Grid Search CV

Imports

In [1]:

```
import numpy as np
import pandas as pd
import seaborn as sns
import matplotlib.pyplot as plt
```

Loading Dataset

In [2]:

```
from sklearn.datasets import load_iris
```

In [3]:

```
iris = load_iris()
```

In [4]:

```
type(iris)
```

Out[4]:

```
sklearn.utils.Bunch
```

See all the keys

In [5]:

```
iris.keys()
```

Out[5]:

```
dict_keys(['data', 'target', 'frame', 'target_names', 'DESCR', 'feature_names', 'filenam
e'])
```

Description

In [6]:

```
print(iris["DESCR"])
```

```
.. _iris_dataset:

Iris plants dataset
--------------------

**Data Set Characteristics:**

    :Number of Instances: 150 (50 in each of three classes)
    :Number of Attributes: 4 numeric, predictive attributes and the class
    :Attribute Information:
        - sepal length in cm
        - sepal width in cm
        - petal length in cm
        - petal width in cm
        - class:
                - Iris-Setosa
                - Iris-Versicolour
                - Iris-Virginica

    :Summary Statistics:

    ============== ==== ==== ======= ===== ====================
                    Min  Max   Mean    SD   Class Correlation
    ============== ==== ==== ======= ===== ====================
```

```
    sepal length:   4.3  7.9   5.84   0.83    0.7826
    sepal width:    2.0  4.4   3.05   0.43   -0.4194
    petal length:   1.0  6.9   3.76   1.76    0.9490  (high!)
    petal width:    0.1  2.5   1.20   0.76    0.9565  (high!)
    ============== ==== ==== ======= ===== ====================

    :Missing Attribute Values: None
    :Class Distribution: 33.3% for each of 3 classes.
    :Creator: R.A. Fisher
    :Donor: Michael Marshall (MARSHALL%PLU@io.arc.nasa.gov)
    :Date: July, 1988

The famous Iris database, first used by Sir R.A. Fisher. The dataset is taken
from Fisher's paper. Note that it's the same as in R, but not as in the UCI
Machine Learning Repository, which has two wrong data points.

This is perhaps the best known database to be found in the
pattern recognition literature.  Fisher's paper is a classic in the field and
is referenced frequently to this day.  (See Duda & Hart, for example.)  The
data set contains 3 classes of 50 instances each, where each class refers to a
type of iris plant.  One class is linearly separable from the other 2; the
latter are NOT linearly separable from each other.

.. topic:: References

   - Fisher, R.A. "The use of multiple measurements in taxonomic problems"
     Annual Eugenics, 7, Part II, 179-188 (1936); also in "Contributions to
     Mathematical Statistics" (John Wiley, NY, 1950).
   - Duda, R.O., & Hart, P.E. (1973) Pattern Classification and Scene Analysis.
     (Q327.D83) John Wiley & Sons.  ISBN 0-471-22361-1.  See page 218.
   - Dasarathy, B.V. (1980) "Nosing Around the Neighborhood: A New System
     Structure and Classification Rule for Recognition in Partially Exposed
     Environments".  IEEE Transactions on Pattern Analysis and Machine
     Intelligence, Vol. PAMI-2, No. 1, 67-71.
   - Gates, G.W. (1972) "The Reduced Nearest Neighbor Rule".  IEEE Transactions
     on Information Theory, May 1972, 431-433.
   - See also: 1988 MLC Proceedings, 54-64.  Cheeseman et al"s AUTOCLASS II
     conceptual clustering system finds 3 classes in the data.
   - Many, many more ...
```

Data

In [7]:
```
iris["data"][:5] # Independent columns
```

Out[7]:
```
array([[5.1, 3.5, 1.4, 0.2],
       [4.9, 3. , 1.4, 0.2],
       [4.7, 3.2, 1.3, 0.2],
       [4.6, 3.1, 1.5, 0.2],
       [5. , 3.6, 1.4, 0.2]])
```

In [8]:
```
iris["feature_names"] # Column names
```

Out[8]:
```
['sepal length (cm)',
 'sepal width (cm)',
 'petal length (cm)',
 'petal width (cm)']
```

In [9]:
```
np.array(iris["target"]) # Dependent column
```

Out[9]:
```
array([0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
       0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
       0, 0, 0, 0, 0, 0, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1,
       1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1,
       1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2,
```

```
       2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2,
       2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2])
```

In [10]:

```
iris["target_names"]
# So, 0 is setosa, 1 is versicolor and 2 is virginica
```

Out[10]: `array(['setosa', 'versicolor', 'virginica'], dtype='<U10')`

Create Dataframe

In [11]:

```
df = pd.DataFrame(data=iris["data"], columns=iris["feature_names"])
df["target"] = iris["target"]
df.head()
```

Out[11]:

	sepal length (cm)	sepal width (cm)	petal length (cm)	petal width (cm)	target
0	5.1	3.5	1.4	0.2	0
1	4.9	3.0	1.4	0.2	0
2	4.7	3.2	1.3	0.2	0
3	4.6	3.1	1.5	0.2	0
4	5.0	3.6	1.4	0.2	0

In [12]:

```
df.head()
```

Out[12]:

	sepal length (cm)	sepal width (cm)	petal length (cm)	petal width (cm)	target
0	5.1	3.5	1.4	0.2	0
1	4.9	3.0	1.4	0.2	0
2	4.7	3.2	1.3	0.2	0
3	4.6	3.1	1.5	0.2	0
4	5.0	3.6	1.4	0.2	0

In [13]:

```
df["target"].unique()
```

Out[13]: `array([0, 1, 2])`

In [14]:

```
df["target"].replace(range(3), iris["target_names"], inplace=True)
```

In [15]:

```
df.head()
```

Out[15]:

	sepal length (cm)	sepal width (cm)	petal length (cm)	petal width (cm)	target
0	5.1	3.5	1.4	0.2	setosa
1	4.9	3.0	1.4	0.2	setosa
2	4.7	3.2	1.3	0.2	setosa
3	4.6	3.1	1.5	0.2	setosa

	sepal length (cm)	sepal width (cm)	petal length (cm)	petal width (cm)	target
4	5.0	3.6	1.4	0.2	setosa

In [16]:
```
df["target"].unique()
```

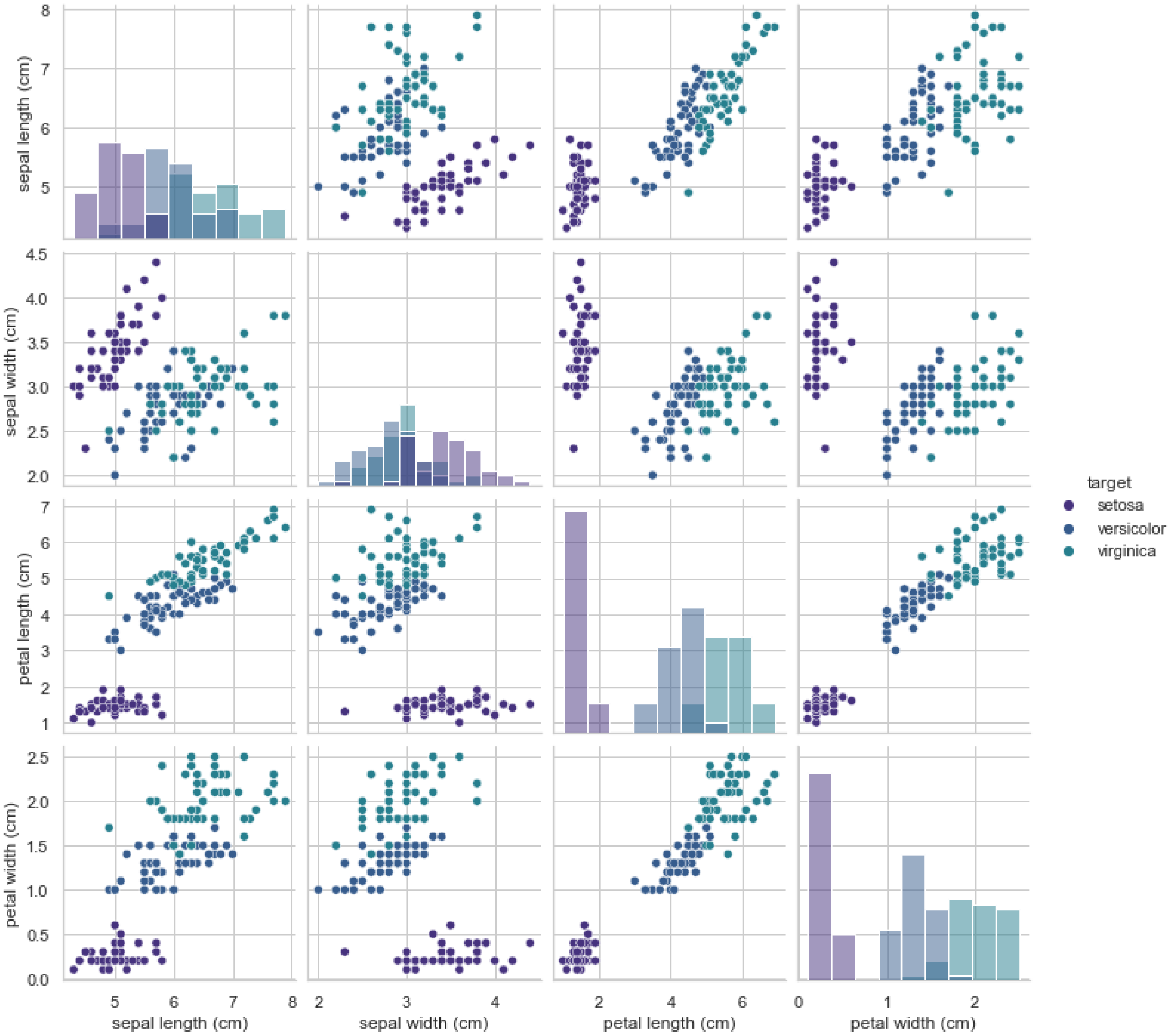
Out[16]: array(['setosa', 'versicolor', 'virginica'], dtype=object)

EDA

In [17]:
```
sns.set(style="whitegrid", palette="viridis")
```

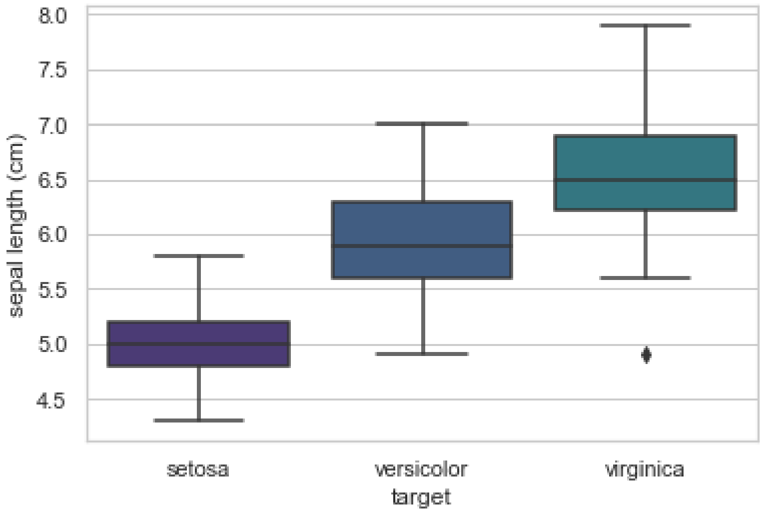
In [18]:
```
sns.pairplot(df, hue="target", diag_kind='hist')
```

Out[18]: <seaborn.axisgrid.PairGrid at 0x234a9cdc070>



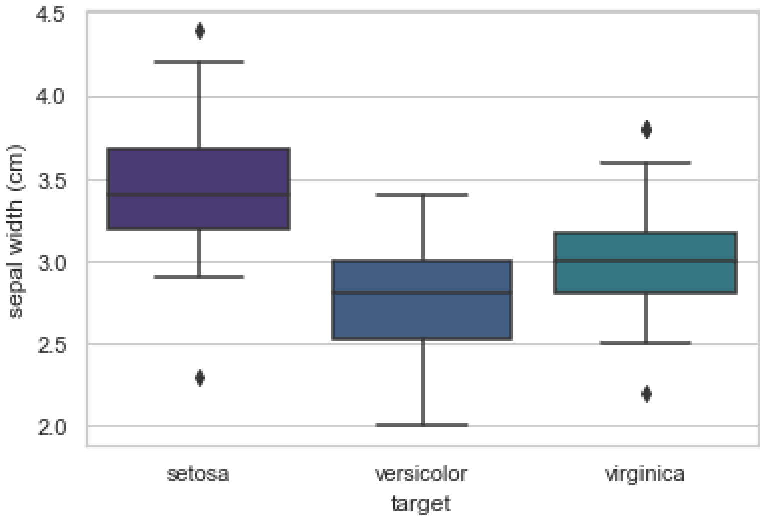
In [19]:
```
sns.boxplot(x="target", y="sepal length (cm)", data=df)
```

Out[19]: <AxesSubplot:xlabel='target', ylabel='sepal length (cm)'>



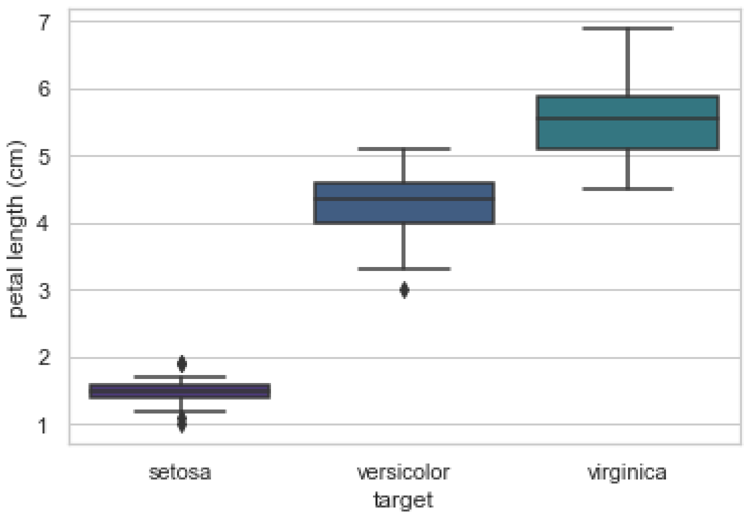
In [20]:
```
sns.boxplot(x="target", y="sepal width (cm)", data=df)
```

Out[20]: <AxesSubplot:xlabel='target', ylabel='sepal width (cm)'>



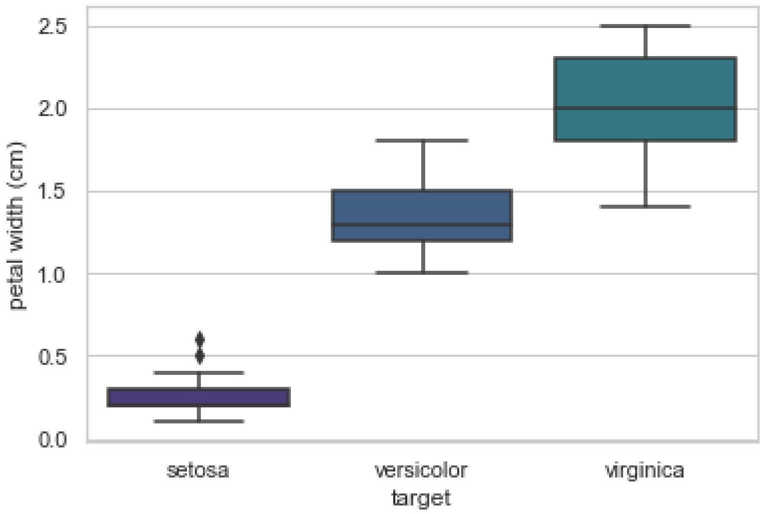
In [21]:
```
sns.boxplot(x="target", y="petal length (cm)", data=df)
```

Out[21]: <AxesSubplot:xlabel='target', ylabel='petal length (cm)'>



In [22]:
```
sns.boxplot(x="target", y="petal width (cm)", data=df)
```

Out[22]: <AxesSubplot:xlabel='target', ylabel='petal width (cm)'>



Feature Selection

In [23]:
```
df.head()
```

Out[23]:

	sepal length (cm)	sepal width (cm)	petal length (cm)	petal width (cm)	target
0	5.1	3.5	1.4	0.2	setosa
1	4.9	3.0	1.4	0.2	setosa
2	4.7	3.2	1.3	0.2	setosa
3	4.6	3.1	1.5	0.2	setosa
4	5.0	3.6	1.4	0.2	setosa

In [24]:
```
X = df.drop("target", axis=1) # Independent
y = df["target"] # Dependent
```

Train Test Split

In [25]:
```
from sklearn.model_selection import train_test_split
```

In [26]:
```
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.3, random_state=202
```

In [27]:
```
X_train[:5]
```

Out[27]:

	sepal length (cm)	sepal width (cm)	petal length (cm)	petal width (cm)
120	6.9	3.2	5.7	2.3
117	7.7	3.8	6.7	2.2
76	6.8	2.8	4.8	1.4
86	6.7	3.1	4.7	1.5
57	4.9	2.4	3.3	1.0

In [28]:
```
y_train[:5]
```

Out[28]:
```
120     virginica
117     virginica
76     versicolor
86     versicolor
57     versicolor
Name: target, dtype: object
```

Grid Search CV

Grid Search

Grid-search is used to find the optimal hyperparameters of a model which results in the most accurate predictions. Grid search builds a model for every combination of hyperparameters specified and evaluates each model.

A model hyperparameter is a characteristic of a model that is external to the model and whose value cannot be estimated from data. The value of the hyperparameter has to be set before the learning process begins. For example, c in Support Vector Machines, k in k-Nearest Neighbors, the number of hidden layers in Neural Networks.

In contrast, a parameter is an internal characteristic of the model and its value can be estimated from data. Example, beta coefficients of linear/logistic regression or support vectors in Support Vector Machines.

Cross Validation

In K Fold cross validation, the data is divided into k subsets. Now the holdout method is repeated k times, such that each time, one of the k subsets is used as the test set/ validation set and the other k-1 subsets are put together to form a training set. The error estimation is averaged over all k trials to get total effectiveness of our model. As can be seen, every data point gets to be in a validation set exactly once, and gets to be in a training set k-1 times. This significantly reduces bias as we are using most of the data for fitting, and also significantly reduces variance as most of the data is also being used in validation set. Interchanging the training and test sets also adds to the effectiveness of this method. As a general rule and empirical evidence, K = 5 or 10 is generally preferred, but nothing’s fixed and it can take any value.

In [29]:
```
from sklearn.model_selection import GridSearchCV
from sklearn.svm import SVC
```

In [30]:
```
print(SVC().get_params().keys())
```

```
dict_keys(['C', 'break_ties', 'cache_size', 'class_weight', 'coef0', 'decision_function_s
hape', 'degree', 'gamma', 'kernel', 'max_iter', 'probability', 'random_state', 'shrinkin
g', 'tol', 'verbose'])
```

In [31]:
```
params = {
    'C': [0.01, 0.1, 1, 10, 100],
    'gamma': [0.01, 0.1, 1, 10, 100],
    'kernel': ['linear', 'rbf', 'poly']
}
```

In [32]:
```
grid = GridSearchCV(SVC(), params, verbose=2)
# 1st param: Sklearn model
# 2nd param: dictionary of model hyperparameter values
# verbose -> Higher verbose will give more information in output
```

In [33]:
```
grid.fit(X_train, y_train)
```

```
Fitting 5 folds for each of 75 candidates, totalling 375 fits
[CV] END ..................C=0.01, gamma=0.01, kernel=linear; total time=   0.0s
[CV] END ..................C=0.01, gamma=0.01, kernel=linear; total time=   0.0s
[CV] END ..................C=0.01, gamma=0.01, kernel=linear; total time=   0.0s
[CV] END ..................C=0.01, gamma=0.01, kernel=linear; total time=   0.0s
[CV] END ..................C=0.01, gamma=0.01, kernel=linear; total time=   0.0s
[CV] END .....................C=0.01, gamma=0.01, kernel=rbf; total time=   0.0s
[CV] END .....................C=0.01, gamma=0.01, kernel=rbf; total time=   0.0s
[CV] END .....................C=0.01, gamma=0.01, kernel=rbf; total time=   0.0s
[CV] END .....................C=0.01, gamma=0.01, kernel=rbf; total time=   0.0s
[CV] END .....................C=0.01, gamma=0.01, kernel=rbf; total time=   0.0s
[CV] END ....................C=0.01, gamma=0.01, kernel=poly; total time=   0.0s
[CV] END ....................C=0.01, gamma=0.01, kernel=poly; total time=   0.0s
[CV] END ....................C=0.01, gamma=0.01, kernel=poly; total time=   0.0s
[CV] END ....................C=0.01, gamma=0.01, kernel=poly; total time=   0.0s
[CV] END ....................C=0.01, gamma=0.01, kernel=poly; total time=   0.0s
[CV] END ...................C=0.01, gamma=0.1, kernel=linear; total time=   0.0s
[CV] END ...................C=0.01, gamma=0.1, kernel=linear; total time=   0.0s
[CV] END ...................C=0.01, gamma=0.1, kernel=linear; total time=   0.0s
[CV] END ...................C=0.01, gamma=0.1, kernel=linear; total time=   0.0s
[CV] END ...................C=0.01, gamma=0.1, kernel=linear; total time=   0.0s
[CV] END ......................C=0.01, gamma=0.1, kernel=rbf; total time=   0.0s
[CV] END ......................C=0.01, gamma=0.1, kernel=rbf; total time=   0.0s
[CV] END ......................C=0.01, gamma=0.1, kernel=rbf; total time=   0.0s
[CV] END ......................C=0.01, gamma=0.1, kernel=rbf; total time=   0.0s
[CV] END ......................C=0.01, gamma=0.1, kernel=rbf; total time=   0.0s
[CV] END .....................C=0.01, gamma=0.1, kernel=poly; total time=   0.0s
[CV] END .....................C=0.01, gamma=0.1, kernel=poly; total time=   0.0s
[CV] END .....................C=0.01, gamma=0.1, kernel=poly; total time=   0.0s
[CV] END .....................C=0.01, gamma=0.1, kernel=poly; total time=   0.0s
[CV] END .....................C=0.01, gamma=0.1, kernel=poly; total time=   0.0s
[CV] END .....................C=0.01, gamma=1, kernel=linear; total time=   0.0s
[CV] END .....................C=0.01, gamma=1, kernel=linear; total time=   0.0s
[CV] END .....................C=0.01, gamma=1, kernel=linear; total time=   0.0s
[CV] END .....................C=0.01, gamma=1, kernel=linear; total time=   0.0s
[CV] END .....................C=0.01, gamma=1, kernel=linear; total time=   0.0s
[CV] END ........................C=0.01, gamma=1, kernel=rbf; total time=   0.0s
[CV] END ........................C=0.01, gamma=1, kernel=rbf; total time=   0.0s
[CV] END ........................C=0.01, gamma=1, kernel=rbf; total time=   0.0s
[CV] END ........................C=0.01, gamma=1, kernel=rbf; total time=   0.0s
[CV] END ........................C=0.01, gamma=1, kernel=rbf; total time=   0.0s
[CV] END .......................C=0.01, gamma=1, kernel=poly; total time=   0.0s
[CV] END .......................C=0.01, gamma=1, kernel=poly; total time=   0.0s
[CV] END .......................C=0.01, gamma=1, kernel=poly; total time=   0.0s
[CV] END .......................C=0.01, gamma=1, kernel=poly; total time=   0.0s
[CV] END .......................C=0.01, gamma=1, kernel=poly; total time=   0.0s
[CV] END ....................C=0.01, gamma=10, kernel=linear; total time=   0.0s
[CV] END ....................C=0.01, gamma=10, kernel=linear; total time=   0.0s
[CV] END ....................C=0.01, gamma=10, kernel=linear; total time=   0.0s
[CV] END ....................C=0.01, gamma=10, kernel=linear; total time=   0.0s
[CV] END ....................C=0.01, gamma=10, kernel=linear; total time=   0.0s
[CV] END .......................C=0.01, gamma=10, kernel=rbf; total time=   0.0s
[CV] END .......................C=0.01, gamma=10, kernel=rbf; total time=   0.0s
[CV] END .......................C=0.01, gamma=10, kernel=rbf; total time=   0.0s
[CV] END .......................C=0.01, gamma=10, kernel=rbf; total time=   0.0s
[CV] END .......................C=0.01, gamma=10, kernel=rbf; total time=   0.0s
[CV] END ......................C=0.01, gamma=10, kernel=poly; total time=   0.0s
[CV] END ......................C=0.01, gamma=10, kernel=poly; total time=   0.0s
[CV] END ......................C=0.01, gamma=10, kernel=poly; total time=   0.0s
[CV] END ......................C=0.01, gamma=10, kernel=poly; total time=   0.0s
```

```
[CV] END ......................C=0.01, gamma=10, kernel=poly; total time=   0.0s
[CV] END ...................C=0.01, gamma=100, kernel=linear; total time=   0.0s
[CV] END ...................C=0.01, gamma=100, kernel=linear; total time=   0.0s
[CV] END ...................C=0.01, gamma=100, kernel=linear; total time=   0.0s
[CV] END ...................C=0.01, gamma=100, kernel=linear; total time=   0.0s
[CV] END ...................C=0.01, gamma=100, kernel=linear; total time=   0.0s
[CV] END ......................C=0.01, gamma=100, kernel=rbf; total time=   0.0s
[CV] END ......................C=0.01, gamma=100, kernel=rbf; total time=   0.0s
[CV] END ......................C=0.01, gamma=100, kernel=rbf; total time=   0.0s
[CV] END ......................C=0.01, gamma=100, kernel=rbf; total time=   0.0s
[CV] END ......................C=0.01, gamma=100, kernel=rbf; total time=   0.0s
[CV] END .....................C=0.01, gamma=100, kernel=poly; total time=   0.0s
[CV] END .....................C=0.01, gamma=100, kernel=poly; total time=   0.0s
[CV] END .....................C=0.01, gamma=100, kernel=poly; total time=   0.0s
[CV] END .....................C=0.01, gamma=100, kernel=poly; total time=   0.0s
[CV] END .....................C=0.01, gamma=100, kernel=poly; total time=   0.0s
[CV] END ...................C=0.1, gamma=0.01, kernel=linear; total time=   0.0s
[CV] END ...................C=0.1, gamma=0.01, kernel=linear; total time=   0.0s
[CV] END ...................C=0.1, gamma=0.01, kernel=linear; total time=   0.0s
[CV] END ...................C=0.1, gamma=0.01, kernel=linear; total time=   0.0s
[CV] END ...................C=0.1, gamma=0.01, kernel=linear; total time=   0.0s
[CV] END ......................C=0.1, gamma=0.01, kernel=rbf; total time=   0.0s
[CV] END ......................C=0.1, gamma=0.01, kernel=rbf; total time=   0.0s
[CV] END ......................C=0.1, gamma=0.01, kernel=rbf; total time=   0.0s
[CV] END ......................C=0.1, gamma=0.01, kernel=rbf; total time=   0.0s
[CV] END ......................C=0.1, gamma=0.01, kernel=rbf; total time=   0.0s
[CV] END .....................C=0.1, gamma=0.01, kernel=poly; total time=   0.0s
[CV] END .....................C=0.1, gamma=0.01, kernel=poly; total time=   0.0s
[CV] END .....................C=0.1, gamma=0.01, kernel=poly; total time=   0.0s
[CV] END .....................C=0.1, gamma=0.01, kernel=poly; total time=   0.0s
[CV] END .....................C=0.1, gamma=0.01, kernel=poly; total time=   0.0s
[CV] END ....................C=0.1, gamma=0.1, kernel=linear; total time=   0.0s
[CV] END ....................C=0.1, gamma=0.1, kernel=linear; total time=   0.0s
[CV] END ....................C=0.1, gamma=0.1, kernel=linear; total time=   0.0s
[CV] END ....................C=0.1, gamma=0.1, kernel=linear; total time=   0.0s
[CV] END ....................C=0.1, gamma=0.1, kernel=linear; total time=   0.0s
[CV] END .......................C=0.1, gamma=0.1, kernel=rbf; total time=   0.0s
[CV] END .......................C=0.1, gamma=0.1, kernel=rbf; total time=   0.0s
[CV] END .......................C=0.1, gamma=0.1, kernel=rbf; total time=   0.0s
[CV] END .......................C=0.1, gamma=0.1, kernel=rbf; total time=   0.0s
[CV] END .......................C=0.1, gamma=0.1, kernel=rbf; total time=   0.0s
[CV] END ......................C=0.1, gamma=0.1, kernel=poly; total time=   0.0s
[CV] END ......................C=0.1, gamma=0.1, kernel=poly; total time=   0.0s
[CV] END ......................C=0.1, gamma=0.1, kernel=poly; total time=   0.0s
[CV] END ......................C=0.1, gamma=0.1, kernel=poly; total time=   0.0s
[CV] END ......................C=0.1, gamma=0.1, kernel=poly; total time=   0.0s
[CV] END ......................C=0.1, gamma=1, kernel=linear; total time=   0.0s
[CV] END ......................C=0.1, gamma=1, kernel=linear; total time=   0.0s
[CV] END ......................C=0.1, gamma=1, kernel=linear; total time=   0.0s
[CV] END ......................C=0.1, gamma=1, kernel=linear; total time=   0.0s
[CV] END ......................C=0.1, gamma=1, kernel=linear; total time=   0.0s
[CV] END .........................C=0.1, gamma=1, kernel=rbf; total time=   0.0s
[CV] END .........................C=0.1, gamma=1, kernel=rbf; total time=   0.0s
[CV] END .........................C=0.1, gamma=1, kernel=rbf; total time=   0.0s
[CV] END .........................C=0.1, gamma=1, kernel=rbf; total time=   0.0s
[CV] END .........................C=0.1, gamma=1, kernel=rbf; total time=   0.0s
[CV] END ........................C=0.1, gamma=1, kernel=poly; total time=   0.0s
[CV] END ........................C=0.1, gamma=1, kernel=poly; total time=   0.0s
[CV] END ........................C=0.1, gamma=1, kernel=poly; total time=   0.0s
[CV] END ........................C=0.1, gamma=1, kernel=poly; total time=   0.0s
[CV] END ........................C=0.1, gamma=1, kernel=poly; total time=   0.0s
[CV] END .....................C=0.1, gamma=10, kernel=linear; total time=   0.0s
[CV] END .....................C=0.1, gamma=10, kernel=linear; total time=   0.0s
[CV] END .....................C=0.1, gamma=10, kernel=linear; total time=   0.0s
[CV] END .....................C=0.1, gamma=10, kernel=linear; total time=   0.0s
[CV] END .....................C=0.1, gamma=10, kernel=linear; total time=   0.0s
[CV] END ........................C=0.1, gamma=10, kernel=rbf; total time=   0.0s
[CV] END ........................C=0.1, gamma=10, kernel=rbf; total time=   0.0s
[CV] END ........................C=0.1, gamma=10, kernel=rbf; total time=   0.0s
```

```
[CV] END ........................C=0.1, gamma=10, kernel=rbf; total time=   0.0s
[CV] END ........................C=0.1, gamma=10, kernel=rbf; total time=   0.0s
[CV] END .......................C=0.1, gamma=10, kernel=poly; total time=   0.0s
[CV] END .......................C=0.1, gamma=10, kernel=poly; total time=   0.0s
[CV] END .......................C=0.1, gamma=10, kernel=poly; total time=   0.0s
[CV] END .......................C=0.1, gamma=10, kernel=poly; total time=   0.0s
[CV] END .......................C=0.1, gamma=10, kernel=poly; total time=   0.0s
[CV] END ....................C=0.1, gamma=100, kernel=linear; total time=   0.0s
[CV] END ....................C=0.1, gamma=100, kernel=linear; total time=   0.0s
[CV] END ....................C=0.1, gamma=100, kernel=linear; total time=   0.0s
[CV] END ....................C=0.1, gamma=100, kernel=linear; total time=   0.0s
[CV] END ....................C=0.1, gamma=100, kernel=linear; total time=   0.0s
[CV] END .......................C=0.1, gamma=100, kernel=rbf; total time=   0.0s
[CV] END .......................C=0.1, gamma=100, kernel=rbf; total time=   0.0s
[CV] END .......................C=0.1, gamma=100, kernel=rbf; total time=   0.0s
[CV] END .......................C=0.1, gamma=100, kernel=rbf; total time=   0.0s
[CV] END .......................C=0.1, gamma=100, kernel=rbf; total time=   0.0s
[CV] END ......................C=0.1, gamma=100, kernel=poly; total time=   0.0s
[CV] END ......................C=0.1, gamma=100, kernel=poly; total time=   0.0s
[CV] END ......................C=0.1, gamma=100, kernel=poly; total time=   0.0s
[CV] END ......................C=0.1, gamma=100, kernel=poly; total time=   0.0s
[CV] END ......................C=0.1, gamma=100, kernel=poly; total time=   0.0s
[CV] END .....................C=1, gamma=0.01, kernel=linear; total time=   0.0s
[CV] END .....................C=1, gamma=0.01, kernel=linear; total time=   0.0s
[CV] END .....................C=1, gamma=0.01, kernel=linear; total time=   0.0s
[CV] END .....................C=1, gamma=0.01, kernel=linear; total time=   0.0s
[CV] END .....................C=1, gamma=0.01, kernel=linear; total time=   0.0s
[CV] END ........................C=1, gamma=0.01, kernel=rbf; total time=   0.0s
[CV] END ........................C=1, gamma=0.01, kernel=rbf; total time=   0.0s
[CV] END ........................C=1, gamma=0.01, kernel=rbf; total time=   0.0s
[CV] END ........................C=1, gamma=0.01, kernel=rbf; total time=   0.0s
[CV] END ........................C=1, gamma=0.01, kernel=rbf; total time=   0.0s
[CV] END .......................C=1, gamma=0.01, kernel=poly; total time=   0.0s
[CV] END .......................C=1, gamma=0.01, kernel=poly; total time=   0.0s
[CV] END .......................C=1, gamma=0.01, kernel=poly; total time=   0.0s
[CV] END .......................C=1, gamma=0.01, kernel=poly; total time=   0.0s
[CV] END .......................C=1, gamma=0.01, kernel=poly; total time=   0.0s
[CV] END ......................C=1, gamma=0.1, kernel=linear; total time=   0.0s
[CV] END ......................C=1, gamma=0.1, kernel=linear; total time=   0.0s
[CV] END ......................C=1, gamma=0.1, kernel=linear; total time=   0.0s
[CV] END ......................C=1, gamma=0.1, kernel=linear; total time=   0.0s
[CV] END ......................C=1, gamma=0.1, kernel=linear; total time=   0.0s
[CV] END .........................C=1, gamma=0.1, kernel=rbf; total time=   0.0s
[CV] END .........................C=1, gamma=0.1, kernel=rbf; total time=   0.0s
[CV] END .........................C=1, gamma=0.1, kernel=rbf; total time=   0.0s
[CV] END .........................C=1, gamma=0.1, kernel=rbf; total time=   0.0s
[CV] END .........................C=1, gamma=0.1, kernel=rbf; total time=   0.0s
[CV] END ........................C=1, gamma=0.1, kernel=poly; total time=   0.0s
[CV] END ........................C=1, gamma=0.1, kernel=poly; total time=   0.0s
[CV] END ........................C=1, gamma=0.1, kernel=poly; total time=   0.0s
[CV] END ........................C=1, gamma=0.1, kernel=poly; total time=   0.0s
[CV] END ........................C=1, gamma=0.1, kernel=poly; total time=   0.0s
[CV] END ........................C=1, gamma=1, kernel=linear; total time=   0.0s
[CV] END ........................C=1, gamma=1, kernel=linear; total time=   0.0s
[CV] END ........................C=1, gamma=1, kernel=linear; total time=   0.0s
[CV] END ........................C=1, gamma=1, kernel=linear; total time=   0.0s
[CV] END ........................C=1, gamma=1, kernel=linear; total time=   0.0s
[CV] END ...........................C=1, gamma=1, kernel=rbf; total time=   0.0s
[CV] END ...........................C=1, gamma=1, kernel=rbf; total time=   0.0s
[CV] END ...........................C=1, gamma=1, kernel=rbf; total time=   0.0s
[CV] END ...........................C=1, gamma=1, kernel=rbf; total time=   0.0s
[CV] END ...........................C=1, gamma=1, kernel=rbf; total time=   0.0s
[CV] END ..........................C=1, gamma=1, kernel=poly; total time=   0.0s
[CV] END ..........................C=1, gamma=1, kernel=poly; total time=   0.0s
[CV] END ..........................C=1, gamma=1, kernel=poly; total time=   0.0s
[CV] END ..........................C=1, gamma=1, kernel=poly; total time=   0.0s
[CV] END ..........................C=1, gamma=1, kernel=poly; total time=   0.0s
[CV] END .......................C=1, gamma=10, kernel=linear; total time=   0.0s
[CV] END .......................C=1, gamma=10, kernel=linear; total time=   0.0s
```

```
[CV] END .......................C=1, gamma=10, kernel=linear; total time=   0.0s
[CV] END .......................C=1, gamma=10, kernel=linear; total time=   0.0s
[CV] END .......................C=1, gamma=10, kernel=linear; total time=   0.0s
[CV] END ..........................C=1, gamma=10, kernel=rbf; total time=   0.0s
[CV] END ..........................C=1, gamma=10, kernel=rbf; total time=   0.0s
[CV] END ..........................C=1, gamma=10, kernel=rbf; total time=   0.0s
[CV] END ..........................C=1, gamma=10, kernel=rbf; total time=   0.0s
[CV] END ..........................C=1, gamma=10, kernel=rbf; total time=   0.0s
[CV] END .........................C=1, gamma=10, kernel=poly; total time=   0.0s
[CV] END .........................C=1, gamma=10, kernel=poly; total time=   0.0s
[CV] END .........................C=1, gamma=10, kernel=poly; total time=   0.0s
[CV] END .........................C=1, gamma=10, kernel=poly; total time=   0.0s
[CV] END .........................C=1, gamma=10, kernel=poly; total time=   0.0s
[CV] END ......................C=1, gamma=100, kernel=linear; total time=   0.0s
[CV] END ......................C=1, gamma=100, kernel=linear; total time=   0.0s
[CV] END ......................C=1, gamma=100, kernel=linear; total time=   0.0s
[CV] END ......................C=1, gamma=100, kernel=linear; total time=   0.0s
[CV] END ......................C=1, gamma=100, kernel=linear; total time=   0.0s
[CV] END .........................C=1, gamma=100, kernel=rbf; total time=   0.0s
[CV] END .........................C=1, gamma=100, kernel=rbf; total time=   0.0s
[CV] END .........................C=1, gamma=100, kernel=rbf; total time=   0.0s
[CV] END .........................C=1, gamma=100, kernel=rbf; total time=   0.0s
[CV] END .........................C=1, gamma=100, kernel=rbf; total time=   0.0s
[CV] END ........................C=1, gamma=100, kernel=poly; total time=   0.0s
[CV] END ........................C=1, gamma=100, kernel=poly; total time=   0.0s
[CV] END ........................C=1, gamma=100, kernel=poly; total time=   0.0s
[CV] END ........................C=1, gamma=100, kernel=poly; total time=   0.0s
[CV] END ........................C=1, gamma=100, kernel=poly; total time=   0.0s
[CV] END ....................C=10, gamma=0.01, kernel=linear; total time=   0.0s
[CV] END ....................C=10, gamma=0.01, kernel=linear; total time=   0.0s
[CV] END ....................C=10, gamma=0.01, kernel=linear; total time=   0.0s
[CV] END ....................C=10, gamma=0.01, kernel=linear; total time=   0.0s
[CV] END ....................C=10, gamma=0.01, kernel=linear; total time=   0.0s
[CV] END .......................C=10, gamma=0.01, kernel=rbf; total time=   0.0s
[CV] END .......................C=10, gamma=0.01, kernel=rbf; total time=   0.0s
[CV] END .......................C=10, gamma=0.01, kernel=rbf; total time=   0.0s
[CV] END .......................C=10, gamma=0.01, kernel=rbf; total time=   0.0s
[CV] END .......................C=10, gamma=0.01, kernel=rbf; total time=   0.0s
[CV] END ......................C=10, gamma=0.01, kernel=poly; total time=   0.0s
[CV] END ......................C=10, gamma=0.01, kernel=poly; total time=   0.0s
[CV] END ......................C=10, gamma=0.01, kernel=poly; total time=   0.0s
[CV] END ......................C=10, gamma=0.01, kernel=poly; total time=   0.0s
[CV] END ......................C=10, gamma=0.01, kernel=poly; total time=   0.0s
[CV] END .....................C=10, gamma=0.1, kernel=linear; total time=   0.0s
[CV] END .....................C=10, gamma=0.1, kernel=linear; total time=   0.0s
[CV] END .....................C=10, gamma=0.1, kernel=linear; total time=   0.0s
[CV] END .....................C=10, gamma=0.1, kernel=linear; total time=   0.0s
[CV] END .....................C=10, gamma=0.1, kernel=linear; total time=   0.0s
[CV] END ........................C=10, gamma=0.1, kernel=rbf; total time=   0.0s
[CV] END ........................C=10, gamma=0.1, kernel=rbf; total time=   0.0s
[CV] END ........................C=10, gamma=0.1, kernel=rbf; total time=   0.0s
[CV] END ........................C=10, gamma=0.1, kernel=rbf; total time=   0.0s
[CV] END ........................C=10, gamma=0.1, kernel=rbf; total time=   0.0s
[CV] END .......................C=10, gamma=0.1, kernel=poly; total time=   0.0s
[CV] END .......................C=10, gamma=0.1, kernel=poly; total time=   0.0s
[CV] END .......................C=10, gamma=0.1, kernel=poly; total time=   0.0s
[CV] END .......................C=10, gamma=0.1, kernel=poly; total time=   0.0s
[CV] END .......................C=10, gamma=0.1, kernel=poly; total time=   0.0s
[CV] END .......................C=10, gamma=1, kernel=linear; total time=   0.0s
[CV] END .......................C=10, gamma=1, kernel=linear; total time=   0.0s
[CV] END .......................C=10, gamma=1, kernel=linear; total time=   0.0s
[CV] END .......................C=10, gamma=1, kernel=linear; total time=   0.0s
[CV] END .......................C=10, gamma=1, kernel=linear; total time=   0.0s
[CV] END ..........................C=10, gamma=1, kernel=rbf; total time=   0.0s
[CV] END ..........................C=10, gamma=1, kernel=rbf; total time=   0.0s
[CV] END ..........................C=10, gamma=1, kernel=rbf; total time=   0.0s
[CV] END ..........................C=10, gamma=1, kernel=rbf; total time=   0.0s
[CV] END ..........................C=10, gamma=1, kernel=rbf; total time=   0.0s
[CV] END .........................C=10, gamma=1, kernel=poly; total time=   0.0s
```

```
[CV] END .........................C=10, gamma=1, kernel=poly; total time=   0.0s
[CV] END .........................C=10, gamma=1, kernel=poly; total time=   0.0s
[CV] END .........................C=10, gamma=1, kernel=poly; total time=   0.0s
[CV] END .........................C=10, gamma=1, kernel=poly; total time=   0.0s
[CV] END ......................C=10, gamma=10, kernel=linear; total time=   0.0s
[CV] END ......................C=10, gamma=10, kernel=linear; total time=   0.0s
[CV] END ......................C=10, gamma=10, kernel=linear; total time=   0.0s
[CV] END ......................C=10, gamma=10, kernel=linear; total time=   0.0s
[CV] END ......................C=10, gamma=10, kernel=linear; total time=   0.0s
[CV] END .........................C=10, gamma=10, kernel=rbf; total time=   0.0s
[CV] END .........................C=10, gamma=10, kernel=rbf; total time=   0.0s
[CV] END .........................C=10, gamma=10, kernel=rbf; total time=   0.0s
[CV] END .........................C=10, gamma=10, kernel=rbf; total time=   0.0s
[CV] END .........................C=10, gamma=10, kernel=rbf; total time=   0.0s
[CV] END ........................C=10, gamma=10, kernel=poly; total time=   0.0s
[CV] END ........................C=10, gamma=10, kernel=poly; total time=   0.0s
[CV] END ........................C=10, gamma=10, kernel=poly; total time=   0.0s
[CV] END ........................C=10, gamma=10, kernel=poly; total time=   0.0s
[CV] END ........................C=10, gamma=10, kernel=poly; total time=   0.0s
[CV] END .....................C=10, gamma=100, kernel=linear; total time=   0.0s
[CV] END .....................C=10, gamma=100, kernel=linear; total time=   0.0s
[CV] END .....................C=10, gamma=100, kernel=linear; total time=   0.0s
[CV] END .....................C=10, gamma=100, kernel=linear; total time=   0.0s
[CV] END .....................C=10, gamma=100, kernel=linear; total time=   0.0s
[CV] END ........................C=10, gamma=100, kernel=rbf; total time=   0.0s
[CV] END ........................C=10, gamma=100, kernel=rbf; total time=   0.0s
[CV] END ........................C=10, gamma=100, kernel=rbf; total time=   0.0s
[CV] END ........................C=10, gamma=100, kernel=rbf; total time=   0.0s
[CV] END ........................C=10, gamma=100, kernel=rbf; total time=   0.0s
[CV] END .......................C=10, gamma=100, kernel=poly; total time=   0.0s
[CV] END .......................C=10, gamma=100, kernel=poly; total time=   0.0s
[CV] END .......................C=10, gamma=100, kernel=poly; total time=   0.0s
[CV] END .......................C=10, gamma=100, kernel=poly; total time=   0.0s
[CV] END .......................C=10, gamma=100, kernel=poly; total time=   0.0s
[CV] END ...................C=100, gamma=0.01, kernel=linear; total time=   0.0s
[CV] END ...................C=100, gamma=0.01, kernel=linear; total time=   0.0s
[CV] END ...................C=100, gamma=0.01, kernel=linear; total time=   0.0s
[CV] END ...................C=100, gamma=0.01, kernel=linear; total time=   0.0s
[CV] END ...................C=100, gamma=0.01, kernel=linear; total time=   0.0s
[CV] END ......................C=100, gamma=0.01, kernel=rbf; total time=   0.0s
[CV] END ......................C=100, gamma=0.01, kernel=rbf; total time=   0.0s
[CV] END ......................C=100, gamma=0.01, kernel=rbf; total time=   0.0s
[CV] END ......................C=100, gamma=0.01, kernel=rbf; total time=   0.0s
[CV] END ......................C=100, gamma=0.01, kernel=rbf; total time=   0.0s
[CV] END .....................C=100, gamma=0.01, kernel=poly; total time=   0.0s
[CV] END .....................C=100, gamma=0.01, kernel=poly; total time=   0.0s
[CV] END .....................C=100, gamma=0.01, kernel=poly; total time=   0.0s
[CV] END .....................C=100, gamma=0.01, kernel=poly; total time=   0.0s
[CV] END .....................C=100, gamma=0.01, kernel=poly; total time=   0.0s
[CV] END ....................C=100, gamma=0.1, kernel=linear; total time=   0.0s
[CV] END ....................C=100, gamma=0.1, kernel=linear; total time=   0.0s
[CV] END ....................C=100, gamma=0.1, kernel=linear; total time=   0.0s
[CV] END ....................C=100, gamma=0.1, kernel=linear; total time=   0.0s
[CV] END ....................C=100, gamma=0.1, kernel=linear; total time=   0.0s
[CV] END .......................C=100, gamma=0.1, kernel=rbf; total time=   0.0s
[CV] END .......................C=100, gamma=0.1, kernel=rbf; total time=   0.0s
[CV] END .......................C=100, gamma=0.1, kernel=rbf; total time=   0.0s
[CV] END .......................C=100, gamma=0.1, kernel=rbf; total time=   0.0s
[CV] END .......................C=100, gamma=0.1, kernel=rbf; total time=   0.0s
[CV] END ......................C=100, gamma=0.1, kernel=poly; total time=   0.0s
[CV] END ......................C=100, gamma=0.1, kernel=poly; total time=   0.0s
[CV] END ......................C=100, gamma=0.1, kernel=poly; total time=   0.0s
[CV] END ......................C=100, gamma=0.1, kernel=poly; total time=   0.0s
[CV] END ......................C=100, gamma=0.1, kernel=poly; total time=   0.0s
[CV] END ......................C=100, gamma=1, kernel=linear; total time=   0.0s
[CV] END ......................C=100, gamma=1, kernel=linear; total time=   0.0s
[CV] END ......................C=100, gamma=1, kernel=linear; total time=   0.0s
[CV] END ......................C=100, gamma=1, kernel=linear; total time=   0.0s
[CV] END ......................C=100, gamma=1, kernel=linear; total time=   0.0s
```

```
[CV] END .........................C=100, gamma=1, kernel=rbf; total time=   0.0s
[CV] END .........................C=100, gamma=1, kernel=rbf; total time=   0.0s
[CV] END .........................C=100, gamma=1, kernel=rbf; total time=   0.0s
[CV] END .........................C=100, gamma=1, kernel=rbf; total time=   0.0s
[CV] END .........................C=100, gamma=1, kernel=rbf; total time=   0.0s
[CV] END ........................C=100, gamma=1, kernel=poly; total time=   0.0s
[CV] END ........................C=100, gamma=1, kernel=poly; total time=   0.0s
[CV] END ........................C=100, gamma=1, kernel=poly; total time=   0.0s
[CV] END ........................C=100, gamma=1, kernel=poly; total time=   0.0s
[CV] END ........................C=100, gamma=1, kernel=poly; total time=   0.0s
[CV] END .....................C=100, gamma=10, kernel=linear; total time=   0.0s
[CV] END .....................C=100, gamma=10, kernel=linear; total time=   0.0s
[CV] END .....................C=100, gamma=10, kernel=linear; total time=   0.0s
[CV] END .....................C=100, gamma=10, kernel=linear; total time=   0.0s
[CV] END .....................C=100, gamma=10, kernel=linear; total time=   0.0s
[CV] END ........................C=100, gamma=10, kernel=rbf; total time=   0.0s
[CV] END ........................C=100, gamma=10, kernel=rbf; total time=   0.0s
[CV] END ........................C=100, gamma=10, kernel=rbf; total time=   0.0s
[CV] END ........................C=100, gamma=10, kernel=rbf; total time=   0.0s
[CV] END ........................C=100, gamma=10, kernel=rbf; total time=   0.0s
[CV] END .......................C=100, gamma=10, kernel=poly; total time=   0.0s
[CV] END .......................C=100, gamma=10, kernel=poly; total time=   0.0s
[CV] END .......................C=100, gamma=10, kernel=poly; total time=   0.0s
[CV] END .......................C=100, gamma=10, kernel=poly; total time=   0.0s
[CV] END .......................C=100, gamma=10, kernel=poly; total time=   0.0s
[CV] END ....................C=100, gamma=100, kernel=linear; total time=   0.0s
[CV] END ....................C=100, gamma=100, kernel=linear; total time=   0.0s
[CV] END ....................C=100, gamma=100, kernel=linear; total time=   0.0s
[CV] END ....................C=100, gamma=100, kernel=linear; total time=   0.0s
[CV] END ....................C=100, gamma=100, kernel=linear; total time=   0.0s
[CV] END .......................C=100, gamma=100, kernel=rbf; total time=   0.0s
[CV] END .......................C=100, gamma=100, kernel=rbf; total time=   0.0s
[CV] END .......................C=100, gamma=100, kernel=rbf; total time=   0.0s
[CV] END .......................C=100, gamma=100, kernel=rbf; total time=   0.0s
[CV] END .......................C=100, gamma=100, kernel=rbf; total time=   0.0s
[CV] END ......................C=100, gamma=100, kernel=poly; total time=   0.0s
[CV] END ......................C=100, gamma=100, kernel=poly; total time=   0.0s
[CV] END ......................C=100, gamma=100, kernel=poly; total time=   0.0s
[CV] END ......................C=100, gamma=100, kernel=poly; total time=   0.0s
[CV] END ......................C=100, gamma=100, kernel=poly; total time=   0.0s
```

Out[33]:

```
GridSearchCV(estimator=SVC(),
             param_grid={'C': [0.01, 0.1, 1, 10, 100],
                         'gamma': [0.01, 0.1, 1, 10, 100],
                         'kernel': ['linear', 'rbf', 'poly']},
             verbose=2)
```

In [34]:

```
grid.best_params_
```

Out[34]:

```
{'C': 0.1, 'gamma': 1, 'kernel': 'rbf'}
```

In [35]:

```
grid_pred = grid.predict(X_test)
# The grid model has been fitted with the best combination as seen above
# We can directly predict without fitting again as refit=True by default in GridSearchCV
```

In [36]:

```
from sklearn.metrics import classification_report, confusion_matrix
```

In [37]:

```
print(confusion_matrix(y_test, grid_pred))
print(classification_report(y_test, grid_pred))
```

```
[[18  0  0]
 [ 0 11  2]
 [ 0  3 11]]
              precision    recall  f1-score   support
```

```
      setosa       1.00      1.00      1.00        18
  versicolor       0.79      0.85      0.81        13
   virginica       0.85      0.79      0.81        14

    accuracy                           0.89        45
   macro avg       0.88      0.88      0.88        45
weighted avg       0.89      0.89      0.89        45
```