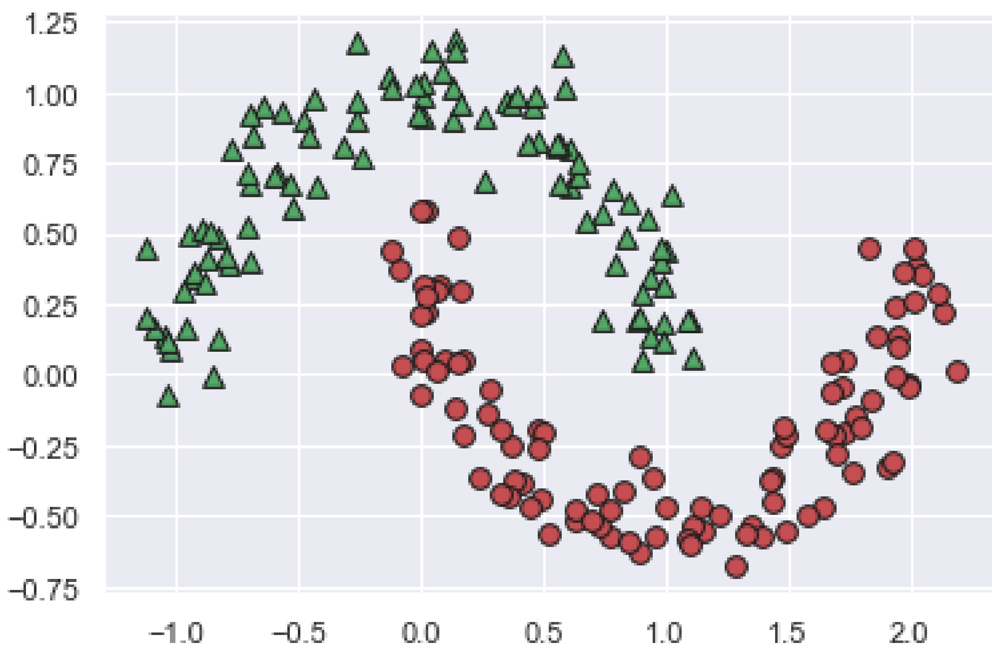
```
import numpy as np
import matplotlib.pyplot as plt
from scipy import stats
import seaborn as sns; sns.set()
from sklearn.metrics import confusion_matrix

from sklearn.datasets import make_moons
N=200

#Generating Data.
X,y= make_moons(n_samples=N, noise=0.1)

#Splitting into Train and Test Data.
from sklearn.model_selection import train_test_split
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size =
0.25, random_state = 0)

#Plotting the Dataset.
for i in range(0,200):
    if y[i]==1:

plt.scatter(X[i,0],X[i,1],edgecolor='k',marker='o',facecolor='r',s=60)
;
    else:

plt.scatter(X[i,0],X[i,1],edgecolor='k',marker='^',facecolor='g',s=60)
;
```




```
#Function to plot Support Vectors.
def plot_svc_decision_function(model, ax=None, plot_support=True):
```

```
    if ax is None:
        ax = plt.gca()
    xlim = ax.get_xlim()
    ylim = ax.get_ylim()

    # create grid to evaluate model
    x = np.linspace(xlim[0], xlim[1], 30)
    y = np.linspace(ylim[0], ylim[1], 30)
    Y_train, X_train = np.meshgrid(y, x)
    xy = np.vstack([X_train.ravel(), Y_train.ravel()]).T
    P = model.decision_function(xy).reshape(X_train.shape)

    # plot decision boundary and margins
    ax.contour(X_train, Y_train, P, colors='k',
               levels=[-1, 0, 1], alpha=0.5,
               linestyles=['--', '-', '--'])

    # plot support vectors
    if plot_support:
        ax.scatter(model.support_vectors_[:, 0],
                   model.support_vectors_[:, 1],edgecolors='k',
                   s=N, linewidth=1, facecolors='none');
    ax.set_xlim(xlim)
    ax.set_ylim(ylim)


#Function to plot Dataset.
def plot_scatter_plot():
    for i in range(0,len(X_train)):
        if y_train[i]==1:

plt.scatter(X_train[i,0],X_train[i,1],edgecolor='k',marker='o',facecol
or='r',s=100);
        else:

plt.scatter(X_train[i,0],X_train[i,1],edgecolor='k',marker='^',facecol
or='g',s=100);

#Function to plot the predicted labels and actual labels with
different markers.
def plot_predictions():
    for i in range(0,len(X_test)):
        if y_test[i]==0 and y_predict[i]==0:

plt.scatter(X_test[i,0],X_test[i,1],facecolor='g',edgecolors='k',marke
r='^',s=100)
        elif y_test[i]==0 and y_predict[i]==1:

plt.scatter(X_test[i,0],X_test[i,1],facecolor='b',edgecolors='k',marke
r='s',s=100)
```

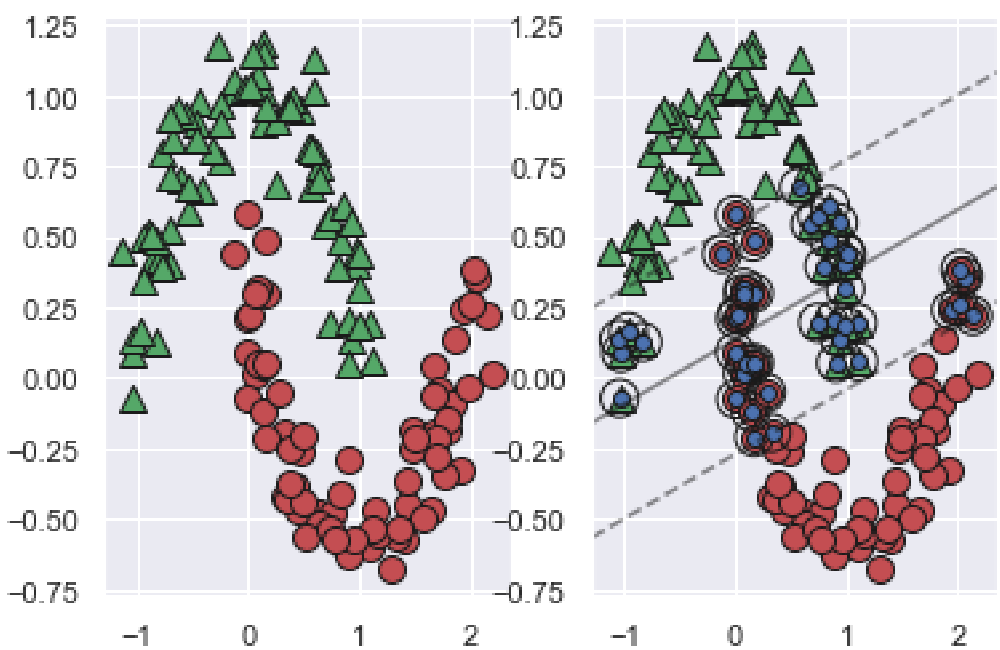
```
        elif y_test[i]==1 and y_predict[i]==1:

plt.scatter(X_test[i,0],X_test[i,1],facecolor='r',edgecolors='k',marke
r='d',s=100)
        elif y_test[i]==1 and y_predict[i]==0:

plt.scatter(X_test[i,0],X_test[i,1],facecolor='y',edgecolors='k',marke
r='o',s=100)
```

```
#Linear SVM.
from sklearn.svm import SVC
model=SVC(kernel='linear')
model.fit(X_train,y_train)
```

```
SVC(kernel='linear')
```

```
plt.subplot(1,2,1)
plot_scatter_plot()

plt.subplot(1,2,2)
plot_scatter_plot()
plot_svc_decision_function(model);
plt.scatter(model.support_vectors_[:,0],model.support_vectors_[:,1],fa
cecolor='b',edgecolors='k')
```

```
<matplotlib.collections.PathCollection at 0x1a20adf7e80>
```




```
#10-Fold Cross-validation using Training Data.
from sklearn.model_selection import KFold,cross_val_score
kf=KFold(n_splits=10)
```

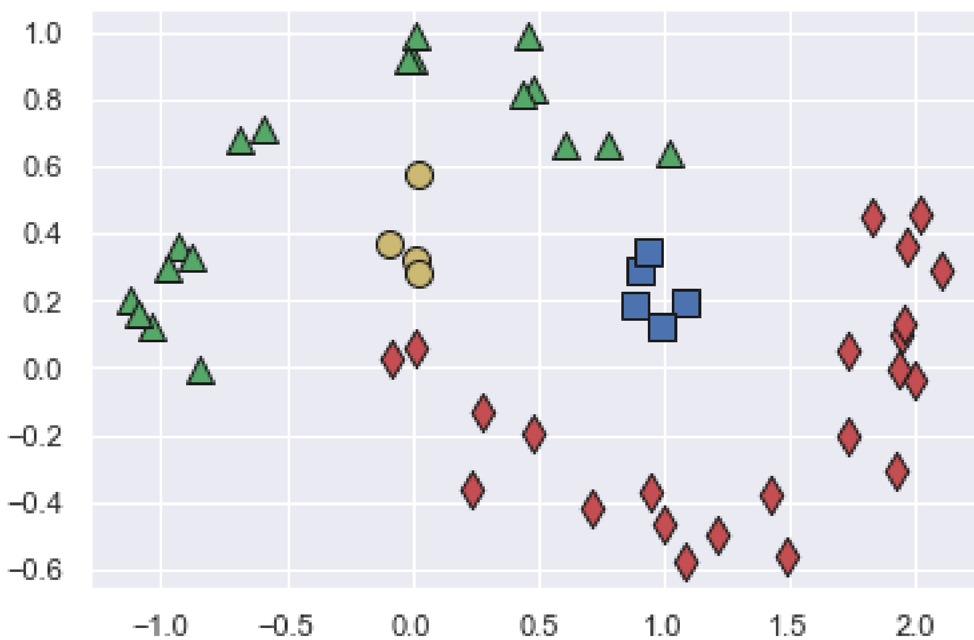
```
kfold=cross_val_score(model,X_train,y_train,cv=kf,scoring='accuracy')
print("Avg accuracy: {}".format(result.mean()))
```

```
Avg accuracy: 0.9974999999999999
```

```
#Predicting the outputs using the built model.
from sklearn.model_selection import cross_val_predict
y_train_pred=cross_val_predict(model,X_train,y_train,cv=10)

#Confusion Matrix and Accuracy Scores.
from sklearn.metrics import confusion_matrix,accuracy_score
confusion=confusion_matrix(y_train,y_train_pred)
print(confusion)
accuracy=accuracy_score(y_train,y_train_pred)
print("Accuracy: ",accuracy)
```

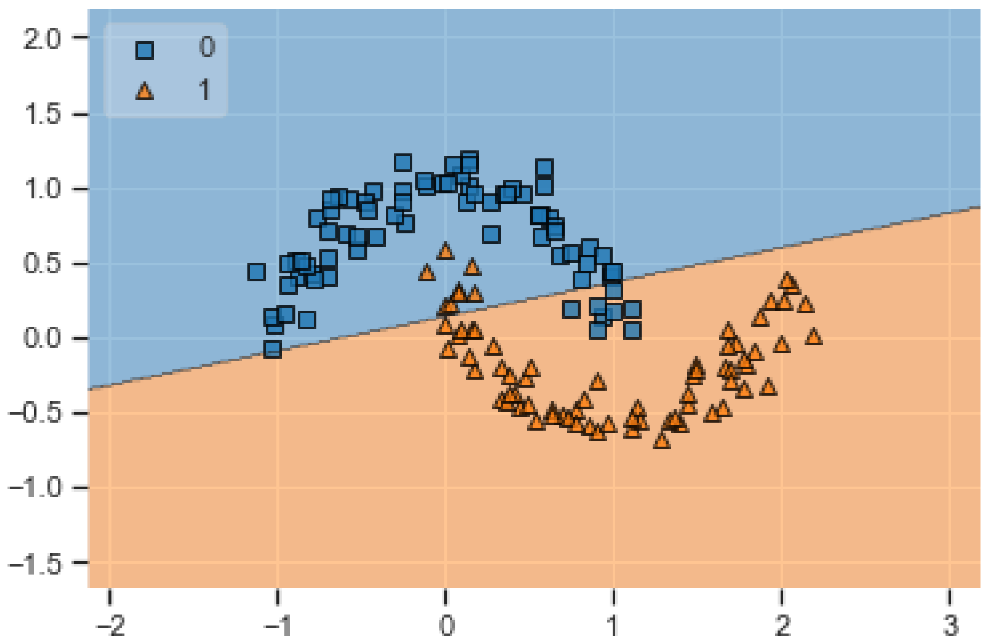
```
[[69  8]
 [ 9 64]]
Accuracy:  0.8866666666666667
```

```
#Plotting the Predicted model.
y_predict=model.predict(X_test)
plot_predictions()
```




```
#Plotting the Decision Regions.
from mlxtend.plotting import plot_decision_regions
plot_decision_regions(X_train,y_train,clf=model,legend=2)
```

```
<AxesSubplot:>
```

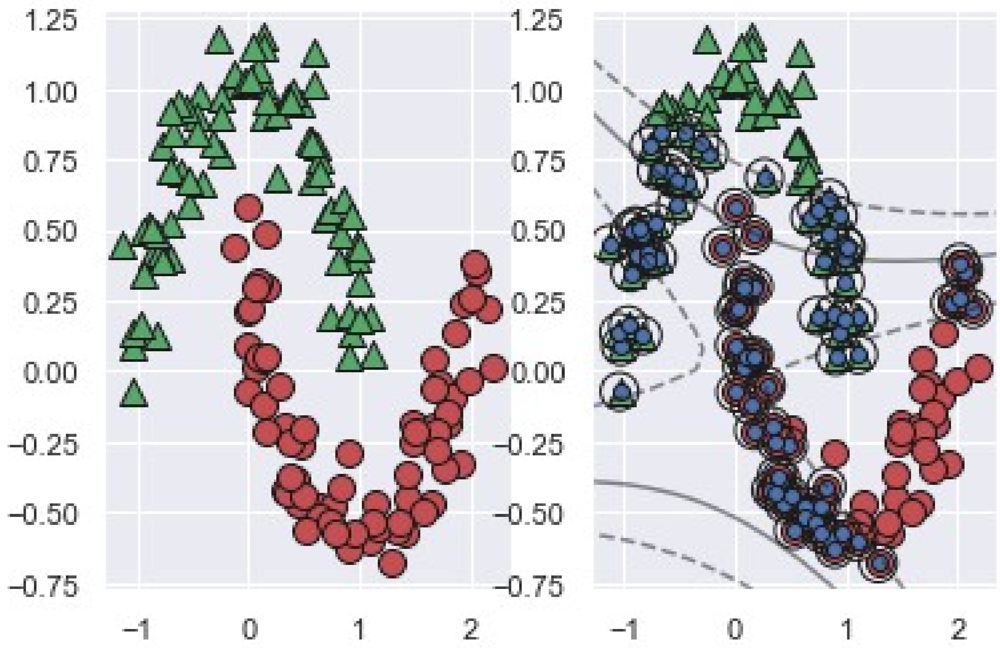



```
#Quadratic SVM.
model=SVC(kernel='poly',degree=2)
model.fit(X_train,y_train)
```

```
SVC(degree=2, kernel='poly')
```

```
plt.subplot(1,2,1)
plot_scatter_plot()

plt.subplot(1,2,2)
plot_scatter_plot()
plot_svc_decision_function(model);
plt.scatter(model.support_vectors_[:,0],model.support_vectors_[:,1],fa
cecolor='b',edgecolors='k')
```

```
<matplotlib.collections.PathCollection at 0x1a20a590100>
```



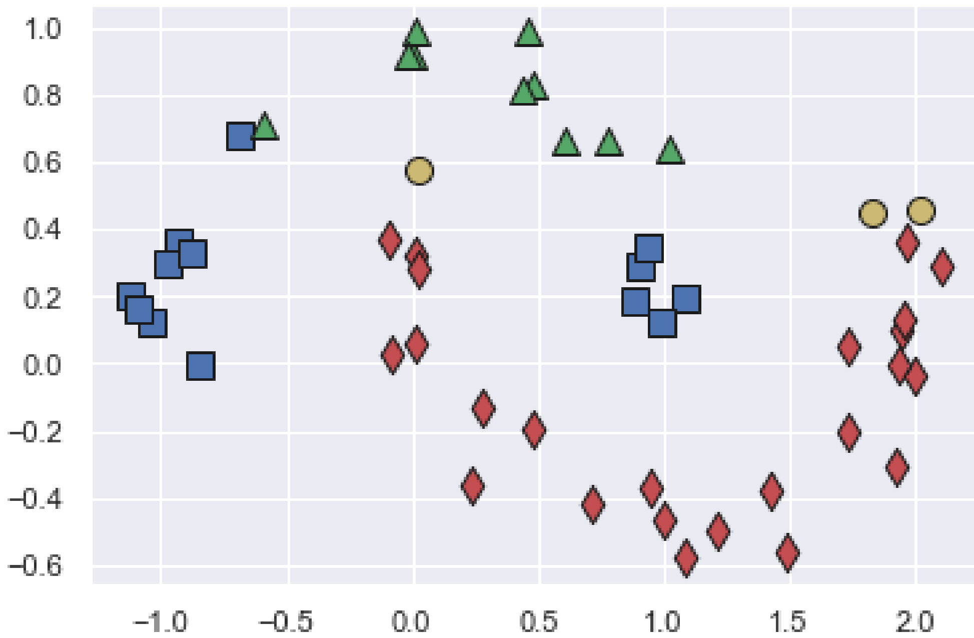

```
#10-fold Cross Validation.
from sklearn.model_selection import KFold,cross_val_score
kf=KFold(n_splits=10)
result=cross_val_score(model,X_test,y_test,cv=kf)
print("Avg accuracy: {}".format(result.mean()))
```

```
Avg accuracy: 0.6799999999999999
```

```
#Predicting the outputs using the built model.
from sklearn.model_selection import cross_val_predict
y_train_pred=cross_val_predict(model,X_train,y_train,cv=10)

#Confusion Matrix and Accuracy Scores.
from sklearn.metrics import confusion_matrix,accuracy_score
confusion=confusion_matrix(y_train,y_train_pred)
print(confusion)
accuracy=accuracy_score(y_train,y_train_pred)
print("Accuracy: ",accuracy)
```

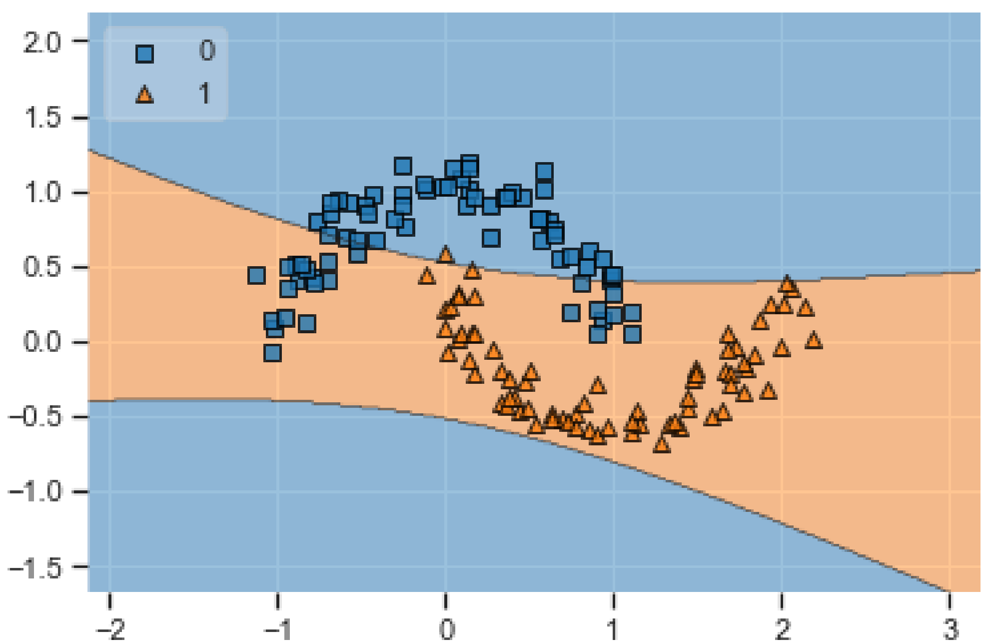
```
[[50 27]
 [ 3 70]]
Accuracy:  0.8
```

```
#Plotting the Predicted Model.
y_predict=model.predict(X_test)
plot_predictions()
```




```
#plotting the Decision Regions.
from mlxtend.plotting import plot_decision_regions
plot_decision_regions(X_train,y_train,clf=model,legend=2)
```

```
<AxesSubplot:>
```

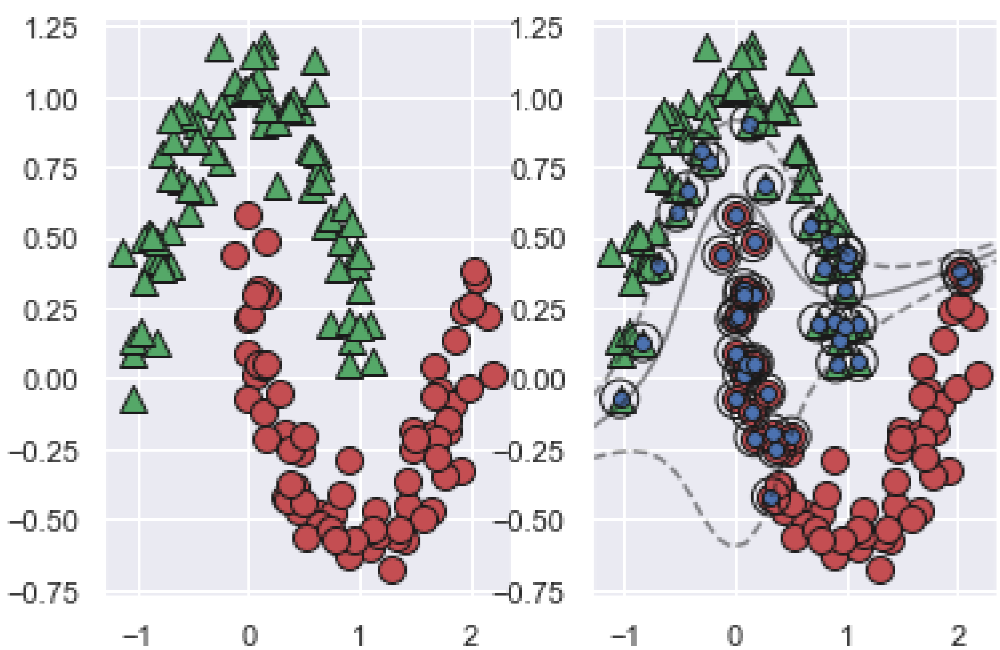



```
#Cubic SVM.
model=SVC(kernel='poly',degree=3)
model.fit(X_train,y_train)
```

```
SVC(kernel='poly')
```

```
plt.subplot(1,2,1)
plot_scatter_plot()

plt.subplot(1,2,2)
plot_scatter_plot()
plot_svc_decision_function(model);
plt.scatter(model.support_vectors_[:,0],model.support_vectors_[:,1],ed
gecolors='k',facecolor='b')
```

```
<matplotlib.collections.PathCollection at 0x1a205e2f160>
```



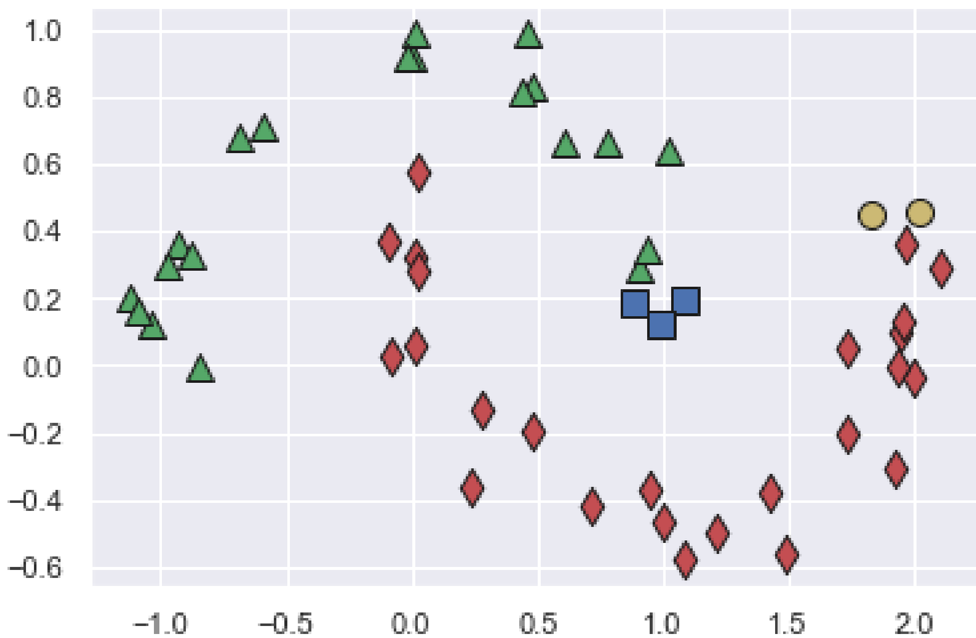

```
#10-fold Cross Validation.
from sklearn.model_selection import KFold,cross_val_score
kf=KFold(n_splits=10)
result=cross_val_score(model,X_test,y_test,cv=kf)
print("Avg accuracy: {}".format(result.mean()))
```

```
Avg accuracy: 0.74
```

```
#Predicting the outputs using the built model.
from sklearn.model_selection import cross_val_predict
y_train_pred=cross_val_predict(model,X_train,y_train,cv=10)

#Confusion Matrix and Accuracy Scores.
from sklearn.metrics import confusion_matrix,accuracy_score
confusion=confusion_matrix(y_train,y_train_pred)
print(confusion)
accuracy=accuracy_score(y_train,y_train_pred)
print("Accuracy: ",accuracy)
```

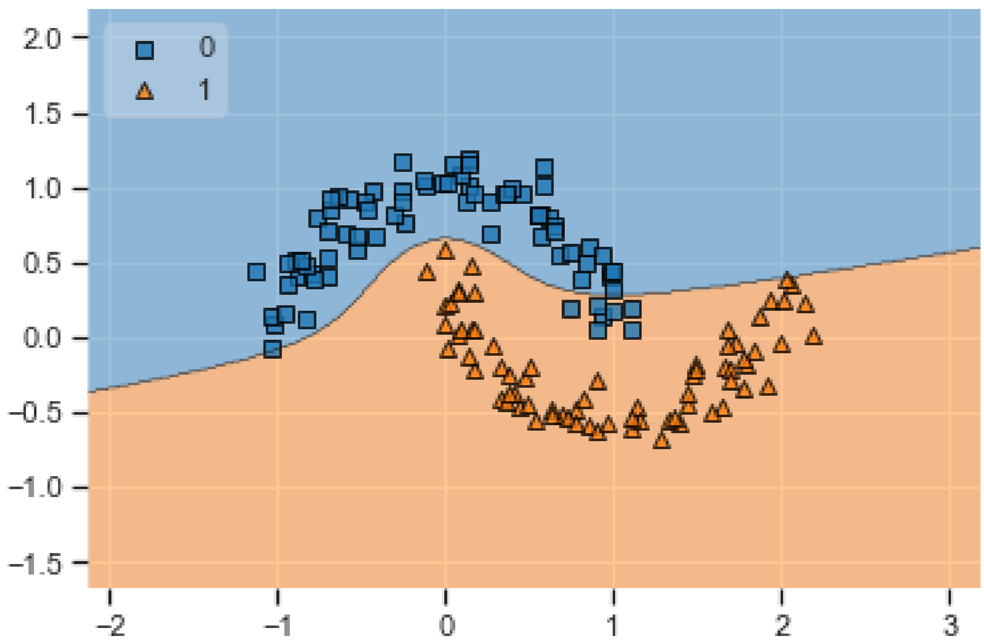
```
[[70  7]
 [ 0 73]]
Accuracy:  0.9533333333333334
```

```
#Plotting the predicted labels.
y_predict=model.predict(X_test)
plot_predictions()
```

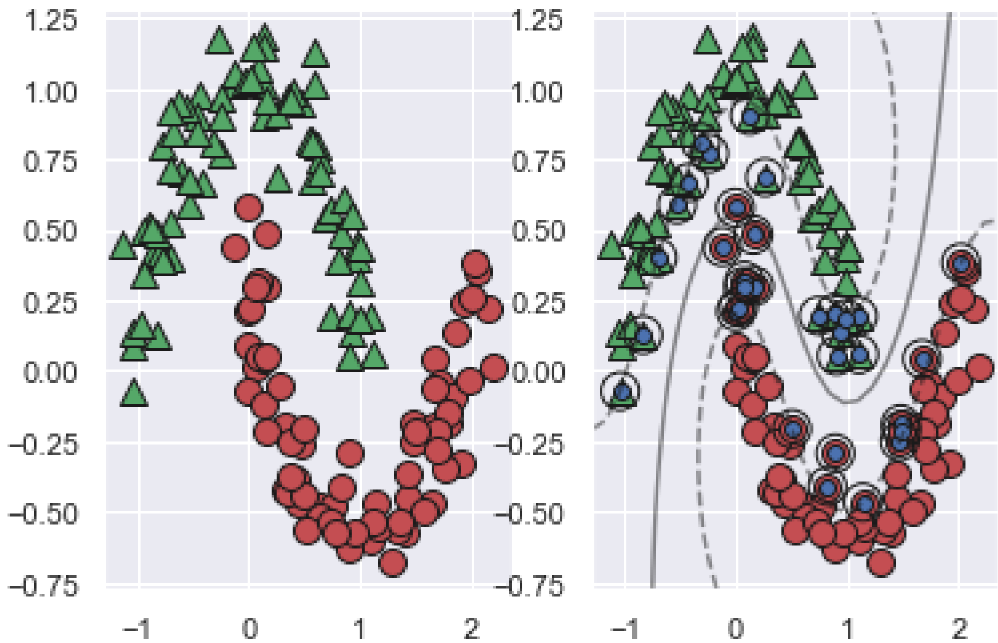



```
#Plotting the decision regions.
from mlxtend.plotting import plot_decision_regions
plot_decision_regions(X_train,y_train,clf=model,legend=2)
```

```
<AxesSubplot:>
```




```
#Gaussian SVM.
model=SVC(kernel='rbf')
model.fit(X_train,y_train)

SVC()

plt.subplot(1,2,1)
plot_scatter_plot()

plt.subplot(1,2,2)
plot_scatter_plot()
plot_svc_decision_function(model);
plt.scatter(model.support_vectors_[:,0],model.support_vectors_[:,1],fa
cecolor='b',edgecolors='k')

<matplotlib.collections.PathCollection at 0x1a2061c5ae0>
```



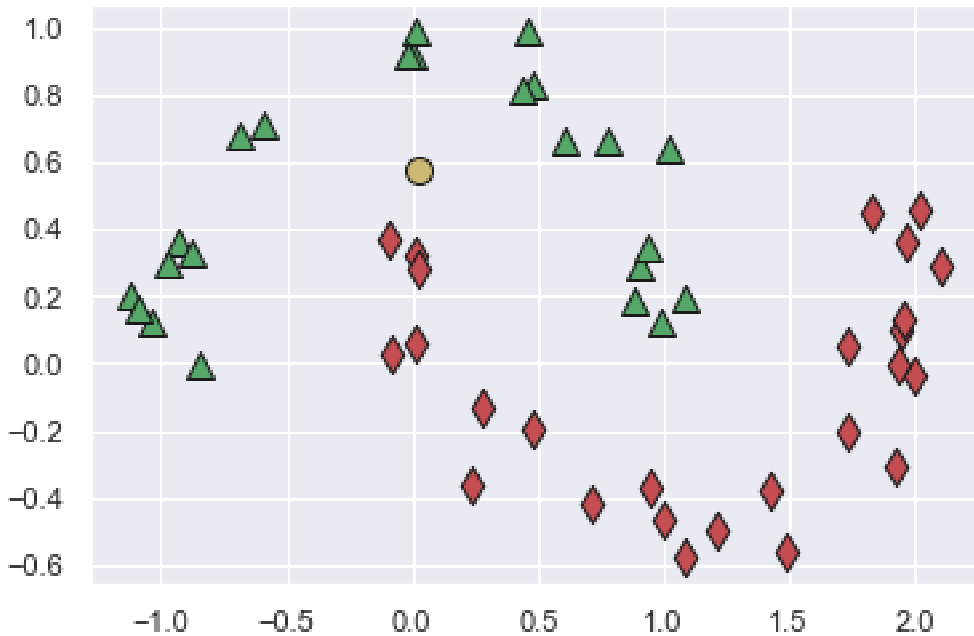

```
#10-fold cross-validation.
from sklearn.model_selection import KFold,cross_val_score
kf=KFold(n_splits=10)
result=cross_val_score(model,X_test,y_test,cv=kf)
print("Avg accuracy: {}".format(result.mean()))
```

```
Avg accuracy: 0.9800000000000001
```

```
#Predicting the outputs using the built model.
from sklearn.model_selection import cross_val_predict
y_train_pred=cross_val_predict(model,X_train,y_train,cv=10)

#Confusion Matrix and Accuracy Scores.
from sklearn.metrics import confusion_matrix,accuracy_score
confusion=confusion_matrix(y_train,y_train_pred)
print(confusion)
accuracy=accuracy_score(y_train,y_train_pred)
print("Accuracy: ",accuracy)
```

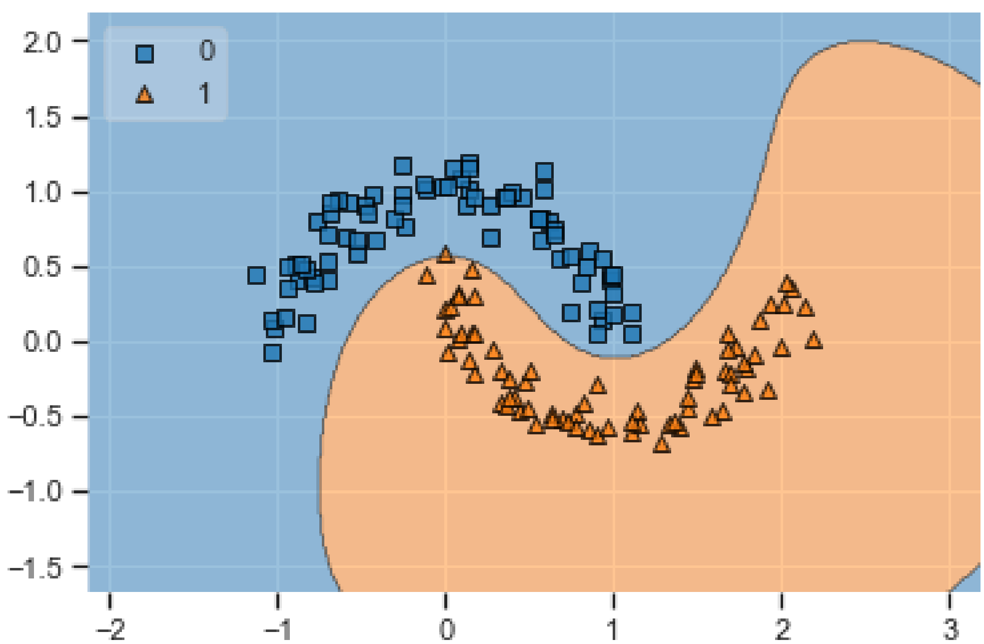
```
[[77  0]
 [ 2 71]]
Accuracy:  0.9866666666666667
```

```
#Plotting the predicted labels.
y_predict=model.predict(X_test)
plot_predictions()
```




```
#Plotting the decision regions.
from mlxtend.plotting import plot_decision_regions
plot_decision_regions(X_train,y_train,clf=model,legend=2)
```

```
<AxesSubplot:>
```



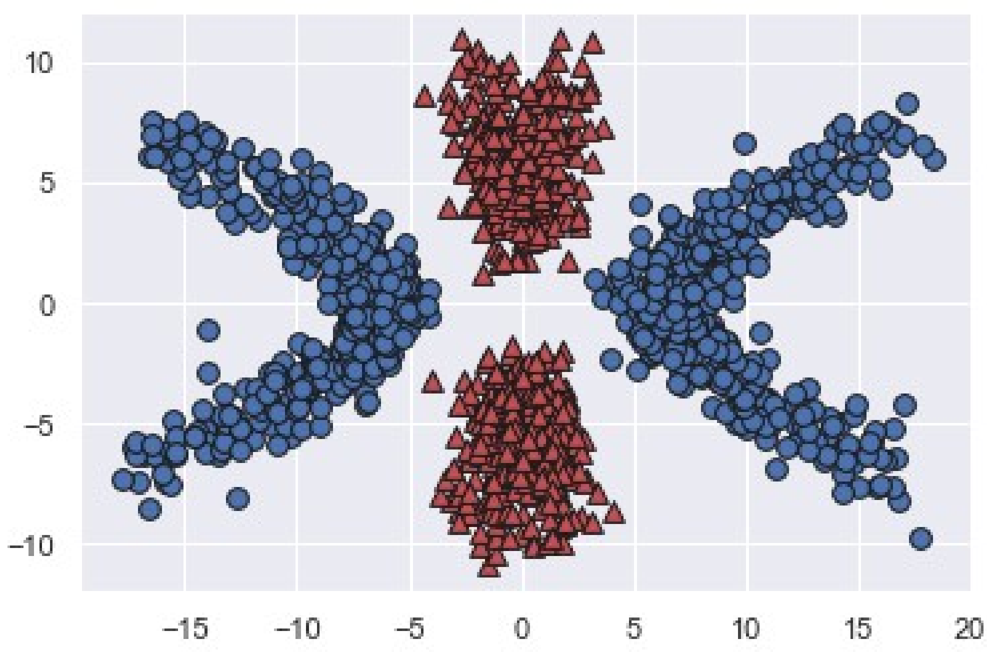

```
'''Comparison of Results:
1.Linear SVM:
->Accuracy: 0.87
->Confusion Matrix:
```

```
 [63 10]
 [ 9 68]

2.Quadratic SVM:
->Accuracy: 0.72
->Confusion Matrix:
 [42 31]
 [ 1 76]

3.Cubic SVM:
->Accuracy: 0.96
->Confusion Matrix:
 [64  9]
 [ 1 76]

4.Gaussian SVM:
->Accuracy: 0.98
->Confusion Matrix:
 [72  1]
 [ 2 75]

 Conclusion: Gaussian SVM works best for this data, followed by Cubic
and Linear. Quadratic SVM is the worst performer.'''
```

```
'Comparison of Results:\n1.Linear SVM:\n->Accuracy: 0.87\n->Confusion
Matrix:\n [63 10]\n [ 9 68]\n\n2.Quadratic SVM:\n->Accuracy: 0.72\n-
>Confusion Matrix:\n [42 31]\n [ 1 76]\n\n3.Cubic SVM:\n->Accuracy:
0.96\n->Confusion Matrix:\n [64  9]\n [ 1 76]\n \n4.Gaussian SVM:\n-
>Accuracy: 0.98\n->Confusion Matrix:\n [72  1]\n [ 2 75]\n \n
Conclusion: Gaussian SVM works best for this data, followed by Cubic
and Linear. Quadratic SVM is the worst performer.'
```

```
t = np.arange(-2, 2, 0.01)
N = t.size
a = 0.5
b = 2
c = 4
d = 2
h = 2
k = 2

x_1 = np.array([a*np.sinh(t), k+b*np.cosh(t), a*np.sinh(t), -k-
b*np.cosh(t)]).T
y_2 = np.array([h+c*np.cosh(t), d*np.sinh(t), -h-c*np.cosh(t),
d*np.sinh(t)]).T

class_1=np.concatenate((x_1[:,0:2],x_1[:,2:4]),axis=0)
class_2=np.concatenate((y_2[:,0:2],y_2[:,2:4]),axis=0)

#add noise
```

```
class_1 += np.random.normal(0, 1, class_1.shape)
class_2 += np.random.normal(0, 0.9, class_2.shape)

X=np.concatenate((class_1,class_2),axis=0)

y_1=np.ones((2*N,1),dtype=int)
y_2=np.zeros((2*N,1),dtype=int)

y=np.concatenate((y_1,y_2),axis=0)
y=np.ravel(y, order = 'C')

from sklearn.model_selection import train_test_split
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size =
0.25, random_state = 0)

#plot
plt.scatter(class_1[:,0],
class_1[:,1],edgecolors='k',facecolor='r',marker='^',s=60)
plt.scatter(class_2[:,0],
class_2[:,1],edgecolors='k',facecolor='b',marker='o',s=60)
plt.show()
```




```
#Linear Discriminant Analysis.
from sklearn.discriminant_analysis import LinearDiscriminantAnalysis
model=LinearDiscriminantAnalysis()
X_LDA=model.fit_transform(X_train,y_train)

#10-fold Cross-validation.
from sklearn.model_selection import KFold,cross_val_score
kf=KFold(n_splits=10)
```

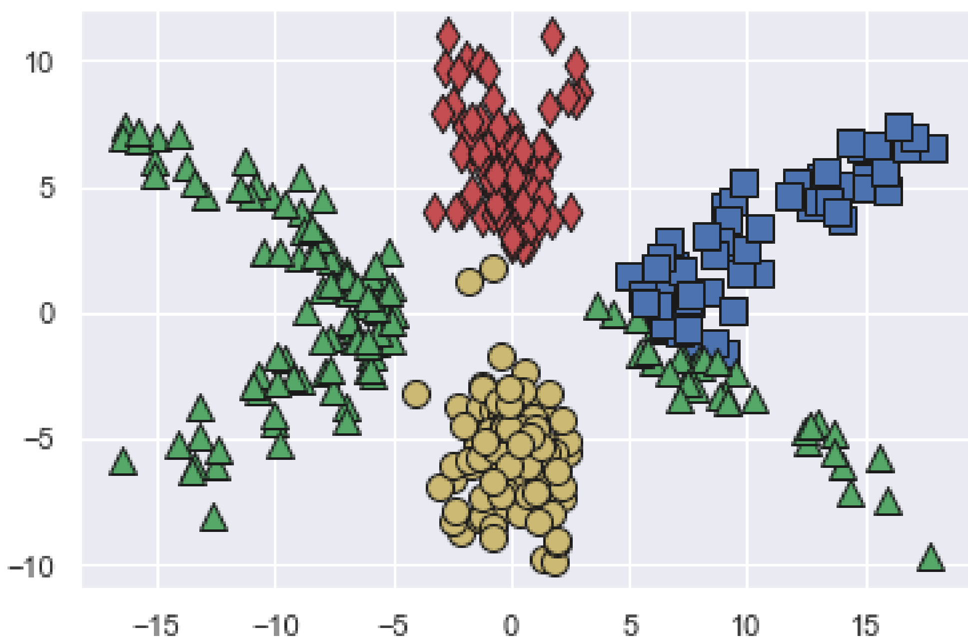
```
result=cross_val_score(model,X_test,y_test,cv=kf)
print("Avg accuracy: {}".format(result.mean()))
```

```
Avg accuracy: 0.45
```

```
#Predicting the outputs using the built model.
from sklearn.model_selection import cross_val_predict
y_train_pred=cross_val_predict(model,X_train,y_train,cv=10)

#Confusion Matrix and Accuracy Scores.
from sklearn.metrics import confusion_matrix,accuracy_score
confusion=confusion_matrix(y_train,y_train_pred)
print(confusion)
accuracy=accuracy_score(y_train,y_train_pred)
print("Accuracy: ",accuracy)
```

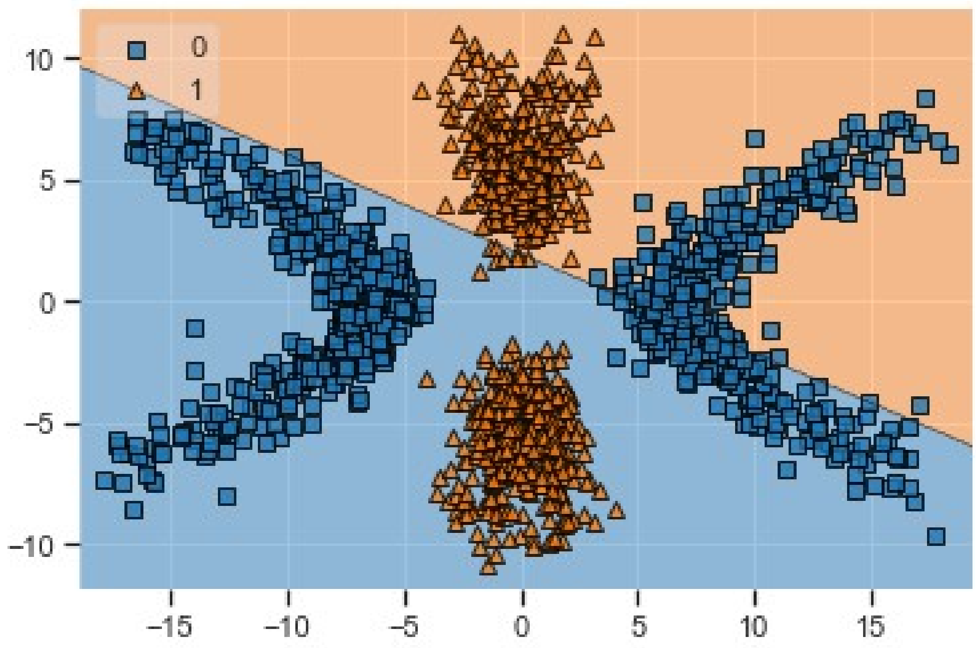
```
[[383 222]
 [336 259]]
Accuracy:  0.535
```

```
#Plotting the predicted labels.
y_predict=model.predict(X_test)
plot_predictions()
```



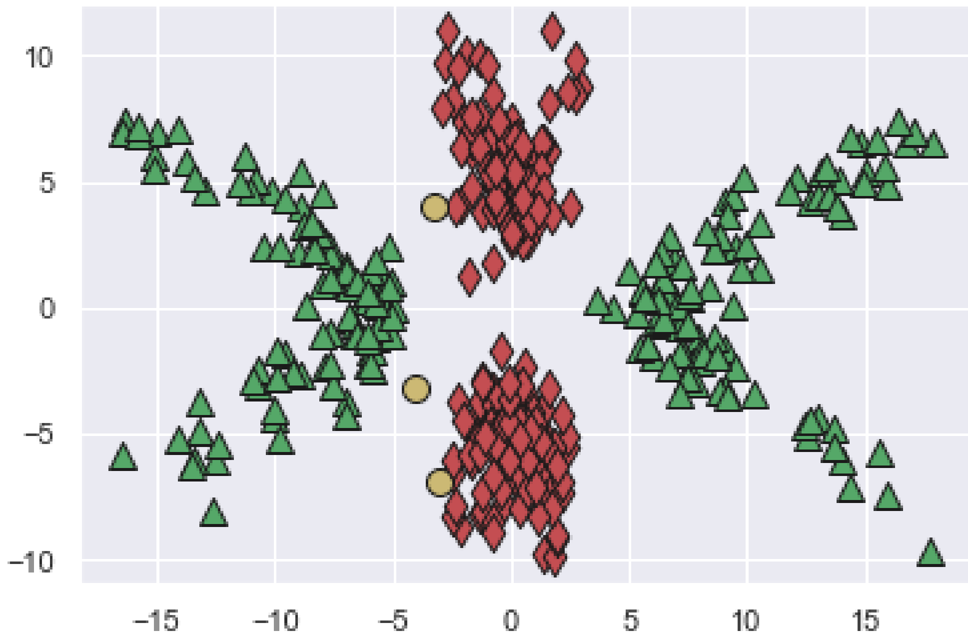

```
#Plotting the decision regions.
from mlxtend.plotting import plot_decision_regions
plot_decision_regions(X,y,clf=model,legend=2)
```

```
<AxesSubplot:>
```



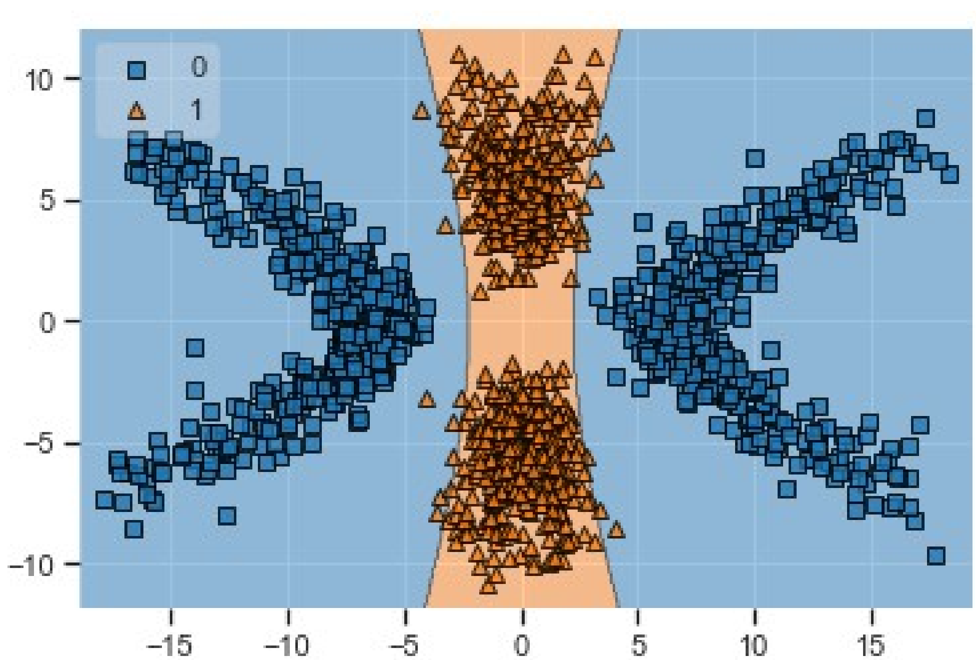

```
#Quadratic Discriminant Analysis.
from sklearn.discriminant_analysis import
QuadraticDiscriminantAnalysis
model=QuadraticDiscriminantAnalysis()
X_QDA=model.fit(X_train,y_train)

#10-fold Cross-validation.
from sklearn.model_selection import KFold,cross_val_score
kf=KFold(n_splits=10)
result=cross_val_score(model,X_test,y_test,cv=kf)
print("Avg accuracy: {}".format(result.mean()))

Avg accuracy: 0.99

#Predicting the outputs using the built model.
from sklearn.model_selection import cross_val_predict
y_train_pred=cross_val_predict(model,X_train,y_train,cv=10)

#Confusion Matrix and Accuracy Scores.
from sklearn.metrics import confusion_matrix,accuracy_score
confusion=confusion_matrix(y_train,y_train_pred)
print(confusion)
accuracy=accuracy_score(y_train,y_train_pred)
print("Accuracy: ",accuracy)

[[605   0]
 [ 13 582]]
Accuracy:  0.9891666666666666
```

```python
#Plotting the predicted labels.
y_predict=model.predict(X_test)
plot_predictions()
```




```python
#Plotting the decision regions.
from mlxtend.plotting import plot_decision_regions
plot_decision_regions(X,y,clf=model,legend=2)
```

```
<AxesSubplot:>
```



```
#Polynomial SVM
model=SVC(kernel='poly',degree=2)
model.fit(X_train,y_train)
```

```
SVC(degree=2, kernel='poly')
```

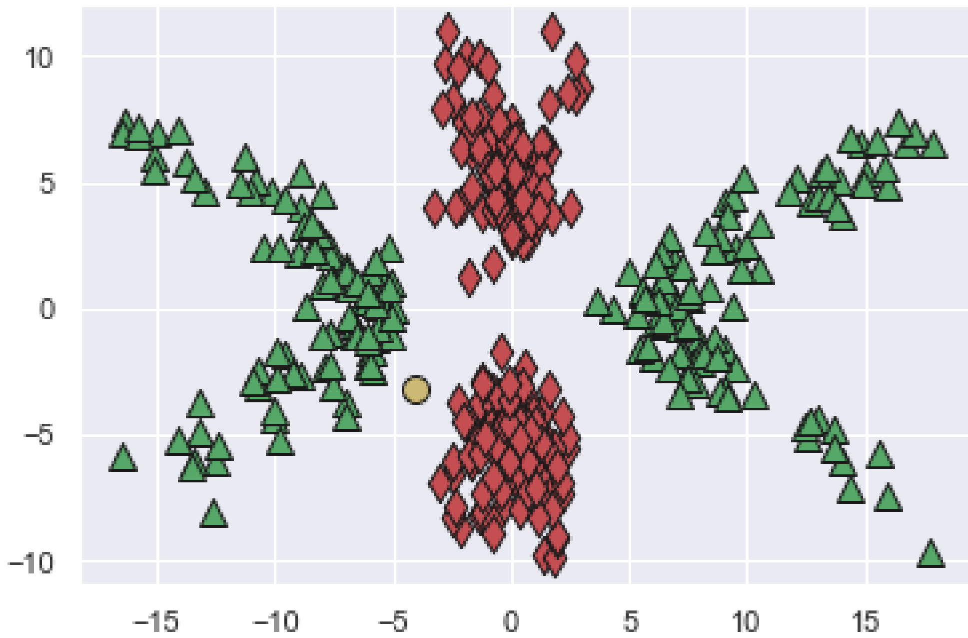
```
#10-fold cross-validation.
from sklearn.model_selection import KFold,cross_val_score
kf=KFold(n_splits=10)
result=cross_val_score(model,X_test,y_test,cv=kf)
print("Avg accuracy: {}".format(result.mean()))
```

```
Avg accuracy: 0.9974999999999999
```

```
#Predicting the outputs using the built model.
from sklearn.model_selection import cross_val_predict
y_train_pred=cross_val_predict(model,X_train,y_train,cv=10)

#Confusion Matrix and Accuracy Scores.
from sklearn.metrics import confusion_matrix,accuracy_score
confusion=confusion_matrix(y_train,y_train_pred)
print(confusion)
accuracy=accuracy_score(y_train,y_train_pred)
print("Accuracy: ",accuracy)
```

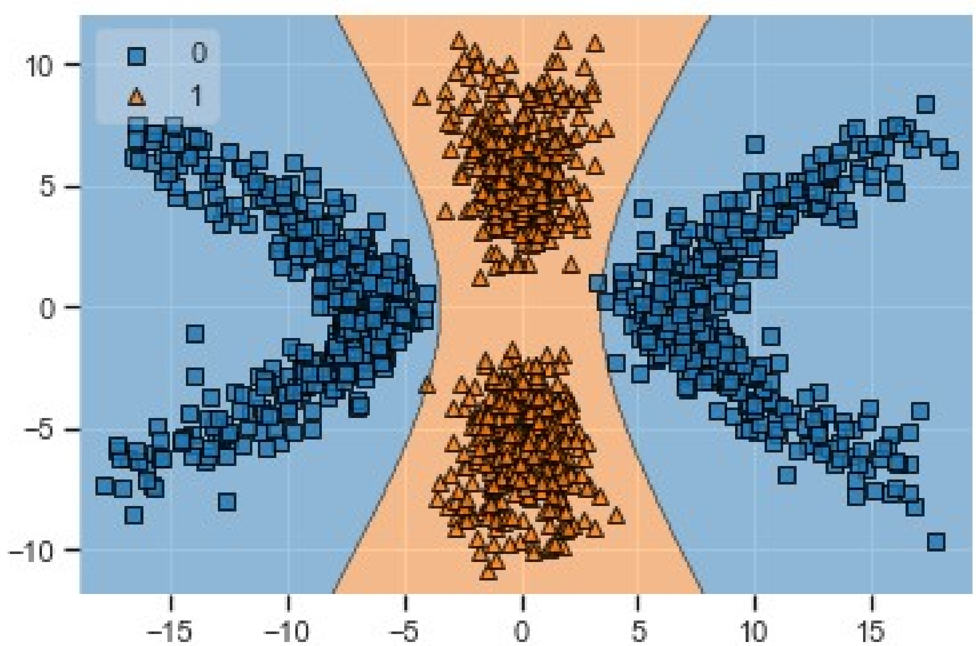
```
[[604   1]
 [  0 595]]
Accuracy:  0.9991666666666666
```

```
#Plotting the predicted labels.
y_predict=model.predict(X_test)
plot_predictions()
```




```
#Plotting the decision regions.
from mlxtend.plotting import plot_decision_regions
plot_decision_regions(X,y,clf=model,legend=2)
```

```
<AxesSubplot:>
```




```
#k-NN
from sklearn.neighbors import KNeighborsRegressor
knn_model = KNeighborsRegressor(n_neighbors=2)
knn_model.fit(X_train, y_train)
```

```
KNeighborsRegressor(n_neighbors=2)
```

```
#10-fold cross-validation.
from sklearn.model_selection import KFold,cross_val_score
kf=KFold(n_splits=10)
result=cross_val_score(model,X_test,y_test,cv=kf)
print("Avg accuracy: {}".format(result.mean()))
```

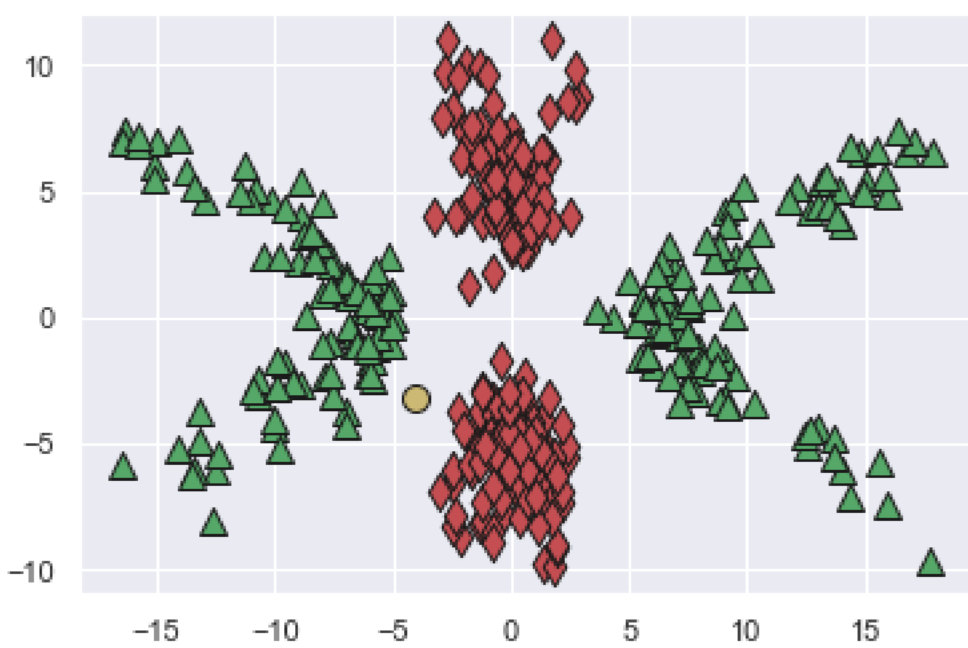
```
Avg accuracy: 0.9974999999999999
```

```
#Predicting the outputs using the built model.
from sklearn.model_selection import cross_val_predict
y_train_pred=cross_val_predict(model,X_train,y_train,cv=10)
```

```
#Confusion Matrix and Accuracy Scores.
from sklearn.metrics import confusion_matrix,accuracy_score
confusion=confusion_matrix(y_train,y_train_pred)
print(confusion)
accuracy=accuracy_score(y_train,y_train_pred)
print("Accuracy: ",accuracy)
```

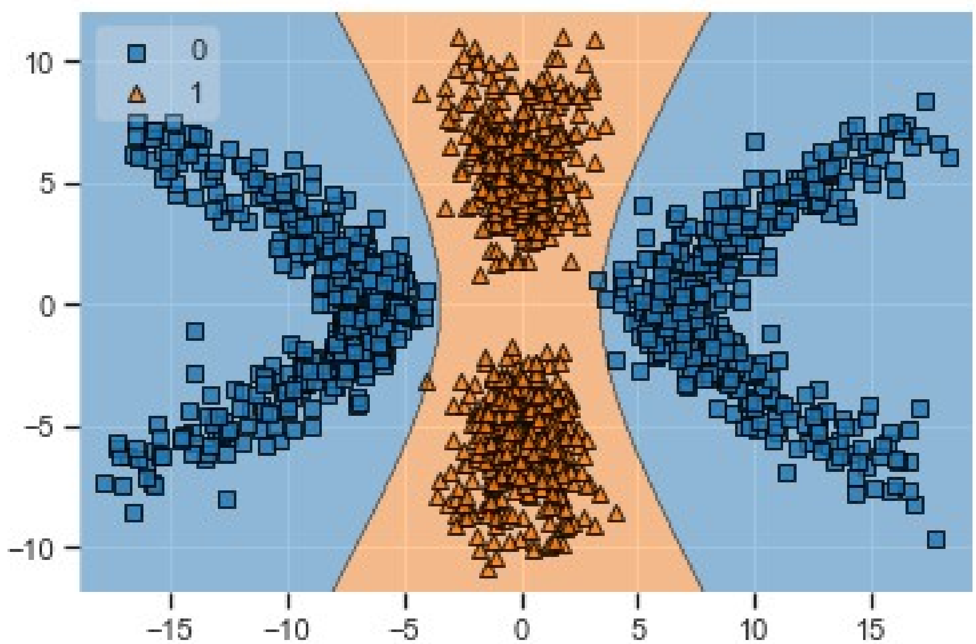
```
[[604   1]
 [  0 595]]
Accuracy:  0.9991666666666666
```

```
#Plotting the predicted labels.
y_predict=model.predict(X_test)
plot_predictions()
```



```python
#Plottig the decision regions.
from mlxtend.plotting import plot_decision_regions
plot_decision_regions(X,y,clf=model,legend=2)
```

```
<AxesSubplot:>
```




```
'''Comparison of Results:
1.Linear Discriminant Analysis:
->Accuracy: 0.53
->Confusion Matrix:
 [383 222]
 [336 259]

2.Quadratic Discriminant:
->Accuracy: 0.98
->Confusion Matrix:
 [605   0]
 [ 13 582]

3.Polynomial Kernel:
->Accuracy: 0.99
->Confusion Matrix:
 [604   1]
 [  0 595]

4.k-NN:
->Accuracy: 0.99
->Confusion Matrix:
 [604   1]
 [  0 595]
```

```
 Conclusion: k-NN works best for this data, followed by Poly SVM and
Quadratic Discriminant. Linear SVM is the worst performer.'''
```