Task 1:

Download the data (sonar.all-data) from the Sonar, Mines vs. Rocks Data Set: https://archive.ics.uci.edu/ml/datasets/Connectionist+Bench+ (Sonar,+Mines+vs.+Rocks)

In [2]:

```python
import plotly as ply
import pandas as pd
import numpy as np
import math
import sklearn.preprocessing as MinMaxscaler
import matplotlib.pyplot as plt
%matplotlib inline
from pathlib import Path

import sklearn
from sklearn.datasets import load_linnerud


!pip install mglearn

from matplotlib import rc
font = {'family' : 'monospace', 'weight' : 'bold', 'size'   : 25}
rc('font', **font)

plt.rcParams['figure.figsize'] = [20, 10]
plt.rcParams['lines.linewidth'] = 5.0
plt.rcParams['lines.markersize'] = 15.0

import warnings
warnings.filterwarnings("ignore", category=DeprecationWarning)
warnings.filterwarnings("ignore", category=FutureWarning)
```

```
Requirement already satisfied: mglearn in /Users/macbookpro/opt/anaconda3/lib/
python3.8/site-packages (0.1.9)
Requirement already satisfied: numpy in /Users/macbookpro/opt/anaconda3/lib/py
thon3.8/site-packages (from mglearn) (1.18.5)
Requirement already satisfied: pandas in /Users/macbookpro/opt/anaconda3/lib/p
ython3.8/site-packages (from mglearn) (1.0.5)
Requirement already satisfied: pillow in /Users/macbookpro/opt/anaconda3/lib/p
ython3.8/site-packages (from mglearn) (7.2.0)
Requirement already satisfied: imageio in /Users/macbookpro/opt/anaconda3/lib/
python3.8/site-packages (from mglearn) (2.9.0)
Requirement already satisfied: matplotlib in /Users/macbookpro/opt/anaconda3/l
ib/python3.8/site-packages (from mglearn) (3.2.2)
Requirement already satisfied: cycler in /Users/macbookpro/opt/anaconda3/lib/p
ython3.8/site-packages (from mglearn) (0.10.0)
Requirement already satisfied: joblib in /Users/macbookpro/opt/anaconda3/lib/p
ython3.8/site-packages (from mglearn) (0.16.0)
Requirement already satisfied: scikit-learn in /Users/macbookpro/opt/anaconda3
/lib/python3.8/site-packages (from mglearn) (0.23.1)
Requirement already satisfied: python-dateutil>=2.6.1 in /Users/macbookpro/opt
/anaconda3/lib/python3.8/site-packages (from pandas->mglearn) (2.8.1)
Requirement already satisfied: pytz>=2017.2 in /Users/macbookpro/opt/anaconda3
/lib/python3.8/site-packages (from pandas->mglearn) (2020.1)
Requirement already satisfied: pyparsing!=2.0.4,!=2.1.2,!=2.1.6,>=2.0.1 in /Us
ers/macbookpro/opt/anaconda3/lib/python3.8/site-packages (from matplotlib->mgl
earn) (2.4.7)
Requirement already satisfied: kiwisolver>=1.0.1 in /Users/macbookpro/opt/anac
onda3/lib/python3.8/site-packages (from matplotlib->mglearn) (1.2.0)
Requirement already satisfied: six in /Users/macbookpro/opt/anaconda3/lib/pyth
on3.8/site-packages (from cycler->mglearn) (1.15.0)
Requirement already satisfied: threadpoolctl>=2.0.0 in /Users/macbookpro/opt/a
naconda3/lib/python3.8/site-packages (from scikit-learn->mglearn) (2.1.0)
Requirement already satisfied: scipy>=0.19.1 in /Users/macbookpro/opt/anaconda
3/lib/python3.8/site-packages (from scikit-learn->mglearn) (1.5.0)
```

In [3]:
```python
## Load data

df = pd.read_csv('sonar.all-data', header =None,  prefix='X')
df
```

Out[3]:

	X0	X1	X2	X3	X4	X5	X6	X7	X8	X9	...	)
0	0.0200	0.0371	0.0428	0.0207	0.0954	0.0986	0.1539	0.1601	0.3109	0.2111	...	0.0(
1	0.0453	0.0523	0.0843	0.0689	0.1183	0.2583	0.2156	0.3481	0.3337	0.2872	...	0.0(
2	0.0262	0.0582	0.1099	0.1083	0.0974	0.2280	0.2431	0.3771	0.5598	0.6194	...	0.0:
3	0.0100	0.0171	0.0623	0.0205	0.0205	0.0368	0.1098	0.1276	0.0598	0.1264	...	0.0
4	0.0762	0.0666	0.0481	0.0394	0.0590	0.0649	0.1209	0.2467	0.3564	0.4459	...	0.0(
...	...	...	...	...	...	...	...	...	...	...	...	
203	0.0187	0.0346	0.0168	0.0177	0.0393	0.1630	0.2028	0.1694	0.2328	0.2684	...	0.0
204	0.0323	0.0101	0.0298	0.0564	0.0760	0.0958	0.0990	0.1018	0.1030	0.2154	...	0.0(
205	0.0522	0.0437	0.0180	0.0292	0.0351	0.1171	0.1257	0.1178	0.1258	0.2529	...	0.0'
206	0.0303	0.0353	0.0490	0.0608	0.0167	0.1354	0.1465	0.1123	0.1945	0.2354	...	0.0(
207	0.0260	0.0363	0.0136	0.0272	0.0214	0.0338	0.0655	0.1400	0.1843	0.2354	...	0.0'

208 rows × 61 columns

Substitute the categories M and R of the last column for integers

In [4]:
```python
from sklearn.preprocessing import LabelEncoder

le = LabelEncoder()
# df_encoded = pd.DataFrame()
le.fit(df.X60)
```

Out[4]:   LabelEncoder()

In [5]:
```python
df["X60"] = le.fit_transform(df["X60"])
df
```

Out[5]:

	X0	X1	X2	X3	X4	X5	X6	X7	X8	X9	...	)
0	0.0200	0.0371	0.0428	0.0207	0.0954	0.0986	0.1539	0.1601	0.3109	0.2111	...	0.00
1	0.0453	0.0523	0.0843	0.0689	0.1183	0.2583	0.2156	0.3481	0.3337	0.2872	...	0.00
2	0.0262	0.0582	0.1099	0.1083	0.0974	0.2280	0.2431	0.3771	0.5598	0.6194	...	0.02
3	0.0100	0.0171	0.0623	0.0205	0.0205	0.0368	0.1098	0.1276	0.0598	0.1264	...	0.0
4	0.0762	0.0666	0.0481	0.0394	0.0590	0.0649	0.1209	0.2467	0.3564	0.4459	...	0.00
...	...	...	...	...	...	...	...	...	...	...	...	
203	0.0187	0.0346	0.0168	0.0177	0.0393	0.1630	0.2028	0.1694	0.2328	0.2684	...	0.0
204	0.0323	0.0101	0.0298	0.0564	0.0760	0.0958	0.0990	0.1018	0.1030	0.2154	...	0.00
205	0.0522	0.0437	0.0180	0.0292	0.0351	0.1171	0.1257	0.1178	0.1258	0.2529	...	0.0
206	0.0303	0.0353	0.0490	0.0608	0.0167	0.1354	0.1465	0.1123	0.1945	0.2354	...	0.00
207	0.0260	0.0363	0.0136	0.0272	0.0214	0.0338	0.0655	0.1400	0.1843	0.2354	...	0.0

208 rows × 61 columns

Find the best parameters on the validation set using gridsearch (min. 2 parameters) for one model.

In [6]:

```python
from sklearn.model_selection import train_test_split
from sklearn import preprocessing
from sklearn import svm
from sklearn.svm import SVC

X = np.array(df.iloc[:,:60])
y = df.iloc[:,-1:].values.ravel()

X_train, X_test, y_train, y_test = train_test_split(X, y, random_state=0)
scaler = preprocessing.StandardScaler().fit(X_train)
X_train_transformed = scaler.transform(X_train)
clf = svm.SVC(C=1).fit(X_train_transformed, y_train)
X_test_transformed = scaler.transform(X_test)
clf.score(X_test_transformed, y_test)
```

Out[6]: 0.8269230769230769

In [7]:
```python
from sklearn.linear_model import LogisticRegression
from sklearn.model_selection import cross_val_score

logreg = LogisticRegression(solver='liblinear', C=0.1)

scores = cross_val_score(logreg, X, y)
print("Cross-validation scores: {}".format(scores))
```

Cross-validation scores: [0.54761905 0.66666667 0.61904762 0.70731707 0.4146341
5]

In [8]:
```python
print("Average cross-validation score: {:.2f}".format(scores.mean()))
```

Average cross-validation score: 0.59

In [9]:
```python
from sklearn.model_selection import train_test_split
from sklearn.model_selection import cross_val_score
from sklearn.model_selection import GridSearchCV
from sklearn.neighbors import KNeighborsClassifier
from sklearn.svm import SVC

X_train, X_test, y_train, y_test = train_test_split(X, y)
cross_val_scores = []

neighbors = np.arange(1,61)
# list(range(1, 61))
# np.arange(1,61)
for i in neighbors:
    knn = KNeighborsClassifier(n_neighbors=i)
    scores = cross_val_score(knn, X_train, y_train, cv=10)
    cross_val_scores.append(np.mean(scores))

print("best cross-validation score: {:.3f}".format(np.max(cross_val_scores)))
best_n_neighbors = neighbors[np.argmax(cross_val_scores)]
print("best n_neighbors:", best_n_neighbors)

knn = KNeighborsClassifier(n_neighbors=best_n_neighbors)
knn.fit(X_train, y_train)
print("test-set score: {:.3f}".format(knn.score(X_test, y_test)))
```

best cross-validation score: 0.859
best n_neighbors: 1
test-set score: 0.692

In [10]:
```python
from sklearn.pipeline import make_pipeline
clf = make_pipeline(preprocessing.StandardScaler(), svm.SVC(C=1))
cross_val_score(clf, X, y)
```

Out[10]: array([0.54761905, 0.78571429, 0.61904762, 0.70731707, 0.53658537])

In [11]:
```python
print("Size of training set: {}, size of test set: {}".format(X_train.shape[0
```

Size of training set: 156, size of test set: 52

In [12]:
```python
from sklearn.svm import SVC

# split data into train+validation set and test set
X_trainval, X_test, y_trainval, y_test = train_test_split(X, y, random_state=

# split train+validation set into training and validation sets
X_train, X_valid, y_train, y_valid = train_test_split(X_trainval, y_trainval,

print("Size of training set: {}\n size of validation set: {}\n size of test s
       " {}\n".format(X_train.shape[0], X_valid.shape[0], X_test.shape[0]))
```

Size of training set: 117
 size of validation set: 39
 size of test set: 52

In [13]:
```python
best_score = 0
for gamma in [0.001, 0.01, 0.1, 1, 10, 100]:
    for C in [0.001, 0.01, 0.1, 1, 10, 100]:
        # for each combination of parameters,
        # train an SVC
        svm = SVC(gamma=gamma, C=C)
        # perform cross-validation
        scores = cross_val_score(svm, X_trainval, y_trainval, cv=5)
        # compute mean cross-validation accuracy
        score = np.mean(scores)

        # if we got a better score, store the score and parameters
        if score > best_score:
            best_score = score
            best_parameters = {'C': C, 'gamma': gamma}
```

In [14]:
```python
# rebuild a model on the combined training and validation set
svm = SVC(**best_parameters)
svm.fit(X_trainval, y_trainval)

test_score = svm.score(X_test, y_test)
print("Best score on validation set: {:.2f}".format(best_score))
print("Best parameters: ", best_parameters)
print("Test set score with best parameters: {:.2f}".format(test_score))
```

Best score on validation set: 0.87
Best parameters: {'C': 10, 'gamma': 1}
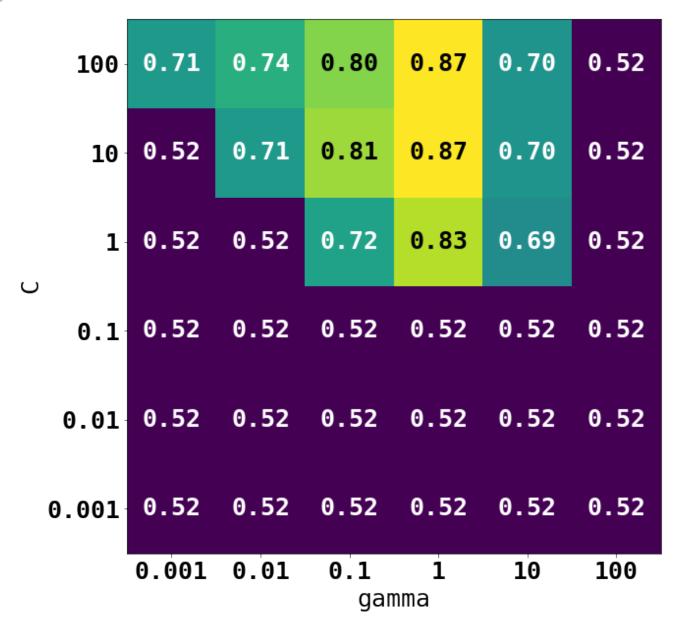Test set score with best parameters: 0.85

In [15]:
```python
param_grid = {'C': [0.001, 0.01, 0.1, 1, 10,100],#,1000],
              'gamma': [0.001, 0.01, 0.1, 1, 10, 100]}

grid_search = GridSearchCV(SVC(), param_grid, cv=5)
X_train, X_test, y_train, y_test = train_test_split(X, y, random_state=42)
grid_search.fit(X_train, y_train)

print("Test set score: {:.2f}".format(grid_search.score(X_test, y_test)))
print("Best parameters: {}".format(grid_search.best_params_))
print("Best cross-validation score: {:.2f}\n".format(grid_search.best_score_)
print("Best estimator:\n{}".format(grid_search.best_estimator_))
```

```
Test set score: 0.94
Best parameters: {'C': 10, 'gamma': 1}
Best cross-validation score: 0.87

Best estimator:
SVC(C=10, gamma=1)
```

Plot a heatmap of the parameters

In [16]:
```python
import mglearn

# convert to DataFrame
results = pd.DataFrame(grid_search.cv_results_)
# show the first 5 rows
display(results.head())
```
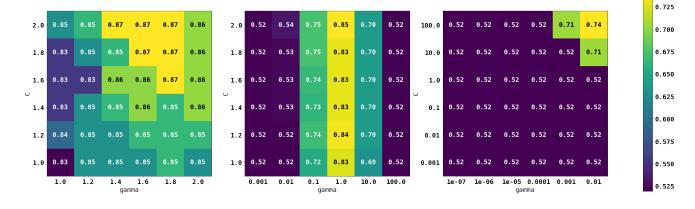
	mean_fit_time	std_fit_time	mean_score_time	std_score_time	param_C	param_gamma
0	0.001996	0.000085	0.000842	0.000097	0.001	0.001
1	0.002431	0.000623	0.001046	0.000440	0.001	0.01
2	0.001714	0.000056	0.000652	0.000050	0.001	0.1
3	0.001668	0.000025	0.000635	0.000009	0.001	1
4	0.001684	0.000027	0.000629	0.000005	0.001	10

In [17]:
```python
param_grid_linear = {'C': np.linspace(1, 2, 6),
                     'gamma': np.linspace(1, 2, 6)}

param_grid_one_log = {'C': np.linspace(1, 2, 6),
                      'gamma': np.logspace(-3, 2, 6)}

param_grid_range = {'C': np.logspace(-3, 2, 6),
                    'gamma': np.logspace(-7, -2, 6)}
```

In [18]:
```python
scores = np.array(results.mean_test_score).reshape(6, 6)
# plot the mean cross-validation scores
mglearn.tools.heatmap(scores, xlabel='gamma', xticklabels=param_grid['gamma']
ylabel='C', yticklabels=param_grid['C'], cmap="viridis")
```

Out[18]: `<matplotlib.collections.PolyCollection at 0x126941940>`

In [19]:
```python
font = {'family' : 'monospace', 'weight' : 'bold', 'size'   : 18}
rc('font', **font)
plt.rcParams['figure.figsize'] = [35, 10]

def plot_params():
    fig, axes = plt.subplots(1, 3)
    for param_grid, ax in zip([param_grid_linear, param_grid_one_log,
                               param_grid_range], axes):
        grid_search = GridSearchCV(SVC(), param_grid, cv=5)
        grid_search.fit(X_train, y_train)
        scores = grid_search.cv_results_['mean_test_score'].reshape(6, 6)

        # plot the mean cross-validation scores
        scores_image = mglearn.tools.heatmap(scores, xlabel='gamma', ylabel='(
                        yticklabels=param_grid['C'], cmap="viridis", ax=ax)
    plt.colorbar(scores_image, ax=axes.tolist())
```

In [20]:
```python
plot_params()
```


Plot a ROC curve

In [21]:
```python
font = {'family' : 'monospace', 'weight' : 'bold', 'size'   : 25}
rc('font', **font)
plt.rcParams['figure.figsize'] = [20, 12]
plt.rcParams['lines.markersize'] = 20
```
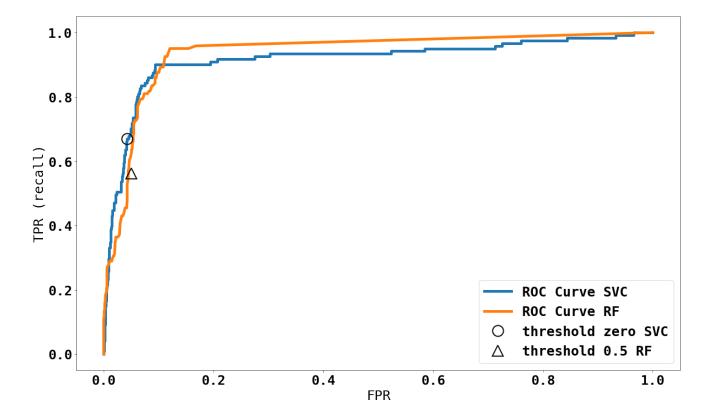
In [22]:
```python
from sklearn.metrics import precision_recall_curve
from sklearn.ensemble import RandomForestClassifier
from mglearn.datasets import make_blobs

X, y = make_blobs(n_samples=(4000, 500), centers=2, cluster_std=[7.0, 2],rand
X_train, X_test, y_train, y_test = train_test_split(X, y, random_state=0)
svc = SVC(gamma=.05).fit(X_train, y_train)
precision, recall, thresholds = precision_recall_curve(y_test, svc.decision_f
# find threshold closest to zero
close_zero = np.argmin(np.abs(thresholds))

rf = RandomForestClassifier(n_estimators=100, random_state=0, max_features=2)
rf.fit(X_train, y_train)
# RandomForestClassifier has predict_proba, but not decision_function
precision_rf, recall_rf, thresholds_rf = precision_recall_curve(
    y_test, rf.predict_proba(X_test)[:, 1])
```

In [23]:
```python
from sklearn.metrics import roc_curve

def plot_roc_curve():
    fpr, tpr, thresholds = roc_curve(y_test, svc.decision_function(X_test))
    fpr_rf, tpr_rf, thresholds_rf = roc_curve(y_test, rf.predict_proba(X_test

    close_zero = np.argmin(np.abs(thresholds))

    plt.plot(fpr, tpr, label="ROC Curve SVC")
    plt.plot(fpr_rf, tpr_rf, label="ROC Curve RF")
    plt.xlabel("FPR")
    plt.ylabel("TPR (recall)")
    plt.plot(fpr[close_zero], tpr[close_zero], 'o',
             label="threshold zero SVC", fillstyle="none", c='k', mew=2)
    close_default_rf = np.argmin(np.abs(thresholds_rf - 0.5))
    plt.plot(fpr_rf[close_default_rf], tpr[close_default_rf], '^',
             label="threshold 0.5 RF", fillstyle="none", c='k', mew=2)
    plt.legend(loc=4)
```

In [24]:
```python
plot_roc_curve()
```

Task 2

Find the best two models by creating a complete pipeline.

One model should predict the morphologic pattern and the other the fetal state.

Use the best combination of parameters and techniques.

```
In [25]:  !pip install xlrd
```

Requirement already satisfied: xlrd in /Users/macbookpro/opt/anaconda3/lib/python3.8/site-packages (1.2.0)

```
In [57]:  import xlrd

          dfs = pd.read_excel("CTG.xls", sheet_name="Data", header=1)
          dfs = dfs.drop(['Unnamed: 9','Unnamed: 42','Unnamed: 44'], axis = 1)
          dfs = dfs[:-3]
          dfs
```

Out[57]:

	b	e	AC	FM	UC	DL	DS	DP	DR	LB	...	C	D	E	AD	DE	LI
0	240.0	357.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	120.0	...	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0
1	5.0	632.0	4.0	0.0	4.0	2.0	0.0	0.0	0.0	132.0	...	-1.0	-1.0	-1.0	1.0	-1.0	-1.0
2	177.0	779.0	2.0	0.0	5.0	2.0	0.0	0.0	0.0	133.0	...	-1.0	-1.0	-1.0	1.0	-1.0	-1.0
3	411.0	1192.0	2.0	0.0	6.0	2.0	0.0	0.0	0.0	134.0	...	-1.0	-1.0	-1.0	1.0	-1.0	-1.0
4	533.0	1147.0	4.0	0.0	5.0	0.0	0.0	0.0	0.0	132.0	...	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	..
2121	2059.0	2867.0	0.0	0.0	6.0	0.0	0.0	0.0	0.0	140.0	...	-1.0	-1.0	1.0	-1.0	-1.0	-1.0
2122	1576.0	2867.0	1.0	0.0	9.0	0.0	0.0	0.0	0.0	140.0	...	-1.0	-1.0	1.0	-1.0	-1.0	-1.0
2123	1576.0	2596.0	1.0	0.0	7.0	0.0	0.0	0.0	0.0	140.0	...	-1.0	-1.0	1.0	-1.0	-1.0	-1.0
2124	1576.0	3049.0	1.0	0.0	9.0	0.0	0.0	0.0	0.0	140.0	...	-1.0	-1.0	1.0	-1.0	-1.0	-1.0
2125	2796.0	3415.0	1.0	1.0	5.0	0.0	0.0	0.0	0.0	142.0	...	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0

2126 rows × 43 columns

In [58]:

```
dfs.dtypes
```

Out[58]:
```
b               float64
e               float64
AC              float64
FM              float64
UC              float64
DL              float64
DS              float64
DP              float64
DR              float64
LB              float64
AC.1            float64
FM.1            float64
UC.1            float64
DL.1            float64
DS.1            float64
DP.1            float64
ASTV            float64
MSTV            float64
ALTV            float64
MLTV            float64
Width           float64
Min             float64
Max             float64
Nmax            float64
Nzeros          float64
Mode            float64
Mean            float64
Median          float64
Variance        float64
Tendency        float64
Unnamed: 31     float64
A               float64
B               float64
C               float64
D               float64
E               float64
AD              float64
DE              float64
LD              float64
FS              float64
SUSP            float64
CLASS           float64
NSP             float64
dtype: object
```

In [59]:
```python
# def _assert_all_finite(X):
#     """Like assert_all_finite, but only for ndarray."""
#     X = np.asanyarray(X)
#     # First try an O(n) time, O(1) space solution for the common case that
#     # everything is finite; fall back to O(n) space np.isfinite to prevent
#     # false positives from overflow in sum method.
#     if (X.dtype.char in np.typecodes['AllFloat'] and not np.isfinite(X.sum(
#             and not np.isfinite(X).all()):
#         raise ValueError("Input contains NaN, infinity"
#                          " or a value too large for %r." % X.dtype)
```

In [60]:
```python
import pandas as pd

def clean_dataset(dfs):
    assert isinstance(dfs, pd.DataFrame), "df needs to be a pd.DataFrame"
    dfs.dropna(inplace=True)
    indices_to_keep = ~dfs.isin([np.nan, np.inf, -np.inf]).any(1)
    return dfs[indices_to_keep].astype(np.float64)
```

In [82]:
```python
# dfs.values
X1 = dfs.iloc[:,:40].to_numpy(dtype='int')
y1 = dfs.iloc[:,-1:].to_numpy()
```

In [83]:
```python
from sklearn.svm import SVC
from sklearn.model_selection import train_test_split
from sklearn.preprocessing import MinMaxScaler

# X1 = np.array(dfs.iloc[:,:46])
# y1 = dfs.iloc[:,-1:].values

X1_train, X1_test, y1_train, y1_test = train_test_split(X1,y1, random_state=0

scaler = MinMaxScaler().fit(X1_train)

X1_train_scaled = scaler.transform(X1_train)
```

In [84]:
```python
svm = SVC()

# learn an SVM on the scaled training data
svm.fit(X1_train_scaled, y1_train)
#svm.fit(X_train, y_train)

# scale the test data and score the scaled data
X1_test_scaled = scaler.transform(X1_test)
print("Test score: {:.2f}".format(svm.score(X1_test_scaled, y1_test)))
```

```
Test score: 0.98
```

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sing ravel().
  return f(**kwargs)
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In [85]:
```python
from sklearn.model_selection import GridSearchCV

param_grid = {'C': [0.001, 0.01, 0.1, 1, 10, 100],
'gamma': [0.001, 0.01, 0.1, 1, 10, 100]}

grid = GridSearchCV(SVC(), param_grid=param_grid, cv=5)
grid.fit(X1_train_scaled, y1_train)

print("Best cross-validation accuracy: {:.2f}".format(grid.best_score_))
print("Best set score: {:.2f}".format(grid.score(X1_test_scaled, y1_test)))
print("Best parameters: ", grid.best_params_)
```

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Best cross-validation accuracy: 0.99
Best set score: 0.99
Best parameters:  {'C': 100, 'gamma': 0.1}
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  return f(**kwargs)
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In [86]:
```python
from sklearn.pipeline import Pipeline

pipe = Pipeline([("scaler", MinMaxScaler()), ("svm", SVC())])

pipe.fit(X1_train, y1_train)
print("Test score: {:.2f}".format(pipe.score(X1_test, y1_test)))
```

```
Test score: 0.98
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sing ravel().
  return f(**kwargs)
```

In [87]:

```python
pipe = Pipeline([("scaler", MinMaxScaler()), ("svm", SVC())])

param_grid = {'svm__C': [0.001, 0.01, 0.1, 1, 10, 100],
              'svm__gamma': [0.001, 0.01, 0.1, 1, 10, 100]}

grid = GridSearchCV(pipe, param_grid=param_grid, cv=5)
grid.fit(X1_train, y1_train)
print("Best cross-validation accuracy: {:.2f}".format(grid.best_score_))
print("Test set score: {:.2f}".format(grid.score(X1_test, y1_test)))
print("Best parameters: {}".format(grid.best_params_))
```

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Best cross-validation accuracy: 0.99
Test set score: 0.99
Best parameters: {'svm__C': 100, 'svm__gamma': 0.1}

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