Comparaison de LOF, OC-SVM et Isolation Forest

Jeux de données

Nous utilisons deux jeux de données Shuttle et KDD-Cup99 HTTP

Algorithmes comparées

Nous comparons LOF, OC-SVM et Isolation Forest qui sont des méthodes non supervisées de détection d'anomalies Pour chacune de ces méthodes,

- Nous utilisons l'implémentation faite par sckit-learn
- Nous les initialisons avec les valeurs par défaut
- Pour chaque méthode, nous faisons varier un paramètre et exécutons la méthode sur le jeu de données un certain nombre (x) de fois.
- La moyenne des x temps d'exécution et de AUC donne la valeur à considérer pour cette valeur de paramètre concernant cette méthode.
  - Isolation Forest : Contamination (0 à 0,5 pas de 0,1) ----Plutôt faire varier n_estimators (50 à 300 pas de 10)----
  - OC-SVM : nu (0,1 à 1 pas de 0,1) comme dans Goldein et Uchida
  - LOF : n_neighbors (5 à 200 pas de 5) comme dans Goldein et Uchida
- Ceci permet de connaître pour chaque algorithme la valeur du paramètre le plus important qui permet d'avoir le meilleur résultat.
- La courbe ROC sera alors déssinée pour toutes les méthodes ensemble en utilisant leur meilleur paramètres.
- Un tableau sera fait pour comparer le temps d'exécution moyen, la précision moyenne, la AUC moyenne, le rappel moyen des méthodes sur chaque jeu de données.
- Les interprétations seront données pour chaque méthode à propos de chaque jeu de données et pour tous les jeux de données par la suite.

NB: On ne peut pas dessiner la courbe des AUCs comme dans Goldein et Uchida parce que les méthodes qu'ils ont comparé ont des paramètres en commun notamment les méthodes basées sur les plus proche voisins. Ce qui fait qu'ils ont pu tracer la courbe des AUCs en fansant varier le nombre de voinsins et comparer les performances des méthodes entre elle. Dans notre cas, ces trois méthodes n'ont rien en commun pour un tel exercice.

Métriques de comparaison

Nous comparaons ces méthodes sur la base du temps d'éxécution et sur la base de l'air sous la courbe ROC (ROC AUC)

- Nous calculons le temps d'exécution de la fonction sur ces jeux de données avec la fonction time() que nous appelons avant de lancer l'initialisation de la méthode pour avoir l'heure de début. Nous appelons encore la fonction time() à la fin de l'exécution de la fonction predict() de la méthode pour avoir l'heure

de fin du traitement. La différence entre ces deux moments nous donne le temps d'éxécution de la méthode en secondes (s)

- Nous calculons l'air sous la courbe ROC avec la fonction roc_auc_score() de scikit-learn
- La précision
- Le rappel
- Le score f1
- la courbe ROC #### Temps d'exécution Le temps d'exécution est le temps qui sépare le lancement de la méthode à la fin de sa prédiction. Ceci permettra d'évaluer les différentes méthodes en fonction de temps qu'elles prennent pour classer les observations dans le dataset en anomalies ou normales. Il sera tenu compte du fait que le temps d'exécution peut être fonction du type du jeu de données de la taille du jeu de données et du nombre de dimension. #### Précision ()

```
TP/(TP + FP)
```

Le taux d'observations classées positives (ici normale) par la méthode par rapport à toutes les observations réellement normales #### Rappel (TPR)

```
TP/(TP + FN)
```

C'est le taux d'observations positives (ici normale) ayant été correctement détectées par la méthode. #### Score f1

```
TP/(TP + (FN + FP)/2))
F1 est la moyenne harmonique de la précision et du
rappel. F1 donne plus de poids aux faibles valeurs e
t est donc utile pour comparer deux méthodes de clas
sification
```

Courbe ROC

O = Outlier = Négatif N = Normal = Positif

```
O | N
```

O | VN | FP

N | FN | VP

ROC AUC

In [63]:

```python
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
from time import time
from sklearn.ensemble import IsolationForest
from sklearn.svm import OneClassSVM
from sklearn.neighbors import LocalOutlierFactor
from sklearn.metrics import confusion_matrix
from sklearn.metrics import roc_auc_score
from matplotlib.mlab import frange
import statistics
from sklearn.metrics import confusion_matrix
from sklearn.metrics import precision_score, recall_score
from sklearn.metrics import f1_score
from sklearn.metrics import roc_curve
```

Chargement du jeu de données Shuttle

Shuttle contient 10 attributs dont le dernier est la classe à expliquer. Il y a 46464 observations dont 878 anormales. Avec le dernier attribut, nous avons les classes "o" pour les anomalies et "n" pour les observations normales.

In [ ]:

```python
data_brut_Shuttle = pd.read_csv('/Users/thesard/Doctorat/These
2018/ISEP/Developpements/EspaceIntelliJ/LearningAllInPython/Le
arning_IHM_Features/datasets/imported_datasets/shuttle-unsuper
vised-ad_2019-06-14 17:33:02.493755.csv', header=None, index_c
ol=None)
X_Shuttle = data_brut_Shuttle[[0, 1, 2, 3, 4, 5, 6, 7, 8]]
y_brut_Shuttle = data_brut_Shuttle[[9]]
data_brut_Shuttle.describe()
```

Chargement du jeu de données KDD99-Cup HTTP

KDD99-Cup HTTP contient 30 attributs dont le dernier est la classe à expliquer. Il y a 620098 observations dont 1052 anormales. Avec le dernier attribut, nous avons les classes "o" pour les anomalies et "n" pour les observations normales.

In [2]:

```
data_brut_KDD99CUP = pd.read_csv('/Users/thesard/Doctorat/Thes
e2018/ISEP/Developpements/EspaceIntelliJ/LearningAllInPython/L
earning_IHM_Features/datasets/imported_datasets/kdd99-unsuperv
ised-ad_2019-06-24 16:08:29.815617.csv', header=None, index_co
l=None)
X_KDD99CUP = data_brut_KDD99CUP[[0, 1, 2, 3, 4, 5, 6, 7, 8, 9,
10, 11, 12, 13 ,14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25
, 26, 27, 28]]
y_brut_KDD99CUP = data_brut_KDD99CUP[[29]]
data_brut_KDD99CUP.describe()
```

Out[2]:

	0	1	2	3
count	620098.000000	620098.000000	6.200980e+05	620098.000000
mean	0.627670	280.374673	4.099298e+03	0.005012
std	53.972528	1509.901935	2.369388e+04	0.098271
min	0.000000	0.000000	0.000000e+00	0.000000
25%	0.000000	210.000000	4.580000e+02	0.000000
50%	0.000000	240.000000	1.425000e+03	0.000000
75%	0.000000	302.000000	3.731000e+03	0.000000
max	41065.000000	54540.000000	1.173059e+07	21.000000

8 rows × 29 columns

Transformation de la classe à expliquer

L'objectif ici est de remplacer les "o" par -1 et les "n" par 1 afin de faire les matrices de confusion avec la fonction dédiée de scikit-learn.

```python
y_transform_Shuttle = y_brut_Shuttle
y_transform_Shuttle = np.where(y_transform_Shuttle=='o',-1,1)
#y_transform
y_transform_KDD99CUP = y_brut_KDD99CUP
y_transform_KDD99CUP = np.where(y_transform_KDD99CUP=='o',-1,1
)
#y_transform_KDD99CUP
```

Shuttle

Exécution de Isolation Forest sur le jeux de données Shuttle.

```python
max_samples = 'auto'

averages_executions_time_IF_Shuttle = []
averages_roc_auc_IF_Shuttle = []

for j in range(50, 300, 10):
    n_estimators = j
    executions_time_IF_Shuttle = []
    roc_auc_IF_Shuttle = []
    for i in range(5):
        start_IF_Shuttle = time()

        func_IF_Shuttle = IsolationForest(n_estimators=n_estimators, max_samples=max_samples)
        func_IF_Shuttle.fit(X_Shuttle)
        y_pred_IF_Shuttle = func_IF_Shuttle.predict(X_Shuttle)

        # Calcul du temps d'exécution
        exec_time_IF_Shuttle = time() - start_IF_Shuttle
        executions_time_IF_Shuttle.append(exec_time_IF_Shuttle)

        # Calcul de l'aire sous la courbe ROC
        auc_IF_Shuttle = roc_auc_score(y_transform_Shuttle, y_pred_IF_Shuttle)
        roc_auc_IF_Shuttle.append(auc_IF_Shuttle)
        #print("ROC AUC for Isolation Forest applied on Shuttle")
        #print(roc_auc_IF_Shuttle)
    print("Execution time of IsolationForest applied on Shuttle (in second)")
    print(executions_time_IF_Shuttle)
    print("ROC AUC for Isolation Forest applied on Shuttle")
    print(roc_auc_IF_Shuttle)
    averages_executions_time_IF_Shuttle.append(statistics.mean(executions_time_IF_Shuttle))
    averages_roc_auc_IF_Shuttle.append(statistics.mean(roc_auc_IF_Shuttle))
```

```
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le (in second)
[1.9620060920715332, 1.937892198562622, 2.03054213
52386475, 1.7484748363494873, 1.7734181880950928]
ROC AUC for Isolation Forest applied on Shuttle
[0.9511147769761468, 0.9534365544231049, 0.9534475
2270284, 0.9522756656996257, 0.9511147769761468]

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[2.4199650287628174, 1.8720722198486328, 1.9596931
93435669, 2.120850086212158, 2.619346857070923]
ROC AUC for Isolation Forest applied on Shuttle
[0.9522866339793609, 0.9534365544231049, 0.9540169
987848446, 0.9516952213378863, 0.9505343326144072]

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80908203, 3.018112897872925, 2.8080661296844482]
ROC AUC for Isolation Forest applied on Shuttle
[0.9528561100613655, 0.9516952213378863, 0.9511147
769761468, 0.9522756656996257, 0.9574996649552819]

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7404785, 2.7383267879486084, 2.557403802871704]
ROC AUC for Isolation Forest applied on Shuttle
[0.9540279670645795, 0.949373443890928, 0.95111477
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79333496, 3.7645888328552246, 3.9434187412261963]
ROC AUC for Isolation Forest applied on Shuttle
[0.9528561100613655, 0.9534365544231049, 0.9545974
43146584, 0.949373443890928, 0.9511147769761468]

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272583, 3.194585084915161, 3.313184976577759]
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[0.954597443146584, 0.9516952213378863, 0.95169522
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6582, 4.084864139556885, 4.080386161804199]
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[4.505600929260254, 4.276264905929565, 4.567481040
95459, 4.8709869384765625, 5.762482166290283]
ROC AUC for Isolation Forest applied on Shuttle
[0.9540169987848446, 0.9511147769761468, 0.9516952
213378863, 0.9516952213378863, 0.9516952213378863]

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[6.549117088317871, 5.936007976531982, 6.490163326
263428, 5.941627025604248, 5.944984197616577]
ROC AUC for Isolation Forest applied on Shuttle
[0.9505343326144072, 0.9511147769761468, 0.9534365
544231049, 0.9516952213378863, 0.954597443146584]

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le (in second)
[5.251681089401245, 6.1203718185424805, 6.67904615
4022217, 5.22798490524292, 5.0449378490448]
ROC AUC for Isolation Forest applied on Shuttle
[0.954597443146584, 0.9516952213378863, 0.95170618
96176212, 0.9522756656996257, 0.9511147769761468]

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Execution time of IsolationForest applied on Shutt
le (in second)
[5.327769041061401, 5.3705363273620605, 5.28141283
9889526, 5.279926776885986, 5.238170146942139]
ROC AUC for Isolation Forest applied on Shuttle
[0.9511147769761468, 0.9511147769761468, 0.9511147
769761468, 0.9505343326144072, 0.9540169987848446]

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[6.481889009475708, 6.234066009521484, 6.854332923
88916, 5.548670768737793, 5.1609039306640625]
ROC AUC for Isolation Forest applied on Shuttle
[0.9505343326144072, 0.9540169987848446, 0.9493734
43890928, 0.9516952213378863, 0.9516952213378863]

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le (in second)
[5.71312403678894, 5.899142742156982, 5.4688489437
10327, 5.5085320472717285, 5.438029050827026]
ROC AUC for Isolation Forest applied on Shuttle
[0.9522756656996257, 0.9522756656996257, 0.9545974
43146584, 0.9505343326144072, 0.9528561100613655]

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[5.81515908241272, 5.665471076965332, 5.8328258991
241455, 5.71075177192688, 5.901670217514038]
ROC AUC for Isolation Forest applied on Shuttle
[0.954597443146584, 0.9516952213378863, 0.95227566
56996257, 0.9522756656996257, 0.9540169987848446]

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[6.340713977813721, 6.445217132568359, 6.282129764
556885, 6.749686002731323, 6.975047826766968]
ROC AUC for Isolation Forest applied on Shuttle
[0.9528561100613655, 0.9505343326144072, 0.9522756
656996257, 0.9522756656996257, 0.9534365544231049]

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260742, 7.5102739334106445, 6.727222919464111]
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[0.9511147769761468, 0.9516952213378863, 0.9528561
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  " be removed in 0.22.", DeprecationWarning)

Execution time of IsolationForest applied on Shuttle (in second)
[7.919260025024414, 7.943836212158203, 8.434997797012329, 7.999182224273682, 9.34497594833374]
ROC AUC for Isolation Forest applied on Shuttle
[0.9522756656996257, 0.9516952213378863, 0.9522756656996257, 0.9511147769761468, 0.9505343326144072]

/Users/thesard/anaconda3/lib/python3.7/site-packages/sklearn/ensemble/iforest.py:213: FutureWarning: default contamination parameter 0.1 will change in version 0.22 to "auto". This will change the predict method behavior.
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/Users/thesard/anaconda3/lib/python3.7/site-packages

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Execution time of IsolationForest applied on Shutt
le (in second)
[8.157154083251953, 7.800147771835327, 8.469619274
139404, 8.21420693397522, 8.173691034317017]
ROC AUC for Isolation Forest applied on Shuttle
[0.9516952213378863, 0.9516952213378863, 0.9516952
213378863, 0.9511147769761468, 0.9511147769761468]

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Execution time of IsolationForest applied on Shutt
le (in second)
[8.519244194030762, 8.809086799621582, 8.718647003
173828, 9.354079008102417, 8.848625898361206]
ROC AUC for Isolation Forest applied on Shuttle
[0.9499538882526675, 0.9516952213378863, 0.9528561
100613655, 0.9522756656996257, 0.9511147769761468]

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Execution time of IsolationForest applied on Shutt
le (in second)
[9.285672903060913, 8.918629169464111, 9.039498805
999756, 9.71994068145752, 8.873069047927856]
ROC AUC for Isolation Forest applied on Shuttle
[0.9522756656996257, 0.9522756656996257, 0.9511147
769761468, 0.9528561100613655, 0.9522756656996257]

/Users/thesard/anaconda3/lib/python3.7/site-packag
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Execution time of IsolationForest applied on Shutt
le (in second)
[9.461913108825684, 9.167571067810059, 9.809134006
500244, 9.363332748413086, 9.77196478843689]
ROC AUC for Isolation Forest applied on Shuttle
[0.9511147769761468, 0.954597443146584, 0.95227566
56996257, 0.9522756656996257, 0.949953888252675]

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Execution time of IsolationForest applied on Shutt
le (in second)
[9.180898189544678, 8.93524694442749, 8.6925320625
30518, 8.766607999801636, 8.724555969238281]
ROC AUC for Isolation Forest applied on Shuttle
[0.9516952213378863, 0.9511147769761468, 0.9516952
213378863, 0.9522756656996257, 0.9516952213378863]
```

Résultat de Isolation Forest sur Shuttle

In [54]:

```python
print("Execution time of IsolationForest applied on Shuttle (i
n second)")
print(averages_executions_time_IF_Shuttle)
plt.plot(range(50, 300, 10), averages_executions_time_IF_Shutt
le,  "g-", label="IForest on Shuttle")
#plt.axis([0, 1, 0, 1])
plt.xlabel('n_estimators')
plt.ylabel('Execution time')
plt.legend(loc="best")
plt.show()
```

```
Execution time of IsolationForest applied on Shutt
le (in second)
[1.8904666900634766, 2.19838547706604, 3.061095285
4156492, 3.3027215957641602, 3.538767194747925, 3.
4117008686065673, 3.5509314060211183, 4.2408480644
22607, 4.796563196182251, 6.1723799228668215, 5.66
4804363250733, 5.299563026428222, 6.05597252845764
2, 5.605535364151001, 5.785175609588623, 6.5585589
40887451, 7.291825008392334, 8.4375638961792, 7.73
620638847351, 8.328450441360474, 8.162963819503783
, 8.849936580657959, 9.167372798919677, 9.51478314
3997192, 8.859968233108521]
```
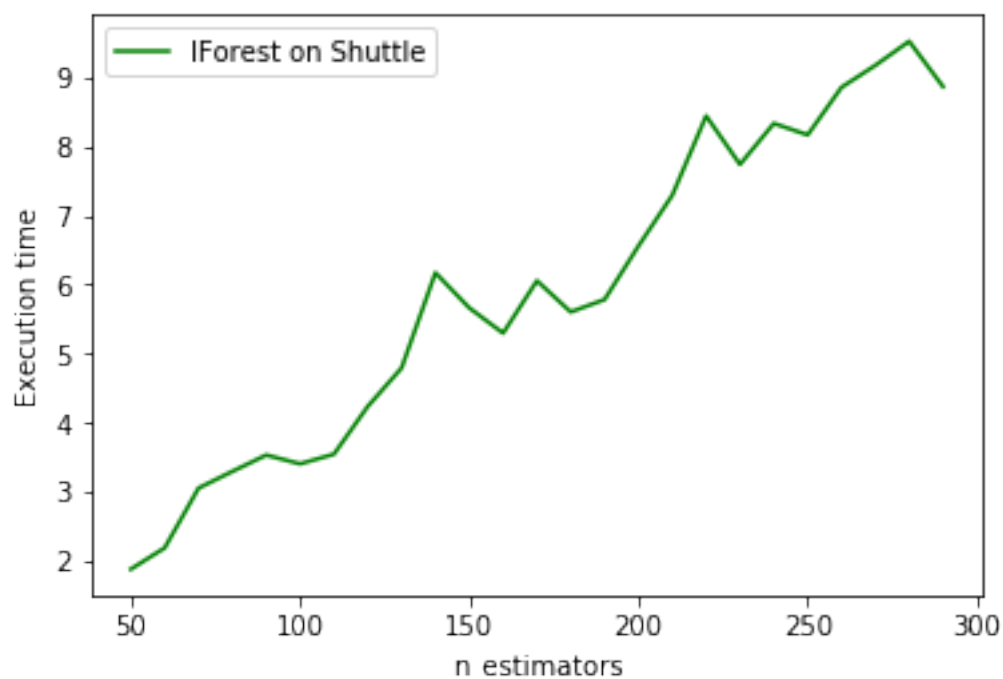

In [56]:

```python
print("ROC AUC for Isolation Forest applied on Shuttle")
print(averages_roc_auc_IF_Shuttle)
print("La valeur max est "+str(max(averages_roc_auc_IF_Shuttle
))+" à l'index "+str(averages_roc_auc_IF_Shuttle.index(max(ave
rages_roc_auc_IF_Shuttle))))
plt.plot(range(50, 300, 10), averages_roc_auc_IF_Shuttle,  "g-
", label="ROC AUC of IForest on Shuttle")
#plt.axis([0, 1, 0, 1])
plt.xlabel('n_estimators')
plt.ylabel('AUC')
plt.legend(loc="best")
plt.show()
```

```
ROC AUC for Isolation Forest applied on Shuttle
[0.9522778593555729, 0.9523939482279208, 0.9530882
878060613, 0.9518135038661811, 0.9522756656996259,
0.9529743925896603, 0.9526239323166695, 0.95262393
23166695, 0.9520434879549301, 0.9522756656996259,
0.9522778593555729, 0.9515791324655384, 0.95146304
35931904, 0.9525078434443216, 0.9529721989337133,
0.9522756656996259, 0.9521595768272779, 0.95192739
90825821, 0.9518113102102342, 0.9515791324655384,
0.9514630435931904, 0.9515791324655384, 0.95215957
68272779, 0.95204348795493, 0.9516952213378863]
La valeur max est 0.9530882878060613 à l'index 2
```
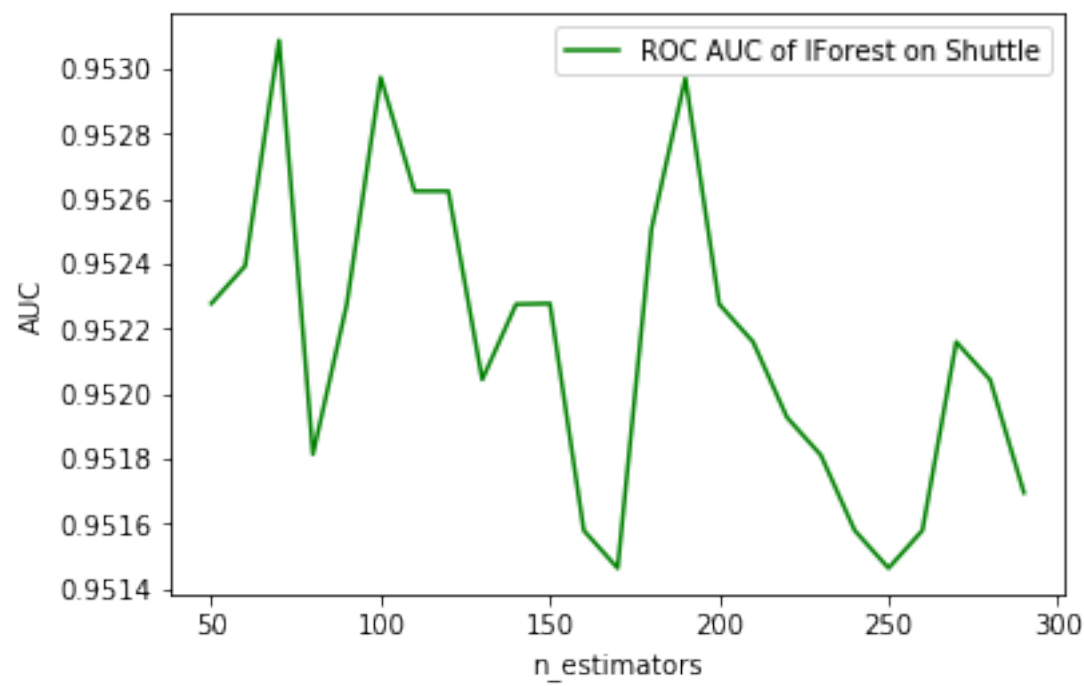

Interprétation du résultat de IsolationForest sur Shuttle

Le temps d'exécution de IForest n'est pas lié à la variation de contamination (le taux d'anomalies dans le jeu de données). Par contre en ce qui concerne l'aire sous la coube ROC, la meilleure performance est arrivée quand contamination est à 0,1. 0,1 est d'ailleurs la valeur par défaut de contamination au niveau de scikit-learn. Conclusion: Refaire l'exercice en faisant varier cette fois-ci n_estimators (le nombre d'estimateurs de l'emsemble à utiliser pour tester l'aberrance des observations).

Avec n_estimators entre 50 et 300, on remarque que le temps d'exécution augmente au fur et à mesure que le nombre d'estimateurs augmente. Concernant la performance, la meilleure estimation a été obtenu pour un taux de AUC = 0.9530882878060613 avec n_estimators = 70 ===> (50+2*10) A noter que quelque soit la valeur de n_estimators, la AUC est toujours supérieure à 0,95

Exécution de OC-SVM sur Shuttle

```python
averages_executions_time_OCSVM_Shuttle = []
averages_roc_auc_OCSVM_Shuttle = []

for j in frange(0.1, 1., 0.1):
    nu = j
    executions_time_OCSVM_Shuttle = []
    roc_auc_OCSVM_Shuttle = []
    for i in range(5):
        start_OCSVM_Shuttle = time()

        func_OCSVM_Shuttle = OneClassSVM(nu=nu)
        func_OCSVM_Shuttle.fit(X_Shuttle)
        y_pred_OCSVM_Shuttle = func_OCSVM_Shuttle.predict(X_Sh
uttle)

        # Calcul du temps d'exécution
        exec_time_OCSVM_Shuttle = time() - start_OCSVM_Shuttle
        executions_time_OCSVM_Shuttle.append(exec_time_OCSVM_S
huttle)

        # Calcul de l'aire sous la courbe ROC
        auc_OCSVM_Shuttle = roc_auc_score(y_transform_Shuttle,
y_pred_OCSVM_Shuttle)
        roc_auc_OCSVM_Shuttle.append(auc_OCSVM_Shuttle)

    print("Execution time of OC-SVM applied on Shuttle (in sec
ond)")
    print(executions_time_OCSVM_Shuttle)
    print("ROC AUC for OC-SVM applied on Shuttle")
    print(roc_auc_OCSVM_Shuttle)
    averages_executions_time_OCSVM_Shuttle.append(statistics.m
ean(executions_time_OCSVM_Shuttle))
    averages_roc_auc_OCSVM_Shuttle.append(statistics.mean(roc_
auc_OCSVM_Shuttle))
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packag
es/ipykernel_launcher.py:34: MatplotlibDeprecation
Warning: numpy.arange
/Users/thesard/anaconda3/lib/python3.7/site-packag
es/sklearn/svm/base.py:196: FutureWarning: The def
ault value of gamma will change from 'auto' to 'sc
ale' in version 0.22 to account better for unscale
d features. Set gamma explicitly to 'auto' or 'sca
le' to avoid this warning.
   "avoid this warning.", FutureWarning)
/Users/thesard/anaconda3/lib/python3.7/site-packag
es/sklearn/svm/base.py:196: FutureWarning: The def
ault value of gamma will change from 'auto' to 'sc
ale' in version 0.22 to account better for unscale
d features. Set gamma explicitly to 'auto' or 'sca
le' to avoid this warning.
   "avoid this warning.", FutureWarning)
/Users/thesard/anaconda3/lib/python3.7/site-packag
es/sklearn/svm/base.py:196: FutureWarning: The def
ault value of gamma will change from 'auto' to 'sc
ale' in version 0.22 to account better for unscale
d features. Set gamma explicitly to 'auto' or 'sca
le' to avoid this warning.
   "avoid this warning.", FutureWarning)
/Users/thesard/anaconda3/lib/python3.7/site-packag
es/sklearn/svm/base.py:196: FutureWarning: The def
ault value of gamma will change from 'auto' to 'sc
ale' in version 0.22 to account better for unscale
d features. Set gamma explicitly to 'auto' or 'sca
le' to avoid this warning.
   "avoid this warning.", FutureWarning)
/Users/thesard/anaconda3/lib/python3.7/site-packag
es/sklearn/svm/base.py:196: FutureWarning: The def
ault value of gamma will change from 'auto' to 'sc
ale' in version 0.22 to account better for unscale
d features. Set gamma explicitly to 'auto' or 'sca
le' to avoid this warning.
   "avoid this warning.", FutureWarning)

Execution time of OC-SVM applied on Shuttle (in se
cond)
[329.46220993995667, 261.47730708122253, 274.28071
904182434, 245.17911291122437, 240.5820107460022]
ROC AUC for OC-SVM applied on Shuttle
[0.6188546777389493, 0.6188546777389493, 0.6188546
777389493, 0.6188546777389493, 0.6188546777389493]
```

Execution time of OC-SVM applied on Shuttle (in second)
[218.47312903404236, 216.3624849319458, 214.21477723121643, 215.6682789325714, 214.08669090270996]
ROC AUC for OC-SVM applied on Shuttle
[0.7269955947990666, 0.7269955947990666, 0.7269955947990666, 0.726995947990666, 0.7269955947990666]

```
/Users/thesard/anaconda3/lib/python3.7/site-packag
es/sklearn/svm/base.py:196: FutureWarning: The def
ault value of gamma will change from 'auto' to 'sc
ale' in version 0.22 to account better for unscale
d features. Set gamma explicitly to 'auto' or 'sca
le' to avoid this warning.
  "avoid this warning.", FutureWarning)
/Users/thesard/anaconda3/lib/python3.7/site-packag
es/sklearn/svm/base.py:196: FutureWarning: The def
ault value of gamma will change from 'auto' to 'sc
ale' in version 0.22 to account better for unscale
d features. Set gamma explicitly to 'auto' or 'sca
le' to avoid this warning.
  "avoid this warning.", FutureWarning)
/Users/thesard/anaconda3/lib/python3.7/site-packag
es/sklearn/svm/base.py:196: FutureWarning: The def
ault value of gamma will change from 'auto' to 'sc
ale' in version 0.22 to account better for unscale
d features. Set gamma explicitly to 'auto' or 'sca
le' to avoid this warning.
  "avoid this warning.", FutureWarning)
/Users/thesard/anaconda3/lib/python3.7/site-packag
es/sklearn/svm/base.py:196: FutureWarning: The def
ault value of gamma will change from 'auto' to 'sc
ale' in version 0.22 to account better for unscale
d features. Set gamma explicitly to 'auto' or 'sca
le' to avoid this warning.
  "avoid this warning.", FutureWarning)
/Users/thesard/anaconda3/lib/python3.7/site-packag
es/sklearn/svm/base.py:196: FutureWarning: The def
ault value of gamma will change from 'auto' to 'sc
ale' in version 0.22 to account better for unscale
d features. Set gamma explicitly to 'auto' or 'sca
le' to avoid this warning.
  "avoid this warning.", FutureWarning)

Execution time of OC-SVM applied on Shuttle (in se
cond)
[191.5847761631012, 184.71183609962463, 180.269457
81707764, 189.2221701145172, 181.08830785751343]
ROC AUC for OC-SVM applied on Shuttle
[0.7737174183377845, 0.7737174183377845, 0.7737174
183377845, 0.7737174183377845, 0.7737174183377845]
```

/Users/thesard/anaconda3/lib/python3.7/site-packages/sklearn/svm/base.py:196: FutureWarning: The default value of gamma will change from 'auto' to 'scale' in version 0.22 to account better for unscaled features. Set gamma explicitly to 'auto' or 'scale' to avoid this warning.
  "avoid this warning.", FutureWarning)
/Users/thesard/anaconda3/lib/python3.7/site-packages/sklearn/svm/base.py:196: FutureWarning: The default value of gamma will change from 'auto' to 'scale' in version 0.22 to account better for unscaled features. Set gamma explicitly to 'auto' or 'scale' to avoid this warning.
  "avoid this warning.", FutureWarning)
/Users/thesard/anaconda3/lib/python3.7/site-packages/sklearn/svm/base.py:196: FutureWarning: The default value of gamma will change from 'auto' to 'scale' in version 0.22 to account better for unscaled features. Set gamma explicitly to 'auto' or 'scale' to avoid this warning.
  "avoid this warning.", FutureWarning)
/Users/thesard/anaconda3/lib/python3.7/site-packages/sklearn/svm/base.py:196: FutureWarning: The default value of gamma will change from 'auto' to 'scale' in version 0.22 to account better for unscaled features. Set gamma explicitly to 'auto' or 'scale' to avoid this warning.
  "avoid this warning.", FutureWarning)
/Users/thesard/anaconda3/lib/python3.7/site-packages/sklearn/svm/base.py:196: FutureWarning: The default value of gamma will change from 'auto' to 'scale' in version 0.22 to account better for unscaled features. Set gamma explicitly to 'auto' or 'scale' to avoid this warning.
  "avoid this warning.", FutureWarning)

Execution time of OC-SVM applied on Shuttle (in second)
[161.18653416633606, 160.5630328655243, 160.26079177856445, 160.88182997703552, 161.40579509735107]
ROC AUC for OC-SVM applied on Shuttle
[0.775169428691041, 0.775169428691041, 0.775169428691041, 0.775169428691041, 0.775169428691041]

/Users/thesard/anaconda3/lib/python3.7/site-packages/sklearn/svm/base.py:196: FutureWarning: The default value of gamma will change from 'auto' to 'scale' in version 0.22 to account better for unscaled features. Set gamma explicitly to 'auto' or 'scale' to avoid this warning.
  "avoid this warning.", FutureWarning)
/Users/thesard/anaconda3/lib/python3.7/site-packages/sklearn/svm/base.py:196: FutureWarning: The default value of gamma will change from 'auto' to 'scale' in version 0.22 to account better for unscaled features. Set gamma explicitly to 'auto' or 'scale' to avoid this warning.
  "avoid this warning.", FutureWarning)
/Users/thesard/anaconda3/lib/python3.7/site-packages/sklearn/svm/base.py:196: FutureWarning: The default value of gamma will change from 'auto' to 'scale' in version 0.22 to account better for unscaled features. Set gamma explicitly to 'auto' or 'scale' to avoid this warning.
  "avoid this warning.", FutureWarning)
/Users/thesard/anaconda3/lib/python3.7/site-packages/sklearn/svm/base.py:196: FutureWarning: The default value of gamma will change from 'auto' to 'scale' in version 0.22 to account better for unscaled features. Set gamma explicitly to 'auto' or 'scale' to avoid this warning.
  "avoid this warning.", FutureWarning)
/Users/thesard/anaconda3/lib/python3.7/site-packages/sklearn/svm/base.py:196: FutureWarning: The default value of gamma will change from 'auto' to 'scale' in version 0.22 to account better for unscaled features. Set gamma explicitly to 'auto' or 'scale' to avoid this warning.
  "avoid this warning.", FutureWarning)

Execution time of OC-SVM applied on Shuttle (in second)
[150.68664383888245, 150.58169770240784, 148.8878152370453, 148.7774007320404, 149.51005792617798]
ROC AUC for OC-SVM applied on Shuttle
[0.7442227397273692, 0.7442227397273692, 0.7442227397273692, 0.7442227397273692, 0.7442227397273692]

Execution time of OC-SVM applied on Shuttle (in se
cond)
[141.95292973518372, 141.27181887626648, 148.45246
386528015, 145.09825491905212, 144.94975304603577]
ROC AUC for OC-SVM applied on Shuttle
[0.7015329207794384, 0.7015329207794384, 0.7015329
207794384, 0.7015329207794384, 0.7015329207794384]

Execution time of OC-SVM applied on Shuttle (in second)
[138.45889115333557, 136.31735110282898, 136.81975293159485, 138.9244029521942, 143.10618805885315]
ROC AUC for OC-SVM applied on Shuttle
[0.6525248979949985, 0.6525248979949985, 0.6525248979949985, 0.6525248979949985, 0.6525248979949985]

```
/Users/thesard/anaconda3/lib/python3.7/site-packag
es/sklearn/svm/base.py:196: FutureWarning: The def
ault value of gamma will change from 'auto' to 'sc
ale' in version 0.22 to account better for unscale
d features. Set gamma explicitly to 'auto' or 'sca
le' to avoid this warning.
   "avoid this warning.", FutureWarning)
/Users/thesard/anaconda3/lib/python3.7/site-packag
es/sklearn/svm/base.py:196: FutureWarning: The def
ault value of gamma will change from 'auto' to 'sc
ale' in version 0.22 to account better for unscale
d features. Set gamma explicitly to 'auto' or 'sca
le' to avoid this warning.
   "avoid this warning.", FutureWarning)
/Users/thesard/anaconda3/lib/python3.7/site-packag
es/sklearn/svm/base.py:196: FutureWarning: The def
ault value of gamma will change from 'auto' to 'sc
ale' in version 0.22 to account better for unscale
d features. Set gamma explicitly to 'auto' or 'sca
le' to avoid this warning.
   "avoid this warning.", FutureWarning)
/Users/thesard/anaconda3/lib/python3.7/site-packag
es/sklearn/svm/base.py:196: FutureWarning: The def
ault value of gamma will change from 'auto' to 'sc
ale' in version 0.22 to account better for unscale
d features. Set gamma explicitly to 'auto' or 'sca
le' to avoid this warning.
   "avoid this warning.", FutureWarning)
/Users/thesard/anaconda3/lib/python3.7/site-packag
es/sklearn/svm/base.py:196: FutureWarning: The def
ault value of gamma will change from 'auto' to 'sc
ale' in version 0.22 to account better for unscale
d features. Set gamma explicitly to 'auto' or 'sca
le' to avoid this warning.
   "avoid this warning.", FutureWarning)

Execution time of OC-SVM applied on Shuttle (in se
cond)
[121.23537707328796, 121.62225794792175, 121.03575
110435486, 122.10104298591614, 121.69169592857361]
ROC AUC for OC-SVM applied on Shuttle
[0.601708857982714, 0.601708857982714, 0.601708857
982714, 0.601708857982714, 0.601708857982714]
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packag
es/sklearn/svm/base.py:196: FutureWarning: The def
ault value of gamma will change from 'auto' to 'sc
ale' in version 0.22 to account better for unscale
d features. Set gamma explicitly to 'auto' or 'sca
le' to avoid this warning.
    "avoid this warning.", FutureWarning)
/Users/thesard/anaconda3/lib/python3.7/site-packag
es/sklearn/svm/base.py:196: FutureWarning: The def
ault value of gamma will change from 'auto' to 'sc
ale' in version 0.22 to account better for unscale
d features. Set gamma explicitly to 'auto' or 'sca
le' to avoid this warning.
    "avoid this warning.", FutureWarning)
/Users/thesard/anaconda3/lib/python3.7/site-packag
es/sklearn/svm/base.py:196: FutureWarning: The def
ault value of gamma will change from 'auto' to 'sc
ale' in version 0.22 to account better for unscale
d features. Set gamma explicitly to 'auto' or 'sca
le' to avoid this warning.
    "avoid this warning.", FutureWarning)
/Users/thesard/anaconda3/lib/python3.7/site-packag
es/sklearn/svm/base.py:196: FutureWarning: The def
ault value of gamma will change from 'auto' to 'sc
ale' in version 0.22 to account better for unscale
d features. Set gamma explicitly to 'auto' or 'sca
le' to avoid this warning.
    "avoid this warning.", FutureWarning)
/Users/thesard/anaconda3/lib/python3.7/site-packag
es/sklearn/svm/base.py:196: FutureWarning: The def
ault value of gamma will change from 'auto' to 'sc
ale' in version 0.22 to account better for unscale
d features. Set gamma explicitly to 'auto' or 'sca
le' to avoid this warning.
    "avoid this warning.", FutureWarning)

Execution time of OC-SVM applied on Shuttle (in se
cond)
[119.410649061203, 112.79455494880676, 117.1170990
4670715, 111.87071490287781, 120.11324286460876]
ROC AUC for OC-SVM applied on Shuttle
[0.5511121835651296, 0.5511121835651296, 0.5511121
835651296, 0.5511121835651296, 0.5511121835651296]
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packag
es/sklearn/svm/base.py:196: FutureWarning: The def
ault value of gamma will change from 'auto' to 'sc
ale' in version 0.22 to account better for unscale
d features. Set gamma explicitly to 'auto' or 'sca
le' to avoid this warning.
  "avoid this warning.", FutureWarning)
/Users/thesard/anaconda3/lib/python3.7/site-packag
es/sklearn/svm/base.py:196: FutureWarning: The def
ault value of gamma will change from 'auto' to 'sc
ale' in version 0.22 to account better for unscale
d features. Set gamma explicitly to 'auto' or 'sca
le' to avoid this warning.
  "avoid this warning.", FutureWarning)
/Users/thesard/anaconda3/lib/python3.7/site-packag
es/sklearn/svm/base.py:196: FutureWarning: The def
ault value of gamma will change from 'auto' to 'sc
ale' in version 0.22 to account better for unscale
d features. Set gamma explicitly to 'auto' or 'sca
le' to avoid this warning.
  "avoid this warning.", FutureWarning)
/Users/thesard/anaconda3/lib/python3.7/site-packag
es/sklearn/svm/base.py:196: FutureWarning: The def
ault value of gamma will change from 'auto' to 'sc
ale' in version 0.22 to account better for unscale
d features. Set gamma explicitly to 'auto' or 'sca
le' to avoid this warning.
  "avoid this warning.", FutureWarning)
/Users/thesard/anaconda3/lib/python3.7/site-packag
es/sklearn/svm/base.py:196: FutureWarning: The def
ault value of gamma will change from 'auto' to 'sc
ale' in version 0.22 to account better for unscale
d features. Set gamma explicitly to 'auto' or 'sca
le' to avoid this warning.
  "avoid this warning.", FutureWarning)

Execution time of OC-SVM applied on Shuttle (in se
cond)
[107.6783459186554, 108.68707871437073, 107.134278
05900574, 111.51461815834045, 108.39957904815674]
ROC AUC for OC-SVM applied on Shuttle
[0.5, 0.5, 0.5, 0.5, 0.5]
```

Résultat de OC-SVM sur shuttle

```python
print("Execution time of OC-SVM applied on Shuttle (in second)
")
print(averages_executions_time_OCSVM_Shuttle)
plt.plot(frange(0.1, 1., 0.1), averages_executions_time_OCSVM_
Shuttle,  "g-", label="OC-SVM on Shuttle")
#plt.axis([0, 1, 0, 1])
plt.xlabel('nu')
plt.ylabel('Execution time')
plt.legend(loc="best")
plt.show()
```

```
Execution time of OC-SVM applied on Shuttle (in se
cond)
[270.19627194404603, 215.7610722064972, 185.375309
61036683, 160.8595967769623, 149.6887230873108, 14
4.34504408836364, 138.72531723976135, 121.53722500
801086, 116.2612521648407, 108.68277997970581]

/Users/thesard/anaconda3/lib/python3.7/site-packag
es/ipykernel_launcher.py:3: MatplotlibDeprecationW
arning: numpy.arange
  This is separate from the ipykernel package so w
e can avoid doing imports until
```
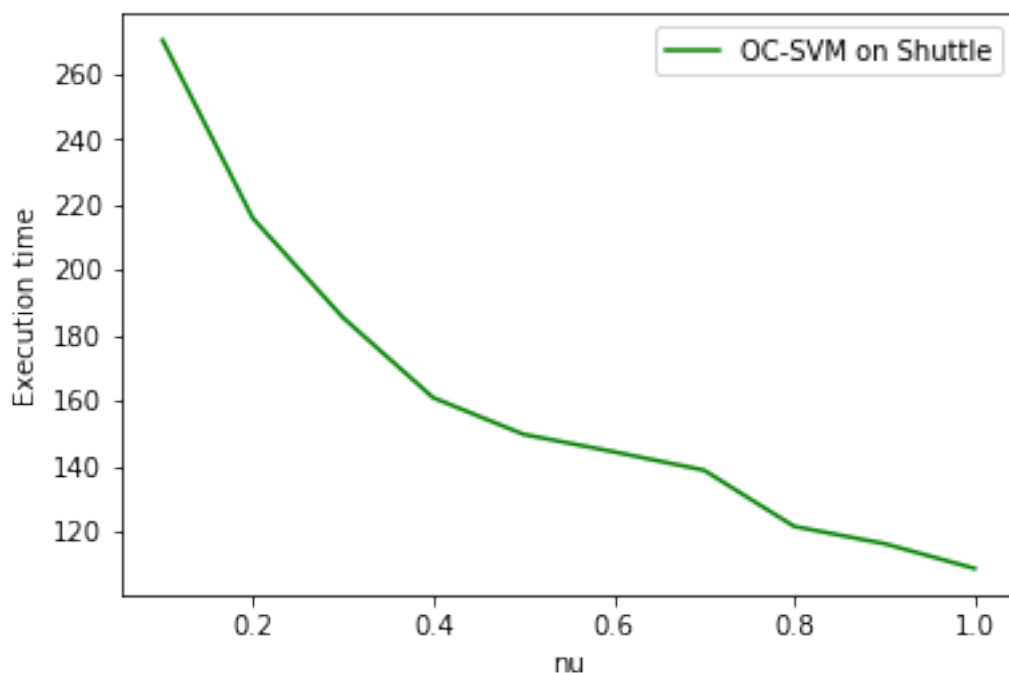
```python
print("ROC AUC for OC-SVM applied on Shuttle")
print(averages_roc_auc_OCSVM_Shuttle)
plt.plot(frange(0.1, 1., 0.1), averages_roc_auc_OCSVM_Shuttle,
"g-", label="ROC AUC of OCSVM on Shuttle")
#plt.axis([0, 1, 0, 1])
plt.xlabel('nu')
plt.ylabel('AUC')
plt.legend(loc="best")
plt.show()
```

```
ROC AUC for OC-SVM applied on Shuttle
[0.6188546777389493, 0.7269955947990666, 0.7737174
183377845, 0.775169428691041, 0.7442227397273692,
0.7015329207794384, 0.6525248979949985, 0.60170885
7982714, 0.5511121835651296, 0.5]

/Users/thesard/anaconda3/lib/python3.7/site-packag
es/ipykernel_launcher.py:3: MatplotlibDeprecationW
arning: numpy.arange
  This is separate from the ipykernel package so w
e can avoid doing imports until
```
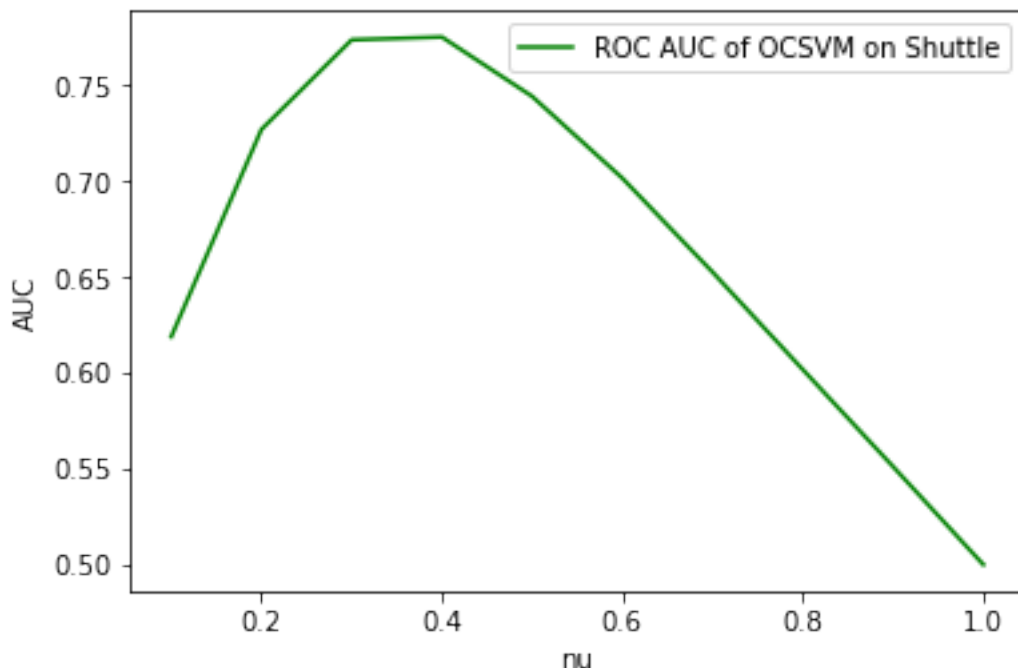

Interprétation du résultat de OC-SVM sur Shuttle

Plus la valeur de nu augmente plus le temps d'exécution diminue. OC-SVM est donc plus rapide sur Shuttle avec un nu plus grand. Mais, celà n'entraîne pas un bon résultat de la méthode. Puisqu'à partir d'un nu de 0.5, la prédiction de l'algorithme devient de plus en plus aléatoire. La meilleure performance est atteinte à nu= 0.4

Exécution de LOF sur Shuttle

```python
averages_executions_time_LOF_Shuttle = []
averages_roc_auc_LOF_Shuttle = []

for j in range(5, 200, 5):
    n_neighbors = j
    executions_time_LOF_Shuttle = []
    roc_auc_LOF_Shuttle = []
    for i in range(5):
        start_LOF_Shuttle = time()

        func_LOF_Shuttle = LocalOutlierFactor(n_neighbors=n_ne
ighbors,novelty=True)
        func_LOF_Shuttle.fit(X_Shuttle)
        y_pred_LOF_Shuttle = func_LOF_Shuttle.predict(X_Shuttl
e)

        # Calcul du temps d'exécution
        exec_time_LOF_Shuttle = time() - start_LOF_Shuttle
        executions_time_LOF_Shuttle.append(exec_time_LOF_Shutt
le)

        # Calcul de l'aire sous la courbe ROC
        auc_LOF_Shuttle = roc_auc_score(y_transform_Shuttle, y
_pred_LOF_Shuttle)
        roc_auc_LOF_Shuttle.append(auc_LOF_Shuttle)

    print("Execution time of LOF applied on Shuttle (in second
)")
    print(executions_time_LOF_Shuttle)
    print("ROC AUC for LOF applied on Shuttle")
    print(roc_auc_LOF_Shuttle)
    averages_executions_time_LOF_Shuttle.append(statistics.mea
n(executions_time_LOF_Shuttle))
    averages_roc_auc_LOF_Shuttle.append(statistics.mean(roc_au
c_LOF_Shuttle))
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packag
es/sklearn/neighbors/lof.py:236: FutureWarning: de
fault contamination parameter 0.1 will change in v
ersion 0.22 to "auto". This will change the predic
t method behavior.
  FutureWarning)
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es/sklearn/neighbors/lof.py:236: FutureWarning: de
fault contamination parameter 0.1 will change in v
ersion 0.22 to "auto". This will change the predic
t method behavior.
  FutureWarning)

Execution time of LOF applied on Shuttle (in secon
d)
[8.548911094665527, 7.140587091445923, 6.541306972
503662, 6.311285018920898, 6.982913017272949]
ROC AUC for LOF applied on Shuttle
[0.5215160920903762, 0.5215160920903762, 0.5215160
920903762, 0.5215160920903762, 0.5215160920903762]
```

```
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es/sklearn/neighbors/lof.py:236: FutureWarning: de
fault contamination parameter 0.1 will change in v
ersion 0.22 to "auto". This will change the predic
t method behavior.
  FutureWarning)
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  FutureWarning)
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ersion 0.22 to "auto". This will change the predic
t method behavior.
  FutureWarning)
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es/sklearn/neighbors/lof.py:236: FutureWarning: de
fault contamination parameter 0.1 will change in v
ersion 0.22 to "auto". This will change the predic
t method behavior.
  FutureWarning)


Execution time of LOF applied on Shuttle (in secon
d)
[8.106007814407349, 10.845497131347656, 9.74558281
8984985, 8.954133987426758, 9.703468084335327]
ROC AUC for LOF applied on Shuttle
[0.5303294171661024, 0.5303294171661024, 0.5303294
171661024, 0.5303294171661024, 0.5303294171661024]
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packag
es/sklearn/neighbors/lof.py:236: FutureWarning: de
fault contamination parameter 0.1 will change in v
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es/sklearn/neighbors/lof.py:236: FutureWarning: de
fault contamination parameter 0.1 will change in v
ersion 0.22 to "auto". This will change the predic
t method behavior.
  FutureWarning)

Execution time of LOF applied on Shuttle (in secon
d)
[10.239574193954468, 10.467014074325562, 10.775267
124176025, 10.272745132446289, 10.155516147613525]
ROC AUC for LOF applied on Shuttle
[0.5464129627777061, 0.5464129627777061, 0.5464129
627777061, 0.5464129627777061, 0.5464129627777061]
```

/Users/thesard/anaconda3/lib/python3.7/site-packag
es/sklearn/neighbors/lof.py:236: FutureWarning: de
fault contamination parameter 0.1 will change in v
ersion 0.22 to "auto". This will change the predic
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  FutureWarning)
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es/sklearn/neighbors/lof.py:236: FutureWarning: de
fault contamination parameter 0.1 will change in v
ersion 0.22 to "auto". This will change the predic
t method behavior.
  FutureWarning)

Execution time of LOF applied on Shuttle (in secon
d)
[11.09737491607666, 11.359040021896362, 12.2650189
39971924, 11.640704870223999, 11.218759775161743]
ROC AUC for LOF applied on Shuttle
[0.5597715279848037, 0.5597715279848037, 0.5597715
279848037, 0.5597715279848037, 0.5597715279848037]

/Users/thesard/anaconda3/lib/python3.7/site-packag
es/sklearn/neighbors/lof.py:236: FutureWarning: de
fault contamination parameter 0.1 will change in v
ersion 0.22 to "auto". This will change the predic
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es/sklearn/neighbors/lof.py:236: FutureWarning: de
fault contamination parameter 0.1 will change in v
ersion 0.22 to "auto". This will change the predic
t method behavior.
  FutureWarning)

Execution time of LOF applied on Shuttle (in secon
d)
[12.55742621421814, 11.96461796760559, 12.57378101
348877, 13.2724769115448, 12.296541929244995]
ROC AUC for LOF applied on Shuttle
[0.5707113501557596, 0.5707113501557596, 0.5707113
501557596, 0.5707113501557596, 0.5707113501557596]

/Users/thesard/anaconda3/lib/python3.7/site-packag
es/sklearn/neighbors/lof.py:236: FutureWarning: de
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es/sklearn/neighbors/lof.py:236: FutureWarning: de
fault contamination parameter 0.1 will change in v
ersion 0.22 to "auto". This will change the predic
t method behavior.
  FutureWarning)

Execution time of LOF applied on Shuttle (in secon
d)
[14.968611001968384, 15.172990322113037, 15.481447
219848633, 12.923413276672363, 13.751121997833252]
ROC AUC for LOF applied on Shuttle
[0.5833266957335241, 0.5833266957335241, 0.5833266
957335241, 0.5833266957335241, 0.5833266957335241]

```
/Users/thesard/anaconda3/lib/python3.7/site-packag
es/sklearn/neighbors/lof.py:236: FutureWarning: de
fault contamination parameter 0.1 will change in v
ersion 0.22 to "auto". This will change the predic
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es/sklearn/neighbors/lof.py:236: FutureWarning: de
fault contamination parameter 0.1 will change in v
ersion 0.22 to "auto". This will change the predic
t method behavior.
  FutureWarning)

Execution time of LOF applied on Shuttle (in secon
d)
[13.90953803062439, 13.948063850402832, 13.7747738
36135864, 14.092037916183472, 13.781497240066528]
ROC AUC for LOF applied on Shuttle
[0.6071569449398353, 0.6071569449398353, 0.6071569
449398353, 0.6071569449398353, 0.6071569449398353]
```

```
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es/sklearn/neighbors/lof.py:236: FutureWarning: de
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t method behavior.
   FutureWarning)
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es/sklearn/neighbors/lof.py:236: FutureWarning: de
fault contamination parameter 0.1 will change in v
ersion 0.22 to "auto". This will change the predic
t method behavior.
   FutureWarning)


Execution time of LOF applied on Shuttle (in secon
d)
[15.525487184524536, 15.68483567237854, 15.3881759
64355469, 15.29531216621399, 16.37880516052246]
ROC AUC for LOF applied on Shuttle
[0.6206598467119195, 0.6206598467119195, 0.6206598
467119195, 0.6206598467119195, 0.6206598467119195]
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packag
es/sklearn/neighbors/lof.py:236: FutureWarning: de
fault contamination parameter 0.1 will change in v
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  FutureWarning)
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es/sklearn/neighbors/lof.py:236: FutureWarning: de
fault contamination parameter 0.1 will change in v
ersion 0.22 to "auto". This will change the predic
t method behavior.
  FutureWarning)

Execution time of LOF applied on Shuttle (in secon
d)
[17.36264991760254, 25.102497816085815, 21.2008988
8572693, 16.928543090820312, 20.417612075805664]
ROC AUC for LOF applied on Shuttle
[0.6278985115819538, 0.6278985115819538, 0.6278985
115819538, 0.6278985115819538, 0.6278985115819538]
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packag
es/sklearn/neighbors/lof.py:236: FutureWarning: de
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  FutureWarning)
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es/sklearn/neighbors/lof.py:236: FutureWarning: de
fault contamination parameter 0.1 will change in v
ersion 0.22 to "auto". This will change the predic
t method behavior.
  FutureWarning)


Execution time of LOF applied on Shuttle (in secon
d)
[22.502599954605103, 19.250303030014038, 22.291309
83352661, 23.09649991891357, 17.23454785346985]
ROC AUC for LOF applied on Shuttle
[0.6358931132894875, 0.6358931132894875, 0.6358931
132894875, 0.6358931132894875, 0.6358931132894875]
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packag
es/sklearn/neighbors/lof.py:236: FutureWarning: de
fault contamination parameter 0.1 will change in v
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es/sklearn/neighbors/lof.py:236: FutureWarning: de
fault contamination parameter 0.1 will change in v
ersion 0.22 to "auto". This will change the predic
t method behavior.
  FutureWarning)

Execution time of LOF applied on Shuttle (in secon
d)
[20.515130043029785, 18.800599813461304, 18.743254
1847229, 20.603824853897095, 20.3718318939209]
ROC AUC for LOF applied on Shuttle
[0.6389370482705246, 0.6389370482705246, 0.6389370
482705246, 0.6389370482705246, 0.6389370482705246]
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packag
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fault contamination parameter 0.1 will change in v
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es/sklearn/neighbors/lof.py:236: FutureWarning: de
fault contamination parameter 0.1 will change in v
ersion 0.22 to "auto". This will change the predic
t method behavior.
  FutureWarning)


Execution time of LOF applied on Shuttle (in secon
d)
[19.592599153518677, 20.091093063354492, 17.522411
108016968, 17.463611841201782, 20.06765127182007]
ROC AUC for LOF applied on Shuttle
[0.6446098725311001, 0.6446098725311001, 0.6446098
725311001, 0.6446098725311001, 0.6446098725311001]
```

```
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fault contamination parameter 0.1 will change in v
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fault contamination parameter 0.1 will change in v
ersion 0.22 to "auto". This will change the predic
t method behavior.
  FutureWarning)

Execution time of LOF applied on Shuttle (in secon
d)
[20.842701196670532, 24.88567304611206, 26.1012651
9203186, 23.518700122833252, 20.749629020690918]
ROC AUC for LOF applied on Shuttle
[0.6439855550504205, 0.6439855550504205, 0.6439855
550504205, 0.6439855550504205, 0.6439855550504205]
```

```
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fault contamination parameter 0.1 will change in v
ersion 0.22 to "auto". This will change the predic
t method behavior.
  FutureWarning)
/Users/thesard/anaconda3/lib/python3.7/site-packag
es/sklearn/neighbors/lof.py:236: FutureWarning: de
fault contamination parameter 0.1 will change in v
ersion 0.22 to "auto". This will change the predic
t method behavior.
  FutureWarning)


Execution time of LOF applied on Shuttle (in secon
d)
[19.079163789749146, 19.068058013916016, 19.510679
721832275, 20.462062120437622, 19.97934603691101]
ROC AUC for LOF applied on Shuttle
[0.6452341900117797, 0.6452341900117797, 0.6452341
900117797, 0.6452341900117797, 0.6452341900117797]
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packag
es/sklearn/neighbors/lof.py:236: FutureWarning: de
fault contamination parameter 0.1 will change in v
ersion 0.22 to "auto". This will change the predic
t method behavior.
  FutureWarning)
/Users/thesard/anaconda3/lib/python3.7/site-packag
es/sklearn/neighbors/lof.py:236: FutureWarning: de
fault contamination parameter 0.1 will change in v
ersion 0.22 to "auto". This will change the predic
t method behavior.
  FutureWarning)
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es/sklearn/neighbors/lof.py:236: FutureWarning: de
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fault contamination parameter 0.1 will change in v
ersion 0.22 to "auto". This will change the predic
t method behavior.
  FutureWarning)
/Users/thesard/anaconda3/lib/python3.7/site-packag
es/sklearn/neighbors/lof.py:236: FutureWarning: de
fault contamination parameter 0.1 will change in v
ersion 0.22 to "auto". This will change the predic
t method behavior.
  FutureWarning)

Execution time of LOF applied on Shuttle (in secon
d)
[19.98332905769348, 20.267674922943115, 29.3762052
0591736, 25.0815589427948, 22.414516925811768]
ROC AUC for LOF applied on Shuttle
[0.6454746177017341, 0.6454746177017341, 0.6454746
177017341, 0.6454746177017341, 0.6454746177017341]
```

/Users/thesard/anaconda3/lib/python3.7/site-packag
es/sklearn/neighbors/lof.py:236: FutureWarning: de
fault contamination parameter 0.1 will change in v
ersion 0.22 to "auto". This will change the predic
t method behavior.
  FutureWarning)
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es/sklearn/neighbors/lof.py:236: FutureWarning: de
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  FutureWarning)
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  FutureWarning)
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ersion 0.22 to "auto". This will change the predic
t method behavior.
  FutureWarning)
/Users/thesard/anaconda3/lib/python3.7/site-packag
es/sklearn/neighbors/lof.py:236: FutureWarning: de
fault contamination parameter 0.1 will change in v
ersion 0.22 to "auto". This will change the predic
t method behavior.
  FutureWarning)

Execution time of LOF applied on Shuttle (in secon
d)
[22.203749179840088, 22.69283699989319, 23.0709829
33044434, 22.550247192382812, 23.32349419593811]
ROC AUC for LOF applied on Shuttle
[0.6455513956598792, 0.6455513956598792, 0.6455513
956598792, 0.6455513956598792, 0.6455513956598792]

```
/Users/thesard/anaconda3/lib/python3.7/site-packag
es/sklearn/neighbors/lof.py:236: FutureWarning: de
fault contamination parameter 0.1 will change in v
ersion 0.22 to "auto". This will change the predic
t method behavior.
  FutureWarning)
/Users/thesard/anaconda3/lib/python3.7/site-packag
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  FutureWarning)
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ersion 0.22 to "auto". This will change the predic
t method behavior.
  FutureWarning)
/Users/thesard/anaconda3/lib/python3.7/site-packag
es/sklearn/neighbors/lof.py:236: FutureWarning: de
fault contamination parameter 0.1 will change in v
ersion 0.22 to "auto". This will change the predic
t method behavior.
  FutureWarning)

Execution time of LOF applied on Shuttle (in secon
d)
[22.011680126190186, 21.317906141281128, 23.827029
943466187, 28.214295148849487, 24.37269616127014]
ROC AUC for LOF applied on Shuttle
[0.6433274582663202, 0.6433274582663202, 0.6433274
582663202, 0.6433274582663202, 0.6433274582663202]
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packag
es/sklearn/neighbors/lof.py:236: FutureWarning: de
fault contamination parameter 0.1 will change in v
ersion 0.22 to "auto". This will change the predic
t method behavior.
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/Users/thesard/anaconda3/lib/python3.7/site-packag
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  FutureWarning)
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t method behavior.
  FutureWarning)
/Users/thesard/anaconda3/lib/python3.7/site-packag
es/sklearn/neighbors/lof.py:236: FutureWarning: de
fault contamination parameter 0.1 will change in v
ersion 0.22 to "auto". This will change the predic
t method behavior.
  FutureWarning)


Execution time of LOF applied on Shuttle (in secon
d)
[23.76908278465271, 23.217936992645264, 23.4089560
50872803, 23.79703998565674, 22.809025049209595]
ROC AUC for LOF applied on Shuttle
[0.6452223472678289, 0.6452223472678289, 0.6452223
472678289, 0.6452223472678289, 0.6452223472678289]
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packag
es/sklearn/neighbors/lof.py:236: FutureWarning: de
fault contamination parameter 0.1 will change in v
ersion 0.22 to "auto". This will change the predic
t method behavior.
  FutureWarning)
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t method behavior.
  FutureWarning)
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t method behavior.
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fault contamination parameter 0.1 will change in v
ersion 0.22 to "auto". This will change the predic
t method behavior.
  FutureWarning)
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es/sklearn/neighbors/lof.py:236: FutureWarning: de
fault contamination parameter 0.1 will change in v
ersion 0.22 to "auto". This will change the predic
t method behavior.
  FutureWarning)

Execution time of LOF applied on Shuttle (in secon
d)
[24.00037717819214, 23.512400150299072, 32.2018852
2338867, 25.832989931106567, 26.433369159698486]
ROC AUC for LOF applied on Shuttle
[0.6439846805862048, 0.6439846805862048, 0.6439846
805862048, 0.6439846805862048, 0.6439846805862048]
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packag
es/sklearn/neighbors/lof.py:236: FutureWarning: de
fault contamination parameter 0.1 will change in v
ersion 0.22 to "auto". This will change the predic
t method behavior.
  FutureWarning)
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fault contamination parameter 0.1 will change in v
ersion 0.22 to "auto". This will change the predic
t method behavior.
  FutureWarning)
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ersion 0.22 to "auto". This will change the predic
t method behavior.
  FutureWarning)
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es/sklearn/neighbors/lof.py:236: FutureWarning: de
fault contamination parameter 0.1 will change in v
ersion 0.22 to "auto". This will change the predic
t method behavior.
  FutureWarning)
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es/sklearn/neighbors/lof.py:236: FutureWarning: de
fault contamination parameter 0.1 will change in v
ersion 0.22 to "auto". This will change the predic
t method behavior.
  FutureWarning)


Execution time of LOF applied on Shuttle (in secon
d)
[28.55326795578003, 23.9446861743927, 26.600772857
666016, 24.454368114471436, 25.80253291130066]
ROC AUC for LOF applied on Shuttle
[0.6426153945477606, 0.6426153945477606, 0.6426153
945477606, 0.6426153945477606, 0.6426153945477606]
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packag
es/sklearn/neighbors/lof.py:236: FutureWarning: de
fault contamination parameter 0.1 will change in v
ersion 0.22 to "auto". This will change the predic
t method behavior.
  FutureWarning)
/Users/thesard/anaconda3/lib/python3.7/site-packag
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ersion 0.22 to "auto". This will change the predic
t method behavior.
  FutureWarning)
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ersion 0.22 to "auto". This will change the predic
t method behavior.
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fault contamination parameter 0.1 will change in v
ersion 0.22 to "auto". This will change the predic
t method behavior.
  FutureWarning)
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es/sklearn/neighbors/lof.py:236: FutureWarning: de
fault contamination parameter 0.1 will change in v
ersion 0.22 to "auto". This will change the predic
t method behavior.
  FutureWarning)

Execution time of LOF applied on Shuttle (in secon
d)
[24.520621061325073, 25.380983114242554, 25.671968
936920166, 26.67810082435608, 26.24145793914795]
ROC AUC for LOF applied on Shuttle
[0.6397022044593278, 0.6397022044593278, 0.6397022
044593278, 0.6397022044593278, 0.6397022044593278]
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packag
es/sklearn/neighbors/lof.py:236: FutureWarning: de
fault contamination parameter 0.1 will change in v
ersion 0.22 to "auto". This will change the predic
t method behavior.
  FutureWarning)
/Users/thesard/anaconda3/lib/python3.7/site-packag
es/sklearn/neighbors/lof.py:236: FutureWarning: de
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ersion 0.22 to "auto". This will change the predic
t method behavior.
  FutureWarning)
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es/sklearn/neighbors/lof.py:236: FutureWarning: de
fault contamination parameter 0.1 will change in v
ersion 0.22 to "auto". This will change the predic
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  FutureWarning)
/Users/thesard/anaconda3/lib/python3.7/site-packag
es/sklearn/neighbors/lof.py:236: FutureWarning: de
fault contamination parameter 0.1 will change in v
ersion 0.22 to "auto". This will change the predic
t method behavior.
  FutureWarning)
/Users/thesard/anaconda3/lib/python3.7/site-packag
es/sklearn/neighbors/lof.py:236: FutureWarning: de
fault contamination parameter 0.1 will change in v
ersion 0.22 to "auto". This will change the predic
t method behavior.
  FutureWarning)


Execution time of LOF applied on Shuttle (in secon
d)
[31.295750856399536, 27.675748109817505, 29.594388
961791992, 28.73183512687683, 22.946579933166504]
ROC AUC for LOF applied on Shuttle
[0.6340622850379573, 0.6340622850379573, 0.6340622
850379573, 0.6340622850379573, 0.6340622850379573]
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packag
es/sklearn/neighbors/lof.py:236: FutureWarning: de
fault contamination parameter 0.1 will change in v
ersion 0.22 to "auto". This will change the predic
t method behavior.
  FutureWarning)
/Users/thesard/anaconda3/lib/python3.7/site-packag
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fault contamination parameter 0.1 will change in v
ersion 0.22 to "auto". This will change the predic
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  FutureWarning)
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fault contamination parameter 0.1 will change in v
ersion 0.22 to "auto". This will change the predic
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  FutureWarning)
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fault contamination parameter 0.1 will change in v
ersion 0.22 to "auto". This will change the predic
t method behavior.
  FutureWarning)
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es/sklearn/neighbors/lof.py:236: FutureWarning: de
fault contamination parameter 0.1 will change in v
ersion 0.22 to "auto". This will change the predic
t method behavior.
  FutureWarning)

Execution time of LOF applied on Shuttle (in secon
d)
[23.47481083869934, 23.13122034072876, 23.19342398
6434937, 822.1039469242096, 25.384517908096313]
ROC AUC for LOF applied on Shuttle
[0.6311600632292595, 0.6311600632292595, 0.6311600
632292595, 0.6311600632292595, 0.6311600632292595]
```

/Users/thesard/anaconda3/lib/python3.7/site-packag
es/sklearn/neighbors/lof.py:236: FutureWarning: de
fault contamination parameter 0.1 will change in v
ersion 0.22 to "auto". This will change the predic
t method behavior.
  FutureWarning)
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fault contamination parameter 0.1 will change in v
ersion 0.22 to "auto". This will change the predic
t method behavior.
  FutureWarning)
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fault contamination parameter 0.1 will change in v
ersion 0.22 to "auto". This will change the predic
t method behavior.
  FutureWarning)
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es/sklearn/neighbors/lof.py:236: FutureWarning: de
fault contamination parameter 0.1 will change in v
ersion 0.22 to "auto". This will change the predic
t method behavior.
  FutureWarning)

Execution time of LOF applied on Shuttle (in secon
d)
[1755.7952139377594, 26.021297931671143, 36.120474
81536865, 24.064188957214355, 24.732654094696045]
ROC AUC for LOF applied on Shuttle
[0.6276554604993521, 0.6276554604993521, 0.6276554
604993521, 0.6276554604993521, 0.6276554604993521]

```
/Users/thesard/anaconda3/lib/python3.7/site-packag
es/sklearn/neighbors/lof.py:236: FutureWarning: de
fault contamination parameter 0.1 will change in v
ersion 0.22 to "auto". This will change the predic
t method behavior.
  FutureWarning)
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ersion 0.22 to "auto". This will change the predic
t method behavior.
  FutureWarning)
/Users/thesard/anaconda3/lib/python3.7/site-packag
es/sklearn/neighbors/lof.py:236: FutureWarning: de
fault contamination parameter 0.1 will change in v
ersion 0.22 to "auto". This will change the predic
t method behavior.
  FutureWarning)
/Users/thesard/anaconda3/lib/python3.7/site-packag
es/sklearn/neighbors/lof.py:236: FutureWarning: de
fault contamination parameter 0.1 will change in v
ersion 0.22 to "auto". This will change the predic
t method behavior.
  FutureWarning)

Execution time of LOF applied on Shuttle (in secon
d)
[29.610510110855103, 25.375948190689087, 26.244962
93067932, 26.375334978103638, 32.57053589820862]
ROC AUC for LOF applied on Shuttle
[0.6256837935396983, 0.6256837935396983, 0.6256837
935396983, 0.6256837935396983, 0.6256837935396983]
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packag
es/sklearn/neighbors/lof.py:236: FutureWarning: de
fault contamination parameter 0.1 will change in v
ersion 0.22 to "auto". This will change the predic
t method behavior.
  FutureWarning)
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ersion 0.22 to "auto". This will change the predic
t method behavior.
  FutureWarning)
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ersion 0.22 to "auto". This will change the predic
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  FutureWarning)
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es/sklearn/neighbors/lof.py:236: FutureWarning: de
fault contamination parameter 0.1 will change in v
ersion 0.22 to "auto". This will change the predic
t method behavior.
  FutureWarning)

Execution time of LOF applied on Shuttle (in secon
d)
[28.53094506263733, 27.911957025527954, 27.7712321
2814331, 26.486833333969116, 28.033424854278564]
ROC AUC for LOF applied on Shuttle
[0.6253665878915988, 0.6253665878915988, 0.6253665
878915988, 0.6253665878915988, 0.6253665878915988]
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packag
es/sklearn/neighbors/lof.py:236: FutureWarning: de
fault contamination parameter 0.1 will change in v
ersion 0.22 to "auto". This will change the predic
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ersion 0.22 to "auto". This will change the predic
t method behavior.
  FutureWarning)
/Users/thesard/anaconda3/lib/python3.7/site-packag
es/sklearn/neighbors/lof.py:236: FutureWarning: de
fault contamination parameter 0.1 will change in v
ersion 0.22 to "auto". This will change the predic
t method behavior.
  FutureWarning)

Execution time of LOF applied on Shuttle (in secon
d)
[32.20329809188843, 33.18260097503662, 28.63064217
567444, 28.9147789478302, 30.17589807510376]
ROC AUC for LOF applied on Shuttle
[0.6239314921747445, 0.6239314921747445, 0.6239314
921747445, 0.6239314921747445, 0.6239314921747445]
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packag
es/sklearn/neighbors/lof.py:236: FutureWarning: de
fault contamination parameter 0.1 will change in v
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  FutureWarning)
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t method behavior.
  FutureWarning)
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fault contamination parameter 0.1 will change in v
ersion 0.22 to "auto". This will change the predic
t method behavior.
  FutureWarning)


Execution time of LOF applied on Shuttle (in secon
d)
[33.00988006591797, 31.16098117828369, 29.51857304
573059, 29.466418981552124, 28.89672613143921]
ROC AUC for LOF applied on Shuttle
[0.6199341913209777, 0.6199341913209777, 0.6199341
913209777, 0.6199341913209777, 0.6199341913209777]
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packag
es/sklearn/neighbors/lof.py:236: FutureWarning: de
fault contamination parameter 0.1 will change in v
ersion 0.22 to "auto". This will change the predic
t method behavior.
  FutureWarning)
/Users/thesard/anaconda3/lib/python3.7/site-packag
es/sklearn/neighbors/lof.py:236: FutureWarning: de
fault contamination parameter 0.1 will change in v
ersion 0.22 to "auto". This will change the predic
t method behavior.
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es/sklearn/neighbors/lof.py:236: FutureWarning: de
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ersion 0.22 to "auto". This will change the predic
t method behavior.
  FutureWarning)
/Users/thesard/anaconda3/lib/python3.7/site-packag
es/sklearn/neighbors/lof.py:236: FutureWarning: de
fault contamination parameter 0.1 will change in v
ersion 0.22 to "auto". This will change the predic
t method behavior.
  FutureWarning)
/Users/thesard/anaconda3/lib/python3.7/site-packag
es/sklearn/neighbors/lof.py:236: FutureWarning: de
fault contamination parameter 0.1 will change in v
ersion 0.22 to "auto". This will change the predic
t method behavior.
  FutureWarning)

Execution time of LOF applied on Shuttle (in secon
d)
[33.044429779052734, 29.72644305229187, 30.9037990
57006836, 29.281348943710327, 35.302117109298706]
ROC AUC for LOF applied on Shuttle
[0.6152138584689161, 0.6152138584689161, 0.6152138
584689161, 0.6152138584689161, 0.6152138584689161]
```

/Users/thesard/anaconda3/lib/python3.7/site-packag
es/sklearn/neighbors/lof.py:236: FutureWarning: de
fault contamination parameter 0.1 will change in v
ersion 0.22 to "auto". This will change the predic
t method behavior.
  FutureWarning)
/Users/thesard/anaconda3/lib/python3.7/site-packag
es/sklearn/neighbors/lof.py:236: FutureWarning: de
fault contamination parameter 0.1 will change in v
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t method behavior.
  FutureWarning)
/Users/thesard/anaconda3/lib/python3.7/site-packag
es/sklearn/neighbors/lof.py:236: FutureWarning: de
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t method behavior.
  FutureWarning)
/Users/thesard/anaconda3/lib/python3.7/site-packag
es/sklearn/neighbors/lof.py:236: FutureWarning: de
fault contamination parameter 0.1 will change in v
ersion 0.22 to "auto". This will change the predic
t method behavior.
  FutureWarning)
/Users/thesard/anaconda3/lib/python3.7/site-packag
es/sklearn/neighbors/lof.py:236: FutureWarning: de
fault contamination parameter 0.1 will change in v
ersion 0.22 to "auto". This will change the predic
t method behavior.
  FutureWarning)

Execution time of LOF applied on Shuttle (in secon
d)
[33.06908082962036, 34.36426019668579, 32.27237606
048584, 31.718379020690918, 34.16162896156311]
ROC AUC for LOF applied on Shuttle
[0.6070766691248273, 0.6070766691248273, 0.6070766
691248273, 0.6070766691248273, 0.6070766691248273]

```
/Users/thesard/anaconda3/lib/python3.7/site-packag
es/sklearn/neighbors/lof.py:236: FutureWarning: de
fault contamination parameter 0.1 will change in v
ersion 0.22 to "auto". This will change the predic
t method behavior.
  FutureWarning)
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es/sklearn/neighbors/lof.py:236: FutureWarning: de
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  FutureWarning)
/Users/thesard/anaconda3/lib/python3.7/site-packag
es/sklearn/neighbors/lof.py:236: FutureWarning: de
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t method behavior.
  FutureWarning)
/Users/thesard/anaconda3/lib/python3.7/site-packag
es/sklearn/neighbors/lof.py:236: FutureWarning: de
fault contamination parameter 0.1 will change in v
ersion 0.22 to "auto". This will change the predic
t method behavior.
  FutureWarning)
/Users/thesard/anaconda3/lib/python3.7/site-packag
es/sklearn/neighbors/lof.py:236: FutureWarning: de
fault contamination parameter 0.1 will change in v
ersion 0.22 to "auto". This will change the predic
t method behavior.
  FutureWarning)

Execution time of LOF applied on Shuttle (in secon
d)
[29.008259057998657, 28.686951875686646, 37.209456
92062378, 34.627143144607544, 31.784306287765503]
ROC AUC for LOF applied on Shuttle
[0.600604034907812, 0.600604034907812, 0.600604034
907812, 0.600604034907812, 0.600604034907812]
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packag
es/sklearn/neighbors/lof.py:236: FutureWarning: de
fault contamination parameter 0.1 will change in v
ersion 0.22 to "auto". This will change the predic
t method behavior.
  FutureWarning)
/Users/thesard/anaconda3/lib/python3.7/site-packag
es/sklearn/neighbors/lof.py:236: FutureWarning: de
fault contamination parameter 0.1 will change in v
ersion 0.22 to "auto". This will change the predic
t method behavior.
  FutureWarning)
/Users/thesard/anaconda3/lib/python3.7/site-packag
es/sklearn/neighbors/lof.py:236: FutureWarning: de
fault contamination parameter 0.1 will change in v
ersion 0.22 to "auto". This will change the predic
t method behavior.
  FutureWarning)
/Users/thesard/anaconda3/lib/python3.7/site-packag
es/sklearn/neighbors/lof.py:236: FutureWarning: de
fault contamination parameter 0.1 will change in v
ersion 0.22 to "auto". This will change the predic
t method behavior.
  FutureWarning)
/Users/thesard/anaconda3/lib/python3.7/site-packag
es/sklearn/neighbors/lof.py:236: FutureWarning: de
fault contamination parameter 0.1 will change in v
ersion 0.22 to "auto". This will change the predic
t method behavior.
  FutureWarning)


Execution time of LOF applied on Shuttle (in secon
d)
[30.09407091140747, 31.068660974502563, 31.0579860
2104187, 30.35109782218933, 30.627393007278442]
ROC AUC for LOF applied on Shuttle
[0.5925326552421332, 0.5925326552421332, 0.5925326
552421332, 0.5925326552421332, 0.5925326552421332]
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packag
es/sklearn/neighbors/lof.py:236: FutureWarning: de
fault contamination parameter 0.1 will change in v
ersion 0.22 to "auto". This will change the predic
t method behavior.
  FutureWarning)
/Users/thesard/anaconda3/lib/python3.7/site-packag
es/sklearn/neighbors/lof.py:236: FutureWarning: de
fault contamination parameter 0.1 will change in v
ersion 0.22 to "auto". This will change the predic
t method behavior.
  FutureWarning)
/Users/thesard/anaconda3/lib/python3.7/site-packag
es/sklearn/neighbors/lof.py:236: FutureWarning: de
fault contamination parameter 0.1 will change in v
ersion 0.22 to "auto". This will change the predic
t method behavior.
  FutureWarning)
/Users/thesard/anaconda3/lib/python3.7/site-packag
es/sklearn/neighbors/lof.py:236: FutureWarning: de
fault contamination parameter 0.1 will change in v
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t method behavior.
  FutureWarning)
/Users/thesard/anaconda3/lib/python3.7/site-packag
es/sklearn/neighbors/lof.py:236: FutureWarning: de
fault contamination parameter 0.1 will change in v
ersion 0.22 to "auto". This will change the predic
t method behavior.
  FutureWarning)

Execution time of LOF applied on Shuttle (in secon
d)
[30.898460865020752, 32.192503929138184, 31.596322
774887085, 30.930474996566772, 32.383541107177734]
ROC AUC for LOF applied on Shuttle
[0.580420381632174, 0.580420381632174, 0.5804420
381632174, 0.580420381632174, 0.580420381632174]
```

/Users/thesard/anaconda3/lib/python3.7/site-packag
es/sklearn/neighbors/lof.py:236: FutureWarning: de
fault contamination parameter 0.1 will change in v
ersion 0.22 to "auto". This will change the predic
t method behavior.
  FutureWarning)
/Users/thesard/anaconda3/lib/python3.7/site-packag
es/sklearn/neighbors/lof.py:236: FutureWarning: de
fault contamination parameter 0.1 will change in v
ersion 0.22 to "auto". This will change the predic
t method behavior.
  FutureWarning)
/Users/thesard/anaconda3/lib/python3.7/site-packag
es/sklearn/neighbors/lof.py:236: FutureWarning: de
fault contamination parameter 0.1 will change in v
ersion 0.22 to "auto". This will change the predic
t method behavior.
  FutureWarning)
/Users/thesard/anaconda3/lib/python3.7/site-packag
es/sklearn/neighbors/lof.py:236: FutureWarning: de
fault contamination parameter 0.1 will change in v
ersion 0.22 to "auto". This will change the predic
t method behavior.
  FutureWarning)
/Users/thesard/anaconda3/lib/python3.7/site-packag
es/sklearn/neighbors/lof.py:236: FutureWarning: de
fault contamination parameter 0.1 will change in v
ersion 0.22 to "auto". This will change the predic
t method behavior.
  FutureWarning)

Execution time of LOF applied on Shuttle (in secon
d)
[31.535628080368042, 29.67800807952881, 31.0082800
38833618, 29.331932067871094, 29.513152837753296]
ROC AUC for LOF applied on Shuttle
[0.5716147216600389, 0.5716147216600389, 0.5716147
216600389, 0.5716147216600389, 0.5716147216600389]

```
/Users/thesard/anaconda3/lib/python3.7/site-packag
es/sklearn/neighbors/lof.py:236: FutureWarning: de
fault contamination parameter 0.1 will change in v
ersion 0.22 to "auto". This will change the predic
t method behavior.
  FutureWarning)
/Users/thesard/anaconda3/lib/python3.7/site-packag
es/sklearn/neighbors/lof.py:236: FutureWarning: de
fault contamination parameter 0.1 will change in v
ersion 0.22 to "auto". This will change the predic
t method behavior.
  FutureWarning)
/Users/thesard/anaconda3/lib/python3.7/site-packag
es/sklearn/neighbors/lof.py:236: FutureWarning: de
fault contamination parameter 0.1 will change in v
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t method behavior.
  FutureWarning)
/Users/thesard/anaconda3/lib/python3.7/site-packag
es/sklearn/neighbors/lof.py:236: FutureWarning: de
fault contamination parameter 0.1 will change in v
ersion 0.22 to "auto". This will change the predic
t method behavior.
  FutureWarning)
/Users/thesard/anaconda3/lib/python3.7/site-packag
es/sklearn/neighbors/lof.py:236: FutureWarning: de
fault contamination parameter 0.1 will change in v
ersion 0.22 to "auto". This will change the predic
t method behavior.
  FutureWarning)

Execution time of LOF applied on Shuttle (in secon
d)
[31.129746198654175, 29.830172061920166, 31.112814
903259277, 30.072266101837158, 29.939199209213257]
ROC AUC for LOF applied on Shuttle
[0.5646713258786342, 0.5646713258786342, 0.5646713
258786342, 0.5646713258786342, 0.5646713258786342]
```

/Users/thesard/anaconda3/lib/python3.7/site-packag
es/sklearn/neighbors/lof.py:236: FutureWarning: de
fault contamination parameter 0.1 will change in v
ersion 0.22 to "auto". This will change the predic
t method behavior.
  FutureWarning)
/Users/thesard/anaconda3/lib/python3.7/site-packag
es/sklearn/neighbors/lof.py:236: FutureWarning: de
fault contamination parameter 0.1 will change in v
ersion 0.22 to "auto". This will change the predic
t method behavior.
  FutureWarning)
/Users/thesard/anaconda3/lib/python3.7/site-packag
es/sklearn/neighbors/lof.py:236: FutureWarning: de
fault contamination parameter 0.1 will change in v
ersion 0.22 to "auto". This will change the predic
t method behavior.
  FutureWarning)
/Users/thesard/anaconda3/lib/python3.7/site-packag
es/sklearn/neighbors/lof.py:236: FutureWarning: de
fault contamination parameter 0.1 will change in v
ersion 0.22 to "auto". This will change the predic
t method behavior.
  FutureWarning)
/Users/thesard/anaconda3/lib/python3.7/site-packag
es/sklearn/neighbors/lof.py:236: FutureWarning: de
fault contamination parameter 0.1 will change in v
ersion 0.22 to "auto". This will change the predic
t method behavior.
  FutureWarning)

Execution time of LOF applied on Shuttle (in secon
d)
[31.273830890655518, 30.44507074356079, 37.1128168
1060791, 34.68531513214111, 31.82643485069275]
ROC AUC for LOF applied on Shuttle
[0.5561072480890957, 0.5561072480890957, 0.5561072
480890957, 0.5561072480890957, 0.5561072480890957]

```
/Users/thesard/anaconda3/lib/python3.7/site-packag
es/sklearn/neighbors/lof.py:236: FutureWarning: de
fault contamination parameter 0.1 will change in v
ersion 0.22 to "auto". This will change the predic
t method behavior.
  FutureWarning)
/Users/thesard/anaconda3/lib/python3.7/site-packag
es/sklearn/neighbors/lof.py:236: FutureWarning: de
fault contamination parameter 0.1 will change in v
ersion 0.22 to "auto". This will change the predic
t method behavior.
  FutureWarning)
/Users/thesard/anaconda3/lib/python3.7/site-packag
es/sklearn/neighbors/lof.py:236: FutureWarning: de
fault contamination parameter 0.1 will change in v
ersion 0.22 to "auto". This will change the predic
t method behavior.
  FutureWarning)
/Users/thesard/anaconda3/lib/python3.7/site-packag
es/sklearn/neighbors/lof.py:236: FutureWarning: de
fault contamination parameter 0.1 will change in v
ersion 0.22 to "auto". This will change the predic
t method behavior.
  FutureWarning)
/Users/thesard/anaconda3/lib/python3.7/site-packag
es/sklearn/neighbors/lof.py:236: FutureWarning: de
fault contamination parameter 0.1 will change in v
ersion 0.22 to "auto". This will change the predic
t method behavior.
  FutureWarning)

Execution time of LOF applied on Shuttle (in secon
d)
[33.049050092697144, 35.441572189331055, 43.897033
92982483, 41.15648293495178, 41.83665609359741]
ROC AUC for LOF applied on Shuttle
[0.547893280786862, 0.547893280786862, 0.547893280
786862, 0.547893280786862, 0.547893280786862]
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packag
es/sklearn/neighbors/lof.py:236: FutureWarning: de
fault contamination parameter 0.1 will change in v
ersion 0.22 to "auto". This will change the predic
t method behavior.
  FutureWarning)
/Users/thesard/anaconda3/lib/python3.7/site-packag
es/sklearn/neighbors/lof.py:236: FutureWarning: de
fault contamination parameter 0.1 will change in v
ersion 0.22 to "auto". This will change the predic
t method behavior.
  FutureWarning)
/Users/thesard/anaconda3/lib/python3.7/site-packag
es/sklearn/neighbors/lof.py:236: FutureWarning: de
fault contamination parameter 0.1 will change in v
ersion 0.22 to "auto". This will change the predic
t method behavior.
  FutureWarning)
/Users/thesard/anaconda3/lib/python3.7/site-packag
es/sklearn/neighbors/lof.py:236: FutureWarning: de
fault contamination parameter 0.1 will change in v
ersion 0.22 to "auto". This will change the predic
t method behavior.
  FutureWarning)
/Users/thesard/anaconda3/lib/python3.7/site-packag
es/sklearn/neighbors/lof.py:236: FutureWarning: de
fault contamination parameter 0.1 will change in v
ersion 0.22 to "auto". This will change the predic
t method behavior.
  FutureWarning)


Execution time of LOF applied on Shuttle (in secon
d)
[33.169673919677734, 34.13337707519531, 34.7417118
5493469, 33.59257698059082, 33.5199248790741]
ROC AUC for LOF applied on Shuttle
[0.5385403613206189, 0.5385403613206189, 0.5385403
613206189, 0.5385403613206189, 0.5385403613206189]
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packag
es/sklearn/neighbors/lof.py:236: FutureWarning: de
fault contamination parameter 0.1 will change in v
ersion 0.22 to "auto". This will change the predic
t method behavior.
  FutureWarning)
/Users/thesard/anaconda3/lib/python3.7/site-packag
es/sklearn/neighbors/lof.py:236: FutureWarning: de
fault contamination parameter 0.1 will change in v
ersion 0.22 to "auto". This will change the predic
t method behavior.
  FutureWarning)
/Users/thesard/anaconda3/lib/python3.7/site-packag
es/sklearn/neighbors/lof.py:236: FutureWarning: de
fault contamination parameter 0.1 will change in v
ersion 0.22 to "auto". This will change the predic
t method behavior.
  FutureWarning)
/Users/thesard/anaconda3/lib/python3.7/site-packag
es/sklearn/neighbors/lof.py:236: FutureWarning: de
fault contamination parameter 0.1 will change in v
ersion 0.22 to "auto". This will change the predic
t method behavior.
  FutureWarning)
/Users/thesard/anaconda3/lib/python3.7/site-packag
es/sklearn/neighbors/lof.py:236: FutureWarning: de
fault contamination parameter 0.1 will change in v
ersion 0.22 to "auto". This will change the predic
t method behavior.
  FutureWarning)

Execution time of LOF applied on Shuttle (in secon
d)
[34.08888387680054, 32.08362698554993, 32.52544093
132019, 35.860275745391846, 36.32122993469238]
ROC AUC for LOF applied on Shuttle
[0.5299433786918755, 0.5299433786918755, 0.5299433
786918755, 0.5299433786918755, 0.5299433786918755]
```

Résultat de LOF sur shuttle

```
In [51]:
```

```
print("Execution time of LOF applied on Shuttle (in second)")
print(averages_executions_time_LOF_Shuttle)
plt.plot(range(5, 200, 5), averages_executions_time_LOF_Shuttl
e,  "g-", label="LOF on Shuttle")
#plt.axis([0, 200, 0, 200])
plt.xlabel('k')
plt.ylabel('Execution time')
plt.legend(loc="best")
plt.show()
```

```
Execution time of LOF applied on Shuttle (in secon
d)
[7.105000638961792, 9.4709379673300415, 10.38202333
4503174, 11.516179704666138, 12.53296880722046, 14
.459516763687134, 13.901182174682617, 15.654523229
598999, 20.202440357208253, 20.87505211830139, 19.
806928157806396, 18.947473287582397, 23.2195937156
67724, 19.619861936569215, 23.42465701103210, 22.
768262100219726, 23.948721504211427, 23.4004081726
0742, 26.39620432853699, 25.871125602722167, 25.69
8626375198366, 28.048860597610474, 183.45758399963
378, 373.3467659473419, 28.035458421707155, 27.746
878480911256, 30.621443653106688, 30.4105158805847
18, 31.651627588272095, 33.11714501380921, 32.2632
2345733642, 30.639841747283935, 31.600260734558105
, 30.213400220870973, 30.41683969497608, 33.06869
368553161, 39.07615904808044, 33.83145294189453, 3
4.17589149475098]
```
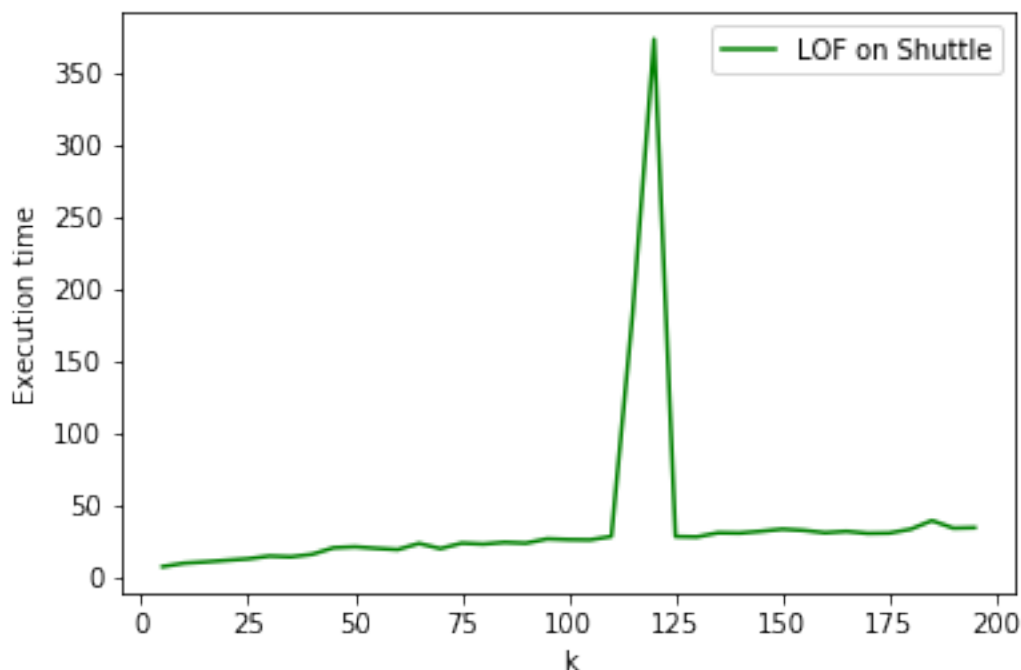
```
print("ROC AUC for LOF applied on Shuttle")
print(averages_roc_auc_LOF_Shuttle)
print("La valeur max est "+str(max(averages_roc_auc_LOF_Shuttl
e))+" à l'index "+str(averages_roc_auc_LOF_Shuttle.index(max(a
verages_roc_auc_LOF_Shuttle))))
plt.plot(range(5, 200, 5), averages_roc_auc_LOF_Shuttle,  "g-"
, label="ROC AUC of LOF on Shuttle")
#plt.axis([0, 1, 0, 1])
plt.xlabel('k')
plt.ylabel('AUC')
plt.legend(loc="best")
plt.show()
```

```
ROC AUC for LOF applied on Shuttle
[0.5215160920903762, 0.5303294171661024, 0.5464129
627777061, 0.5597715279848037, 0.5707113501557596,
0.5833266957335241, 0.6071569449398353, 0.62065984
67119195, 0.6278985115819538, 0.6358931132894875,
0.6389370482705246, 0.6446098725311001, 0.64398555
50504205, 0.6452341900117797, 0.6454746177017341,
0.6455513956598792, 0.6433274582663202, 0.64522234
72678289, 0.6439846805862048, 0.6426153945477606,
0.6397022044593278, 0.6340622850379573, 0.63116006
32292595, 0.6276554604993521, 0.6256837935396983,
0.6253665878915988, 0.6239314921747445, 0.61993419
13209777, 0.6152138584689161, 0.6070766691248273,
0.600604034907812, 0.5925326552421332, 0.580442038
1632174, 0.5716147216600389, 0.5646713258786342, 0
.5561072480890957, 0.547893280786862, 0.5385403613
206189, 0.5299433786918755]
La valeur max est 0.6455513956598792 à l'index 15
```
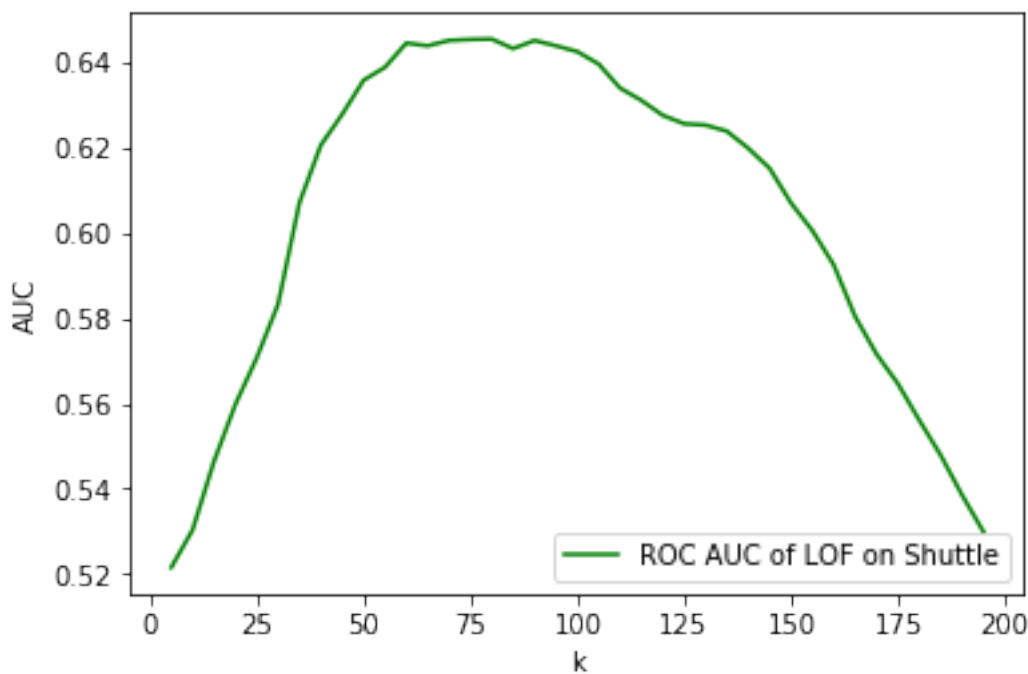
Interprétation du résultat de LOF sur Shuttle

Plus le nombre de n_neighbors augmente, plus de temps d'éxécution est important. Ceci s'explique par le fait que plus le nombre de voisins à considérer est grand plus il faudra calculer les distances et les densité afin d'estimer le degré d'abberrance d'une observation. Concernant la performance de la méthode, elle atteint son plus fort (AUC = 0.6455513956598792) à taux à n_estimators= 80 ((15+1)*5) pour un temps d'exécution de 22.768262100219726

Exécution des méthodes avec les meilleurs paramètres trouvés sur Shuttle

In [60]:

```
executions_time_Shuttle = []
precisions_Shuttle = []
recalls_Shuttle = []
roc_aucs_Shuttle = []
f1_scores_Shuttle = []
methods = []

# Isolation Forest
methods.append('IForest')
start_time = time()
n_estimators = 70
func_IF_Shuttle = IsolationForest(n_estimators=n_estimators, m
```

```python
ax_samples=max_samples)
func_IF_Shuttle.fit(X_Shuttle)

y_pred_IF_Shuttle = func_IF_Shuttle.predict(X_Shuttle)
# Calcul du temps d'exécution
executions_time_Shuttle.append(time() - start_time)
# Precision
precisions_Shuttle.append(precision_score(y_transform_Shuttle,
y_pred_IF_Shuttle))
# Recall
recalls_Shuttle.append(recall_score(y_transform_Shuttle, y_pre
d_IF_Shuttle))
# f1_score
f1_scores_Shuttle.append(f1_score(y_transform_Shuttle, y_pred_
IF_Shuttle))
# Calcul de l'aire sous la courbe ROC
auc_IF_Shuttle = roc_auc_score(y_transform_Shuttle, y_pred_IF_
Shuttle)
roc_aucs_Shuttle.append(auc_IF_Shuttle)
print("Confusion Matrice IForest")
print(confusion_matrix(y_transform_Shuttle, y_pred_IF_Shuttle)
)

# OC-SVM
methods.append('OC-SVM')
start_time = time()
nu = 0.4
func_OCSVM_Shuttle = OneClassSVM(nu=nu)
func_OCSVM_Shuttle.fit(X_Shuttle)
y_pred_OCSVM_Shuttle = func_OCSVM_Shuttle.predict(X_Shuttle)
# Calcul du temps d'exécution
executions_time_Shuttle.append(time() - start_time)
# Precision
precisions_Shuttle.append(precision_score(y_transform_Shuttle,
y_pred_OCSVM_Shuttle))
# Recall
recalls_Shuttle.append(recall_score(y_transform_Shuttle, y_pre
d_OCSVM_Shuttle))
# f1_score
f1_scores_Shuttle.append(f1_score(y_transform_Shuttle, y_pred_
OCSVM_Shuttle))
# Calcul de l'aire sous la courbe ROC
auc_OCSVM_Shuttle = roc_auc_score(y_transform_Shuttle, y_pred_
OCSVM_Shuttle)
roc_aucs_Shuttle.append(auc_OCSVM_Shuttle)
print("Confusion Matrice OC-SVM")
print(confusion_matrix(y_transform_Shuttle, y_pred_OCSVM_Shutt
le))

# LOF
```

```python
methods.append('LOF')

start_time = time()
n_neighbors = 80
func_LOF_Shuttle = LocalOutlierFactor(n_neighbors=n_neighbors,
novelty=True)
func_LOF_Shuttle.fit(X_Shuttle)
y_pred_LOF_Shuttle = func_LOF_Shuttle.predict(X_Shuttle)
# Calcul du temps d'exécution
executions_time_Shuttle.append(time() - start_time)
# Precision
precisions_Shuttle.append(precision_score(y_transform_Shuttle,
y_pred_LOF_Shuttle))
# Recall
recalls_Shuttle.append(recall_score(y_transform_Shuttle, y_pre
d_LOF_Shuttle))
# f1_score
f1_scores_Shuttle.append(f1_score(y_transform_Shuttle, y_pred_
LOF_Shuttle))
# Calcul de l'aire sous la courbe ROC
auc_LOF_Shuttle = roc_auc_score(y_transform_Shuttle, y_pred_LO
F_Shuttle)
roc_aucs_Shuttle.append(auc_LOF_Shuttle)
print("Confusion Matrice LOF")
print(confusion_matrix(y_transform_Shuttle, y_pred_LOF_Shuttle
))
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packag
es/sklearn/ensemble/iforest.py:213: FutureWarning:
default contamination parameter 0.1 will change in
version 0.22 to "auto". This will change the predi
ct method behavior.
  FutureWarning)
/Users/thesard/anaconda3/lib/python3.7/site-packag
es/sklearn/ensemble/iforest.py:223: FutureWarning:
behaviour="old" is deprecated and will be removed
in version 0.22. Please use behaviour="new", which
makes the decision_function change to match other
anomaly detection algorithm API.
  FutureWarning)
/Users/thesard/anaconda3/lib/python3.7/site-packag
es/sklearn/ensemble/iforest.py:417: DeprecationWar
ning: threshold_ attribute is deprecated in 0.20 a
nd will be removed in 0.22.
  " be removed in 0.22.", DeprecationWarning)

Confusion Matrice IForest
[[  868     10]
 [ 3779 41807]]

/Users/thesard/anaconda3/lib/python3.7/site-packag
es/sklearn/svm/base.py:196: FutureWarning: The def
ault value of gamma will change from 'auto' to 'sc
ale' in version 0.22 to account better for unscale
d features. Set gamma explicitly to 'auto' or 'sca
le' to avoid this warning.
  "avoid this warning.", FutureWarning)

Confusion Matrice OC-SVM
[[  831     47]
 [18058 27528]]

/Users/thesard/anaconda3/lib/python3.7/site-packag
es/sklearn/neighbors/lof.py:236: FutureWarning: de
fault contamination parameter 0.1 will change in v
ersion 0.22 to "auto". This will change the predic
t method behavior.
  FutureWarning)

Confusion Matrice LOF
[[  336    542]
 [ 4175 41411]]
```

Présentation des résultats sur Shuttle

Résultat : Temps d'exécution, précision, rappel, score f1, AUC

In [61]:

```python
print("Methods ===>")
print(methods)
print("Execution Time ===>")
print(executions_time_Shuttle)
print("Precision ===>")
print(precisions_Shuttle)
print("Recall ===>")
print(recalls_Shuttle)
print("f1_score ===>")
print(f1_scores_Shuttle)
print("ROC AUC ===>")
print(roc_aucs_Shuttle)
```

```
Methods ===>
['IForest', 'OC-SVM', 'LOF']
Execution Time ===>
[2.5428619384765625, 176.90204691886902, 24.813835
859298706]
Precision ===>
[0.9997608628069924, 0.9982955575702629, 0.9870807
80873835]
Recall ===>
[0.9171017417628219, 0.6038696090905102, 0.9084148
642126969]
f1_score ===>
[0.9566490852716726, 0.7525320867675401, 0.9461154
456870652]
ROC AUC ===>
[0.9528561100613655, 0.775169428691041, 0.64555139
56598792]
```

Interprétation des résultats en fonction du Temps d'exécution, précision, rappel, score f1, AUC sur Shuttle

IsolationForest a eu de meilleures performances que les autres. Entre OC-SVM et LOF : OC-SVM a découvert et bien classé plus d'anomalies que LOF. Par contre, LOF a découvert et bien placé plus d'observations normales que OC-SVM. La question est donc de savoir ce qui importe le plus entre la découverte des anomalies et celle des observations normales car c'est en fonction de l'importance que nous donnons à l'un ou à l'autre que nous pourront dire la méthode la meilleure entre OC-SVM et LOF. Cette question fait remarquer qu'en réalité, toutes les méthodes ont sont performantes dans des conditions données en fonction de ce que l'on souhaite obtenir comme résultat. Dans ce cas précis, OC-SVM lance beaucoup de fausse alertes mais attrappe beaucoup d'anomalies. Par contre, LOF n'attrappe pas beaucoup d'anomalies mais reconnais beaucoup de données normales. On peut peut-être se dire que dans le cas espèce OC-SVM est mieux dans la mesure où une méthode de détection d'anomalies a pour but principal de détecter les anomalies et donc laisser passer des anomalies en ferait une méthode moins bonne et que les observations normales que OC-SVM aurait classé comme anormales sont peut être des nouveautés. Considérant l'aire sous la courbe ROC, nous avons l'ordre suivant IForest - OC-SVM et LOF

Tableau du résultat TOBC = VN/(VN + FP) TNBC = VP/(FN + VP)

Méthode |Précision | Rappel | Score f1 | AUC | TOBC | TNBC | CPU Time |

IForest |0.9997608 |0.9084148|0.9566490 |0.9528561|0.9886105|0.9171017|2.5428619 |

OC-SVM |0.9982955 |0.6038696|0.7525321 |0.7751694|0.9464692|0.6038696|176.90205 |

LOF |0.9870808 |0.9171017|0.9461154 |0.6455514|0.3826879|0.9084149|24.813836 |

Resultat: Courbe ROC pour Shuttle

In [64]:

```python
fpr_IF_Shuttle, tpr_IF_Shuttle, thresholds_IF_Shuttle = roc_cu
rve(y_transform_Shuttle, y_pred_IF_Shuttle)
fpr_LOF_Shuttle, tpr_LOF_Shuttle, thresholds_LOF_Shuttle = roc
_curve(y_transform_Shuttle, y_pred_LOF_Shuttle)
fpr_OCSVM_Shuttle, tpr_OCSVM_Shuttle, thresholds_OCSVM_Shuttle
= roc_curve(y_transform_Shuttle, y_pred_OCSVM_Shuttle)
```

In [65]:

```python
plt.plot(fpr_IF_Shuttle, tpr_IF_Shuttle, "g-", label="IForest"
)
plt.plot(fpr_LOF_Shuttle, tpr_LOF_Shuttle, "b--", label="LOF")
plt.plot(fpr_OCSVM_Shuttle, tpr_OCSVM_Shuttle, "r-", label="OC
-SVM")
plt.plot([0, 1], [0, 1], 'k--')
plt.axis([0, 1, 0, 1])
plt.xlabel('False Positive Rate')
plt.ylabel('True Positive Rate')
plt.legend(loc="lower right")

plt.show()
```
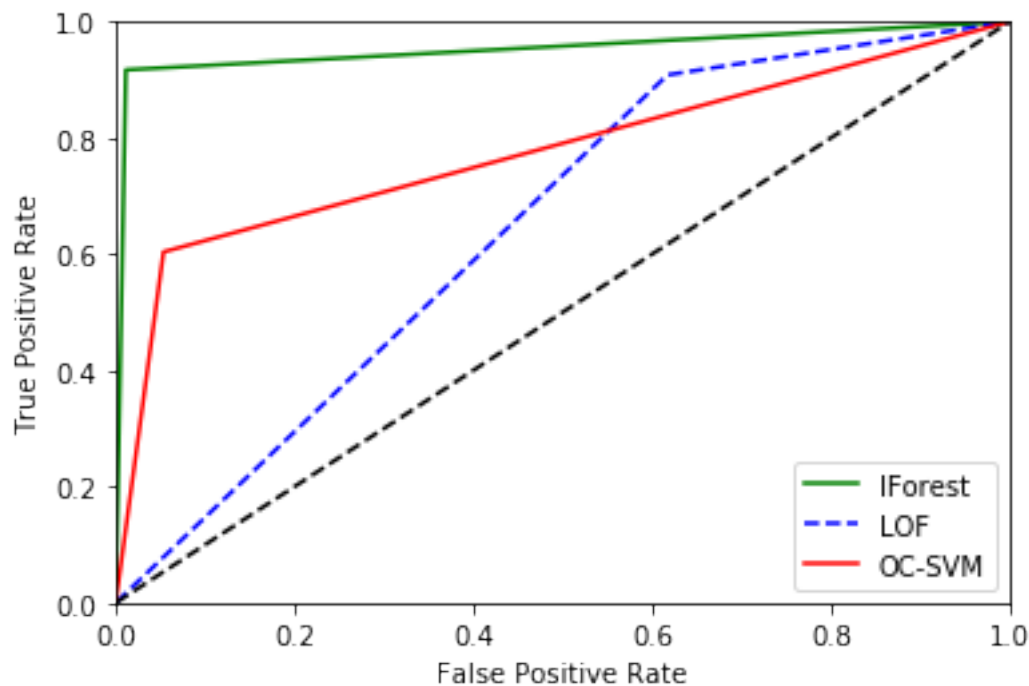
Interprétation de la courbe ROC

La courbe ROC mesurant le taux de faux positif par rapport au taux de vrai positif, plus la courbe s'éloigne de celle oblique en noir, mieux c'est. Ainsi, on peut dire que pour Shuttle, IForest est la meilleure méthode de détection d'anomalies suivi par OC-SVM. Le classement de LOF pourrait s'expliquer par le fait que les anomalies qui y sont présentes sont des anomalies global alors que LOF est doué pour les anomalies locales. POur vérifier ça peut être qu'on peut utiliser une méthode de clustering comme K-means pour voir comment les anomalies seront classées par cette méthode.

Conclusion Shuttle

Pour un jeu de données statique de faible dimension, Isolation forest a tendance à mieux performer et semble être plus rapide que OC-SVM et LOF. OC-SVM détecte beaucoup d'anomalies avec un fort taux de fausses alertes et un temps d'exécution plus grand que LOF. Par contre, LOF détecte moins d'anomalies avec un faible taux de fausses alertes. Notons que la performance des méthodes dépends non seulement du jeu de données considéré mais aussi des valeurs des hypermaramètres. Pour LOF et IsolationForest, le temps d'exécution semble être en correlation positive avec respectivement le nombre de voisins et nombre de d'estimateurs. Par contre, le temps d'exécution serait en correlation négative avec nu.

In [ ]: