrame(np.ones(X.shape[0]), columns=['x0']), X], ax
data0
```

Out[5]:

	x0	fixed acidity	volatile acidity	citric acid	residual sugar	chlorides	free sulfur dioxide	total sulfur dioxide
0	1.0	0.013963	-0.008080	0.015547	0.219457	-0.002292	0.033770	0.073409
1	1.0	-0.053345	0.021332	0.003499	-0.073488	0.009578	-0.074244	-0.014758
2	1.0	0.119732	0.001724	0.039644	0.007800	0.012545	-0.018495	-0.095964
3	1.0	0.033193	-0.047295	-0.008549	0.032340	0.036284	0.040738	0.110532
4	1.0	0.033193	-0.047295	-0.008549	0.032340	0.036284	0.040738	0.110532
...	...	...	...	...	...	...	...	...
4893	1.0	-0.062960	-0.066903	-0.026621	-0.073488	-0.020096	-0.039401	-0.107565
4894	1.0	-0.024499	0.040940	0.015547	0.024672	0.003643	0.075582	0.068769
4895	1.0	-0.034114	-0.037491	-0.086862	-0.079623	-0.014161	-0.018495	-0.063482
4896	1.0	-0.130268	0.011528	-0.020597	-0.081157	-0.070541	-0.053338	-0.065802
4897	1.0	-0.082191	-0.066903	0.027595	-0.085758	-0.076476	-0.046370	-0.093644

4898 rows × 12 columns

In [6]:
```python
Y
```

Out[6]:
```
0       6
1       6
2       6
3       6
4       6
       ..
4893    6
4894    5
4895    6
4896    7
4897    6
Name: quality, Length: 4898, dtype: int64
```

In [7]:
```
# 初始化回归系数
W_init = np.random.randn(data0.shape[1], 1)
W_init
```

Out[7]:
```
array([[-0.70858867],
       [ 0.18540214],
       [-1.33055154],
       [-0.23544762],
       [-1.2120648 ],
       [ 0.55358831],
       [-0.98558146],
       [ 0.17636054],
       [ 1.11635067],
       [ 0.15061614],
       [-1.05368274],
       [ 0.3275769 ]])
```

In [8]:
```
## TODO: 批量梯度下降
## TODO: 随机梯度下降
## TODO: 回归模型在机器学习和统计学上的差异
## TODO: 岭回归
```

In [9]:
```
# 测试内容
print(data0['x0'])
print(data0['x0'][1])
```

```
0       1.0
1       1.0
2       1.0
3       1.0
4       1.0
       ...
4893    1.0
4894    1.0
4895    1.0
4896    1.0
4897    1.0
Name: x0, Length: 4898, dtype: float64
1.0
```

In [10]:
```
# 测试内容
print(data0['x0'][4])

print(W_init[1])
```

```
1.0
[0.18540214]
```

基本要求

将数据集winequality-white.csv按照4:1划分为训练集和测试集。

1. 构造线性回归模型，并采用批量梯度下降和随机梯度下降进行优化；输出训练集和测试集的均方误差（MSE），画出MSE收敛曲线。
2. 对于批量梯度下降和随机梯度下降，采用不同的学习率并进行MSE曲线展示，分析选择最佳的学习率。

特别需要注意：

- 划分数据集时尽可能保持数据分布的一致性，保持样本类别比例相似，可采用分层采样的方式。
- 需要对数据集进行一定的预处理

批量梯度下降第一步：先按4:1划分训练集和测试集

In [11]:
```
# 4:1划分训练集和测试集，这个操作对我是真的难！！！
# x_train, x_test, y_train, y_test = train_test_split(dataset, y, test_size
gbr = data.groupby('quality')  # 用分组函数groupby()进行数据的分组，分组依据为'TYF
gbr.groups     # 获取分组后gbr的数据
```

Out[11]:
```
{3: [251, 253, 294, 445, 740, 873, 1034, 1229, 1417, 1484, 1688, 1931, 2050,
2373, 3087, 3265, 3307, 3409, 3810, 4745], 4: [46, 98, 115, 147, 172, 176, 1
78, 189, 204, 207, 230, 250, 259, 278, 282, 433, 496, 499, 526, 540, 626, 64
1, 646, 659, 662, 687, 690, 702, 780, 831, 905, 906, 908, 914, 948, 991, 99
3, 1027, 1029, 1040, 1042, 1053, 1059, 1109, 1114, 1152, 1154, 1155, 1245, 1
293, 1294, 1349, 1363, 1405, 1420, 1423, 1430, 1474, 1483, 1541, 1558, 1559,
1574, 1577, 1579, 1649, 1652, 1664, 1690, 1702, 1708, 1718, 1739, 1781, 181
7, 1856, 1924, 1951, 1990, 2079, 2116, 2119, 2154, 2156, 2159, 2225, 2237, 2
246, 2275, 2318, 2337, 2346, 2372, 2379, 2380, 2386, 2387, 2388, 2400, 2401,
...], 5: [10, 11, 12, 14, 19, 23, 34, 35, 36, 38, 39, 47, 49, 62, 65, 67, 6
9, 71, 72, 75, 78, 79, 82, 84, 88, 91, 100, 101, 102, 103, 104, 106, 109, 11
1, 112, 113, 114, 118, 119, 120, 121, 122, 126, 130, 132, 133, 134, 135, 13
7, 140, 141, 153, 161, 162, 164, 165, 168, 169, 174, 177, 181, 182, 184, 18
5, 187, 191, 193, 194, 196, 197, 198, 199, 200, 201, 202, 205, 206, 208, 21
0, 212, 215, 216, 217, 218, 219, 220, 225, 229, 240, 241, 244, 249, 252, 26
1, 262, 265, 267, 271, 272, 273, ...], 6: [0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 16,
18, 24, 25, 26, 27, 28, 30, 31, 32, 33, 37, 40, 41, 42, 43, 44, 48, 50, 53,
54, 55, 56, 57, 58, 59, 60, 61, 63, 64, 70, 73, 80, 81, 83, 85, 86, 87, 89,
90, 95, 96, 99, 105, 107, 108, 110, 116, 117, 123, 124, 125, 129, 136, 139,
142, 143, 144, 145, 146, 149, 151, 152, 154, 155, 156, 163, 166, 170, 171, 1
75, 179, 180, 183, 186, 190, 192, 195, 203, 209, 213, 221, 223, 224, 226, 22
7, 228, 231, 232, 233, ...], 7: [13, 15, 21, 29, 45, 51, 52, 66, 76, 77, 92,
93, 94, 97, 127, 128, 131, 138, 148, 150, 157, 160, 167, 173, 211, 214, 222,
238, 242, 246, 247, 248, 256, 257, 279, 287, 288, 289, 290, 293, 297, 308, 3
10, 318, 320, 339, 340, 346, 350, 351, 353, 364, 365, 374, 375, 376, 377, 37
9, 380, 384, 385, 386, 389, 390, 406, 420, 424, 432, 435, 438, 440, 449, 45
2, 453, 454, 456, 473, 476, 491, 507, 509, 514, 548, 550, 551, 552, 553, 55
4, 555, 560, 563, 571, 573, 574, 577, 578, 579, 584, 587, 588, ...], 8: [17,
20, 22, 68, 74, 158, 159, 188, 255, 280, 281, 311, 330, 434, 437, 442, 598,
610, 625, 672, 723, 779, 783, 799, 832, 835, 836, 837, 838, 844, 845, 860, 8
67, 879, 904, 907, 924, 1022, 1086, 1087, 1095, 1106, 1115, 1136, 1137, 118
7, 1216, 1218, 1219, 1266, 1283, 1306, 1333, 1336, 1344, 1345, 1348, 1358, 1
402, 1403, 1406, 1412, 1464, 1493, 1494, 1504, 1619, 1632, 1665, 1715, 1723,
1778, 1779, 1797, 1980, 1981, 1982, 1983, 1984, 1991, 2298, 2333, 2342, 238
2, 2384, 2389, 2390, 2522, 2525, 2663, 2748, 2750, 2753, 2774, 2775, 2776, 2
795, 2803, 2804, 2857, ...], 9: [774, 820, 827, 876, 1605]}
```

In [12]:
```
# 划分各组长度，并将其存入数组
print(len(gbr.groups[3]))
print(len(gbr.groups))
print('-------------------------------------------------------')
for i in range(3, 10):
```

```python
    print(i)
print('-----------------------------------------------------')

x = 0
every_len = []

for i in range(3, 10):
    x += len(gbr.groups[i])
    every_len.append(len(gbr.groups[i]))
    print(len(gbr.groups[i]))

print('-----------------------------------------------------')

print(x)
print(every_len)
```

```
20
7
-----------------------------------------------------
3
4
5
6
7
8
9
-----------------------------------------------------
20
163
1457
2198
880
175
5
-----------------------------------------------------
4898
[20, 163, 1457, 2198, 880, 175, 5]
```

In [13]:

```python
train_rate = 0.8     # 所有数据中80%作为训练数据集，20%作为测试数据集
num_tup = np.array(every_len)    # 全部数据中7种酒的质量的元组数
num_train_tup = np.array([(int)(round(i*train_rate)) for i in num_tup])    #
num_test_tup = num_tup - num_train_tup
print(num_train_tup)
print(num_test_tup)
```

```
[  16  130 1166 1758  704  140    4]
[   4   33  291  440  176   35    1]
```

In [14]:

```python
# 定义分层抽样的字典，格式为：组名：数据个数
typicalNDict_train = {3: num_train_tup[0], 4: num_train_tup[1], 5: num_train
                      7: num_train_tup[4], 8: num_train_tup[5], 9: num_train
typicalNDict_test = {3: num_test_tup[0], 4: num_test_tup[1], 5: num_test_tup
                      7: num_test_tup[4], 8: num_test_tup[5], 9: num_test_tu
print(typicalNDict_train)
print(typicalNDict_test)
```

```
{3: 16, 4: 130, 5: 1166, 6: 1758, 7: 704, 8: 140, 9: 4}
{3: 4, 4: 33, 5: 291, 6: 440, 7: 176, 8: 35, 9: 1}
```

In [15]:

```python
# 测试随机生成数
resultList = random.sample(range(0,20), 16)
print(resultList)
```

```
[13, 14, 12, 6, 9, 11, 3, 2, 7, 10, 15, 17, 19, 18, 16, 1]
```

In [16]:
```
# 开始生成训练集和测试集的前面序号的list
train_list = []
test_list = []

for i in range(3, 10):
    mid_list = random.sample(range(0, len(gbr.groups[i])), typicalNDict_trai
    # mid_list = random.sample(range(0, len(gbr.groups[i]), typicalNDict_tra

    for j in range(0, len(gbr.groups[i])):
        if j in mid_list:
            train_list.append(gbr.groups[i][j])
        else:
            test_list.append(gbr.groups[i][j])

# print(train_list)
# print(test_list)
print('-----------------------------------------------------')
print(len(train_list))
print(len(test_list))
print('-----------------------------------------------------')
# train_list.sort()
# print(train_list)
# test_list.sort()
# print(test_list)
```

```
-----------------------------------------------------
3918
980
-----------------------------------------------------
```

In [17]:
```
# 测试iloc,发现逗号前面的数据即为所有的行，而后面的数据即为所有的列，nice!
test_z = X.iloc[[0,1],:]
print(test_z)
```

```
   fixed acidity  volatile acidity  citric acid  residual sugar  chlorides  \
0       0.013963         -0.008080     0.015547        0.219457  -0.002292
1      -0.053345          0.021332     0.003499       -0.073488   0.009578

   free sulfur dioxide  total sulfur dioxide   density        pH  sulphates  \
0             0.033770              0.073409  0.134425 -0.171151  -0.046334
1            -0.074244             -0.014758 -0.000528  0.101576   0.000178

    alcohol
0 -0.276495
1 -0.163591
```

In [18]:
```
# 开始分层抽样实现生成测试集80%和训练集20%，助教学长这里要给我加分呀，分层做了2天
x_train = data0.iloc[train_list, :]
x_test = data0.iloc[test_list, :]
print(x_train)
print('---------------------------------------------------------------------
print(x_test)
print('---------------------------------------------------------------------
y_train = Y.iloc[train_list]
y_test = Y.iloc[test_list]
print(y_train)
print('---------------------------------------------------------------------
print(y_test)
```

```
       x0  fixed acidity  volatile acidity  citric acid  residual sugar  \
251   1.0       0.158193         -0.017883    -0.074814        0.150438
253   1.0      -0.101422         -0.037491     0.063740       -0.044347
294   1.0       0.215886          0.305646     0.027595       -0.073488
445   1.0       0.023578          0.040940    -0.008549        0.070684
740   1.0       0.004347          0.109568     0.039644       -0.027476
...   ...            ...               ...          ...             ...
4802  1.0      -0.101422          0.001724     0.003499       -0.064286
774   1.0       0.215886         -0.008080     0.069764        0.064549
820   1.0      -0.024499          0.080156    -0.026621       -0.073488
827   1.0       0.052424         -0.037491     0.015547       -0.067353
1605  1.0       0.023578         -0.017883     0.093861       -0.064286

      chlorides  free sulfur dioxide  total sulfur dioxide   density  \
251    0.083762             0.019832              0.136054  0.076588
253   -0.049770            -0.105603             -0.068122 -0.052581
294    0.060023            -0.004558              0.101251  0.053453
445   -0.023063            -0.067276             -0.167890 -0.006311
740   -0.070541            -0.105603             -0.276939 -0.048725
...         ...                  ...                   ...       ...
4802  -0.026031            -0.039401             -0.030999 -0.080343
774   -0.031965            -0.025464             -0.033319  0.057309
820   -0.073508            -0.039401             -0.123807 -0.084391
827   -0.043835            -0.028948              0.001483 -0.067040
1605  -0.040868            -0.015011             -0.058841 -0.071860

            pH  sulphates   alcohol
251  -0.152970   0.011806 -0.115204
253   0.310667  -0.069589  0.191247
294   0.037939  -0.127729 -0.324882
445   0.047030  -0.104473  0.158989
740   0.110667  -0.139357  0.336409
...        ...        ...       ...
4802  0.156121  -0.185868  0.368667
774   0.010667  -0.034706 -0.018430
820   0.201576   0.139713  0.304150
827   0.083394  -0.011450  0.320280
1605  0.165212  -0.081217  0.384796

[3918 rows x 12 columns]
----------------------------------------------------------------------------
--------------------
       x0  fixed acidity  volatile acidity  citric acid  residual sugar  \
1417  1.0       0.167809          0.266430     0.009523        0.140469
1688  1.0      -0.014883         -0.027687    -0.044694       -0.074255
2373  1.0       0.071655          0.197803     0.021571       -0.079623
4745  1.0      -0.072576         -0.017883    -0.050718       -0.053549
204   1.0      -0.101422          0.001724     0.009523       -0.062752
...   ...            ...               ...          ...             ...
4195  1.0       0.023578          0.168391    -0.056742       -0.056617
4335  1.0       0.042809         -0.086511    -0.038670        0.115162
4340  1.0       0.042809         -0.086511    -0.038670        0.115162
4766  1.0      -0.043730          0.040940    -0.050718       -0.021341
876   1.0       0.004347          0.080156     0.003499       -0.033611

      chlorides  free sulfur dioxide  total sulfur dioxide   density  \
1417   0.033316             0.000669              0.529326  0.117074
1688  -0.014161             0.289867              0.180138  0.016823
2373  -0.034933            -0.105603             -0.188772 -0.028290
4745   0.003643             0.883944              0.699859 -0.017108
204    0.021447             0.002411             -0.056521 -0.031374
...         ...                  ...                   ...       ...
4195  -0.017129            -0.039401             -0.119166 -0.104249
4335   0.033316             0.033770              0.038606  0.077938
```

```
4340   0.033316            0.033770             0.038606  0.077938
4766   0.027382           -0.025464            -0.000837 -0.044677
876   -0.082411            0.075582            -0.044920 -0.081499

            pH  sulphates   alcohol
1417 -0.134788   0.162969  0.078344
1688  0.328849   0.162969 -0.179720
2373 -0.125697   0.058318 -0.018430
4745  0.228849   0.174597 -0.002301
204   0.083394   0.011806 -0.050688
...        ...        ...       ...
4195 -0.225697  -0.127729  0.465441
4335 -0.225697  -0.092845 -0.276495
4340 -0.225697  -0.092845 -0.276495
4766  0.074303   0.011806  0.304150
876   0.083394  -0.150985  0.352538

[980 rows x 12 columns]
----------------------------------------------------------------------------
--------------------
251     3
253     3
294     3
445     3
740     3
       ..
4802    8
774     9
820     9
827     9
1605    9
Name: quality, Length: 3918, dtype: int64
----------------------------------------------------------------------------
--------------------
1417    3
1688    3
2373    3
4745    3
204     4
       ..
4195    8
4335    8
4340    8
4766    8
876     9
Name: quality, Length: 980, dtype: int64
```

In [19]:
```
# # 函数定义
# def typicalsamling(group, typicalNDict):
#     name = group.name
#     n = typicalNDict[name]
#     return group.sample(n=n)
```

In [20]:
```
# # 返回值：抽样后的训练数据框,此处抽取的是按照分层抽样的方法，抽取的80%的训练数据
# result_train = data.groupby('quality').apply(typicalsamling, typicalNDict_
# # print(result_train.head())
# print(result_train)
# # result_train.to_csv('csv_data/sample_train.csv', index=False)
```

In [21]:
```
print('x_train\'s length is:')
print(len(x_train))

print('x_test\'s length is:')
```

```
print(len(x_test))

print('y_train\'s length is:')
print(len(y_train))

print('y_test\'s length is:')
print(len(y_test))
```

```
x_train's length is:
3918
x_test's length is:
980
y_train's length is:
3918
y_test's length is:
980
```

分层按4:1划分完数据集后开始进行批量梯度下降

In [22]:
```
y_test = np.array(y_test)
print(y_test[0])
x_test = np.array(x_test)
print(x_test[0])
y_train = np.array(y_train)
print(y_train[0])
x_train = np.array(x_train)
print(x_train[0])
```

```
3
[ 1.00000000e+00  1.67808878e-01  2.66430276e-01  9.52318871e-03
  1.40469097e-01  3.33164508e-02  6.68693615e-04  5.29325621e-01
  1.17073906e-01 -1.34787854e-01  1.62968749e-01  7.83440246e-02]
3
[ 1.          0.15819349 -0.01788345 -0.07481416  0.15043842  0.08376155
  0.01983246  0.13605416  0.07658808 -0.15296967  0.01180596 -0.11520436]
```

In [23]:
```
# 由于在之前已经归一化过，这里就不用再进行归一化的实现
def compute_cost(x_test, y_test, theta): #这个function是计算loss function的值,
    m = y_test.size
    cost = 0
    t = theta.size
    for i in range(0,m):
        # x = x_test[i,1]
        # y = y_test[i]


        f = 0
        for j in range(t):
            f += theta[j] * x_test[i][j]

        cost += (y_test[i] - f) ** 2
    cost = cost / (2 * float(m))
    return cost
# 接下来的函数是计算并返回结果的函数
def gradient_descent(x_train, y_train, x_test, y_test, learning_rate, theta,
    m = y_train.size
    train_history = np.zeros(num_iters)
    test_history = np.zeros(num_iters)
    t = theta.size
    # x_train = np.array(x_train)
    # x_test = np.array(x_test)
    for i in range(num_iters):
        # 初始化h_theta_x
        h_theta_x = []
```

```python
        for k in range(m):
            mid = 0
            for j in range(t):
                mid += theta[j] * x_train[k][j]
            h_theta_x.append(mid)


        for j in range(t):   # BGD的特点就是每次迭代都使用所有的样本
            # 由于实在不想调这个现有的矩阵乘的格式，于是手写矩阵乘
            sum_result = 0
            for k in range(m):
                sum_result += (h_theta_x[k] - y_train[k]) * x_train[k][j]
            theta[j] = theta[j] - learning_rate * sum_result / m
        train_history[i] = compute_cost(x_train, y_train, theta)
        test_history[i] = compute_cost(x_test, y_test, theta)
    return theta, train_history, test_history
```

In [24]:

```python
# 初始化回归系数
W_init = np.random.randn(data0.shape[1], 1)

iteration = 100 # 迭代的轮数
# print('start test which learning rate is 0.5')
# theta0, loss0_train, loss0_test = gradient_descent(x_train, y_train, x_tra
# print(theta0)
# print(loss0_train)
# print(loss0_test)
# print('----------------------------------------------------------------------
print('start test which learning rate is 0.5')
theta1, loss1_train, loss1_test = gradient_descent(x_train, y_train, x_test,
print(theta1)
print(loss1_train)
print(loss1_test)
print('-----------------------------------------------------------------------
print('start test which learning rate is 0.3')
theta2, loss2_train, loss2_test = gradient_descent(x_train, y_train, x_test,
print(theta2)
print(loss2_train)
print(loss2_test)
print('-----------------------------------------------------------------------
print('start test which learning rate is 0.1')
theta3, loss3_train, loss3_test = gradient_descent(x_train, y_train, x_test,
print(theta3)
print(loss3_train)
print(loss3_test)
print('-----------------------------------------------------------------------
print('start test which learning rate is 0.01')
theta4, loss4_train, loss4_test = gradient_descent(x_train, y_train, x_test,
print(theta4)
print(loss4_train)
print(loss4_test)
print('-----------------------------------------------------------------------
print('start test which learning rate is 0.001')
theta5, loss5_train, loss5_test = gradient_descent(x_train, y_train, x_test,
print(theta5)
print(loss5_train)
print(loss5_test)
```

```
start test which learning rate is 0.5
[[ 5.87899257]
 [ 0.27784755]
 [-1.20378095]
 [-0.39291096]
 [-0.82916594]
 [-0.33309062]
 [ 0.19790298]
 [-0.25041193]
 [ 0.38958137]
 [-0.66108212]
 [-0.0131551 ]
 [ 1.73978261]]
[3.67568128 1.2500738  0.64097278 0.48607955 0.444818   0.43204156
 0.42646085 0.42275084 0.41957767 0.41660539 0.41374761 0.41098042
 0.40829566 0.40568917 0.40315786 0.40069903 0.39831013 0.39598871
 0.39373244 0.39153909 0.3894065  0.3873326  0.38531541 0.38335301
 0.38144358 0.37958534 0.37777661 0.37601574 0.37430118 0.37263141
 0.37100498 0.3694205  0.36787662 0.36637205 0.36490554 0.36347589
 0.36208196 0.36072262 0.3593968  0.35810348 0.35684165 0.35561036
 0.35440869 0.35323574 0.35209065 0.3509726  0.34988078 0.34881442
 0.34777278 0.34675513 0.34576079 0.34478909 0.34383937 0.34291102
 0.34200342 0.34111599 0.34024818 0.33939943 0.33856922 0.33775704
 0.33696239 0.3361848  0.33542381 0.33467897 0.33394985 0.33323602
 0.3325371  0.33185268 0.33118238 0.33052584 0.3298827  0.32925262
 0.32863525 0.32803028 0.3274374  0.32685629 0.32628666 0.32572822
 0.3251807  0.32464382 0.32411733 0.32360097 0.32309449 0.32259765
 0.32211023 0.32163198 0.32116271 0.32070218 0.32025019 0.31980655
 0.31937106 0.31894352 0.31852375 0.31811157 0.31770681 0.3173093
 0.31691887 0.31653535 0.3161586  0.31578846]
[3.65965454 1.23924114 0.63290757 0.47955394 0.43920616 0.42702191
 0.4218661  0.41849208 0.4156059  0.41289198 0.41027441 0.40773472
 0.40526765 0.40287061 0.40054147 0.39827811 0.39607837 0.39394016
 0.3918614  0.38984008 0.38787428 0.38596214 0.38410185 0.3822917
 0.38053002 0.37881523 0.37714579 0.37552023 0.37393712 0.37239511
 0.37089288 0.36942916 0.36800275 0.36661246 0.36525719 0.36393582
 0.36264734 0.36139071 0.36016498 0.35896921 0.35780249 0.35666396
 0.35555278 0.35446813 0.35340925 0.35237536 0.35136576 0.35037973
 0.34941661 0.34847572 0.34755646 0.34665819 0.34578034 0.34492233
 0.34408362 0.34326367 0.34246196 0.341678   0.34091131 0.34016141
 0.33942787 0.33871024 0.3380081  0.33732104 0.33664866 0.33599059
 0.33534645 0.33471587 0.33409852 0.33349405 0.33290213 0.33232244
 0.33175469 0.33119856 0.33065377 0.33012004 0.32959709 0.32908465
 0.32858248 0.32809031 0.32760792 0.32713505 0.32667148 0.326217
 0.32577137 0.3253344  0.32490588 0.3244856  0.32407339 0.32366904
 0.32327237 0.32288321 0.32250139 0.32212673 0.32175908 0.32139827
 0.32104414 0.32069656 0.32035536 0.32002041]
-----------------------------------------------------------------------------
---------
start test which learning rate is 0.3
[[ 5.87896612]
 [ 0.06790411]
 [-1.40438277]
 [-0.35161414]
 [-0.57981402]
 [-0.38996113]
 [ 0.39704306]
 [-0.10739781]
 [ 0.44915735]
 [-0.2948843 ]
 [ 0.19698832]
 [ 1.88496048]]
[0.31556987 0.31535356 0.31513951 0.31492768 0.31471804 0.31451058
 0.31430524 0.31410202 0.31390087 0.31370178 0.31350471 0.31330964
```

```
 0.31311655 0.3129254  0.31273617 0.31254884 0.31236338 0.31217978
 0.31199799 0.31181801 0.3116398  0.31146335 0.31128863 0.31111562
 0.3109443  0.31077465 0.31060665 0.31044027 0.31027549 0.3101123
 0.30995067 0.30979059 0.30963204 0.30947499 0.30931943 0.30916534
 0.3090127  0.3088615  0.30871171 0.30856332 0.30841631 0.30827067
 0.30812637 0.30798341 0.30784176 0.30770141 0.30756235 0.30742455
 0.307288   0.3071527  0.30701861 0.30688574 0.30675406 0.30662355
 0.30649422 0.30636603 0.30623898 0.30611306 0.30598825 0.30586454
 0.30574191 0.30562036 0.30549986 0.30538041 0.305262   0.30514462
 0.30502824 0.30491286 0.30479848 0.30468506 0.30457262 0.30446113
 0.30435058 0.30424097 0.30413228 0.3040245  0.30391762 0.30381163
 0.30370653 0.30360229 0.30349892 0.3033964  0.30329472 0.30319387
 0.30309385 0.30299464 0.30289624 0.30279863 0.30270181 0.30260577
 0.3025105  0.30241599 0.30232224 0.30222923 0.30213695 0.30204541
 0.30195458 0.30186447 0.30177507 0.30168636]
[0.31982273 0.3196272  0.31943381 0.31924252 0.3190533  0.31886613
 0.31868098 0.31849782 0.31831663 0.31813738 0.31796004 0.3177846
 0.31761102 0.31743928 0.31726936 0.31710124 0.31693488 0.31677027
 0.31660739 0.31644621 0.31628671 0.31612887 0.31597266 0.31581808
 0.31566509 0.31551368 0.31536382 0.3152155  0.3150687  0.31492339
 0.31477957 0.3146372  0.31449628 0.31435678 0.31421868 0.31408198
 0.31394665 0.31381267 0.31368002 0.3135487  0.31341869 0.31328996
 0.3131625  0.3130363  0.31291134 0.31278761 0.31266509 0.31254376
 0.31242362 0.31230465 0.31218682 0.31207014 0.31195458 0.31184013
 0.31172679 0.31161452 0.31150333 0.3113932  0.31128411 0.31117606
 0.31106903 0.31096301 0.31085798 0.31075395 0.31065088 0.31054878
 0.31044763 0.31034742 0.31024813 0.31014977 0.31005231 0.30995575
 0.30986007 0.30976527 0.30967133 0.30957825 0.30948601 0.30939461
 0.30930404 0.30921428 0.30912533 0.30903717 0.30894981 0.30886322
 0.3087774  0.30869235 0.30860804 0.30852449 0.30844166 0.30835957
 0.30827819 0.30819752 0.30811756 0.30803829 0.30795971 0.30788181
 0.30780458 0.30772801 0.3076521  0.30757684]
----------------------------------------------------------------------------
---------
start test which learning rate is 0.1
[[ 5.8789594 ]
 [ 0.01521603]
 [-1.45933285]
 [-0.33690073]
 [-0.50045624]
 [-0.40416779]
 [ 0.45446114]
 [-0.07112617]
 [ 0.46819957]
 [-0.21980755]
 [ 0.2388424 ]
 [ 1.91817287]]
[0.30165698 0.30162768 0.30159846 0.30156931 0.30154023 0.30151124
 0.30148231 0.30145346 0.30142469 0.30139598 0.30136736 0.3013388
 0.30131032 0.30128191 0.30125358 0.30122531 0.30119712 0.301169
 0.30114096 0.30111298 0.30108507 0.30105724 0.30102948 0.30100178
 0.30097416 0.30094661 0.30091912 0.30089171 0.30086437 0.30083709
 0.30080988 0.30078274 0.30075567 0.30072867 0.30070173 0.30067487
 0.30064807 0.30062133 0.30059467 0.30056807 0.30054153 0.30051507
 0.30048866 0.30046233 0.30043606 0.30040985 0.30038371 0.30035763
 0.30033162 0.30030567 0.30027979 0.30025397 0.30022821 0.30020252
 0.30017689 0.30015133 0.30012582 0.30010038 0.300075   0.30004968
 0.30002443 0.29999923 0.2999741  0.29994903 0.29992402 0.29989907
 0.29987418 0.29984935 0.29982459 0.29979988 0.29977523 0.29975064
 0.29972611 0.29970164 0.29967723 0.29965288 0.29962858 0.29960435
 0.29958017 0.29955605 0.29953199 0.29950798 0.29948403 0.29946014
 0.29943631 0.29941254 0.29938882 0.29936515 0.29934154 0.29931799
 0.2992945  0.29927106 0.29924767 0.29922435 0.29920107 0.29917785
 0.29915469 0.29913158 0.29910852 0.29908552]
```

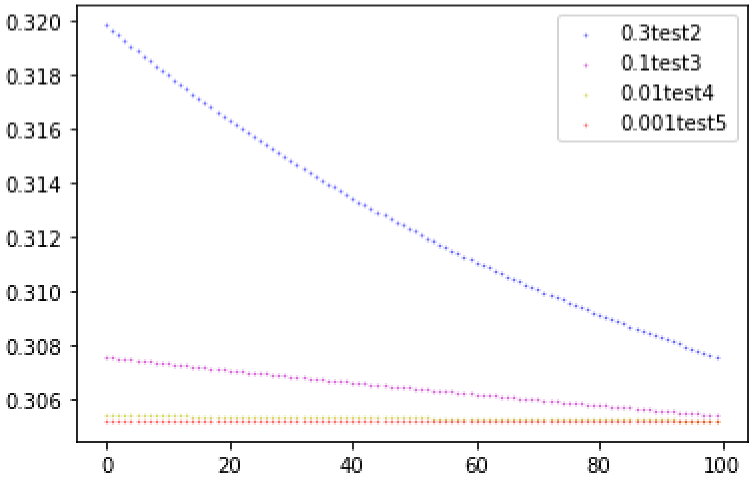
```
[0.30755193 0.30752709 0.30750232 0.30747762 0.30745299 0.30742843
 0.30740394 0.30737952 0.30735517 0.30733088 0.30730667 0.30728252
 0.30725844 0.30723443 0.30721049 0.30718661 0.3071628  0.30713906
 0.30711538 0.30709177 0.30706823 0.30704475 0.30702134 0.30699799
 0.30697471 0.30695149 0.30692834 0.30690525 0.30688223 0.30685927
 0.30683637 0.30681354 0.30679076 0.30676806 0.30674541 0.30672283
 0.30670031 0.30667785 0.30665546 0.30663312 0.30661085 0.30658864
 0.30656648 0.30654439 0.30652236 0.30650039 0.30647848 0.30645663
 0.30643484 0.30641311 0.30639144 0.30636983 0.30634827 0.30632678
 0.30630534 0.30628396 0.30626264 0.30624138 0.30622017 0.30619902
 0.30617793 0.30615689 0.30613592 0.30611499 0.30609413 0.30607332
 0.30605256 0.30603187 0.30601122 0.30599064 0.3059701  0.30594963
 0.3059292  0.30590884 0.30588852 0.30586826 0.30584805 0.3058279
 0.3058078  0.30578776 0.30576777 0.30574783 0.30572794 0.3057081
 0.30568832 0.30566859 0.30564892 0.30562929 0.30560971 0.30559019
 0.30557072 0.3055513  0.30553193 0.30551261 0.30549334 0.30547413
 0.30545496 0.30543584 0.30541677 0.30539775]
--------------------------------------------------------------------------------
---------
start test which learning rate is 0.01
[[ 5.87895885]
 [ 0.01030136]
 [-1.46454349]
 [-0.33543251]
 [-0.49267232]
 [-0.4054939 ]
 [ 0.45997757]
 [-0.06778986]
 [ 0.47004438]
 [-0.21321871]
 [ 0.24247449]
 [ 1.92126937]]
[0.29908323 0.29908093 0.29907863 0.29907634 0.29907405 0.29907175
 0.29906946 0.29906717 0.29906488 0.29906259 0.2990603  0.29905801
 0.29905572 0.29905343 0.29905114 0.29904885 0.29904656 0.29904428
 0.29904199 0.2990397  0.29903742 0.29903513 0.29903285 0.29903057
 0.29902828 0.299026   0.29902372 0.29902144 0.29901916 0.29901688
 0.2990146  0.29901232 0.29901004 0.29900776 0.29900548 0.2990032
 0.29900093 0.29899865 0.29899638 0.2989941  0.29899183 0.29898955
 0.29898728 0.29898501 0.29898273 0.29898046 0.29897819 0.29897592
 0.29897365 0.29897138 0.29896911 0.29896684 0.29896457 0.29896231
 0.29896004 0.29895777 0.29895551 0.29895324 0.29895098 0.29894871
 0.29894645 0.29894418 0.29894192 0.29893966 0.2989374  0.29893514
 0.29893287 0.29893061 0.29892835 0.2989261  0.29892384 0.29892158
 0.29891932 0.29891706 0.29891481 0.29891255 0.2989103  0.29890804
 0.29890579 0.29890353 0.29890128 0.29889903 0.29889677 0.29889452
 0.29889227 0.29889002 0.29888777 0.29888552 0.29888327 0.29888102
 0.29887877 0.29887653 0.29887428 0.29887203 0.29886979 0.29886754
 0.2988653  0.29886305 0.29886081 0.29885856]
[0.30539586 0.30539396 0.30539206 0.30539016 0.30538827 0.30538637
 0.30538448 0.30538258 0.30538069 0.3053788  0.3053769  0.30537501
 0.30537312 0.30537123 0.30536933 0.30536744 0.30536555 0.30536366
 0.30536177 0.30535989 0.305358   0.30535611 0.30535422 0.30535234
 0.30535045 0.30534856 0.30534668 0.30534479 0.30534291 0.30534102
 0.30533914 0.30533726 0.30533538 0.30533349 0.30533161 0.30532973
 0.30532785 0.30532597 0.30532409 0.30532221 0.30532033 0.30531846
 0.30531658 0.3053147  0.30531283 0.30531095 0.30530907 0.3053072
 0.30530532 0.30530345 0.30530158 0.3052997  0.30529783 0.30529596
 0.30529409 0.30529222 0.30529034 0.30528847 0.3052866  0.30528474
 0.30528287 0.305281   0.30527913 0.30527726 0.3052754  0.30527353
 0.30527166 0.3052698  0.30526793 0.30526607 0.30526421 0.30526234
 0.30526048 0.30525862 0.30525675 0.30525489 0.30525303 0.30525117
 0.30524931 0.30524745 0.30524559 0.30524373 0.30524188 0.30524002
 0.30523816 0.3052363  0.30523445 0.30523259 0.30523074 0.30522888
```

```
 0.30522703 0.30522517 0.30522332 0.30522147 0.30521962 0.30521776
 0.30521591 0.30521406 0.30521221 0.30521036]
----------------------------------------------------------------------------
---------
start test which learning rate is 0.001
[[ 5.8789588 ]
 [ 0.00981319]
 [-1.46506182]
 [-0.33528577]
 [-0.49189551]
 [-0.40562563]
 [ 0.46052703]
 [-0.06745904]
 [ 0.47022823]
 [-0.21256823]
 [ 0.24283264]
 [ 1.92157706]]
[0.29885834 0.29885811 0.29885789 0.29885767 0.29885744 0.29885722
 0.29885699 0.29885677 0.29885655 0.29885632 0.2988561  0.29885587
 0.29885565 0.29885542 0.2988552  0.29885498 0.29885475 0.29885453
 0.2988543  0.29885408 0.29885385 0.29885363 0.29885341 0.29885318
 0.29885296 0.29885273 0.29885251 0.29885228 0.29885206 0.29885184
 0.29885161 0.29885139 0.29885116 0.29885094 0.29885072 0.29885049
 0.29885027 0.29885004 0.29884982 0.2988496  0.29884937 0.29884915
 0.29884892 0.2988487  0.29884847 0.29884825 0.29884803 0.2988478
 0.29884758 0.29884735 0.29884713 0.29884691 0.29884668 0.29884646
 0.29884623 0.29884601 0.29884579 0.29884556 0.29884534 0.29884511
 0.29884489 0.29884467 0.29884444 0.29884422 0.29884399 0.29884377
 0.29884355 0.29884332 0.2988431  0.29884287 0.29884265 0.29884243
 0.2988422  0.29884198 0.29884175 0.29884153 0.29884131 0.29884108
 0.29884086 0.29884064 0.29884041 0.29884019 0.29883996 0.29883974
 0.29883952 0.29883929 0.29883907 0.29883884 0.29883862 0.2988384
 0.29883817 0.29883795 0.29883773 0.2988375  0.29883728 0.29883705
 0.29883683 0.29883661 0.29883638 0.29883616]
[0.30521018 0.30520999 0.30520981 0.30520962 0.30520944 0.30520925
 0.30520907 0.30520888 0.3052087  0.30520851 0.30520833 0.30520814
 0.30520796 0.30520777 0.30520759 0.3052074  0.30520722 0.30520703
 0.30520685 0.30520666 0.30520648 0.30520629 0.30520611 0.30520592
 0.30520574 0.30520555 0.30520537 0.30520518 0.305205   0.30520481
 0.30520463 0.30520444 0.30520426 0.30520407 0.30520389 0.3052037
 0.30520352 0.30520333 0.30520315 0.30520297 0.30520278 0.3052026
 0.30520241 0.30520223 0.30520204 0.30520186 0.30520167 0.30520149
 0.3052013  0.30520112 0.30520093 0.30520075 0.30520056 0.30520038
 0.30520019 0.30520001 0.30519982 0.30519964 0.30519946 0.30519927
 0.30519909 0.3051989  0.30519872 0.30519853 0.30519835 0.30519816
 0.30519798 0.30519779 0.30519761 0.30519742 0.30519724 0.30519705
 0.30519687 0.30519669 0.3051965  0.30519632 0.30519613 0.30519595
 0.30519576 0.30519558 0.30519539 0.30519521 0.30519502 0.30519484
 0.30519465 0.30519447 0.30519429 0.3051941  0.30519392 0.30519373
 0.30519355 0.30519336 0.30519318 0.30519299 0.30519281 0.30519262
 0.30519244 0.30519226 0.30519207 0.30519189]
```

In [25]:

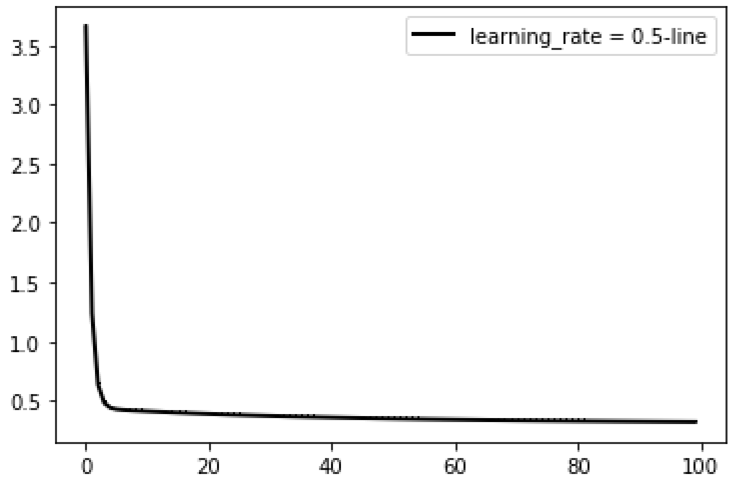
```python
ls = []
for i in range(iteration):
    ls.append(i)
ter = np.array(ls)
# 画散点图
colors0 = '#000000'
# colors1 = '#00CED1' #点的颜色
# colors2 = '#DC143C'
# colors3 = '#66CDAA'
# colors4 = '#BEBEBE'
# colors5 = '#00FA9A'
colors1 = 'k'
```

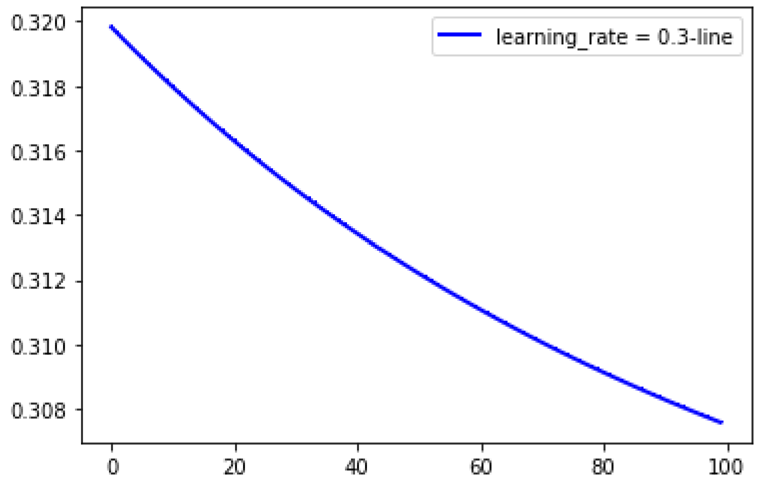
```python
colors2 = 'b'
colors3 = 'm'
colors4 = 'y'
colors5 = 'r'
area = np.pi * 0.5**2  # 点面积
# plt.scatter(ter, loss0, s=area, c=colors0, alpha=0.4, label='train')
# plt.scatter(ter, loss1_train, s=area, c=colors1, alpha=0.4, label='0.5trai
# plt.scatter(ter, loss2_train, s=area, c=colors2, alpha=0.4, label='0.3trai
# plt.scatter(ter, loss3_train, s=area, c=colors3, alpha=0.4, label='0.1trai
# plt.scatter(ter, loss4_train, s=area, c=colors4, alpha=0.4, label='0.01tra
# plt.scatter(ter, loss5_train, s=area, c=colors5, alpha=0.4, label='0.001tr
# plt.scatter(ter, loss1_test, s=area, c=colors1, alpha=0.4, label='0.5test1
plt.scatter(ter, loss2_test, s=area, c=colors2, alpha=0.4, label='0.3test2')
plt.scatter(ter, loss3_test, s=area, c=colors3, alpha=0.4, label='0.1test3')
plt.scatter(ter, loss4_test, s=area, c=colors4, alpha=0.4, label='0.01test4'
plt.scatter(ter, loss5_test, s=area, c=colors5, alpha=0.4, label='0.001test5
# plt.plot(ter, loss1, ls="-",color=colors1,marker =",", lw=2, label="learni
# plt.plot(ter, loss1, ls="-",color=colors1,marker =",", lw=2, label='learni
# plt.plot(ter, loss1, ls="-",color=colors1,marker =",", lw=2, label='learni
# plt.plot(ter, loss1, ls="-",color=colors1,marker =",", lw=2, label='learni
# plt.plot(ter, loss1, ls="-",color=colors1,marker =",", lw=2, label='learni
plt.legend()
plt.show()
```

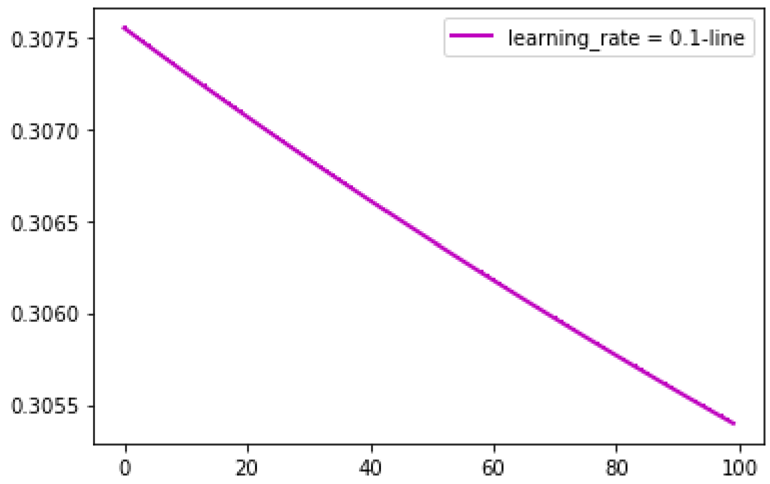


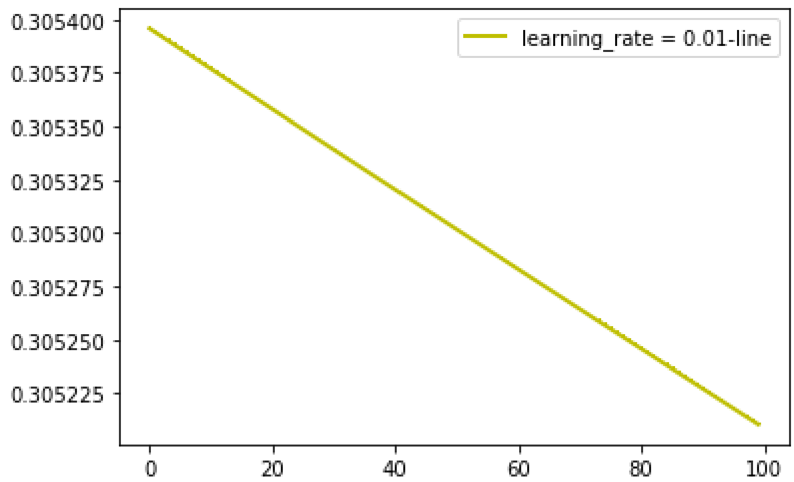
In [26]:

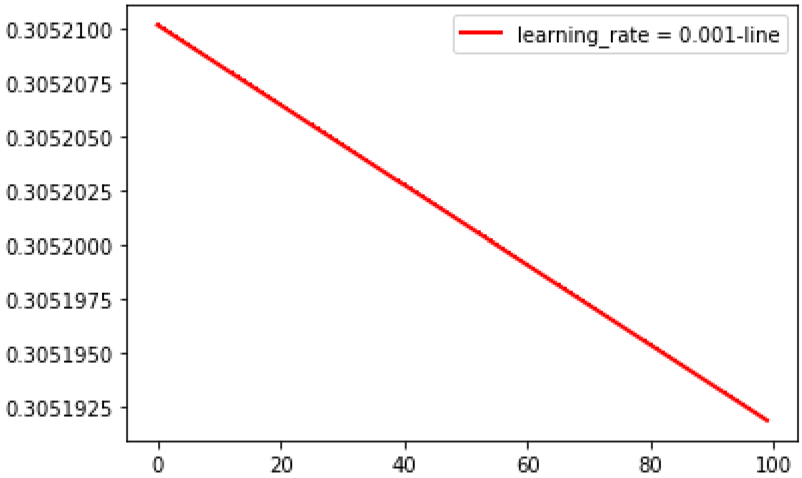
```python
ls2 = []
for i in range(iteration):
    ls2.append(i)
ter2 = np.array(ls2)
# 画曲线图
plt.plot(ter2, loss1_test, ls="-",color=colors1,marker =",", lw=2, label="le
# plt.scatter(ter1, loss2_test, s=area, c=colors2, alpha=0.4, label='0.3test
# plt.scatter(ter1, loss3_test, s=area, c=colors3, alpha=0.4, label='0.1test
# plt.scatter(ter1, loss4_test, s=area, c=colors4, alpha=0.4, label='0.01tes
# plt.scatter(ter1, loss5_test, s=area, c=colors5, alpha=0.4, label='0.001te
plt.legend()
plt.show()
plt.plot(ter2, loss2_test, ls="-",color=colors2,marker =",", lw=2, label="le
plt.legend()
plt.show()
plt.plot(ter2, loss3_test, ls="-",color=colors3,marker =",", lw=2, label="le
plt.legend()
plt.show()
plt.plot(ter2, loss4_test, ls="-",color=colors4,marker =",", lw=2, label="le
plt.legend()
plt.show()
plt.plot(ter2, loss5_test, ls="-",color=colors5,marker =",", lw=2, label="le
plt.legend()
plt.show()
```


learning_rate = 0.5-line
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0
20
40
60
80
100


learning_rate = 0.3-line
0.320
0.318
0.316
0.314
0.312
0.310
0.308
0
20
40
60
80
100


learning_rate = 0.1-line
0.3075
0.3070
0.3065
0.3060
0.3055
0
20
40
60
80
100


learning_rate = 0.01-line
0.305400
0.305375
0.305350
0.305325
0.305300
0.305275
0.305250
0.305225
0
20
40
60
80
100



随机梯度下降

In [27]:
```
# 测试最大值
# print(max(train_list))

# 测试循环
a = 10
while a > 0:
    print(a)
    a -= 1

# 测试参数
theta_test = theta1
print(theta_test.flatten())
```

```
10
9
8
7
6
5
4
3
2
1
[ 5.8789588   0.00981319 -1.46506182 -0.33528577 -0.49189551 -0.40562563
  0.46052703 -0.06745904  0.47022823 -0.21256823  0.24283264  1.92157706]
```

In [28]:
```
def random_down(x_train, y_train, x_test, y_test, learning_rate, theta):
    m = y_train.size
    train_history = np.zeros(500)
    test_history = np.zeros(500)
    t = theta.size
    iter_count = 0
    random_num = random.sample(range(0, m), 500)
    while max(theta) > 0.2 and iter_count < 500:
        # 随机取一个数据
        # random_num = random.sample(range(0, m), 1)
        # print(random_num[iter_count])
        mid = 0
        for j in range(t):
            mid += theta[j] * x_train[random_num[iter_count]][j]

        for j in range(t):
            theta[j] = theta[j] - learning_rate * ((mid - y_train[random_num
        train_history[iter_count] = compute_cost(x_train, y_train, theta)
        test_history[iter_count] = compute_cost(x_test, y_test, theta)
```

```python
        iter_count += 1
    return theta, train_history, test_history
```

In [29]:

```python
# 测试为什么只有一个值
theta1, loss1_train, loss1_test = random_down(x_train, y_train, x_test, y_te
```

In [30]:

```python
print(x_train[1881][4])
```

```
-0.05201556538664837
```

In [31]:

```python
print('start test which learning rate is 0.5')
theta1, loss1_train, loss1_test = random_down(x_train, y_train, x_test, y_te
print(theta1)
print(loss1_train)
print(loss1_test)
print('----------------------------------------------------------------------
print('start test which learning rate is 0.3')
theta2, loss2_train, loss2_test = random_down(x_train, y_train, x_test, y_te
print(theta2)
print(loss2_train)
print(loss2_test)
print('----------------------------------------------------------------------
print('start test which learning rate is 0.1')
theta3, loss3_train, loss3_test = random_down(x_train, y_train, x_test, y_te
print(theta3)
print(loss3_train)
print(loss3_test)
print('----------------------------------------------------------------------
print('start test which learning rate is 0.01')
theta4, loss4_train, loss4_test = random_down(x_train, y_train, x_test, y_te
print(theta4)
print(loss4_train)
print(loss4_test)
print('----------------------------------------------------------------------
print('start test which learning rate is 0.001')
theta5, loss5_train, loss5_test = random_down(x_train, y_train, x_test, y_te
print(theta5)
print(loss5_train)
print(loss5_test)
```

```
start test which learning rate is 0.5
[[ 5.96859337]
 [-1.02520762]
 [-1.55872156]
 [-0.00982726]
 [ 0.87779991]
 [-0.06480655]
 [ 1.61162261]
 [-0.54054783]
 [ 0.49514009]
 [ 1.05619225]
 [ 0.30915472]
 [ 3.00738245]]
[0.32941277 0.42157472 0.35163607 0.48217664 0.49568798 0.30400644
 0.3120192  0.30386908 0.44937359 0.42701833 0.30780884 0.35700342
 0.42583194 1.04241072 0.31740757 0.405254   0.30118228 0.35229988
 0.59147279 0.29701729 0.30131438 0.31861129 0.44004231 0.33591127
 0.38850587 0.44955431 0.63487639 0.5299062  0.34837978 0.40956652
 0.40524937 0.30337353 0.4426383  0.44482012 0.32761347 0.29610583
 0.33867056 0.30148593 0.50390679 0.29504637 0.45631929 0.34061767
 0.33931136 0.41181447 0.48944835 0.29177716 0.34941977 0.69218863
 0.60537814 0.30630585 0.30809465 0.42907231 0.46233423 0.3777044
 0.31858398 0.34929398 0.2977365  0.62050738 0.35009293 0.31184937
 0.70007025 0.49016943 0.30646931 0.42235813 0.30494698 0.30253441
 0.38279733 0.33595012 0.9553314  0.44588592 0.29419728 0.29352564
 0.68525882 0.47137154 0.37220336 0.29931008 0.33970325 0.29591163
 0.45657771 0.39646908 0.41532895 0.38292112 0.30563614 0.32357991
 0.30470366 0.30227971 0.33799966 0.32384716 0.33156195 0.36077966
 0.32775823 0.29872752 0.30968658 0.36569357 0.43822203 0.40877483
 0.29530093 0.2918905  0.29514952 0.35565144 0.31150608 0.6190612
 0.34647269 0.30679245 0.29634105 0.37926487 0.32798833 0.35755358
 0.45959879 0.34920165 0.44888311 0.30492917 0.33347927 0.35458283
 0.30622903 0.2932927  0.34951429 0.32456304 0.42339022 0.44711979
 0.43401079 0.34846785 0.35379085 0.47787189 0.39545231 0.30266623
 0.32172616 0.31316813 0.32266132 0.29890042 0.32824534 0.29668461
 0.31332063 0.44167187 0.36439682 0.33463109 0.30160329 0.29423726
 0.3026141  0.29775943 0.45321415 0.30490385 0.30158268 0.32702909
 0.29459185 0.46050185 0.2900039  0.30809317 0.31351821 0.29341305
 0.35101437 0.35109637 0.29974296 0.33598741 0.33365642 0.40822038
 0.47354261 0.29837596 0.57507603 0.51321044 0.39658633 0.30660135
 0.32172318 0.29771693 0.28880615 0.35916239 0.86847773 0.51362201
 0.51671905 0.47321685 0.4862109  0.39200194 0.30473554 0.55618363
 0.30241481 0.40147646 0.71478739 1.23054886 0.81228192 0.29299273
 0.5345975  0.29116338 0.3061196  0.33695281 0.30600355 0.30804937
 0.36385726 0.63396892 0.32438602 0.31386418 0.32746711 0.29832822
 0.40495505 0.29580868 0.30596557 0.33298823 0.31214107 0.37627989
 0.62265849 0.30218662 0.30358356 0.31461196 0.44083555 0.64554872
 0.88690738 0.93628788 0.82503284 0.63214567 0.31468103 0.35223572
 0.3582755  0.32272636 0.35239489 0.29556007 0.29479822 0.31218476
 0.36823707 0.33025652 0.32358075 0.39398878 0.32129692 0.41804487
 0.52297998 0.45366306 0.5188212  0.3637553  0.37508309 0.38590064
 0.30476984 0.3072598  0.33390781 0.30785376 0.37852315 0.31665186
 0.31451695 0.43999498 0.31691827 0.3668366  0.36032085 0.38267148
 0.38994729 0.31161314 0.30605687 0.33433989 0.30557785 0.31673669
 0.55702565 0.3049482  0.31543813 0.321213   0.30087124 0.33461736
 0.37174685 0.32090242 0.31480671 0.34703863 0.51240741 0.30791216
 0.29670629 0.32717722 0.30229781 0.68065091 0.51815895 0.43613278
 0.3182471  0.32218116 0.31497568 0.30543707 1.55707627 0.33279443
 0.54403033 0.46130777 0.32273558 0.46079188 0.30706703 0.33079173
 0.31286951 0.30516483 0.30440358 0.34655553 0.29603909 0.31029337
 0.30452365 0.31085813 0.30353306 0.29611777 0.39038178 0.30325259
 0.3060281  0.32436374 0.36655716 0.83461115 0.33553162 0.32096473
 0.40269648 0.29844602 0.35955709 0.29466774 0.50592318 0.30642735
 0.31899827 0.32233846 0.29422026 0.32731176 0.47966187 0.30252978
```

```
 0.30878835 0.33215819 0.29995924 0.29323854 0.30626317 0.30320063
 0.46003302 0.29572375 0.33260474 0.33475351 0.42750288 0.41905394
 0.3286455  0.37647956 0.30723788 0.30884986 0.2949825  0.31692673
 0.29365864 0.29482852 0.29483986 0.31278783 0.40809537 0.40505162
 0.33327    0.74691716 0.83924823 0.30533188 0.37247162 0.43434766
 0.53015273 0.53517074 0.48418832 0.2908426  0.30440398 0.51639117
 0.53603461 0.2910089  0.38972522 0.37285702 0.30246549 0.32418004
 0.34030962 0.28952584 0.31051264 0.67085857 0.50853539 0.32134626
 0.36862903 0.38110404 0.57605869 0.31379912 0.64384473 0.35999229
 0.4269451  0.47027635 0.29323602 0.29186758 0.54762569 0.62777775
 0.74987224 0.2889249  0.35123286 0.28843234 0.36500161 0.39487274
 0.31493482 0.32447247 0.46131214 0.29900347 0.29284253 0.5892473
 0.48805828 0.29743423 0.34072546 0.51275321 0.62191712 0.31015624
 0.31874871 0.30899088 0.78621079 0.42018272 0.30318956 0.35344632
 0.45370515 0.65095758 0.3093197  0.29124031 0.48655933 0.3838599
 0.29583283 0.32021235 0.33006497 0.29831975 0.31646209 0.29129787
 0.31634916 0.29620884 0.3079037  0.3851105  0.39537138 0.41881485
 0.40452859 0.31085872 0.29832822 0.32122353 0.29813165 0.31868255
 0.30379586 0.29509492 0.34112502 0.76323631 0.34417186 0.60612135
 0.33271701 0.33970765 0.30277234 0.60810094 0.40634608 0.31073998
 0.31514987 0.30859452 0.40294368 0.438644   0.5547176  0.31030234
 0.29834186 0.5099345  0.30443713 0.30390655 0.38124568 0.30904886
 0.31858204 0.50116708 0.376848   0.3416529  0.29842901 0.31475437
 0.29815802 0.30357633 0.30749851 0.44891107 0.32990574 0.33841639
 0.33755077 0.30373476 0.36746897 0.43176537 0.39676828 0.31396651
 0.32230465 0.30198525 0.46582186 0.50332475 0.30333536 0.30031518
 0.38927964 0.29381436 0.32967084 0.37624121 0.42552163 0.8795794
 0.29199527 0.33143252 0.28823727 0.2910436  0.33520552 0.46641656
 0.4313824  0.37937903 0.28870244 0.28734464 0.59054156 0.33469179
 0.2950991  0.36495218 0.32653088 0.32270183 0.30323715 0.34727125
 0.42945157 0.38273852 0.30960062 0.31928841 0.3341033  0.29629516
 1.12025837 0.82009484 0.31003723 0.39469949 0.32060201 0.66883756
 0.41959507 0.31648743]
[0.33740916 0.42656161 0.35721626 0.48608775 0.50543601 0.31083015
 0.31932274 0.30950382 0.45876959 0.43614093 0.31342726 0.35993061
 0.42787939 1.04167343 0.32288478 0.40845112 0.30780591 0.35726167
 0.59384293 0.30456022 0.30779476 0.32757477 0.45095015 0.34146764
 0.39290175 0.45294496 0.63649795 0.53250191 0.35315061 0.41347402
 0.40918551 0.30928299 0.44630674 0.4484647  0.33313227 0.30373271
 0.34409481 0.30794346 0.5078551  0.30167253 0.46076066 0.34660241
 0.34532272 0.41697086 0.49367387 0.29881303 0.35846932 0.70531058
 0.61774176 0.31393897 0.31297941 0.43119612 0.46404951 0.38065067
 0.32242501 0.35194213 0.30299246 0.62088759 0.35433056 0.31983218
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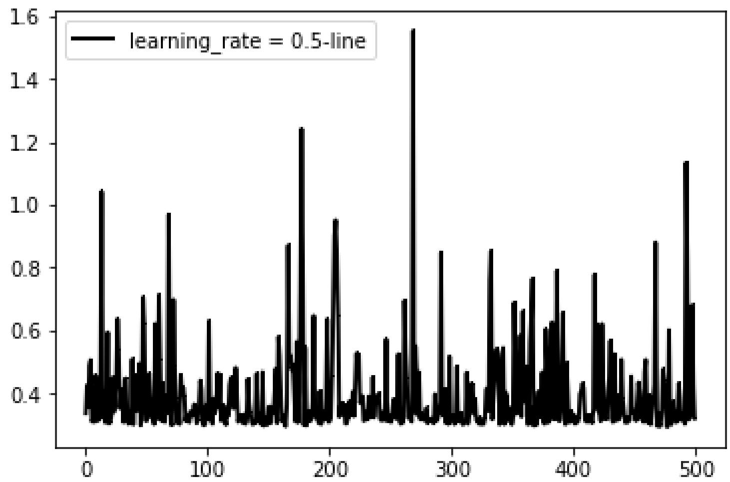
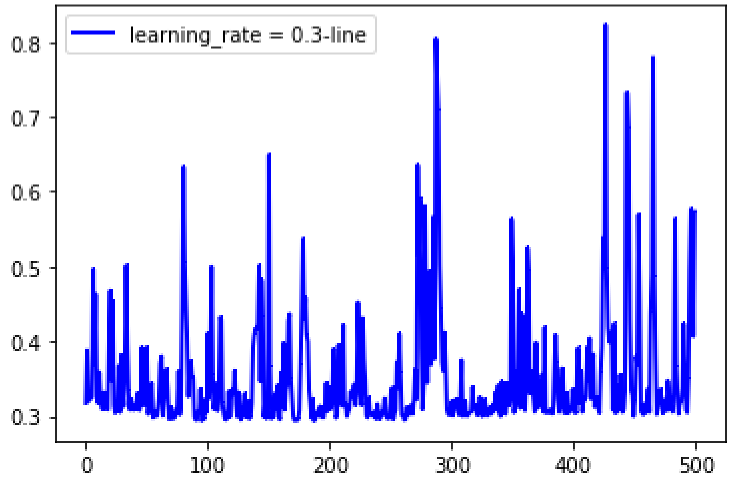
0.30060783	0.30057734	0.30055562	0.30050126	0.30051133	0.30048893
0.30056404	0.30052596	0.30043173	0.30040929	0.30034236	0.3002562
0.30019324	0.30011093	0.30010722	0.30007249	0.30009465	0.30004495
0.30001279	0.30005962	0.30002861	0.30000684	0.29996364	0.29994079
0.29994279	0.29986904	0.29980976	0.29975531	0.29978948	0.29979129
0.29984285	0.2998261	0.2998291	0.29985095	0.29988905	0.29993875
0.2999021	0.29984563	0.2998199	0.29983397	0.29977724	0.29974834
0.29980605	0.29987363	0.29990942	0.29994948	0.29990497	0.29991698
0.29994262	0.29996186	0.29991631	0.29991752	0.29992299	0.29988278
0.29991529	0.29989738	0.29992107	0.29993183	0.29989259	0.29989428
0.29987251	0.29982812	0.29983685	0.29980187	0.29981791	0.29988957
0.29985564	0.2999006	0.29995756	0.29991846	0.29990891	0.29994324
0.29993778	0.29994213	0.2998974	0.29990853	0.29987816	0.29984863
0.29987724	0.29982958	0.29979786	0.29989165	0.29993013	0.29989143
0.29989362	0.29983291	0.29977499	0.29975834	0.29974354	0.29979887
0.29984601	0.29978851	0.29969653	0.2997461	0.29973109	0.29970844
0.29971274	0.29967416	0.29969568	0.29967156	0.29974893	0.2997127
0.29976893	0.29973262	0.29980322	0.29964239	0.2996165	0.29967121
0.29962607	0.29968685	0.29964984	0.29965883	0.29964801	0.29964474
0.29965063	0.2996379	0.29957314	0.29961197	0.29959398	0.29960929
0.29960668	0.2996712	0.29967685	0.29974952	0.29976843	0.2997665
0.29975047	0.29971449	0.29972957	0.29973633	0.29969089	0.29970996
0.29965847	0.29962258	0.29962941	0.29964947	0.29960165	0.29954337
0.29966887	0.29967105	0.29973087	0.29973461	0.29975496	0.29978798
0.29986496	0.2998126	0.29978018	0.29975558	0.29975734	0.29968857
0.29976374	0.29970347	0.29970479	0.2996476	0.29964284	0.29959587
0.29964851	0.29958917	0.29955059	0.2995805	0.29951502	0.29949011
0.29938447	0.29935068	0.29937202	0.29933347	0.29940691	0.2993924
0.29941782	0.29943573	0.29945127	0.2994568	0.29941534	0.29945378
0.2994173	0.2994111	0.29945519	0.29953105	0.29952041	0.29957748
0.29955613	0.29952918	0.29944724	0.29953784	0.29951872	0.29949971
0.29950948	0.29949479	0.29949267	0.29945052	0.29945463	0.29940842
0.29945026	0.29941162	0.29943553	0.29940014	0.29942624	0.2994108
0.29942115	0.29938283	0.29942602	0.29939991	0.29936939	0.29930979
0.29929314	0.29927118	0.29922046	0.29926483	0.29922663	0.29920266
0.29922609	0.29923955	0.29920412	0.29920394	0.29917543	0.29923706
0.29925037	0.29931214	0.29931956	0.29927491	0.29928924	0.29926218
0.29925169	0.29921245	0.29917634	0.29905704	0.2990439	0.29904313
0.29905664	0.29904184	0.29903355	0.29905171	0.29906678	0.29911821
0.2991616	0.29919717	0.29912636	0.29911551	0.29908944	0.29904131
0.29903367	0.29903904	0.29904461	0.29905094	0.29911118	0.29901055
0.29897828	0.29897275	0.29889921	0.29891469	0.29895574	0.29891852
0.29890251	0.29887927	0.29885431	0.29884017	0.29876133	0.29877189
0.29877591	0.29878079	0.29879153	0.29884687	0.29885358	0.29886021
0.29884678	0.29895962	0.29902796	0.29903195	0.29899808	0.29899306
0.29897587	0.29895846	0.29889703	0.29891915	0.29891128	0.29889202
0.2989068	0.29885747	0.29884947	0.29892233	0.2989292	0.29891673
0.29890402	0.29887269	0.29884256	0.29881092	0.2987686	0.29877728
0.29868218	0.29868463	0.29870785	0.29873244	0.29874254	0.29881589
0.29888569	0.29886672	0.29887338	0.29885718	0.29892433	0.29885347
0.29883103	0.29879225	0.29884999	0.29891309	0.29889849	0.29884673
0.29884865	0.29881766	0.29882268	0.29882878	0.29881621	0.29877959
0.29874932	0.29875978	0.29877644	0.29881411	0.29875644	0.29880946
0.29881018	0.29882181	0.29885465	0.29888462	0.29890322	0.29887796
0.29891096	0.29891323	0.2988892	0.29887159	0.29886805	0.29890747

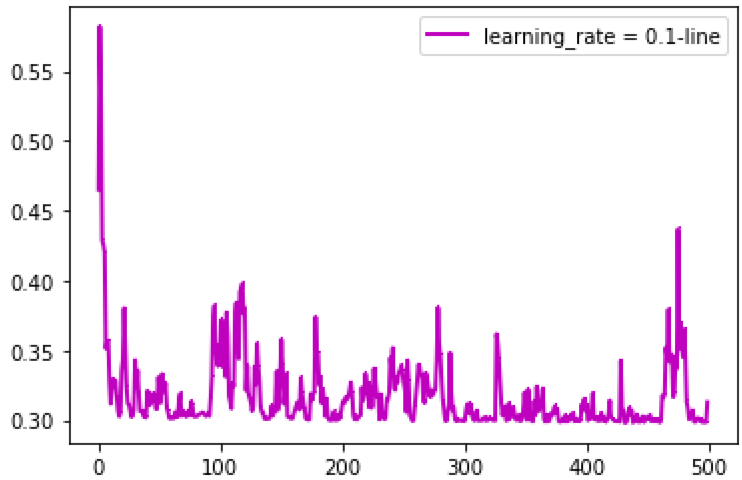
```
 0.29891635 0.29889738 0.2988724  0.29883339 0.29879754 0.2987565
 0.29872744 0.29874681 0.29870822 0.29869936 0.29870991 0.29871389
 0.29874435 0.29875832 0.29875242 0.29874773 0.29872286 0.29869695
 0.29865129 0.29871798 0.2987102  0.29865488 0.29862012 0.2985798
 0.29861248 0.29858563 0.2985824  0.29859448 0.29859699 0.2985451
 0.29852602 0.29852206 0.29855692 0.29861804 0.29860549 0.29858573
 0.29855324 0.29854713 0.29852584 0.29846929 0.29845137 0.2984435
 0.29842308 0.2983701  0.2983474  0.29834594 0.29831805 0.29832039
 0.29829916 0.29831463 0.29832125 0.29830345 0.29830516 0.29828358
 0.29826996 0.29830122 0.29829199 0.29828729 0.29828176 0.29829339
 0.29825916 0.29823712 0.29823635 0.29822616 0.29823951 0.29828824
 0.29828015 0.29830755 0.29832737 0.29830799 0.29831571 0.29832192
 0.29835238 0.29843532 0.29846678 0.29844896 0.29845549 0.29847073
 0.29845482 0.29846723 0.298492   0.29847675 0.2984607  0.29847469
 0.29848983 0.29847041 0.29849443 0.29848285 0.29857531 0.29857282
 0.298585   0.29858013 0.29860034 0.29858839 0.29857942 0.29855748
 0.29853119 0.29852604]
```

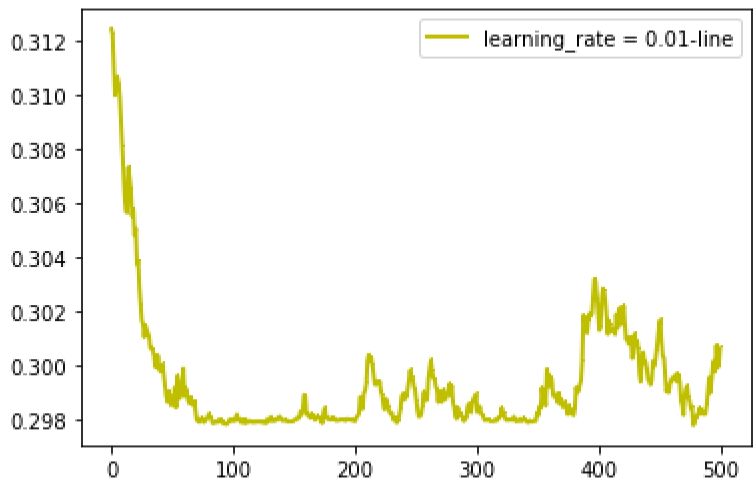
In [32]:

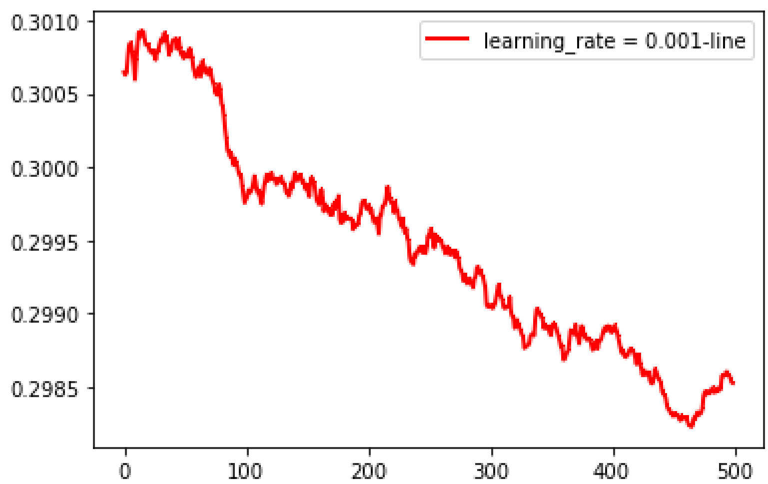
```python
ls1 = []
for i in range(500):
    ls1.append(i)
ter1 = np.array(ls1)

plt.plot(ter1, loss1_test, ls="-",color=colors1,marker =",", lw=2, label="le
# plt.scatter(ter1, loss2_test, s=area, c=colors2, alpha=0.4, label='0.3test
# plt.scatter(ter1, loss3_test, s=area, c=colors3, alpha=0.4, label='0.1test
# plt.scatter(ter1, loss4_test, s=area, c=colors4, alpha=0.4, label='0.01tes
# plt.scatter(ter1, loss5_test, s=area, c=colors5, alpha=0.4, label='0.001te
plt.legend()
plt.show()
plt.plot(ter1, loss2_test, ls="-",color=colors2,marker =",", lw=2, label="le
plt.legend()
plt.show()
plt.plot(ter1, loss3_test, ls="-",color=colors3,marker =",", lw=2, label="le
plt.legend()
plt.show()
plt.plot(ter1, loss4_test, ls="-",color=colors4,marker =",", lw=2, label="le
plt.legend()
plt.show()
plt.plot(ter1, loss5_test, ls="-",color=colors5,marker =",", lw=2, label="le
plt.legend()
plt.show()
```




learning_rate = 0.3-line
0.3
0.4
0.5
0.6
0.7
0.8
0
100
200
300
400
500


learning_rate = 0.1-line
0.30
0.35
0.40
0.45
0.50
0.55
0
100
200
300
400
500


learning_rate = 0.01-line
0.298
0.300
0.302
0.304
0.306
0.308
0.310
0.312
0
100
200
300
400
500


learning_rate = 0.001-line
0.2985
0.2990
0.2995
0.3000
0.3005
0.3010
0
100
200
300
400
500

中级要求

探究回归模型在机器学习和统计学上的差异。

- 回归模型在机器学习领域和统计学领域中都十分常用，而且使用方法也相似，但其实际的含义具有本质的区别。我们希望同学们从回归模型的角度更加充分地理解机器学习和统计学的区别。

回归模型在机器学习和统计学上的差异

从定义上来讲

> 机器学习是一种不依赖于规则设计的数据学习算法
>
> 统计模型是以数学方程形式表现变量之间关系的程式化表达

分属不同的学派

> 机器学习：计算机科学和人工智能的一个分支,通过数据学习构建分析系统，不依赖明确的构建规则
>
> 统计模型：数学的分支用以发现变量之间相关关系从而预测输出

本次实验的线性回归模型方面

1. 自变量和因变量线性相关
2. 同方差
3. 波动均值为0
4. 观测样本相互独立
5. 波动服从正态分布

> Logistics回归同样拥有很多的假设。即使是非线性回归也要遵守一个连续的分割边界的假设。然而机器学习却从这些假设中脱身出来。机器学习最大的好处在于没有连续性分割边界的限制。同样我们也并不需要假设自变量或因变量的分布。

数据区别

> 机器学习应用广泛。 在线学习工具可飞速处理数据。这些机器学习工具可学习数以亿计的观测样本，预测和学习同步进行。一些算法如随机森林和梯度助推在处理大数据时速度很快。机器学习处理数据的广度和深度很大
>
> 统计模型一般应用在较小的数据量和较窄的数据属性上。

公式方面

虽然统计模型和机器学习的最终目标是相似的，但其公式化的结构却非常不同

在统计模型中，估计函数是通过

> 因变量（Y）=f(自变量)+ 扰动函数

机器学习放弃采用函数f的形式，简化为：

> 输出（Y）——> 输入（X）

高级要求

编程实现岭回归算法，求解训练样本的岭回归模型，平均训练误差和平均测试误差（解析法、批量梯度下降法和随机梯度下降法均可）。

In [33]:
```
print(np.mat(x_train).shape)  # 16个数据, 6个特征
print(np.mat(y_train).shape)  # 16个数据
```

```
(3918, 12)
(1, 3918)
```

In [34]:
```
# 岭回归标准方程法求解回归参数
def weights(xArr, yArr, lam = 0.2):  # 设置岭系数为0.2
    xMat = np.mat(xArr)
    yMat = np.mat(yArr)

    xTx = xMat.T * xMat  # 矩阵乘法
    rxTx = xTx + np.eye(xMat.shape[1]) * lam  # 岭回归求解的括号的部分
    # 计算矩阵的值,如果值为0, 说明该矩阵没有逆矩阵
    if np.linalg.det(rxTx) == 0.0:
        print("This matrix cannot do inverse")
        return
    # xTx.I为xTx的逆矩阵
    ws = rxTx.I * xMat.T * yMat.T
    return ws


ws = weights(x_train, y_train)
print(ws)
print('-----------------------------------------------------------------------
l = 0.001
# 测试不同系数所对应的训练损失和测试损失值
for i in range(0, 10):
    ws = weights(x_train, y_train, l)
    train_loss = compute_cost(x_train, y_train, ws)
    test_loss = compute_cost(x_test, y_test, ws)
    l *= 10
    print(train_loss)
    print(test_loss)

    print('-----------------------------------------------------------------

# # 计算预测值
# print(np.mat(data0)*np.mat(ws))
```

```
[[ 5.87894037]
 [ 0.4127918 ]
 [-1.91831047]
 [ 0.01158282]
 [ 4.08774022]
 [-0.24348796]
 [ 1.62156447]
 [-0.17799153]
 [-5.7582935 ]
 [ 0.55317577]
 [ 0.5395441 ]
 [ 1.45578453]]
-----------------------------------------------------------------------------
-------
[[0.27878906]]
[[0.29749259]]
-----------------------------------------------------------------------------
-------
[[0.27879535]]
[[0.29694668]]
-----------------------------------------------------------------------------
-------
[[0.27914613]]
[[0.29392824]]
-----------------------------------------------------------------------------
-------
[[0.28176081]]
[[0.29260018]]
-----------------------------------------------------------------------------
-------
[[0.28659781]]
[[0.29386106]]
-----------------------------------------------------------------------------
-------
[[0.32650866]]
[[0.32825465]]
-----------------------------------------------------------------------------
-------
[[1.08437906]]
[[1.08373295]]
-----------------------------------------------------------------------------
-------
[[9.30757187]]
[[9.30589005]]
-----------------------------------------------------------------------------
-------
[[16.3890661]]
[[16.38700091]]
-----------------------------------------------------------------------------
-------
[[17.53282765]]
[[17.53070776]]
-----------------------------------------------------------------------------
-------
```

本次实验也到此结束🎉

总结与展望

总结

- 本次是机器学习的第二次实验，在做实验的过程中感受到梯度下降算法的高明之处，但首先困扰我许久的是如何进行分层抽样，网络上的分层抽样都需要掉包，所以只好自己来写，通过不断的测试，调参数等步骤，最终终于实现了分层抽样，也对numpy和pandas更加的熟悉
- 然后再通过自己对批量梯度下降和随机梯度下降的了解，实现了这两种算法，并最终用图示的方法给出训练的过程
- 接下来对统计和机器学习中回归模型的分析，了解到了人工智能和统计学上的差别，让我对自己的专业方向有了更多的感悟
- 最后通过实现岭回归模型，对回归方面的算法有了更加熟练的掌握

展望

通过第二次实验，发现自己对机器学习有了更近一步的认识，希望自己能在本学期的课程中学到更多，也希望自己未来能有更好的发展✌️