Note: Go to the end to download the full example code or to run this example in your browser via JupyterLite or Binder

One-Class SVM versus One-Class SVM using Stochastic Gradient Descent

This example shows how to approximate the solution of `sklearn.svm.OneClassSVM` in the case of an RBF kernel with `sklearn.linear_model.SGDOneClassSVM`, a Stochastic Gradient Descent (SGD) version of the One-Class SVM. A kernel approximation is first used in order to apply `sklearn.linear_model.SGDOneClassSVM` which implements a linear One-Class SVM using SGD.

Note that `sklearn.linear_model.SGDOneClassSVM` scales linearly with the number of samples whereas the complexity of a kernelized `sklearn.svm.OneClassSVM` is at best quadratic with respect to the number of samples. It is not the purpose of this example to illustrate the benefits of such an approximation in terms of computation time but rather to show that we obtain similar results on a toy dataset.

```
import matplotlib
import matplotlib.lines as mlines
import matplotlib.pyplot as plt
import numpy as np

from sklearn.kernel_approximation import Nystroem
from sklearn.linear_model import SGDOneClassSVM
from sklearn.pipeline import make_pipeline
from sklearn.svm import OneClassSVM

font = {"weight": "normal", "size": 15}

matplotlib.rc("font", **font)

random_state = 42
rng = np.random.RandomState(random_state)

# Generate train data
X = 0.3 * rng.randn(500, 2)
X_train = np.r_[X + 2, X - 2]
# Generate some regular novel observations
X = 0.3 * rng.randn(20, 2)
X_test = np.r_[X + 2, X - 2]
# Generate some abnormal novel observations
X_outliers = rng.uniform(low=-4, high=4, size=(20, 2))

# OCSVM hyperparameters
nu = 0.05
gamma = 2.0

# Fit the One-Class SVM
clf = OneClassSVM(gamma=gamma, kernel="rbf", nu=nu)
clf.fit(X_train)
y_pred_train = clf.predict(X_train)
y_pred_test = clf.predict(X_test)
y_pred_outliers = clf.predict(X_outliers)
n_error_train = y_pred_train[y_pred_train == -1].size
n_error_test = y_pred_test[y_pred_test == -1].size
n_error_outliers = y_pred_outliers[y_pred_outliers == 1].size

# Fit the One-Class SVM using a kernel approximation and SGD
transform = Nystroem(gamma=gamma, random_state=random_state)
clf_sgd = SGDOneClassSVM(
    nu=nu, shuffle=True, fit_intercept=True, random_state=random_state, tol=1e-4
)
pipe_sgd = make_pipeline(transform, clf_sgd)
pipe_sgd.fit(X_train)
y_pred_train_sgd = pipe_sgd.predict(X_train)
y_pred_test_sgd = pipe_sgd.predict(X_test)
y_pred_outliers_sgd = pipe_sgd.predict(X_outliers)
n_error_train_sgd = y_pred_train_sgd[y_pred_train_sgd == -1].size
n_error_test_sgd = y_pred_test_sgd[y_pred_test_sgd == -1].size
n_error_outliers_sgd = y_pred_outliers_sgd[y_pred_outliers_sgd == 1].size
```

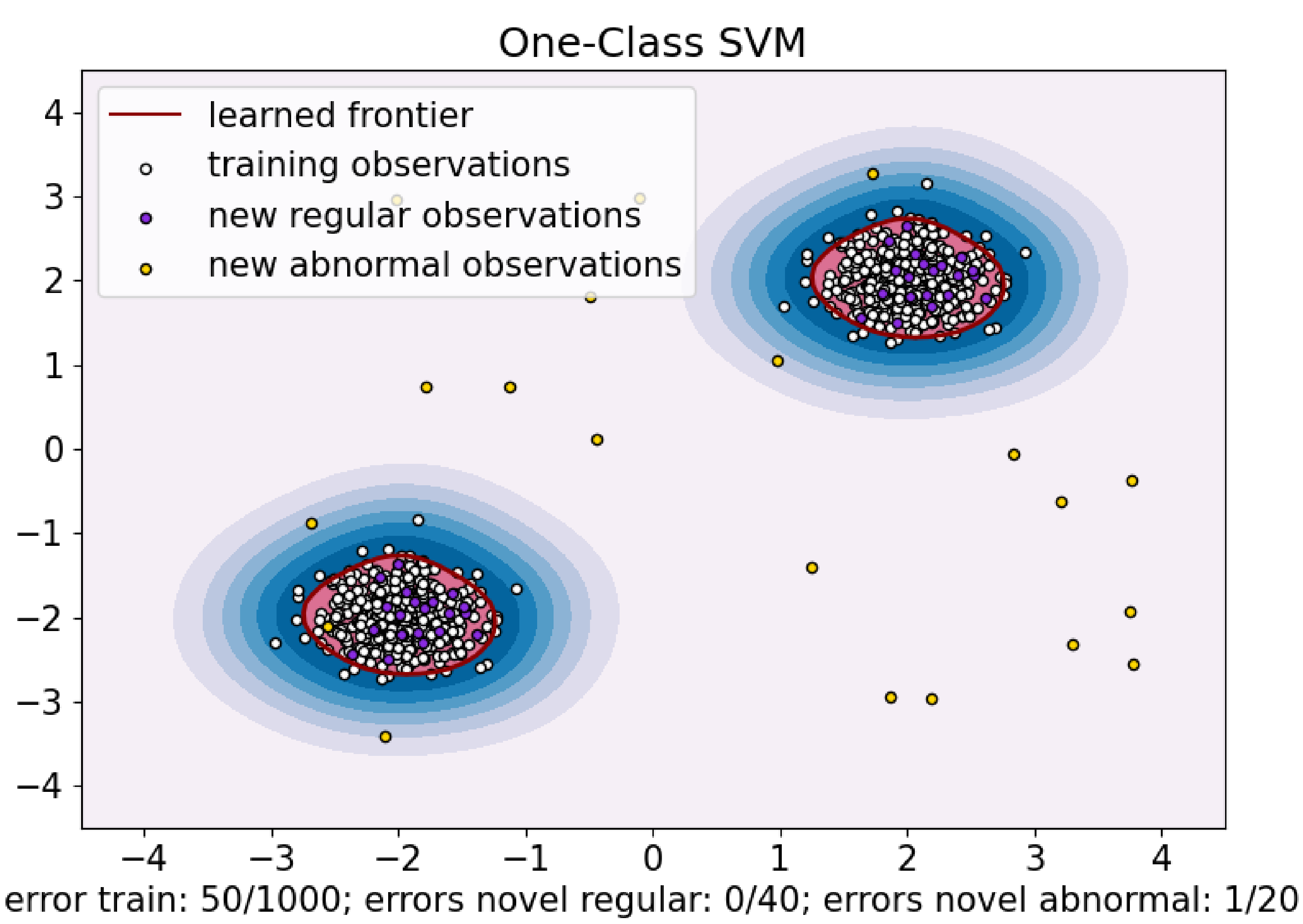
```python
from sklearn.inspection import DecisionBoundaryDisplay

_, ax = plt.subplots(figsize=(9, 6))

xx, yy = np.meshgrid(np.linspace(-4.5, 4.5, 50), np.linspace(-4.5, 4.5, 50))
X = np.concatenate([xx.ravel().reshape(-1, 1), yy.ravel().reshape(-1, 1)], axis=1)
DecisionBoundaryDisplay.from_estimator(
    clf,
    X,
    response_method="decision_function",
    plot_method="contourf",
    ax=ax,
    cmap="PuBu",
)
DecisionBoundaryDisplay.from_estimator(
    clf,
    X,
    response_method="decision_function",
    plot_method="contour",
    ax=ax,
    linewidths=2,
    colors="darkred",
    levels=[0],
)
DecisionBoundaryDisplay.from_estimator(
    clf,
    X,
    response_method="decision_function",
    plot_method="contourf",
    ax=ax,
    colors="palevioletred",
    levels=[0, clf.decision_function(X).max()],
)

s = 20
b1 = plt.scatter(X_train[:, 0], X_train[:, 1], c="white", s=s, edgecolors="k")
b2 = plt.scatter(X_test[:, 0], X_test[:, 1], c="blueviolet", s=s, edgecolors="k")
c = plt.scatter(X_outliers[:, 0], X_outliers[:, 1], c="gold", s=s, edgecolors="k")

ax.set(
    title="One-Class SVM",
    xlim=(-4.5, 4.5),
    ylim=(-4.5, 4.5),
    xlabel=(
        f"error train: {n_error_train}/{X_train.shape[0]}; "
        f"errors novel regular: {n_error_test}/{X_test.shape[0]}; "
        f"errors novel abnormal: {n_error_outliers}/{X_outliers.shape[0]}"
    ),
)
_ = ax.legend(
    [mlines.Line2D([], [], color="darkred", label="learned frontier"), b1, b2, c],
    [
        "learned frontier",
        "training observations",
        "new regular observations",
        "new abnormal observations",
    ],
    loc="upper left",
)
```



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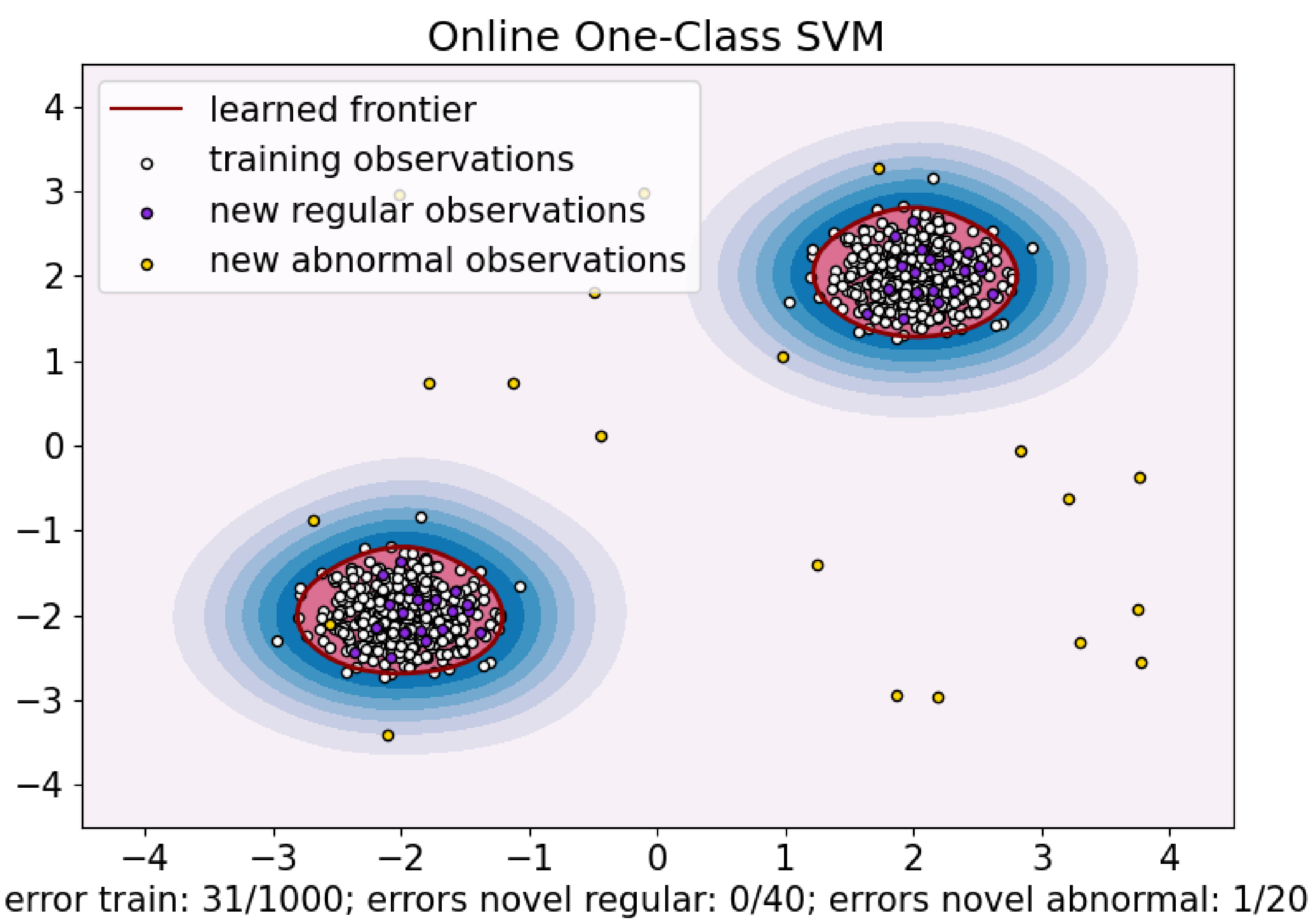
```python
_, ax = plt.subplots(figsize=(9, 6))

xx, yy = np.meshgrid(np.linspace(-4.5, 4.5, 50), np.linspace(-4.5, 4.5, 50))
X = np.concatenate([xx.ravel().reshape(-1, 1), yy.ravel().reshape(-1, 1)], axis=1)
DecisionBoundaryDisplay.from_estimator(
    pipe_sgd,
    X,
    response_method="decision_function",
    plot_method="contourf",
    ax=ax,
    cmap="PuBu",
)
DecisionBoundaryDisplay.from_estimator(
    pipe_sgd,
    X,
    response_method="decision_function",
    plot_method="contour",
    ax=ax,
    linewidths=2,
    colors="darkred",
    levels=[0],
)
DecisionBoundaryDisplay.from_estimator(
    pipe_sgd,
    X,
    response_method="decision_function",
    plot_method="contourf",
    ax=ax,
    colors="palevioletred",
    levels=[0, pipe_sgd.decision_function(X).max()],
)

s = 20
b1 = plt.scatter(X_train[:, 0], X_train[:, 1], c="white", s=s, edgecolors="k")
b2 = plt.scatter(X_test[:, 0], X_test[:, 1], c="blueviolet", s=s, edgecolors="k")
c = plt.scatter(X_outliers[:, 0], X_outliers[:, 1], c="gold", s=s, edgecolors="k")

ax.set(
    title="Online One-Class SVM",
    xlim=(-4.5, 4.5),
    ylim=(-4.5, 4.5),
    xlabel=(
        f"error train: {n_error_train_sgd}/{X_train.shape[0]}; "
        f"errors novel regular: {n_error_test_sgd}/{X_test.shape[0]}; "
        f"errors novel abnormal: {n_error_outliers_sgd}/{X_outliers.shape[0]}"
    ),
)
ax.legend(
    [mlines.Line2D([], [], color="darkred", label="learned frontier"), b1, b2, c],
    [
        "learned frontier",
        "training observations",
        "new regular observations",
        "new abnormal observations",
    ],
    loc="upper left",
)
plt.show()
```



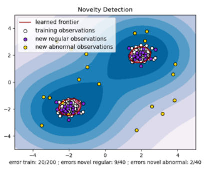
Total running time of the script: (0 minutes 0.418 seconds) launch binder

launch lite

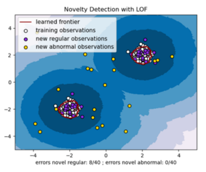
Download Jupyter notebook: plot_sgdocsvm_vs_ocsvm.ipynb

Download Python source code: plot_sgdocsvm_vs_ocsvm.py

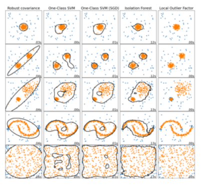
Related examples



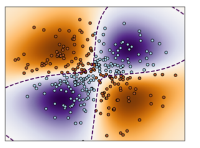
One-class SVM with non-linear kernel (RBF)



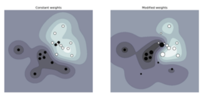
Novelty detection with Local Outlier Factor (LOF)



Comparing anomaly detection algorithms for outlier detection on toy datasets



Non-linear SVM



SVM: Weighted samples

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