Московский государственный технический университет им. Н.Э. Баумана
Кафедра «Системы обработки информации и управления»

Лабораторная работа №4
по дисциплине
«Методы машинного обучения»
на тему
«Подготовка обучающей и тестовой выборки, кросс-валидация и подбор гиперпараметров на примере метода ближайших соседей»

Выполнил:
студент группы ИУ5-24М
Мельников К. И.

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In [166]:
```
import pandas as pd
import math
import seaborn
import numpy
from sklearn.neighbors import NearestNeighbors
from sklearn.model_selection import train_test_split
from sklearn.metrics import accuracy_score
from sklearn.metrics import roc_auc_score

import matplotlib.pyplot as plt
from matplotlib.colors import ListedColormap
from sklearn import neighbors, datasets
from sklearn.neighbors import KNeighborsClassifier
import numpy as np
```

In [3]:
```
class kNN:
    def __init__(self):
        self.data_train = numpy.array([])
        self.labels_train = numpy.array([])

    def train(self, x, y):
        if len(x.shape) == 2 and len(y.shape) == 1 and y.shape[0] == x.sha
            self.data_train = x
            self.labels_train = y
            self.labels = set(y)
            self.num_labels = len(self.labels)
        else:
            print("train unsuccessful, check your data")

    def predict(self, x, k):
        dtype = numpy.dtype([("distance",numpy.float),("label",numpy.int)]
        if x.shape[1] == self.data_train.shape[1]:
            predicted = numpy.array([])
            for vector in x:
                euk_distance = numpy.array([], dtype=dtype)
                for i, train in enumerate(self.data_train):
                    sum_distance = 0
                    for position, point in enumerate(vector):
                        sum_distance += pow(point - train[position], 2)
                    sum_distance = pow(sum_distance, 1/2)
                    euk_distance = numpy.append(euk_distance, numpy.array
                euk_distance = numpy.sort(euk_distance, order="distance")
                euk_distance = euk_distance[:k]
                dtypeP = [("quanity",numpy.int), ("label", numpy.int)]
                prediction = numpy.array([], dtype=dtypeP)
                for label in self.labels:
                    quanity = sum([1 for (x,y) in euk_distance if y == lab
                    print((quanity,label))
                    prediction = numpy.append(prediction, numpy.array((qua
                prediction = numpy.sort(prediction, order="quanity")
                print(prediction)
```

```
                predicted = numpy.append(predicted, prediction[-1][1])
            return predicted
        else:
            print("Wrong dimensions")
            return None
```

```
In [4]: arr = numpy.array([1,2,3])

In [5]: dd = set(arr)

In [6]: iris = pd.read_csv("Iris.csv")

In [6]: iris.head()
```

Out[6]:

	Id	SepalLengthCm	SepalWidthCm	PetalLengthCm	PetalWidthCm	Spec
0	1	5.1	3.5	1.4	0.2	Iris-set
1	2	4.9	3.0	1.4	0.2	Iris-set
2	3	4.7	3.2	1.3	0.2	Iris-set
3	4	4.6	3.1	1.5	0.2	Iris-set
4	5	5.0	3.6	1.4	0.2	Iris-set

```
In [33]: iris.dtypes
```

```
Out[33]: Id                int64
         SepalLengthCm    float64
         SepalWidthCm     float64
         PetalLengthCm    float64
         PetalWidthCm     float64
         Species           object
         dtype: object

In [7]: iris["Cat"] = iris["Species"].astype("category").cat.codes

In [8]: iris.head()
```

Out[8]:

	Id	SepalLengthCm	SepalWidthCm	PetalLengthCm	PetalWidthCm	Spec
0	1	5.1	3.5	1.4	0.2	Iris-set
1	2	4.9	3.0	1.4	0.2	Iris-set
2	3	4.7	3.2	1.3	0.2	Iris-set
3	4	4.6	3.1	1.5	0.2	Iris-set
4	5	5.0	3.6	1.4	0.2	Iris-set

	Cat
0	0
1	0
2	0
3	0
4	0

```
In [205]: xdata = numpy.array(iris[["SepalLengthCm","SepalWidthCm","PetalLengthCm"
```

```
In [186]: ydata = numpy.array(iris[["Cat"]])

In [206]: from sklearn.preprocessing import StandardScaler

In [201]: scaler = StandardScaler()

In [207]: xdata = scaler.fit_transform(xdata)

In [208]: def shuffle(x,y):
              index = numpy.arange(len(x))
              numpy.random.shuffle(index)

              xshuffled = [x[i] for i in index]
              yshuffled = [y[i] for i in index]
              return xshuffled, yshuffled

In [209]: xsh, ysh = shuffle(xdata,ydata)

In [12]: def split(x, p=0.7):
             index = int(len(x)*p)
             return x[:index],x[index:]

In [13]: xtrain, xtest = split(xsh)
         ytrain, ytest = split(ysh)

In [227]: knn = kNN()
          knn.train(numpy.array(xtrain),numpy.array(ytrain).flatten())

In [228]:

(5, 0)
(0, 1)
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(4, 1)
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(2, 2)
[(0, 0) (2, 2) (3, 1)]
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(0, 1)
(5, 2)
[(0, 0) (0, 1) (5, 2)]
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(0, 1)
(5, 2)
[(0, 0) (0, 1) (5, 2)]
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(0, 0)
(3, 1)
(2, 2)
[(0, 0) (2, 2) (3, 1)]
(5, 0)
(0, 1)
(0, 2)
[(0, 1) (0, 2) (5, 0)]
```

```
In [229]: prediction
```

```
Out[229]: array([0., 1., 0., 2., 2., 1., 2., 0., 2., 2., 0., 2., 1., 0., 1., 2., (
                 0., 2., 1., 2., 0., 0., 0., 2., 1., 1., 1., 2., 2., 1., 2., 0., 1
                 2., 1., 1., 1., 1., 0., 1., 2., 2., 1., 0.])
```

```
In [230]: numpy.array(ytest).flatten()
```

```
Out[230]: array([0, 1, 0, 2, 2, 1, 2, 0, 2, 2, 0, 2, 1, 0, 1, 1, 0, 0, 2, 1, 2, 0
                 0, 0, 2, 2, 1, 1, 1, 2, 1, 2, 0, 2, 2, 1, 1, 1, 1, 0, 1, 2, 2, 2
                 0], dtype=int8)
```

```
In [189]: dtype = numpy.dtype([("distance",numpy.float),("label",numpy.int)])
```

```
In [193]: numpy.array([(1.000001, 2),(2.222, 1)], dtype=dtype)
```

```
Out[193]: array([(1.000001, 2), (2.222   , 1)],
                dtype=[('distance', '<f8'), ('label', '<i8')])
```

```
In [ ]: def gridSearch(left, right,knn,xtest):
            results = numpy.array([])
            for i in range(left,right):
                numpy.append(results, [knn.predict(numpy.array(xtest),i)])
            return results
```

```
In [14]: X_train, X_test, y_train, y_test = train_test_split(
                  xsh, ysh, test_size=0.33, random_state=42)
```

```
In [15]: nbrs = NearestNeighbors(n_neighbors=2, algorithm='auto').fit(X_train)
```

```
In [16]: distances, indices = nbrs.kneighbors(X_train)
```

```
In [17]: distances[:20]
```

```
Out[17]: array([[0.        , 0.17320508],
                [0.        , 0.46904158],
                [0.        , 0.2236068 ],
                [0.        , 0.50990195],
                [0.        , 0.2236068 ],
                [0.        , 0.14142136],
                [0.        , 0.        ],
                [0.        , 0.3       ],
                [0.        , 0.46904158],
```

```
                [0.        , 0.37416574],
                [0.        , 0.1       ],
                [0.        , 0.24494897],
                [0.        , 0.24494897],
                [0.        , 0.24494897],
                [0.        , 0.31622777],
                [0.        , 0.17320508],
                [0.        , 0.14142136],
                [0.        , 0.2236068 ],
                [0.        , 0.        ],
                [0.        , 0.28284271]])
```

In [18]:
```
indices[:20]
```

Out[18]:
```
array([[ 0, 71],
       [ 1, 25],
       [ 2, 58],
       [ 3, 57],
       [ 4, 34],
       [ 5, 54],
       [32,  6],
       [ 7, 30],
       [ 8, 56],
       [ 9, 42],
       [10, 82],
       [11, 26],
       [12, 74],
       [13,  4],
       [14, 27],
       [15, 61],
       [16, 46],
       [17, 65],
       [18, 25],
       [19, 41]])
```

In [ ]:

In [19]:
```
knn = KNeighborsClassifier(n_neighbors=7)

knn.fit(X_train, y_train)

y_pred = knn.predict(X_test)
```

```
/home/hexagramg/tmo/venv/lib/python3.6/site-packages/ipykernel_launcher.py:4: Data
  after removing the cwd from sys.path.
```

In [20]:
```
accuracy_score(y_test, y_pred)
```

Out[20]: 0.92

In [21]:
```
y_test
```

```
Out[21]: [array([1], dtype=int8),
          array([1], dtype=int8),
          array([1], dtype=int8),
          array([2], dtype=int8),
          array([0], dtype=int8),
          array([0], dtype=int8),
          array([2], dtype=int8),
          array([1], dtype=int8),
          array([1], dtype=int8),
          array([1], dtype=int8),
          array([1], dtype=int8),
          array([0], dtype=int8),
          array([0], dtype=int8),
          array([2], dtype=int8),
          array([2], dtype=int8),
          array([2], dtype=int8),
          array([1], dtype=int8),
          array([2], dtype=int8),
          array([0], dtype=int8),
          array([0], dtype=int8),
          array([2], dtype=int8),
          array([1], dtype=int8),
          array([1], dtype=int8),
          array([0], dtype=int8),
          array([1], dtype=int8),
          array([1], dtype=int8),
          array([2], dtype=int8),
          array([2], dtype=int8),
          array([2], dtype=int8),
          array([1], dtype=int8),
          array([0], dtype=int8),
          array([0], dtype=int8),
          array([0], dtype=int8),
          array([2], dtype=int8),
          array([2], dtype=int8),
          array([1], dtype=int8),
          array([2], dtype=int8),
          array([1], dtype=int8),
          array([1], dtype=int8),
          array([2], dtype=int8),
          array([0], dtype=int8),
          array([0], dtype=int8),
          array([0], dtype=int8),
          array([1], dtype=int8),
          array([0], dtype=int8),
          array([2], dtype=int8),
          array([2], dtype=int8),
          array([2], dtype=int8),
          array([0], dtype=int8),
          array([2], dtype=int8)]
```

```
In [22]: from sklearn.metrics import balanced_accuracy_score

In [23]: balanced_accuracy_score(y_test, y_pred)

Out[23]: 0.9248366013071895

In [24]: from sklearn.metrics import f1_score

In [25]: print(f1_score(y_test, y_pred, average='macro'))
         print(f1_score(y_test, y_pred, average='micro'))
         print(f1_score(y_test, y_pred, average='weighted'))

0.9237472766884531
0.92
0.9198692810457516


In [26]: y_pred = knn.predict(X_train)

In [27]: print(accuracy_score(y_train, y_pred))
         print(balanced_accuracy_score(y_train, y_pred))
         print(f1_score(y_train, y_pred, average='macro'))
         print(f1_score(y_train, y_pred, average='micro'))
         print(f1_score(y_train, y_pred, average='weighted'))

0.99
0.9895833333333334
0.9897338703308852
0.99
0.9899952617863066


In [28]: from sklearn.model_selection import KFold
         from sklearn.model_selection import LeaveOneOut
         from sklearn.model_selection import LeaveOneGroupOut

In [35]: kf = KFold(n_splits=2)
         accpred = []
         acctrue = []
         for train_index, test_index in kf.split(xsh):
             X_train, X_test = [xsh[i] for i in train_index], [xsh[i] for i in tes
             y_train, y_test = [ysh[i] for i in train_index], [ysh[i] for i in tes
             knn = KNeighborsClassifier(n_neighbors=7)
             knn.fit(X_train, y_train)
             y_pred = knn.predict(X_test)
             accpred.append(y_pred)
             acctrue.append(y_test)

/home/hexagramg/tmo/venv/lib/python3.6/site-packages/ipykernel_launcher.py:8: Data

/home/hexagramg/tmo/venv/lib/python3.6/site-packages/ipykernel_launcher.py:8: Data
```

```
In [36]: accpred

Out[36]: [array([1, 2, 2, 1, 1, 0, 0, 0, 0, 2, 0, 1, 0, 0, 0, 0, 1, 0, 1, 2, 1, 2
                 0, 1, 0, 1, 1, 1, 0, 2, 1, 0, 2, 2, 0, 0, 0, 0, 2, 0, 2, 2, 2, 2
                 1, 2, 1, 2, 1, 0, 2, 2, 1, 2, 1, 0, 1, 1, 0, 1, 1, 2, 0, 1, 2, 0
                 2, 0, 1, 2, 1, 0, 2, 1, 1], dtype=int8),
          array([0, 0, 1, 2, 2, 0, 2, 2, 1, 2, 0, 0, 2, 0, 2, 2, 0, 1, 1, 2, 0, 2
                 0, 0, 1, 1, 0, 2, 2, 1, 2, 1, 1, 2, 2, 1, 2, 1, 2, 2, 1, 0, 2, 2
                 2, 0, 1, 1, 0, 1, 2, 0, 1, 0, 1, 0, 1, 0, 2, 1, 2, 0, 2, 0, 2, 1
                 1, 0, 2, 0, 1, 1, 2, 0, 0], dtype=int8)]

In [34]: acctrue

Out[34]: [[array([1], dtype=int8),
           array([2], dtype=int8),
           array([2], dtype=int8),
           array([1], dtype=int8),
           array([1], dtype=int8),
           array([0], dtype=int8),
           array([0], dtype=int8),
           array([0], dtype=int8),
           array([0], dtype=int8),
           array([2], dtype=int8),
           array([0], dtype=int8),
           array([2], dtype=int8),
           array([0], dtype=int8),
           array([0], dtype=int8),
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           array([0], dtype=int8),
           array([1], dtype=int8),
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 array([2], dtype=int8),
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           array([0], dtype=int8),
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           array([1], dtype=int8),
           array([2], dtype=int8),
           array([0], dtype=int8),
           array([0], dtype=int8)]]
```

```
In [38]: for i,x in enumerate(acctrue):
             print(accuracy_score(acctrue[i], accpred[i]))
             print(balanced_accuracy_score(acctrue[i], accpred[i]))
             print(f1_score(acctrue[i], accpred[i], average='macro'))
             print(f1_score(acctrue[i], accpred[i], average='micro'))
             print(f1_score(acctrue[i], accpred[i], average='weighted'))
             print('/')
```

```
0.9466666666666667
0.9506172839506174
0.9455555555555555
0.9466666666666667
0.9467555555555555
/
0.9333333333333333
0.9404761904761904
0.9346405228758169
0.9333333333333333
0.9333333333333333
/
```

```
In [1]: from sklearn.model_selection import cross_val_score
```

```
In [ ]:
```

```
In [91]: X_train, X_test, y_train, y_test = train_test_split(
                 xsh, ysh, test_size=0.33, random_state=42)
```

```
In [54]: knn = KNeighborsClassifier(n_neighbors=7)
         knn.fit(X_train, y_train)
         kf = KFold(n_splits=2)
```

```
/home/hexagramg/tmo/venv/lib/python3.6/site-packages/ipykernel_launcher.py:2: Data
```

```
In [59]: cross_val_score(knn, X_test, y_test, cv=kf, scoring='f1_macro')
```

```
/home/hexagramg/tmo/venv/lib/python3.6/site-packages/sklearn/model_selection/_vali
  estimator.fit(X_train, y_train, **fit_params)
/home/hexagramg/tmo/venv/lib/python3.6/site-packages/sklearn/model_selection/_vali
  estimator.fit(X_train, y_train, **fit_params)
```

Out[59]: array([0.7   , 0.76388889])

In [58]: cross_val_score(knn, X_test, y_test, cv=kf, scoring='accuracy')

```
/home/hexagramg/tmo/venv/lib/python3.6/site-packages/sklearn/model_selection/_vali
  estimator.fit(X_train, y_train, **fit_params)
/home/hexagramg/tmo/venv/lib/python3.6/site-packages/sklearn/model_selection/_vali
  estimator.fit(X_train, y_train, **fit_params)
```

Out[58]: array([0.68, 0.76])

In [192]: cross_val_score(KNeighborsClassifier(n_neighbors = 5), X_test, y_test, c

```
/home/hexagramg/tmo/venv/lib/python3.6/site-packages/sklearn/model_selection/_vali
  estimator.fit(X_train, y_train, **fit_params)
/home/hexagramg/tmo/venv/lib/python3.6/site-packages/sklearn/model_selection/_vali
  estimator.fit(X_train, y_train, **fit_params)
/home/hexagramg/tmo/venv/lib/python3.6/site-packages/sklearn/model_selection/_vali
  estimator.fit(X_train, y_train, **fit_params)
/home/hexagramg/tmo/venv/lib/python3.6/site-packages/sklearn/model_selection/_vali
  estimator.fit(X_train, y_train, **fit_params)
/home/hexagramg/tmo/venv/lib/python3.6/site-packages/sklearn/model_selection/_vali
  estimator.fit(X_train, y_train, **fit_params)
/home/hexagramg/tmo/venv/lib/python3.6/site-packages/sklearn/model_selection/_vali
  estimator.fit(X_train, y_train, **fit_params)
/home/hexagramg/tmo/venv/lib/python3.6/site-packages/sklearn/model_selection/_vali
  estimator.fit(X_train, y_train, **fit_params)
```

```
Out[192]: array([0.83333333, 0.88888889, 0.88888889, 0.88888889, 0.83333333,
                 1.        , 1.        ])
```

In [60]: from sklearn.model_selection import GridSearchCV

```
In [136]: param = {
              'n_neighbors' : [1,2,3,4,5,6,7,8,9],
              'weights': ['uniform','distance']
          }
```

In [151]: gcv = GridSearchCV(KNeighborsClassifier(), param, scoring='balanced_accu

In [152]: result = gcv.fit(X_train, y_train)

```
/home/hexagramg/tmo/venv/lib/python3.6/site-packages/sklearn/model_selection/_sea
  DeprecationWarning)
/home/hexagramg/tmo/venv/lib/python3.6/site-packages/sklearn/model_selection/_sea
  self.best_estimator_.fit(X, y, **fit_params)
```

```
In [153]: result.score(X_test, y_test)

Out[153]: 0.9237472766884531

In [143]: result.best_params_

Out[143]: {'n_neighbors': 5, 'weights': 'uniform'}

In [ ]:

In [73]: sorted(sklearn.neighbors.VALID_METRICS['brute'])

Out[73]: ['braycurtis',
          'canberra',
          'chebyshev',
          'cityblock',
          'correlation',
          'cosine',
          'cosine',
          'dice',
          'euclidean',
          'hamming',
          'jaccard',
          'kulsinski',
          'l1',
          'l2',
          'mahalanobis',
          'manhattan',
          'matching',
          'minkowski',
          'precomputed',
          'rogerstanimoto',
          'russellrao',
          'seuclidean',
          'sokalmichener',
          'sokalsneath',
          'sqeuclidean',
          'wminkowski',
          'yule']

In [123]: knn = KNeighborsClassifier(n_neighbors=3)

          knn.fit(X_train, y_train)

          y_pred = knn.predict(X_test)

/home/hexagramg/tmo/venv/lib/python3.6/site-packages/ipykernel_launcher.py:4: Data
  after removing the cwd from sys.path.


In [124]: print(accuracy_score(y_test, y_pred))
          print(balanced_accuracy_score(y_test, y_pred))
          print(f1_score(y_test, y_pred, average='macro'))
          print(f1_score(y_test, y_pred, average='micro'))
          print(f1_score(y_test, y_pred, average='weighted'))
```

```
0.92
0.9237472766884531
0.9237472766884531
0.92
0.92
```

```
In [149]: knn = KNeighborsClassifier(n_neighbors=5)

          knn.fit(X_train, y_train)
          kf = KFold(n_splits=7)
          y_pred = knn.predict(X_test)
```

```
/home/hexagramg/tmo/venv/lib/python3.6/site-packages/ipykernel_launcher.py:4: Data
  after removing the cwd from sys.path.
```

```
In [155]: cross_val_score(knn, X_test, y_test, cv=kf, scoring='balanced_accuracy')
```

```
/home/hexagramg/tmo/venv/lib/python3.6/site-packages/sklearn/model_selection/_vali
  estimator.fit(X_train, y_train, **fit_params)
/home/hexagramg/tmo/venv/lib/python3.6/site-packages/sklearn/model_selection/_vali
  estimator.fit(X_train, y_train, **fit_params)
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  estimator.fit(X_train, y_train, **fit_params)
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  estimator.fit(X_train, y_train, **fit_params)
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  estimator.fit(X_train, y_train, **fit_params)
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  estimator.fit(X_train, y_train, **fit_params)
/home/hexagramg/tmo/venv/lib/python3.6/site-packages/sklearn/model_selection/_vali
  estimator.fit(X_train, y_train, **fit_params)
```

```
Out[155]: array([0.83333333, 0.88888889, 0.88888889, 0.88888889, 0.83333333,
                 1.        , 1.        ])
```

```
In [156]: from sklearn.model_selection import learning_curve
          from sklearn.model_selection import validation_curve
```

```
In [212]: def val_curve():
              param_range=[1,2,3,4,5,6,7,8,9,10]
              train_scores, test_scores = validation_curve(
              KNeighborsClassifier(), X_test, y_test, param_name="n_neighbors", pa
              cv=5, scoring="accuracy", n_jobs=1)
              train_scores_mean = np.mean(train_scores, axis=1)
              train_scores_std = np.std(train_scores, axis=1)
              test_scores_mean = np.mean(test_scores, axis=1)
              test_scores_std = np.std(test_scores, axis=1)
```

```
                plt.title("Validation Curve with knn")
                plt.xlabel(r"$\gamma$")
                plt.ylabel("Score")
                plt.ylim(0.0, 1.1)
                lw = 2
                plt.semilogx(param_range, train_scores_mean, label="Training score"
                             color="darkorange", lw=lw)
                plt.fill_between(param_range, train_scores_mean - train_scores_std,
                                 train_scores_mean + train_scores_std, alpha=0.2,
                                 color="darkorange", lw=lw)
                plt.semilogx(param_range, test_scores_mean, label="Cross-validation
                             color="navy", lw=lw)
                plt.fill_between(param_range, test_scores_mean - test_scores_std,
                                 test_scores_mean + test_scores_std, alpha=0.2,
                                 color="navy", lw=lw)
                plt.legend(loc="best")
                plt.show()
```

```
In [213]: val_curve()
```

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  estimator.fit(X_train, y_train, **fit_params)
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  estimator.fit(X_train, y_train, **fit_params)
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  estimator.fit(X_train, y_train, **fit_params)
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  estimator.fit(X_train, y_train, **fit_params)
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  estimator.fit(X_train, y_train, **fit_params)
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  estimator.fit(X_train, y_train, **fit_params)
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  estimator.fit(X_train, y_train, **fit_params)
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  estimator.fit(X_train, y_train, **fit_params)
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  estimator.fit(X_train, y_train, **fit_params)
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  estimator.fit(X_train, y_train, **fit_params)
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  estimator.fit(X_train, y_train, **fit_params)
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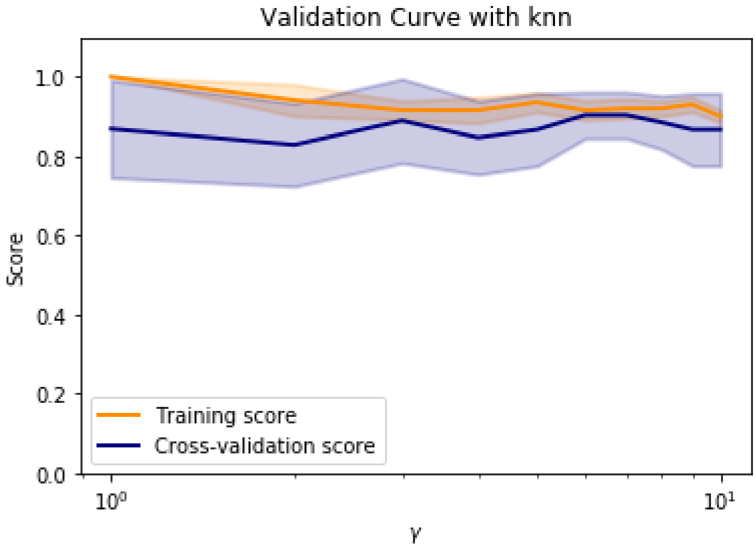
  estimator.fit(X_train, y_train, **fit_params)
```




```
In [172]: def plot_learning_curve(estimator, title, X, y, ylim=None, cv=None,
                                  n_jobs=None, train_sizes=np.linspace(.1, 1.0, 5)
              """
              Generate a simple plot of the test and training learning curve.

              Parameters
              ----------
              estimator : object type that implements the "fit" and "predict" met
                  An object of that type which is cloned for each validation.

              title : string
```

```
        Title for the chart.

    X : array-like, shape (n_samples, n_features)
        Training vector, where n_samples is the number of samples and
        n_features is the number of features.

    y : array-like, shape (n_samples) or (n_samples, n_features), optio
        Target relative to X for classification or regression;
        None for unsupervised learning.

    ylim : tuple, shape (ymin, ymax), optional
        Defines minimum and maximum yvalues plotted.

    cv : int, cross-validation generator or an iterable, optional
        Determines the cross-validation splitting strategy.
        Possible inputs for cv are:
          - None, to use the default 3-fold cross-validation,
          - integer, to specify the number of folds.
          - :term:`CV splitter`,
          - An iterable yielding (train, test) splits as arrays of indi

        For integer/None inputs, if ``y`` is binary or multiclass,
        :class:`StratifiedKFold` used. If the estimator is not a classi
        or if ``y`` is neither binary nor multiclass, :class:`KFold` is

        Refer :ref:`User Guide <cross_validation>` for the various
        cross-validators that can be used here.

    n_jobs : int or None, optional (default=None)
        Number of jobs to run in parallel.
        ``None`` means 1 unless in a :obj:`joblib.parallel_backend` con
        ``-1`` means using all processors. See :term:`Glossary <n_jobs>
        for more details.

    train_sizes : array-like, shape (n_ticks,), dtype float or int
        Relative or absolute numbers of training examples that will be
        generate the learning curve. If the dtype is float, it is regar
        fraction of the maximum size of the training set (that is deter
        by the selected validation method), i.e. it has to be within (0
        Otherwise it is interpreted as absolute sizes of the training s
        Note that for classification the number of samples usually have
        be big enough to contain at least one sample from each class.
        (default: np.linspace(0.1, 1.0, 5))
    """
    plt.figure()
    plt.title(title)
    if ylim is not None:
        plt.ylim(*ylim)
    plt.xlabel("Training examples")
    plt.ylabel("Score")
```

```
            train_sizes, train_scores, test_scores = learning_curve(
                estimator, X, y, cv=cv, n_jobs=n_jobs, train_sizes=train_sizes)
            train_scores_mean = np.mean(train_scores, axis=1)
            train_scores_std = np.std(train_scores, axis=1)
            test_scores_mean = np.mean(test_scores, axis=1)
            test_scores_std = np.std(test_scores, axis=1)
            plt.grid()

            plt.fill_between(train_sizes, train_scores_mean - train_scores_std,
                             train_scores_mean + train_scores_std, alpha=0.1,
                             color="r")
            plt.fill_between(train_sizes, test_scores_mean - test_scores_std,
                             test_scores_mean + test_scores_std, alpha=0.1, colo
            plt.plot(train_sizes, train_scores_mean, 'o-', color="r",
                     label="Training score")
            plt.plot(train_sizes, test_scores_mean, 'o-', color="g",
                     label="Cross-validation score")

            plt.legend(loc="best")
            return plt
```

In [175]:
```
len(xsh)
```

Out[175]: 150

In [210]:
```
plot_learning_curve(KNeighborsClassifier(), 'knn', xsh, ysh, train_sizes
```

```
/home/hexagramg/tmo/venv/lib/python3.6/site-packages/sklearn/model_selection/_spli
  warnings.warn(CV_WARNING, FutureWarning)
/home/hexagramg/tmo/venv/lib/python3.6/site-packages/sklearn/model_selection/_vali
  estimator.fit(X_train, y_train, **fit_params)
/home/hexagramg/tmo/venv/lib/python3.6/site-packages/sklearn/model_selection/_vali
  estimator.fit(X_train, y_train, **fit_params)
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  estimator.fit(X_train, y_train, **fit_params)
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  estimator.fit(X_train, y_train, **fit_params)
```

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  estimator.fit(X_train, y_train, **fit_params)
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  estimator.fit(X_train, y_train, **fit_params)
```

```
Out[210]: <module 'matplotlib.pyplot' from '/home/hexagramg/tmo/venv/lib/python3.6
```