

# 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 scikit-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 dessinée 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 faisant varier le nombre de voisins 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 comparons ces méthodes sur la base du temps d'exécution 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'exécution de la méthode en secondes (s)

- Nous calculons l'aire 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 et est donc utile pour comparer deux méthodes de classification

##### Courbe ROC

O = Outlier = Négatif N = Normal = Positif

---

O | N

---

O | VN | FP

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N | FN | VP

## ROC AUC

In [1]:

```
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 [2]:

```
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()
```

Out[2]:

	0	1	2	3	4
count	46464.000000	46464.000000	46464.000000	46464.000000	46464.000000
mean	44.775482	-0.712509	84.834108	0.279291	3.000000
std	8.753404	44.218007	8.731175	37.317203	1.000000
min	27.000000	-4475.000000	21.000000	-3939.000000	-18.000000
25%	37.000000	0.000000	79.000000	0.000000	3.000000
50%	43.000000	0.000000	83.000000	0.000000	4.000000
75%	49.000000	0.000000	87.000000	0.000000	4.000000
max	123.000000	1963.000000	149.000000	3830.000000	49.000000

## 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 [3]:

```
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[3]:

	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.

In [4]:

```
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.**

In [5]:

```
max_samples = 'auto'

averages_executions_time_IF_Shuttle = []
averages_roc_auc_IF_Shuttle = []

for j in range(10, 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))
```

/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.

FutureWarning)



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```
Execution time of IsolationForest applied on Shuttle (in second)
```

```
[0.43103790283203125, 0.4355888366699219, 0.4150211811065674, 0.5610771179199219, 0.5112731456756592]
```

```
ROC AUC for Isolation Forest applied on Shuttle
```

```
[0.9529767611384505, 0.9499758248121375, 0.9563607127912728, 0.9531412853344756, 0.9505562691738773]
```

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Execution time of IsolationForest applied on Shuttle (in second)

[1.1420910358428955, 0.9584560394287109, 0.7817699909210205, 0.859246015548706, 0.8621351718902588]  
ROC AUC for Isolation Forest applied on Shuttle  
[0.9551778875083238, 0.9540169987848446, 0.9505343326144072, 0.9551778875083238, 0.9528561100613655]

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```

```
[1.2591259479522705, 1.173518180847168, 1.0966122150421143, 1.4128477573394775, 1.6369400024414062]
```

```
ROC AUC for Isolation Forest applied on Shuttle
```

```
[0.9563387762318029, 0.9499538882526675, 0.949373443890928, 0.9505453008941421, 0.9511147769761468]
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" be removed in 0.22.", DeprecationWarning)
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Execution time of IsolationForest applied on Shuttle (in second)

```
[2.034435987472534, 1.726597785949707, 1.6513590812683105, 2.08528995513916, 1.5280189514160156]
```

ROC AUC for Isolation Forest applied on Shuttle

```
[0.9580801093170214, 0.9534365544231049, 0.9511257452558817, 0.9487929995291885, 0.9512463963329668]
```

```
/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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Execution time of IsolationForest applied on Shuttle (in second)

[1.9374489784240723, 1.7611498832702637, 1.9203009605407715, 1.8109049797058105, 1.8666479587554932]

ROC AUC for Isolation Forest applied on Shuttle

[0.9580801093170214, 0.9528561100613655, 0.9522756656996257, 0.9517061896176212, 0.9534365544231049]

/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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```
Execution time of IsolationForest applied on Shuttle (in second)
```

```
[2.131838321685791, 2.1302242279052734, 2.4573941230773926, 2.460753917694092, 2.288135051727295]
```

```
ROC AUC for Isolation Forest applied on Shuttle
```

```
[0.9517061896176212, 0.9511147769761468, 0.9476321108057093, 0.9528561100613655, 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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```
Execution time of IsolationForest applied on Shuttle (in second)
```

```
[2.5886881351470947, 2.6734941005706787, 2.682482957839966, 2.7809369564056396, 3.1526501178741455]
```

```
ROC AUC for Isolation Forest applied on Shuttle
```

```
[0.9534365544231049, 0.9522756656996257, 0.9522756656996257, 0.9487929995291885, 0.9476321108057093]
```

```
/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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Execution time of IsolationForest applied on Shuttle (in second)

```
[3.6802477836608887, 2.9864070415496826, 3.107619047164917, 2.9581282138824463, 2.9837841987609863]
```

ROC AUC for Isolation Forest applied on Shuttle

```
[0.9499538882526675, 0.9516952213378863, 0.9511147769761468, 0.9528561100613655, 0.9516952213378863]
```

```
/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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Execution time of IsolationForest applied on Shuttle (in second)

[3.375458240509033, 3.204303026199341, 3.1923539638519287, 3.2720258235931396, 3.199881076812744]

ROC AUC for Isolation Forest applied on Shuttle

[0.9528561100613655, 0.9569192205935423, 0.9551778875083238, 0.9505343326144072, 0.954597443146584]

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```
Execution time of IsolationForest applied on Shuttle (in second)
```

```
[3.7040088176727295, 3.809349775314331, 3.6794869899749756, 3.80515193939209, 4.868165016174316]
```

```
ROC AUC for Isolation Forest applied on Shuttle
```

```
[0.9505343326144072, 0.9516952213378863, 0.9516952213378863, 0.954597443146584, 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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Execution time of IsolationForest applied on Shuttle (in second)

[6.007195711135864, 5.387622356414795, 4.625060796737671, 4.832353830337524, 5.600948095321655]

ROC AUC for Isolation Forest applied on Shuttle

[0.9528670783411003, 0.9528670783411003, 0.9522756656996257, 0.9511147769761468, 0.9569192205935423]

/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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Execution time of IsolationForest applied on Shuttle (in second)

```
[6.613799095153809, 4.643831014633179, 5.371103048
324585, 4.4284749031066895, 4.740011215209961]
```

ROC AUC for Isolation Forest applied on Shuttle

```
[0.9557583318700631, 0.9511147769761468, 0.9528561
100613655, 0.9499538882526675, 0.9511147769761468]
```

```
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```
Execution time of IsolationForest applied on Shuttle (in second)
```

```
[5.429809093475342, 5.4301769733428955, 6.485217094421387, 5.199697971343994, 5.5244300365448]
```

```
ROC AUC for Isolation Forest applied on Shuttle
```

```
[0.9528561100613655, 0.9499648565324026, 0.9522756656996257, 0.9569192205935423, 0.9540169987848446]
```

```
/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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Execution time of IsolationForest applied on Shutt
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```

```
[6.417048931121826, 5.985644102096558, 5.399899005
889893, 5.4616498947143555, 5.768394947052002]
ROC AUC for Isolation Forest applied on Shuttle
[0.9528561100613655, 0.9505453008941421, 0.9528561
100613655, 0.9511147769761468, 0.949373443890928]
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```
Execution time of IsolationForest applied on Shuttle (in second)
```

```
[7.145005226135254, 5.693637132644653, 5.306113004684448, 5.2800257205963135, 5.891430139541626]
```

```
ROC AUC for Isolation Forest applied on Shuttle
```

```
[0.9522756656996257, 0.9511147769761468, 0.9499538882526675, 0.9534365544231049, 0.9528561100613655]
```

```
/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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```
" be removed in 0.22.", DeprecationWarning)
```

Execution time of IsolationForest applied on Shuttle (in second)

```
[6.699141025543213, 7.057630777359009, 9.505704164505005, 6.221740961074829, 7.797239065170288]
```

ROC AUC for Isolation Forest applied on Shuttle

```
[0.9511147769761468, 0.9511147769761468, 0.9516952213378863, 0.9540169987848446, 0.949373443890928]
```

```
/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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Execution time of IsolationForest applied on Shuttle (in second)
[6.288877248764038, 6.260418891906738, 6.222504138946533, 6.704073905944824, 6.96709680557251]
ROC AUC for Isolation Forest applied on Shuttle
[0.9499538882526675, 0.9522756656996257, 0.9516952213378863, 0.9528561100613655, 0.9528561100613655]
```

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/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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Execution time of IsolationForest applied on Shuttle (in second)

[7.480480194091797, 7.084450006484985, 6.619936943054199, 6.802766799926758, 6.442012071609497]

ROC AUC for Isolation Forest applied on Shuttle

[0.9516952213378863, 0.9511147769761468, 0.9522756656996257, 0.9534365544231049, 0.9511147769761468]

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```
Execution time of IsolationForest applied on Shuttle (in second)
```

```
[7.146161794662476, 7.275901794433594, 7.184439182281494, 7.0973358154296875, 6.747941970825195]
```

```
ROC AUC for Isolation Forest applied on Shuttle
```

```
[0.9528561100613655, 0.9511147769761468, 0.9499538882526675, 0.9528561100613655, 0.9540169987848446]
```

```
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Execution time of IsolationForest applied on Shuttle (in second)

```
[7.219103097915649, 8.352814197540283, 7.578938007354736, 7.480122804641724, 7.699251413345337]
```

ROC AUC for Isolation Forest applied on Shuttle

```
[0.9511147769761468, 0.9516952213378863, 0.9528561100613655, 0.9516952213378863, 0.9522756656996257]
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/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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```
Execution time of IsolationForest applied on Shutt
le (in second)
```

```
[7.977267026901245, 7.974909067153931, 7.759855747
2229, 7.896172046661377, 8.195299863815308]
```

```
ROC AUC for Isolation Forest applied on Shuttle
```

```
[0.9516952213378863, 0.9505343326144072, 0.9516952
213378863, 0.9522756656996257, 0.9522756656996257]
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packag
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Execution time of IsolationForest applied on Shuttle (in second)

```
[9.203197717666626, 9.351696252822876, 8.598716020584106, 10.346078872680664, 9.384166955947876]
```

ROC AUC for Isolation Forest applied on Shuttle

```
[0.9522756656996257, 0.9528561100613655, 0.9534365544231049, 0.9505343326144072, 0.9522756656996257]
```

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Execution time of IsolationForest applied on Shuttle (in second)

[11.22852087020874, 11.436401128768921, 11.66942572593689, 13.157791137695312, 10.030635118484497]

ROC AUC for Isolation Forest applied on Shuttle

[0.9528561100613655, 0.954597443146584, 0.9534365544231049, 0.9522756656996257, 0.9511147769761468]

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Execution time of IsolationForest applied on Shuttle (in second)

```
[12.493605136871338, 11.744182825088501, 12.41071891784668, 9.858978748321533, 10.652988910675049]
```

ROC AUC for Isolation Forest applied on Shuttle

```
[0.9516952213378863, 0.9534365544231049, 0.9511147769761468, 0.9540169987848446, 0.9528561100613655]
```

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/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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Execution time of IsolationForest applied on Shuttle (in second)

[9.929949045181274, 11.447458744049072, 10.070409774780273, 9.06134295463562, 9.069718837738037]

ROC AUC for Isolation Forest applied on Shuttle

[0.9528561100613655, 0.9534365544231049, 0.9534365544231049, 0.9528561100613655, 0.9522756656996257]

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ROC AUC for Isolation Forest applied on Shuttle
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```

```
" be removed in 0.22.", DeprecationWarning)
```

```
Execution time of IsolationForest applied on Shuttle (in second)
```

```
[9.798256874084473, 9.5221266746521, 9.86213207244873, 9.613476037979126, 9.662375211715698]
```

```
ROC AUC for Isolation Forest applied on Shuttle
```

```
[0.9511147769761468, 0.9505343326144072, 0.9528561100613655, 0.9516952213378863, 0.9516952213378863]
```

```
/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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```
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```
" be removed in 0.22.", DeprecationWarning)
```

Execution time of IsolationForest applied on Shuttle (in second)

```
[10.641808986663818, 12.402535915374756, 11.571316957473755, 10.416658878326416, 9.831680059432983]
```

ROC AUC for Isolation Forest applied on Shuttle

```
[0.9511147769761468, 0.9522756656996257, 0.9516952213378863, 0.9516952213378863, 0.9511147769761468]
```

```
/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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" be removed in 0.22.", DeprecationWarning)

Execution time of IsolationForest applied on Shuttle (in second)

[10.692094802856445, 11.535588026046753, 19.43449091911316, 12.972423315048218, 14.10976791381836]

ROC AUC for Isolation Forest applied on Shuttle

[0.949373443890928, 0.9516952213378863, 0.9511147769761468, 0.9522756656996257, 0.9516952213378863]

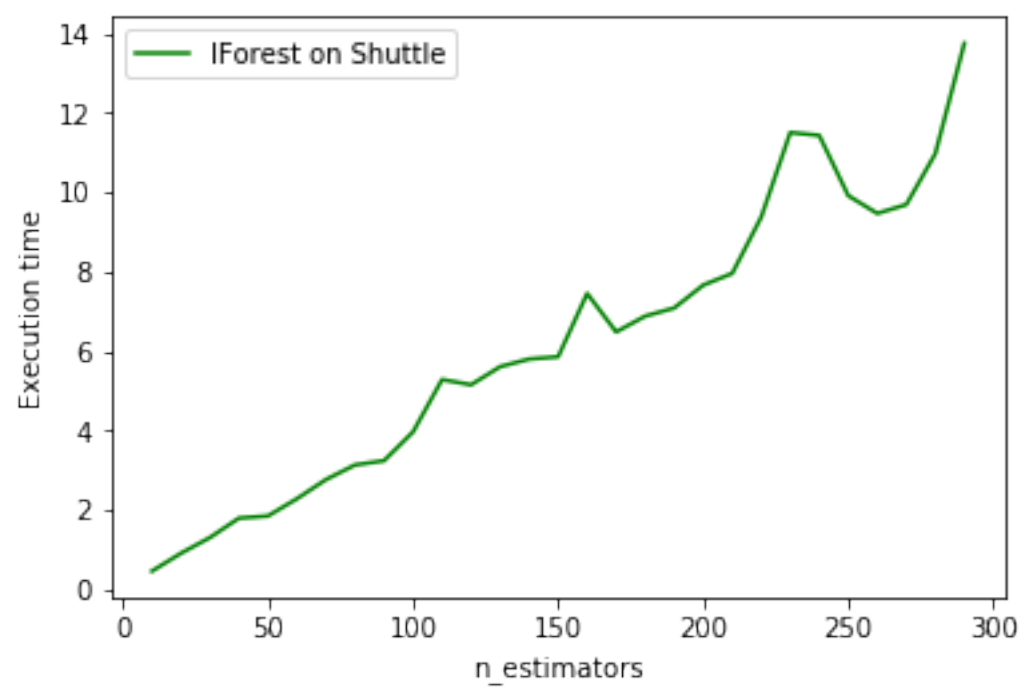
## Résultat de Isolation Forest sur Shuttle

In [7]:

```
print("Execution time of IsolationForest applied on Shuttle (in second)")
print(averages_executions_time_IF_Shuttle)
plt.plot(range(10, 300, 10), averages_executions_time_IF_Shuttle, "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 Shuttle (in second)

```
[0.4707996368408203, 0.9207396507263184, 1.3158088207244873, 1.8051403522491456, 1.8592905521392822, 2.2936691284179687, 2.775650453567505, 3.143237257003784, 3.2488044261932374, 3.9732325077056885, 5.290636157989502, 5.1594438552856445, 5.613866233825684, 5.806527376174927, 5.863242244720459, 7.456291198730469, 6.488594198226929, 6.885929203033447, 7.090356111526489, 7.666045904159546, 7.960700750350952, 9.376771163940429, 11.504554796218873, 11.43209490776062, 9.915775871276855, 9.469358777999878, 9.691673374176025, 10.972800159454346, 13.748872995376587]
```



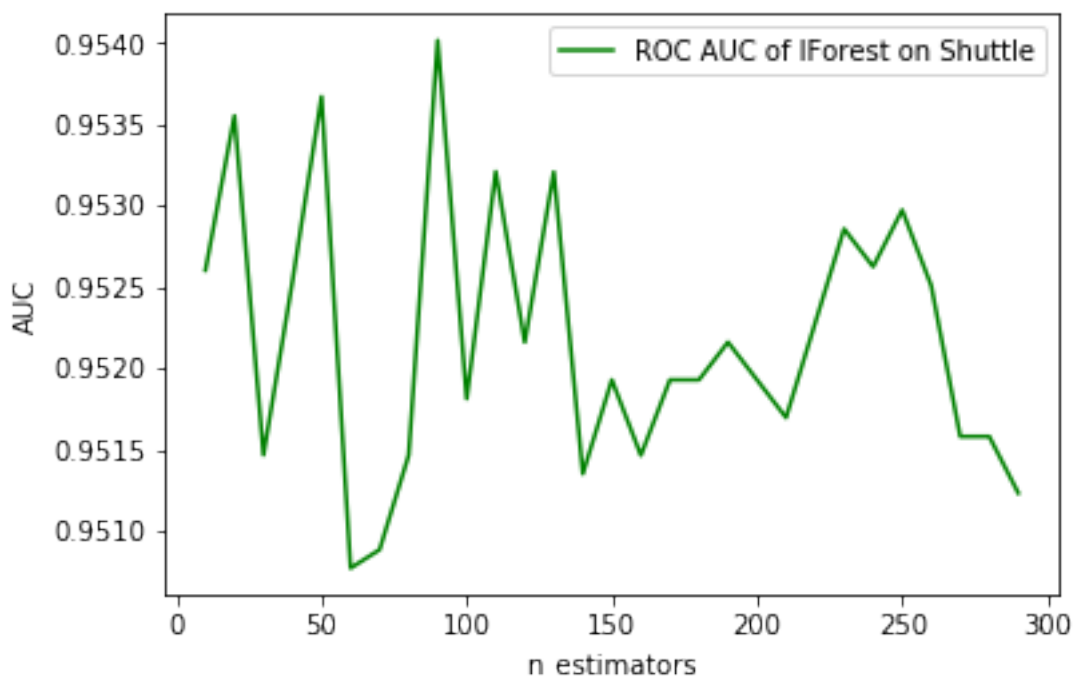
In [8]:

```
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(10, 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

```
[0.9526021706500427, 0.953552643295453, 0.95146523
72491375, 0.9525363609716326, 0.9536709258237478,
0.95076870401505, 0.9508825992314508, 0.9514630435
931904, 0.9540169987848446, 0.9518113102102342, 0.
9532087639903031, 0.9521595768272779, 0.9532065703
343562, 0.9513491483767896, 0.9519273990825821, 0.
9514630435931904, 0.9519273990825821, 0.9519273990
825821, 0.9521595768272779, 0.9519273990825822, 0.
9516952213378863, 0.9522756656996259, 0.9528561100
613654, 0.9526239323166696, 0.9529721989337133, 0.
9525078434443216, 0.9515791324655384, 0.9515791324
655384, 0.9512308658484946]
```

La valeur max est 0.9540169987848446 à l'index 8



In [ ]:

```
max_samples = 'auto'

averages_executions_time_IF_Shuttle = []
averages_roc_auc_IF_Shuttle = []

for j in range(100, len(X_Shuttle), 100):
    max_samples = j
    executions_time_IF_Shuttle = []
    roc_auc_IF_Shuttle = []
    for i in range(5):
        start_IF_Shuttle = time()

        func_IF_Shuttle = IsolationForest(max_samples=max_samp
les)

        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 Shuttl
e")

        #print(roc_auc_IF_Shuttle)
        print("Execution time of IsolationForest applied on Shuttl
e (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))
```

/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-packages/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.

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```
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```

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```
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```
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```

```
" be removed in 0.22 " DeprecationWarning)
```

```
Execution time of IsolationForest applied on Shuttle (in second)
```

```
[4.148074150085449, 3.7550060749053955, 4.611931800842285, 3.532059907913208, 3.527313709259033]
```

```
ROC AUC for Isolation Forest applied on Shuttle
```

```
[0.9487929995291885, 0.9482125551674488, 0.9476321108057093, 0.9487929995291885, 0.949373443890928]
```

```
/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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[4.478538274765015, 3.724726915359497, 3.6360058784484863, 4.175824880599976, 4.259774208068848]
ROC AUC for Isolation Forest applied on Shuttle
[0.9516952213378863, 0.9505343326144072, 0.9528561100613655, 0.9499538882526675, 0.9511147769761468]
```

```
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```

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```
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```
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```

```
FutureWarning)
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Execution time of IsolationForest applied on Shuttle (in second)
[4.736108064651489, 4.259474277496338, 4.54249382019043, 5.127716064453125, 4.321677923202515]
ROC AUC for Isolation Forest applied on Shuttle
[0.9516952213378863, 0.9540169987848446, 0.9522756656996257, 0.9540169987848446, 0.954597443146584]
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```

Execution time of IsolationForest applied on Shuttle (in second)

```
[4.116376161575317, 4.47221827507019, 4.79190993309021, 4.590828895568848, 4.517529249191284]
```

ROC AUC for Isolation Forest applied on Shuttle

```
[0.9528561100613655, 0.9534365544231049, 0.9528561100613655, 0.9557583318700631, 0.9516952213378863]
```

```
/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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Execution time of IsolationForest applied on Shuttle (in second)

[4.814849853515625, 4.264904260635376, 4.105032205581665, 3.9916701316833496, 3.812680959701538]

ROC AUC for Isolation Forest applied on Shuttle

[0.9557583318700631, 0.9540499036240495, 0.9540169987848446, 0.954597443146584, 0.954597443146584]

/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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" be removed in 0.22.", DeprecationWarning)
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Execution time of IsolationForest applied on Shuttle (in second)

```
[4.254163026809692, 4.136675119400024, 4.0483739376068115, 4.0747129917144775, 4.0831427574157715]
```

ROC AUC for Isolation Forest applied on Shuttle

```
[0.9563387762318029, 0.954597443146584, 0.9534365544231049, 0.9563387762318029, 0.9551778875083238]
```

```
/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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Execution time of IsolationForest applied on Shuttle (in second)

[4.969222068786621, 4.094129323959351, 4.129677772521973, 4.245783090591431, 3.892181873321533]

ROC AUC for Isolation Forest applied on Shuttle

[0.9569411571530122, 0.9574996649552819, 0.9534365544231049, 0.9563387762318029, 0.9569192205935423]

/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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Execution time of IsolationForest applied on Shuttle (in second)

```
[3.992812156677246, 4.285337924957275, 4.597761869430542, 4.53666877746582, 4.43488883972168]
```

ROC AUC for Isolation Forest applied on Shuttle

```
[0.9534365544231049, 0.9551778875083238, 0.9557583318700631, 0.954652284545259, 0.9574996649552819]
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/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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```
FutureWarning)
/Users/thesard/anaconda3/lib/python3.7/site-packages/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)
```



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Execution time of IsolationForest applied on Shuttle (in second)

[4.217005968093872, 4.253846883773804, 4.4493489265441895, 4.123769283294678, 4.045113801956177]

ROC AUC for Isolation Forest applied on Shuttle

[0.9580801093170214, 0.9569192205935423, 0.958660553678761, 0.9563387762318029, 0.9580801093170214]

/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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" be removed in 0.22.", DeprecationWarning)
```

Execution time of IsolationForest applied on Shuttle (in second)

```
[4.024677753448486, 4.018186330795288, 3.9037132263183594, 4.845555067062378, 3.9908061027526855]
```

ROC AUC for Isolation Forest applied on Shuttle

```
[0.9569192205935423, 0.9563387762318029, 0.9580801093170214, 0.9569192205935423, 0.954597443146584]
```

```
/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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```
" be removed in 0.22.", DeprecationWarning)
```

Execution time of IsolationForest applied on Shuttle (in second)

```
[4.547332048416138, 4.36632776260376, 4.360507249832153, 4.463628053665161, 4.351456165313721]
```

ROC AUC for Isolation Forest applied on Shuttle

```
[0.9563387762318029, 0.9563387762318029, 0.9563387762318029, 0.958660553678761, 0.9569192205935423]
```

```
/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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```
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/Users/thesard/anaconda3/lib/python3.7/site-packag
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```
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```

Execution time of IsolationForest applied on Shuttle (in second)

```
[4.6120219230651855, 4.415306091308594, 4.41013002
3956299, 4.221622705459595, 4.422367811203003]
```

ROC AUC for Isolation Forest applied on Shuttle

```
[0.9569192205935423, 0.9569301888732772, 0.9557583
318700631, 0.9563387762318029, 0.9574996649552819]
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packag
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```

Execution time of IsolationForest applied on Shuttle (in second)

```
[4.265349864959717, 4.204833745956421, 4.249860048294067, 4.200879812240601, 4.272937059402466]
```

ROC AUC for Isolation Forest applied on Shuttle

```
[0.9569192205935423, 0.9569192205935423, 0.954597443146584, 0.9569192205935423, 0.9563387762318029]
```

```
/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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Execution time of IsolationForest applied on Shuttle (in second)

[4.126558065414429, 4.429951906204224, 5.009196996688843, 4.187208890914917, 4.243081092834473]

ROC AUC for Isolation Forest applied on Shuttle

[0.9580801093170214, 0.9563387762318029, 0.9540169987848446, 0.954597443146584, 0.9569301888732772]

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" be removed in 0.22.", DeprecationWarning)
```

Execution time of IsolationForest applied on Shuttle (in second)

```
[4.208996057510376, 4.229200839996338, 4.377093076  
705933, 4.35145902633667, 4.302983045578003]
```

ROC AUC for Isolation Forest applied on Shuttle

```
[0.9569192205935423, 0.9557583318700631, 0.9569192  
205935423, 0.954597443146584, 0.9563387762318029]
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packag  
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Execution time of IsolationForest applied on Shuttle (in second)

[4.25881814956665, 4.380075216293335, 4.219978094100952, 4.376150846481323, 4.310074090957642]

ROC AUC for Isolation Forest applied on Shuttle

[0.9557583318700631, 0.9574996649552819, 0.9574996649552819, 0.9580801093170214, 0.954597443146584]

/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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```

Execution time of IsolationForest applied on Shuttle (in second)

```
[4.253579139709473, 4.452856063842773, 5.0109429359436035, 4.422084093093872, 5.30122709274292]
```

ROC AUC for Isolation Forest applied on Shuttle

```
[0.958660553678761, 0.9534365544231049, 0.9557583318700631, 0.9569192205935423, 0.9563387762318029]
```

```
/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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```

Execution time of IsolationForest applied on Shuttle (in second)

```
[4.265419006347656, 4.316555023193359, 4.397449970
245361, 4.246073246002197, 4.171237230300903]
```

ROC AUC for Isolation Forest applied on Shuttle

```
[0.9557583318700631, 0.9551778875083238, 0.9534365
544231049, 0.9569192205935423, 0.9540169987848446]
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packag
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Execution time of IsolationForest applied on Shuttle (in second)

```
[4.173925161361694, 4.289420127868652, 4.229168891906738, 4.52254319190979, 4.34238076210022]
```

ROC AUC for Isolation Forest applied on Shuttle

```
[0.9569192205935423, 0.9551778875083238, 0.9557583318700631, 0.9569192205935423, 0.9580801093170214]
```

```
/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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Execution time of IsolationForest applied on Shuttle (in second)

[4.28705906867981, 4.254993915557861, 4.535364151000977, 4.192773818969727, 4.209452152252197]

ROC AUC for Isolation Forest applied on Shuttle

[0.9563387762318029, 0.9580801093170214, 0.954597443146584, 0.9574996649552819, 0.9557583318700631]

/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.

FutureWarning)

/Users/thesard/anaconda3/lib/python3.7/site-packag



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```
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```

```
Execution time of IsolationForest applied on Shutt
le (in second)
```

```
[4.700051784515381, 5.193235874176025, 4.406460762
023926, 4.584855079650879, 4.437547206878662]
```

```
ROC AUC for Isolation Forest applied on Shuttle
```

```
[0.9569192205935423, 0.9557583318700631, 0.9569192
205935423, 0.9563387762318029, 0.9569192205935423]
```

```
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Execution time of IsolationForest applied on Shuttle (in second)

```
[4.474681854248047, 4.502126216888428, 4.5725719928741455, 4.439355134963989, 4.584226846694946]
```

ROC AUC for Isolation Forest applied on Shuttle

```
[0.9563387762318029, 0.9574996649552819, 0.9563387762318029, 0.9551778875083238, 0.9563387762318029]
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packages/sklearn/ensemble/iforest.py:213: FutureWarning: default contamination parameter 0.1 will change in
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Execution time of IsolationForest applied on Shuttle (in second)

[4.467282295227051, 4.510632038116455, 4.621686935424805, 4.446631908416748, 4.477775812149048]

ROC AUC for Isolation Forest applied on Shuttle

[0.9569192205935423, 0.9569192205935423, 0.9569192205935423, 0.954597443146584, 0.954597443146584]

/Users/thesard/anaconda3/lib/python3.7/site-packag

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```



Execution time of IsolationForest applied on Shuttle (in second)

```
[4.5176451206207275, 4.5479278564453125, 5.3514368534088135, 4.6334388256073, 4.559322834014893]
```

ROC AUC for Isolation Forest applied on Shuttle

```
[0.9563387762318029, 0.9569301888732772, 0.9569192205935423, 0.9569192205935423, 0.9569192205935423]
```

```
/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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Execution time of IsolationForest applied on Shuttle (in second)

[4.669980049133301, 4.7169883251190186, 4.52982497215271, 4.702714681625366, 4.798770904541016]

ROC AUC for Isolation Forest applied on Shuttle

[0.9540279670645795, 0.9563387762318029, 0.9563387762318029, 0.9563387762318029, 0.9569192205935423]

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```
/Users/thesard/anaconda3/lib/python3.7/site-packages/sklearn/ensemble/iforest.py:417: DeprecationWarning: threshold_ attribute is deprecated in 0.20 and will be removed in 0.22.
```

```
" be removed in 0.22.", DeprecationWarning)
```

Execution time of IsolationForest applied on Shuttle (in second)

```
[4.524863958358765, 4.477673053741455, 4.4922099113464355, 4.469706058502197, 4.338120937347412]
```

ROC AUC for Isolation Forest applied on Shuttle

```
[0.9557583318700631, 0.9569192205935423, 0.9569192205935423, 0.9574996649552819, 0.9563387762318029]
```

```
/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.
```

```
FutureWarning)
```

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FutureWarning)
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```
FutureWarning)
```

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FutureWarning)
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" be removed in 0.22.", DeprecationWarning)

Execution time of IsolationForest applied on Shuttle (in second)

[4.538113832473755, 4.480103969573975, 4.703557968139648, 4.523444890975952, 4.855432033538818]

ROC AUC for Isolation Forest applied on Shuttle

[0.954597443146584, 0.9563387762318029, 0.9540169987848446, 0.9563387762318029, 0.9551778875083238]

/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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" be removed in 0.22.", DeprecationWarning)
```

Execution time of IsolationForest applied on Shuttle (in second)

```
[4.762862682342529, 4.685791015625, 4.451357126235962, 4.557659149169922, 4.61355185508728]
```

ROC AUC for Isolation Forest applied on Shuttle

```
[0.954597443146584, 0.9557583318700631, 0.9563497445115378, 0.9557583318700631, 0.9557583318700631]
```

```
/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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Execution time of IsolationForest applied on Shuttle (in second)

[4.470401048660278, 4.510869979858398, 4.38883376121521, 4.884421110153198, 4.586853981018066]

ROC AUC for Isolation Forest applied on Shuttle

[0.9551778875083238, 0.9563387762318029, 0.9574996649552819, 0.9551778875083238, 0.9557583318700631]

/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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" be removed in 0.22.", DeprecationWarning)
```

Execution time of IsolationForest applied on Shuttle (in second)

```
[4.493438005447388, 4.61918306350708, 4.630713701248169, 4.520171642303467, 4.56034779548645]
```

ROC AUC for Isolation Forest applied on Shuttle

```
[0.9574996649552819, 0.9563387762318029, 0.9563387762318029, 0.9563387762318029, 0.9563387762318029]
```

```
/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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" be removed in 0.22.", DeprecationWarning)
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Execution time of IsolationForest applied on Shuttle (in second)

```
[4.568108081817627, 4.948651075363159, 5.3407721519470215, 4.459874153137207, 4.734743118286133]
```

ROC AUC for Isolation Forest applied on Shuttle

```
[0.9551778875083238, 0.9557583318700631, 0.9557583318700631, 0.9569192205935423, 0.9569192205935423]
```

```
/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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```

```
FutureWarning)
/Users/thesard/anaconda3/lib/python3.7/site-packag
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```

```
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```

```
" be removed in 0.22.", DeprecationWarning)
```

```
Execution time of IsolationForest applied on Shutt
le (in second)
```

```
[4.463727951049805, 4.515949964523315, 4.509958028
793335, 4.862221002578735, 4.425277948379517]
```

```
ROC AUC for Isolation Forest applied on Shuttle
```

```
[0.9557583318700631, 0.9563497445115378, 0.9563387
762318029, 0.9563387762318029, 0.9569192205935423]
```

```
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```
" be removed in 0.22.", DeprecationWarning)
```

Execution time of IsolationForest applied on Shuttle (in second)

```
[4.473973035812378, 4.473373889923096, 4.619715213775635, 4.535471677780151, 4.635781288146973]
```

ROC AUC for Isolation Forest applied on Shuttle

```
[0.9563387762318029, 0.9569192205935423, 0.9551778875083238, 0.9540169987848446, 0.9551778875083238]
```

```
/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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" be removed in 0.22.", DeprecationWarning)

Execution time of IsolationForest applied on Shuttle (in second)

[4.741816282272339, 4.582215070724487, 4.534056901931763, 5.155771970748901, 4.9053730964660645]

ROC AUC for Isolation Forest applied on Shuttle

[0.9563387762318029, 0.9540169987848446, 0.9551778875083238, 0.9557583318700631, 0.9557583318700631]

/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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```
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```

```
Execution time of IsolationForest applied on Shutt  
le (in second)
```

```
[4.624408006668091, 4.5847978591918945, 4.75039887  
4282837, 4.465402126312256, 4.562676906585693]
```

```
ROC AUC for Isolation Forest applied on Shuttle
```

```
[0.9574996649552819, 0.9557583318700631, 0.9563387  
762318029, 0.9563387762318029, 0.9563387762318029]
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packag  
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Execution time of IsolationForest applied on Shuttle (in second)

[4.502671241760254, 4.5938451290130615, 4.488270044326782, 4.501006126403809, 4.6746368408203125]

ROC AUC for Isolation Forest applied on Shuttle

[0.9540279670645795, 0.9557583318700631, 0.9569192205935423, 0.9534365544231049, 0.9563387762318029]

/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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Execution time of IsolationForest applied on Shuttle (in second)

```
[4.440356254577637, 4.426839828491211, 4.554282188415527, 4.48799204826355, 4.495970964431763]
```

ROC AUC for Isolation Forest applied on Shuttle

```
[0.9557583318700631, 0.9563387762318029, 0.9563387762318029, 0.9557583318700631, 0.9557583318700631]
```

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FutureWarning)
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FutureWarning)
```

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Execution time of IsolationForest applied on Shuttle (in second)

```
[4.8908531665802, 5.03961706161499, 4.487570285797
119, 4.6985087394714355, 4.58998703956604]
```

ROC AUC for Isolation Forest applied on Shuttle

```
[0.9563387762318029, 0.9574996649552819, 0.9528561
100613655, 0.9557583318700631, 0.9557583318700631]
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packag
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" be removed in 0.22.", DeprecationWarning)
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Execution time of IsolationForest applied on Shuttle (in second)

```
[4.537533283233643, 4.425873041152954, 4.521619081497192, 4.444199085235596, 4.583422899246216]
```

ROC AUC for Isolation Forest applied on Shuttle

```
[0.954597443146584, 0.9557583318700631, 0.9557693001497983, 0.9551778875083238, 0.9563387762318029]
```

```
/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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Execution time of IsolationForest applied on Shuttle (in second)

[4.659638166427612, 4.534879922866821, 4.5264317989349365, 4.482944965362549, 4.62916898727417]

ROC AUC for Isolation Forest applied on Shuttle

[0.9528561100613655, 0.9563387762318029, 0.9563387762318029, 0.9569192205935423, 0.9557583318700631]

/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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```
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```

```
Execution time of IsolationForest applied on Shutt
le (in second)
```

```
[4.840900182723999, 4.814973831176758, 4.695256233
215332, 4.843562126159668, 4.749237060546875]
```

```
ROC AUC for Isolation Forest applied on Shuttle
```

```
[0.9557583318700631, 0.9563387762318029, 0.9563497
445115378, 0.9557693001497983, 0.9557583318700631]
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packag
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Execution time of IsolationForest applied on Shuttle (in second)
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ROC AUC for Isolation Forest applied on Shuttle
[0.954597443146584, 0.9557583318700631, 0.954608411426319, 0.9563387762318029, 0.9563387762318029]
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Execution time of IsolationForest applied on Shuttle (in second)

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ROC AUC for Isolation Forest applied on Shuttle

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Execution time of IsolationForest applied on Shuttle (in second)  
[4.802053689956665, 4.687422037124634, 4.800492763519287, 4.750844955444336, 4.751267910003662]  
ROC AUC for Isolation Forest applied on Shuttle  
[0.954597443146584, 0.9563387762318029, 0.9540169987848446, 0.9557583318700631, 0.9551778875083238]

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Execution time of IsolationForest applied on Shuttle (in second)

[4.856210947036743, 4.809416055679321, 4.820804119110107, 4.660868883132935, 4.737995862960815]

ROC AUC for Isolation Forest applied on Shuttle

[0.9528561100613655, 0.9551778875083238, 0.954608411426319, 0.954597443146584, 0.9563387762318029]

/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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```
" be removed in 0.22.", DeprecationWarning)
```

Execution time of IsolationForest applied on Shuttle (in second)

```
[4.657835960388184, 4.764303922653198, 5.51947021484375, 4.9417479038238525, 5.128258228302002]
```

ROC AUC for Isolation Forest applied on Shuttle

```
[0.954597443146584, 0.9563387762318029, 0.9574996649552819, 0.9540169987848446, 0.9557583318700631]
```

```
/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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```
FutureWarning)
```

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/Users/thesard/anaconda3/lib/python3.7/site-packages/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.
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Execution time of IsolationForest applied on Shuttle (in second)

[4.87781286239624, 5.309274196624756, 4.980170965194702, 4.970767021179199, 5.108621120452881]

ROC AUC for Isolation Forest applied on Shuttle

[0.9563387762318029, 0.9534365544231049, 0.9551778875083238, 0.9569192205935423, 0.9580801093170214]

/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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```
" be removed in 0.22.", DeprecationWarning)
```

Execution time of IsolationForest applied on Shuttle (in second)

```
[5.200794696807861, 5.659894227981567, 4.84483003616333, 4.7986040115356445, 4.985297918319702]
```

ROC AUC for Isolation Forest applied on Shuttle

```
[0.9563387762318029, 0.9563387762318029, 0.9534365544231049, 0.9540169987848446, 0.9534365544231049]
```

```
/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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Execution time of IsolationForest applied on Shuttle (in second)

[4.780432939529419, 4.801203012466431, 4.704830884933472, 5.744770050048828, 4.756540298461914]

ROC AUC for Isolation Forest applied on Shuttle

[0.9551778875083238, 0.954597443146584, 0.9551778875083238, 0.9551778875083238, 0.9563387762318029]

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```

```
" be removed in 0.22.", DeprecationWarning)
```

Execution time of IsolationForest applied on Shuttle (in second)

```
[5.140233993530273, 4.837011098861694, 4.957325220108032, 4.750718832015991, 5.014388799667358]
```

ROC AUC for Isolation Forest applied on Shuttle

```
[0.9563387762318029, 0.9563387762318029, 0.954597443146584, 0.9557583318700631, 0.9563387762318029]
```

```
/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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```

```
" be removed in 0.22.", DeprecationWarning)
```

Execution time of IsolationForest applied on Shuttle (in second)

```
[4.868592262268066, 4.949061155319214, 4.769488096237183, 4.786611080169678, 4.992431163787842]
```

ROC AUC for Isolation Forest applied on Shuttle

```
[0.9563497445115378, 0.954597443146584, 0.9534365544231049, 0.9534365544231049, 0.9563387762318029]
```

```
/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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```
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.

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```
" be removed in 0.22.", DeprecationWarning)
```

Execution time of IsolationForest applied on Shuttle (in second)

```
[4.934880971908569, 4.9968531131744385, 4.89920902
2521973, 4.824260950088501, 5.337686777114868]
```

ROC AUC for Isolation Forest applied on Shuttle

```
[0.9563607127912728, 0.9563387762318029, 0.9557583
318700631, 0.9528561100613655, 0.954597443146584]
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packag
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```
" be removed in 0.22.", DeprecationWarning)
```

Execution time of IsolationForest applied on Shuttle (in second)

```
[4.788971900939941, 4.761574983596802, 4.885623931
884766, 5.097329139709473, 5.09189510345459]
```

ROC AUC for Isolation Forest applied on Shuttle

```
[0.9540169987848446, 0.9534365544231049, 0.9563497
445115378, 0.9557583318700631, 0.9551778875083238]
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packag
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Execution time of IsolationForest applied on Shuttle (in second)

[5.0890586376190186, 5.134521722793579, 4.775532960891724, 4.846326112747192, 5.271713018417358]

ROC AUC for Isolation Forest applied on Shuttle

[0.9557583318700631, 0.954597443146584, 0.9534365544231049, 0.9551778875083238, 0.9551778875083238]

/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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```
" be removed in 0.22.", DeprecationWarning)
```

```
Execution time of IsolationForest applied on Shutt  
le (in second)
```

```
[4.88050103187561, 4.849874019622803, 4.9006788730  
62134, 4.992582082748413, 4.922398328781128]
```

```
ROC AUC for Isolation Forest applied on Shuttle
```

```
[0.9540169987848446, 0.9557583318700631, 0.9545974  
43146584, 0.9551778875083238, 0.9551778875083238]
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packag  
es/sklearn/ensemble/iforest.py:213: FutureWarning:  
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FutureWarning)
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```
FutureWarning)
```

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Execution time of IsolationForest applied on Shuttle (in second)

[5.702910900115967, 4.7846839427948, 4.658921957015991, 4.887490749359131, 4.880533218383789]

ROC AUC for Isolation Forest applied on Shuttle

[0.9557583318700631, 0.9528561100613655, 0.9551778875083238, 0.9551778875083238, 0.9557583318700631]

/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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```
" be removed in 0.22.", DeprecationWarning)
```

Execution time of IsolationForest applied on Shuttle (in second)

```
[4.8675620555877686, 5.090875864028931, 4.819585800170898, 4.751140117645264, 4.739552974700928]
```

ROC AUC for Isolation Forest applied on Shuttle

```
[0.9563387762318029, 0.9534365544231049, 0.9569192205935423, 0.9534365544231049, 0.9528561100613655]
```

```
/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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```

```
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```

Execution time of IsolationForest applied on Shuttle (in second)

```
[4.747160911560059, 4.70470118522644, 4.7678987979
88892, 4.892683029174805, 4.771270751953125]
```

ROC AUC for Isolation Forest applied on Shuttle

```
[0.9534365544231049, 0.954597443146584, 0.95575833
18700631, 0.9551778875083238, 0.9540169987848446]
```

```
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```

Execution time of IsolationForest applied on Shuttle (in second)

```
[4.808300018310547, 4.776759147644043, 5.780897855758667, 5.154470205307007, 4.789431095123291]
```

ROC AUC for Isolation Forest applied on Shuttle

```
[0.9563387762318029, 0.9563387762318029, 0.9557583318700631, 0.9551778875083238, 0.9569192205935423]
```

```
/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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Execution time of IsolationForest applied on Shuttle (in second)

[4.950717210769653, 4.747659206390381, 4.757853269577026, 4.652565956115723, 4.07928991317749]

ROC AUC for Isolation Forest applied on Shuttle

[0.9557583318700631, 0.9540169987848446, 0.954608411426319, 0.954597443146584, 0.9528561100613655]

/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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```
" be removed in 0.22.", DeprecationWarning)
```

```
Execution time of IsolationForest applied on Shutt
le (in second)
```

```
[4.170020818710327, 4.084714889526367, 4.181416988
372803, 4.206525087356567, 4.213693857192993]
```

```
ROC AUC for Isolation Forest applied on Shuttle
```

```
[0.9528561100613655, 0.9528561100613655, 0.9534475
2270284, 0.9563387762318029, 0.9540169987848446]
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packag
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```
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Execution time of IsolationForest applied on Shutt
le (in second)
[4.131798982620239, 4.123748064041138, 4.141551971
435547, 4.133470058441162, 4.13214373588562]
ROC AUC for Isolation Forest applied on Shuttle
[0.9528561100613655, 0.9534365544231049, 0.9551778
875083238, 0.9534365544231049, 0.9557583318700631]
```

```
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" be removed in 0.22.", DeprecationWarning)
```

Execution time of IsolationForest applied on Shuttle (in second)

```
[4.602727174758911, 4.255393981933594, 4.20022988319397, 4.200060129165649, 4.164692163467407]
```

ROC AUC for Isolation Forest applied on Shuttle

```
[0.9551778875083238, 0.9563387762318029, 0.9534365544231049, 0.9540169987848446, 0.9569192205935423]
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packag
```



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```

Execution time of IsolationForest applied on Shuttle (in second)

```
[4.156078100204468, 4.210436105728149, 4.198800325393677, 4.101399183273315, 4.111742973327637]
```

ROC AUC for Isolation Forest applied on Shuttle

```
[0.9551778875083238, 0.954608411426319, 0.9540169987848446, 0.9540169987848446, 0.9551778875083238]
```

```
/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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Execution time of IsolationForest applied on Shuttle  
(in second)

[4.237694025039673, 4.207485914230347, 4.180034160  
614014, 4.143377065658569, 4.1879942417144775]

ROC AUC for Isolation Forest applied on Shuttle

[0.9540169987848446, 0.9569192205935423, 0.9528561  
100613655, 0.954597443146584, 0.9528561100613655]

/Users/thesard/anaconda3/lib/python3.7/site-packag  
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Execution time of IsolationForest applied on Shuttle (in second)

```
[4.158291339874268, 4.18778395652771, 4.148787021636963, 4.76625394821167, 4.194598913192749]
```

ROC AUC for Isolation Forest applied on Shuttle

```
[0.954597443146584, 0.9528561100613655, 0.9534365544231049, 0.9557583318700631, 0.9540169987848446]
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" be removed in 0.22.", DeprecationWarning)

Execution time of IsolationForest applied on Shuttle (in second)

[4.152895927429199, 4.126578092575073, 4.1638219356536865, 4.21279501914978, 4.097686052322388]

ROC AUC for Isolation Forest applied on Shuttle

[0.9563387762318029, 0.954597443146584, 0.9528561100613655, 0.9522756656996257, 0.9557583318700631]

/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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```
" be removed in 0.22.", DeprecationWarning)
```

Execution time of IsolationForest applied on Shuttle (in second)

```
[4.105900049209595, 4.236121654510498, 4.167710781097412, 4.122335910797119, 4.156442165374756]
```

ROC AUC for Isolation Forest applied on Shuttle

```
[0.9540169987848446, 0.954597443146584, 0.954597443146584, 0.9528561100613655, 0.9534365544231049]
```

```
/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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Execution time of IsolationForest applied on Shuttle (in second)

[4.106305122375488, 4.121552228927612, 4.196439981460571, 4.097630262374878, 4.167471885681152]

ROC AUC for Isolation Forest applied on Shuttle

[0.9528561100613655, 0.9563387762318029, 0.9557583318700631, 0.9551888557880587, 0.954597443146584]

/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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" be removed in 0.22.", DeprecationWarning)
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Execution time of IsolationForest applied on Shuttle (in second)

```
[4.135257244110107, 4.12260103225708, 4.147418975830078, 4.120250225067139, 4.141215562820435]
```

ROC AUC for Isolation Forest applied on Shuttle

```
[0.954597443146584, 0.9528561100613655, 0.9551778875083238, 0.9551778875083238, 0.9528561100613655]
```

```
/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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" be removed in 0.22.", DeprecationWarning)
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Execution time of IsolationForest applied on Shuttle (in second)

```
[4.16346287727356, 4.1365978717803955, 4.246464014053345, 4.21725606918335, 4.143774032592773]
```

ROC AUC for Isolation Forest applied on Shuttle

```
[0.9528561100613655, 0.9534365544231049, 0.9528561100613655, 0.9534365544231049, 0.9540169987848446]
```

```
/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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```
FutureWarning)
/Users/thesard/anaconda3/lib/python3.7/site-packag
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```

Execution time of IsolationForest applied on Shuttle (in second)

```
[4.156052827835083, 4.489112138748169, 4.417968988
418579, 4.23259973526001, 4.173002004623413]
```

ROC AUC for Isolation Forest applied on Shuttle

```
[0.9528561100613655, 0.9540169987848446, 0.9551778
875083238, 0.9528561100613655, 0.9540169987848446]
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packag
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/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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```
" be removed in 0.22.", DeprecationWarning)
```

Execution time of IsolationForest applied on Shuttle (in second)

```
[4.174431085586548, 4.2025909423828125, 4.1188788414001465, 4.12981390953064, 4.164712905883789]
```

ROC AUC for Isolation Forest applied on Shuttle

```
[0.9528561100613655, 0.9534365544231049, 0.9557583318700631, 0.9563387762318029, 0.9540169987848446]
```

```
/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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Execution time of IsolationForest applied on Shuttle (in second)

[4.144618988037109, 4.154699087142944, 4.10352087020874, 4.127372741699219, 4.166360139846802]

ROC AUC for Isolation Forest applied on Shuttle  
[0.9528561100613655, 0.9563387762318029, 0.9534365544231049, 0.9551778875083238, 0.954597443146584]

/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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```
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```

```
Execution time of IsolationForest applied on Shutt
le (in second)
```

```
[4.149406909942627, 4.1718831062316895, 4.09648990
6311035, 4.197532892227173, 4.147481918334961]
```

```
ROC AUC for Isolation Forest applied on Shuttle
```

```
[0.9540169987848446, 0.954597443146584, 0.95285611
00613655, 0.954597443146584, 0.9557583318700631]
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packag
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Execution time of IsolationForest applied on Shuttle (in second)

[4.652638912200928, 4.266588926315308, 4.213021755218506, 4.8463733196258545, 4.160382986068726]

ROC AUC for Isolation Forest applied on Shuttle

[0.95344752270284, 0.9522866339793609, 0.9528561100613655, 0.9563497445115378, 0.9551778875083238]

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```

Execution time of IsolationForest applied on Shuttle (in second)

```
[4.129449129104614, 4.070695877075195, 4.076005220413208, 4.114376068115234, 4.118208885192871]
```

ROC AUC for Isolation Forest applied on Shuttle

```
[0.9534365544231049, 0.9528561100613655, 0.9528561100613655, 0.9528561100613655, 0.9540169987848446]
```

```
/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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```

Execution time of IsolationForest applied on Shuttle (in second)

```
[4.082532167434692, 4.0920569896698, 4.13264894485
4736, 4.1221888065338135, 4.156895160675049]
```

ROC AUC for Isolation Forest applied on Shuttle

```
[0.9557583318700631, 0.9534365544231049, 0.9528561
100613655, 0.9551778875083238, 0.9534365544231049]
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packag
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```
FutureWarning)
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```

```
" be removed in 0.22.", DeprecationWarning)
```

Execution time of IsolationForest applied on Shuttle (in second)

```
[4.097096920013428, 4.062762022018433, 4.09480094909668, 4.496379852294922, 4.045645713806152]
```

ROC AUC for Isolation Forest applied on Shuttle

```
[0.9528561100613655, 0.9528561100613655, 0.9534365544231049, 0.9540169987848446, 0.9551778875083238]
```

```
/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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```
" be removed in 0.22.", DeprecationWarning)
```

Execution time of IsolationForest applied on Shuttle (in second)

```
[4.23173713684082, 4.082456827163696, 4.081829071044922, 4.0850749015808105, 4.120152711868286]
```

ROC AUC for Isolation Forest applied on Shuttle

```
[0.9557583318700631, 0.9540169987848446, 0.9557693001497983, 0.9540169987848446, 0.9534365544231049]
```

```
/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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```
FutureWarning)
/Users/thesard/anaconda3/lib/python3.7/site-packag
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```
" be removed in 0.22.", DeprecationWarning)
```

```
Execution time of IsolationForest applied on Shutt
le (in second)
```

```
[4.065204858779907, 4.115309000015259, 4.263576984
405518, 4.198784112930298, 4.184323787689209]
```

```
ROC AUC for Isolation Forest applied on Shuttle
```

```
[0.9528561100613655, 0.9528561100613655, 0.9534365
544231049, 0.9551778875083238, 0.9528561100613655]
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packag
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```
" be removed in 0.22.", DeprecationWarning)

Execution time of IsolationForest applied on Shuttle (in second)
[4.682752847671509, 4.7411110401153564, 4.794591903686523, 4.668941020965576, 4.579882383346558]
ROC AUC for Isolation Forest applied on Shuttle
[0.9540169987848446, 0.9528561100613655, 0.9528561100613655, 0.9528561100613655, 0.9551778875083238]
```

```
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```
" be removed in 0.22.", DeprecationWarning)
```

Execution time of IsolationForest applied on Shuttle (in second)

```
[5.083781957626343, 4.686967849731445, 5.407116889953613, 7.233683824539185, 4.758606910705566]
```

ROC AUC for Isolation Forest applied on Shuttle

```
[0.9551778875083238, 0.954597443146584, 0.9534365544231049, 0.9517061896176212, 0.95344752270284]
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packag
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Execution time of IsolationForest applied on Shuttle (in second)

```
[4.690019845962524, 4.655879020690918, 4.60390305519104, 4.6965649127960205, 4.646094083786011]
```

ROC AUC for Isolation Forest applied on Shuttle

```
[0.9557583318700631, 0.9528561100613655, 0.9540169987848446, 0.9534365544231049, 0.9551778875083238]
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```
/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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FutureWarning)
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FutureWarning)
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FutureWarning)
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```

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" be removed in 0.22.", DeprecationWarning)

Execution time of IsolationForest applied on Shuttle (in second)

[5.330290079116821, 9.552674770355225, 4.7587220668792725, 6.958981037139893, 6.891879081726074]

ROC AUC for Isolation Forest applied on Shuttle

[0.9551778875083238, 0.9540169987848446, 0.9551778875083238, 0.9522756656996257, 0.954597443146584]

/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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" be removed in 0.22.", DeprecationWarning)
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Execution time of IsolationForest applied on Shuttle (in second)

```
[8.911643981933594, 10.376023054122925, 6.582597017288208, 7.78216290473938, 7.665164947509766]
```

ROC AUC for Isolation Forest applied on Shuttle

```
[0.9540169987848446, 0.9528561100613655, 0.9534365544231049, 0.9551778875083238, 0.9551778875083238]
```

```
/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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" be removed in 0.22.", DeprecationWarning)

Execution time of IsolationForest applied on Shuttle (in second)

[5.361832141876221, 9.958606719970703, 10.032252311706543, 9.938575029373169, 10.642192125320435]

ROC AUC for Isolation Forest applied on Shuttle

[0.9563497445115378, 0.9540169987848446, 0.9540169987848446, 0.9534365544231049, 0.9528561100613655]

/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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```
" be removed in 0.22.", DeprecationWarning)
```

Execution time of IsolationForest applied on Shuttle (in second)

```
[10.115410804748535, 9.957961797714233, 10.004939079284668, 10.180608034133911, 10.00364375114441]
```

ROC AUC for Isolation Forest applied on Shuttle

```
[0.9528561100613655, 0.9557583318700631, 0.954597443146584, 0.9551778875083238, 0.9551888557880587]
```

```
/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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Execution time of IsolationForest applied on Shuttle (in second)

[10.163347005844116, 10.409924030303955, 10.516189813613892, 10.040916919708252, 10.013225078582764]

ROC AUC for Isolation Forest applied on Shuttle

[0.9534365544231049, 0.9540169987848446, 0.9551888557880587, 0.9528670783411003, 0.9551778875083238]

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Execution time of IsolationForest applied on Shuttle (in second)

```
[10.104305982589722, 10.191167831420898, 10.114380121231079, 10.018120288848877, 10.773678064346313]
```

ROC AUC for Isolation Forest applied on Shuttle

```
[0.9528561100613655, 0.954597443146584, 0.954597443146584, 0.9534365544231049, 0.9540169987848446]
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```
FutureWarning)
/Users/thesard/anaconda3/lib/python3.7/site-packages/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.
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```

```
" be removed in 0.22.", DeprecationWarning)
```

Execution time of IsolationForest applied on Shuttle (in second)

```
[9.997313976287842, 10.110953092575073, 10.232331037521362, 10.012572288513184, 10.003322124481201]
```

ROC AUC for Isolation Forest applied on Shuttle

```
[0.9551778875083238, 0.9540169987848446, 0.9540169987848446, 0.954597443146584, 0.9557583318700631]
```

```
/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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```
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/Users/thesard/anaconda3/lib/python3.7/site-packag
```

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" be removed in 0.22.", DeprecationWarning)
```

Execution time of IsolationForest applied on Shuttle (in second)

```
[9.964524030685425, 11.02226996421814, 11.27618813
5147095, 10.066093921661377, 9.922521114349365]
```

ROC AUC for Isolation Forest applied on Shuttle

```
[0.9557583318700631, 0.9563387762318029, 0.9545974
43146584, 0.9540169987848446, 0.9528561100613655]
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packag
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" be removed in 0.22.", DeprecationWarning)
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Execution time of IsolationForest applied on Shuttle (in second)

```
[9.971811056137085, 9.958449125289917, 10.026356935501099, 10.052617073059082, 10.441946029663086]
```

ROC AUC for Isolation Forest applied on Shuttle

```
[0.954597443146584, 0.9557583318700631, 0.9540169987848446, 0.9551778875083238, 0.9540169987848446]
```

```
/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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Execution time of IsolationForest applied on Shuttle (in second)

[10.61733078956604, 9.948754787445068, 10.0886549949646, 9.907145023345947, 10.386997938156128]

ROC AUC for Isolation Forest applied on Shuttle

[0.9528561100613655, 0.9528561100613655, 0.9534365544231049, 0.9557583318700631, 0.9534365544231049]

/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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```

Execution time of IsolationForest applied on Shuttle (in second)

```
[10.09251594543457, 14.029850721359253, 11.4702048
30169678, 10.762430906295776, 12.569727182388306]
```

ROC AUC for Isolation Forest applied on Shuttle

```
[0.9528561100613655, 0.9528561100613655, 0.9522756
656996257, 0.9528670783411003, 0.9540169987848446]
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packag
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Execution time of IsolationForest applied on Shuttle (in second)

[10.212498903274536, 9.98242974281311, 9.971210241317749, 10.05333399772644, 10.114333868026733]

ROC AUC for Isolation Forest applied on Shuttle

[0.9528561100613655, 0.9534365544231049, 0.9557583318700631, 0.9528670783411003, 0.9551778875083238]

/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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```
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```
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```

```
" be removed in 0.22.", DeprecationWarning)
```

Execution time of IsolationForest applied on Shuttle (in second)

```
[11.441342115402222, 10.100228071212769, 10.177656173706055, 10.915761947631836, 10.990360975265503]
```

ROC AUC for Isolation Forest applied on Shuttle

```
[0.9569192205935423, 0.9528561100613655, 0.9528561100613655, 0.9528561100613655, 0.9551778875083238]
```

```
/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.
```

```
FutureWarning)
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```

```
FutureWarning)
```

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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
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```
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```
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ning: threshold_ attribute is deprecated in 0.20 a
nd will be removed in 0.22.
```

```
" be removed in 0.22.", DeprecationWarning)
```

Execution time of IsolationForest applied on Shuttle (in second)

```
[10.49820613861084, 28.24275803565979, 23.24915409
0881348, 18.9231698513031, 21.056166887283325]
```

ROC AUC for Isolation Forest applied on Shuttle

```
[0.954597443146584, 0.9534365544231049, 0.95285611
00613655, 0.9528561100613655, 0.9540279670645795]
```

```
/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
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```
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```



anomaly detection algorithm API.

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```
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```

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```
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```
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```

```
" be removed in 0.22.", DeprecationWarning)
```

Execution time of IsolationForest applied on Shuttle (in second)

```
[20.281461000442505, 20.460325956344604, 19.75034809112549, 22.153796195983887, 21.502185344696045]
```

ROC AUC for Isolation Forest applied on Shuttle

```
[0.9528561100613655, 0.9528561100613655, 0.9534365544231049, 0.9534365544231049, 0.9534365544231049]
```

/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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FutureWarning)

In [ ]:

```
print("Execution time of IsolationForest applied on Shuttle (in second)")
print(averages_executions_time_IF_Shuttle)
plt.plot(range(100, len(X_Shuttle), 100), averages_executions_time_IF_Shuttle, "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()
```

In [ ]:

```
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(100, len(X_Shuttle), 100), 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()
```

## 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'ensemble 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

In [19]:

```
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_Shuttle)

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

        # 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 seconds)")
    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.mean(executions_time_OCSVM_Shuttle))
    averages_roc_auc_OCSVM_Shuttle.append(statistics.mean(roc_auc_OCSVM_Shuttle))
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packages/ipykernel_launcher.py:34: MatplotlibDeprecationWarning: numpy.arange
```

```
/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.
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```
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```
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```
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```
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```
/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)

```
[329.46220993995667, 261.47730708122253, 274.28071904182434, 245.17911291122437, 240.5820107460022]
```

ROC AUC for OC-SVM applied on Shuttle

```
[0.6188546777389493, 0.6188546777389493, 0.6188546777389493, 0.6188546777389493, 0.6188546777389493]
```

```
/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.
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```
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```

```
/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.
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```

```
"avoid this warning.", FutureWarning)
```

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, 0.7269955947990666, 0.7269955947990666]
```

```
/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.
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```
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```

```
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```

```
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```

```
/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.
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```
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```
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```

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```

```
"avoid this warning.", FutureWarning)
```

Execution time of OC-SVM applied on Shuttle (in second)

```
[191.5847761631012, 184.71183609962463, 180.26945781707764, 189.2221701145172, 181.08830785751343]
```

ROC AUC for OC-SVM applied on Shuttle

```
[0.7737174183377845, 0.7737174183377845, 0.7737174183377845, 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.
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```

```
"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-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  
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```
/Users/thesard/anaconda3/lib/python3.7/site-packag  
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```
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```
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```

```
/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)

```
[150.68664383888245, 150.58169770240784, 148.88781  
52370453, 148.7774007320404, 149.51005792617798]
```

ROC AUC for OC-SVM applied on Shuttle

```
[0.7442227397273692, 0.7442227397273692, 0.7442227  
397273692, 0.7442227397273692, 0.7442227397273692]
```

```
/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)

```
[141.95292973518372, 141.27181887626648, 148.45246386528015, 145.09825491905212, 144.94975304603577]
```

ROC AUC for OC-SVM applied on Shuttle

```
[0.7015329207794384, 0.7015329207794384, 0.7015329207794384, 0.7015329207794384, 0.7015329207794384]
```

```
/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.
```

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"avoid this warning.", FutureWarning)
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/Users/thesard/anaconda3/lib/python3.7/site-packag  
es/sklearn/svm/base.py:196: FutureWarning: The def  
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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  
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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)

```
[138.45889115333557, 136.31735110282898, 136.81975  
293159485, 138.9244029521942, 143.10618805885315]
```

ROC AUC for OC-SVM applied on Shuttle

```
[0.6525248979949985, 0.6525248979949985, 0.6525248  
979949985, 0.6525248979949985, 0.6525248979949985]
```

```
/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)

```
[121.23537707328796, 121.62225794792175, 121.03575110435486, 122.10104298591614, 121.69169592857361]
```

ROC AUC for OC-SVM applied on Shuttle

```
[0.601708857982714, 0.601708857982714, 0.601708857982714, 0.601708857982714, 0.601708857982714]
```

```
/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)

```
[119.410649061203, 112.79455494880676, 117.11709904670715, 111.87071490287781, 120.11324286460876]
```

ROC AUC for OC-SVM applied on Shuttle

```
[0.5511121835651296, 0.5511121835651296, 0.5511121835651296, 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

In [22]:

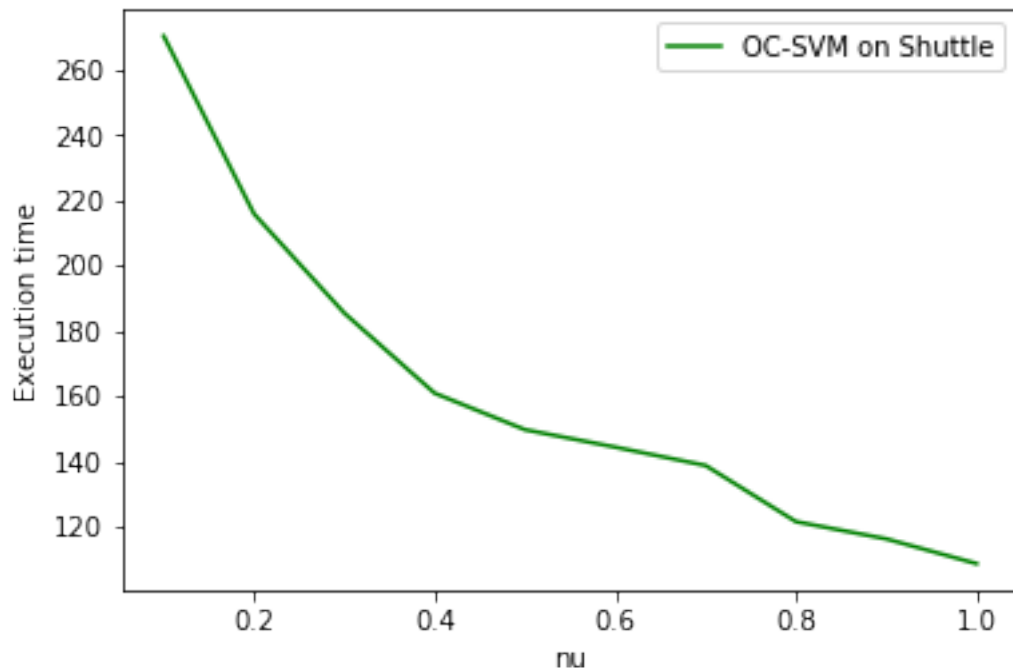
```
print("Execution time of OC-SVM applied on Shuttle (in second)")
print(averages_executions_time_OCSVM_Shuttle)
plt.plot(frange(0.1, 1., 0.1), averages_executions_time_OCSVM_Shuttle, "g-", label="OC-SVM on Shuttle")
#plt.axis([0, 1, 0, 1])
plt.xlabel('nu')
plt.ylabel('Execution time')
plt.legend(loc="best")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

Execution time of OC-SVM applied on Shuttle (in second)

```
[270.19627194404603, 215.7610722064972, 185.37530961036683, 160.8595967769623, 149.6887230873108, 144.34504408836364, 138.72531723976135, 121.53722500801086, 116.2612521648407, 108.68277997970581]
```

/Users/thesard/anaconda3/lib/python3.7/site-packages/ipykernel\_launcher.py:3: MatplotlibDeprecationWarning: numpy.arange

This is separate from the ipykernel package so we can avoid doing imports until





In [25]:

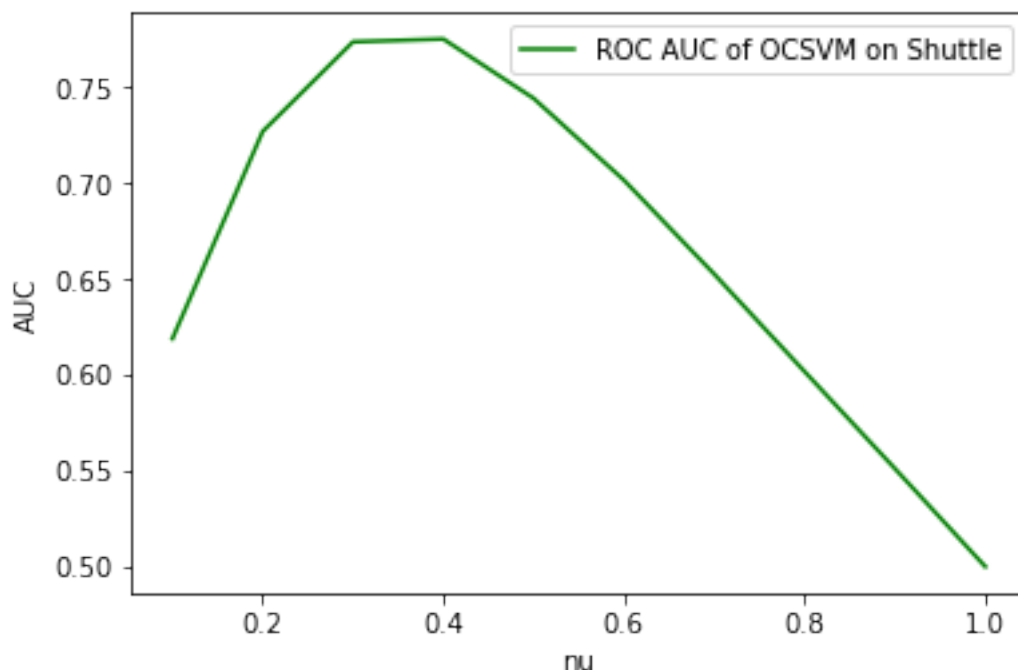
```
print("ROC AUC for OC-SVM applied on Shuttle")
print(averages_roc_auc_OCSVM_Shuttle)
plt.plot(frang(0.1, 1., 0.1), averages_roc_auc_OCSVM_Shuttle,
"b-", label="ROC AUC of OCSVM on Shuttle")
#plt.axis([0, 1, 0, 1])
plt.xlabel('nu')
plt.ylabel('AUC')
plt.legend(loc="best")
plt.show()
```

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, cela 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**

In [35]:

```
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_neigh
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.me
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-packages/sklearn/neighbors/lof.py:236: FutureWarning: default contamination parameter 0.1 will change in version 0.22 to "auto". This will change the predict method behavior.
```

```
FutureWarning)
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packages/sklearn/neighbors/lof.py:236: FutureWarning: default contamination parameter 0.1 will change in version 0.22 to "auto". This will change the predict method behavior.
```

```
FutureWarning)
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packages/sklearn/neighbors/lof.py:236: FutureWarning: default contamination parameter 0.1 will change in version 0.22 to "auto". This will change the predict method behavior.
```

```
FutureWarning)
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packages/sklearn/neighbors/lof.py:236: FutureWarning: default contamination parameter 0.1 will change in version 0.22 to "auto". This will change the predict method behavior.
```

```
FutureWarning)
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packages/sklearn/neighbors/lof.py:236: FutureWarning: default contamination parameter 0.1 will change in version 0.22 to "auto". This will change the predict method behavior.
```

```
FutureWarning)
```

Execution time of LOF applied on Shuttle (in seconds)

```
[8.548911094665527, 7.140587091445923, 6.541306972503662, 6.311285018920898, 6.982913017272949]
```

ROC AUC for LOF applied on Shuttle

```
[0.5215160920903762, 0.5215160920903762, 0.5215160920903762, 0.5215160920903762, 0.5215160920903762]
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packages/sklearn/neighbors/lof.py:236: FutureWarning: default contamination parameter 0.1 will change in version 0.22 to "auto". This will change the predict method behavior.
```

```
FutureWarning)
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packages/sklearn/neighbors/lof.py:236: FutureWarning: default contamination parameter 0.1 will change in version 0.22 to "auto". This will change the predict method behavior.
```

```
FutureWarning)
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packages/sklearn/neighbors/lof.py:236: FutureWarning: default contamination parameter 0.1 will change in version 0.22 to "auto". This will change the predict method behavior.
```

```
FutureWarning)
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packages/sklearn/neighbors/lof.py:236: FutureWarning: default contamination parameter 0.1 will change in version 0.22 to "auto". This will change the predict method behavior.
```

```
FutureWarning)
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packages/sklearn/neighbors/lof.py:236: FutureWarning: default contamination parameter 0.1 will change in version 0.22 to "auto". This will change the predict method behavior.
```

```
FutureWarning)
```

Execution time of LOF applied on Shuttle (in seconds)

```
[8.106007814407349, 10.845497131347656, 9.745582818984985, 8.954133987426758, 9.703468084335327]
```

ROC AUC for LOF applied on Shuttle

```
[0.5303294171661024, 0.5303294171661024, 0.5303294171661024, 0.5303294171661024, 0.5303294171661024]
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packages/sklearn/neighbors/lof.py:236: FutureWarning: default contamination parameter 0.1 will change in version 0.22 to "auto". This will change the predict method behavior.
```

```
FutureWarning)
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packages/sklearn/neighbors/lof.py:236: FutureWarning: default contamination parameter 0.1 will change in version 0.22 to "auto". This will change the predict method behavior.
```

```
FutureWarning)
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packages/sklearn/neighbors/lof.py:236: FutureWarning: default contamination parameter 0.1 will change in version 0.22 to "auto". This will change the predict method behavior.
```

```
FutureWarning)
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packages/sklearn/neighbors/lof.py:236: FutureWarning: default contamination parameter 0.1 will change in version 0.22 to "auto". This will change the predict method behavior.
```

```
FutureWarning)
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packages/sklearn/neighbors/lof.py:236: FutureWarning: default contamination parameter 0.1 will change in version 0.22 to "auto". This will change the predict method behavior.
```

```
FutureWarning)
```

Execution time of LOF applied on Shuttle (in seconds)

```
[10.239574193954468, 10.467014074325562, 10.775267124176025, 10.272745132446289, 10.155516147613525]
```

ROC AUC for LOF applied on Shuttle

```
[0.5464129627777061, 0.5464129627777061, 0.5464129627777061, 0.5464129627777061, 0.5464129627777061]
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packages/sklearn/neighbors/lof.py:236: FutureWarning: default contamination parameter 0.1 will change in version 0.22 to "auto". This will change the predict method behavior.
```

```
FutureWarning)
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packages/sklearn/neighbors/lof.py:236: FutureWarning: default contamination parameter 0.1 will change in version 0.22 to "auto". This will change the predict method behavior.
```

```
FutureWarning)
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packages/sklearn/neighbors/lof.py:236: FutureWarning: default contamination parameter 0.1 will change in version 0.22 to "auto". This will change the predict method behavior.
```

```
FutureWarning)
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packages/sklearn/neighbors/lof.py:236: FutureWarning: default contamination parameter 0.1 will change in version 0.22 to "auto". This will change the predict method behavior.
```

```
FutureWarning)
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packages/sklearn/neighbors/lof.py:236: FutureWarning: default contamination parameter 0.1 will change in version 0.22 to "auto". This will change the predict method behavior.
```

```
FutureWarning)
```

Execution time of LOF applied on Shuttle (in seconds)

```
[11.09737491607666, 11.359040021896362, 12.265018939971924, 11.640704870223999, 11.218759775161743]
```

ROC AUC for LOF applied on Shuttle

```
[0.5597715279848037, 0.5597715279848037, 0.5597715279848037, 0.5597715279848037, 0.5597715279848037]
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packages/sklearn/neighbors/lof.py:236: FutureWarning: default contamination parameter 0.1 will change in version 0.22 to "auto". This will change the predict method behavior.
```

```
FutureWarning)
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packages/sklearn/neighbors/lof.py:236: FutureWarning: default contamination parameter 0.1 will change in version 0.22 to "auto". This will change the predict method behavior.
```

```
FutureWarning)
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packages/sklearn/neighbors/lof.py:236: FutureWarning: default contamination parameter 0.1 will change in version 0.22 to "auto". This will change the predict method behavior.
```

```
FutureWarning)
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packages/sklearn/neighbors/lof.py:236: FutureWarning: default contamination parameter 0.1 will change in version 0.22 to "auto". This will change the predict method behavior.
```

```
FutureWarning)
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packages/sklearn/neighbors/lof.py:236: FutureWarning: default contamination parameter 0.1 will change in version 0.22 to "auto". This will change the predict method behavior.
```

```
FutureWarning)
```

Execution time of LOF applied on Shuttle (in seconds)

```
[12.55742621421814, 11.96461796760559, 12.57378101348877, 13.2724769115448, 12.296541929244995]
```

ROC AUC for LOF applied on Shuttle

```
[0.5707113501557596, 0.5707113501557596, 0.5707113501557596, 0.5707113501557596, 0.5707113501557596]
```



```
/Users/thesard/anaconda3/lib/python3.7/site-packages/sklearn/neighbors/lof.py:236: FutureWarning: default contamination parameter 0.1 will change in version 0.22 to "auto". This will change the predict method behavior.
```

```
FutureWarning)
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packages/sklearn/neighbors/lof.py:236: FutureWarning: default contamination parameter 0.1 will change in version 0.22 to "auto". This will change the predict method behavior.
```

```
FutureWarning)
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packages/sklearn/neighbors/lof.py:236: FutureWarning: default contamination parameter 0.1 will change in version 0.22 to "auto". This will change the predict method behavior.
```

```
FutureWarning)
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packages/sklearn/neighbors/lof.py:236: FutureWarning: default contamination parameter 0.1 will change in version 0.22 to "auto". This will change the predict method behavior.
```

```
FutureWarning)
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packages/sklearn/neighbors/lof.py:236: FutureWarning: default contamination parameter 0.1 will change in version 0.22 to "auto". This will change the predict method behavior.
```

```
FutureWarning)
```

Execution time of LOF applied on Shuttle (in seconds)

```
[14.968611001968384, 15.172990322113037, 15.481447219848633, 12.923413276672363, 13.751121997833252]
```

ROC AUC for LOF applied on Shuttle

```
[0.5833266957335241, 0.5833266957335241, 0.5833266957335241, 0.5833266957335241, 0.5833266957335241]
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packages/sklearn/neighbors/lof.py:236: FutureWarning: default contamination parameter 0.1 will change in version 0.22 to "auto". This will change the predict method behavior.
```

```
FutureWarning)
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packages/sklearn/neighbors/lof.py:236: FutureWarning: default contamination parameter 0.1 will change in version 0.22 to "auto". This will change the predict method behavior.
```

```
FutureWarning)
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packages/sklearn/neighbors/lof.py:236: FutureWarning: default contamination parameter 0.1 will change in version 0.22 to "auto". This will change the predict method behavior.
```

```
FutureWarning)
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packages/sklearn/neighbors/lof.py:236: FutureWarning: default contamination parameter 0.1 will change in version 0.22 to "auto". This will change the predict method behavior.
```

```
FutureWarning)
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packages/sklearn/neighbors/lof.py:236: FutureWarning: default contamination parameter 0.1 will change in version 0.22 to "auto". This will change the predict method behavior.
```

```
FutureWarning)
```

Execution time of LOF applied on Shuttle (in seconds)

```
[13.90953803062439, 13.948063850402832, 13.774773836135864, 14.092037916183472, 13.781497240066528]
```

ROC AUC for LOF applied on Shuttle

```
[0.6071569449398353, 0.6071569449398353, 0.6071569449398353, 0.6071569449398353, 0.6071569449398353]
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packages/sklearn/neighbors/lof.py:236: FutureWarning: default contamination parameter 0.1 will change in version 0.22 to "auto". This will change the predict method behavior.
```

```
FutureWarning)
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packages/sklearn/neighbors/lof.py:236: FutureWarning: default contamination parameter 0.1 will change in version 0.22 to "auto". This will change the predict method behavior.
```

```
FutureWarning)
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packages/sklearn/neighbors/lof.py:236: FutureWarning: default contamination parameter 0.1 will change in version 0.22 to "auto". This will change the predict method behavior.
```

```
FutureWarning)
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packages/sklearn/neighbors/lof.py:236: FutureWarning: default contamination parameter 0.1 will change in version 0.22 to "auto". This will change the predict method behavior.
```

```
FutureWarning)
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packages/sklearn/neighbors/lof.py:236: FutureWarning: default contamination parameter 0.1 will change in version 0.22 to "auto". This will change the predict method behavior.
```

```
FutureWarning)
```

Execution time of LOF applied on Shuttle (in seconds)

```
[15.525487184524536, 15.68483567237854, 15.388175964355469, 15.29531216621399, 16.37880516052246]
```

ROC AUC for LOF applied on Shuttle

```
[0.6206598467119195, 0.6206598467119195, 0.6206598467119195, 0.6206598467119195, 0.6206598467119195]
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packages/sklearn/neighbors/lof.py:236: FutureWarning: default contamination parameter 0.1 will change in version 0.22 to "auto". This will change the predict method behavior.
```

```
FutureWarning)
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packages/sklearn/neighbors/lof.py:236: FutureWarning: default contamination parameter 0.1 will change in version 0.22 to "auto". This will change the predict method behavior.
```

```
FutureWarning)
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packages/sklearn/neighbors/lof.py:236: FutureWarning: default contamination parameter 0.1 will change in version 0.22 to "auto". This will change the predict method behavior.
```

```
FutureWarning)
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packages/sklearn/neighbors/lof.py:236: FutureWarning: default contamination parameter 0.1 will change in version 0.22 to "auto". This will change the predict method behavior.
```

```
FutureWarning)
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packages/sklearn/neighbors/lof.py:236: FutureWarning: default contamination parameter 0.1 will change in version 0.22 to "auto". This will change the predict method behavior.
```

```
FutureWarning)
```

Execution time of LOF applied on Shuttle (in seconds)

```
[17.36264991760254, 25.102497816085815, 21.20089888572693, 16.928543090820312, 20.417612075805664]
```

ROC AUC for LOF applied on Shuttle

```
[0.6278985115819538, 0.6278985115819538, 0.6278985115819538, 0.6278985115819538, 0.6278985115819538]
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packages/sklearn/neighbors/lof.py:236: FutureWarning: default contamination parameter 0.1 will change in version 0.22 to "auto". This will change the predict method behavior.
```

```
FutureWarning)
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packages/sklearn/neighbors/lof.py:236: FutureWarning: default contamination parameter 0.1 will change in version 0.22 to "auto". This will change the predict method behavior.
```

```
FutureWarning)
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packages/sklearn/neighbors/lof.py:236: FutureWarning: default contamination parameter 0.1 will change in version 0.22 to "auto". This will change the predict method behavior.
```

```
FutureWarning)
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packages/sklearn/neighbors/lof.py:236: FutureWarning: default contamination parameter 0.1 will change in version 0.22 to "auto". This will change the predict method behavior.
```

```
FutureWarning)
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packages/sklearn/neighbors/lof.py:236: FutureWarning: default contamination parameter 0.1 will change in version 0.22 to "auto". This will change the predict method behavior.
```

```
FutureWarning)
```

Execution time of LOF applied on Shuttle (in seconds)

```
[22.502599954605103, 19.250303030014038, 22.29130983352661, 23.096499919891357, 17.23454785346985]
```

ROC AUC for LOF applied on Shuttle

```
[0.6358931132894875, 0.6358931132894875, 0.6358931132894875, 0.6358931132894875, 0.6358931132894875]
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packages/sklearn/neighbors/lof.py:236: FutureWarning: default contamination parameter 0.1 will change in version 0.22 to "auto". This will change the predict method behavior.
```

```
FutureWarning)
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packages/sklearn/neighbors/lof.py:236: FutureWarning: default contamination parameter 0.1 will change in version 0.22 to "auto". This will change the predict method behavior.
```

```
FutureWarning)
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packages/sklearn/neighbors/lof.py:236: FutureWarning: default contamination parameter 0.1 will change in version 0.22 to "auto". This will change the predict method behavior.
```

```
FutureWarning)
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packages/sklearn/neighbors/lof.py:236: FutureWarning: default contamination parameter 0.1 will change in version 0.22 to "auto". This will change the predict method behavior.
```

```
FutureWarning)
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packages/sklearn/neighbors/lof.py:236: FutureWarning: default contamination parameter 0.1 will change in version 0.22 to "auto". This will change the predict method behavior.
```

```
FutureWarning)
```

Execution time of LOF applied on Shuttle (in seconds)

```
[20.515130043029785, 18.800599813461304, 18.7432541847229, 20.603824853897095, 20.3718318939209]
```

ROC AUC for LOF applied on Shuttle

```
[0.6389370482705246, 0.6389370482705246, 0.6389370482705246, 0.6389370482705246, 0.6389370482705246]
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packages/sklearn/neighbors/lof.py:236: FutureWarning: default contamination parameter 0.1 will change in version 0.22 to "auto". This will change the predict method behavior.
```

```
FutureWarning)
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packages/sklearn/neighbors/lof.py:236: FutureWarning: default contamination parameter 0.1 will change in version 0.22 to "auto". This will change the predict method behavior.
```

```
FutureWarning)
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packages/sklearn/neighbors/lof.py:236: FutureWarning: default contamination parameter 0.1 will change in version 0.22 to "auto". This will change the predict method behavior.
```

```
FutureWarning)
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packages/sklearn/neighbors/lof.py:236: FutureWarning: default contamination parameter 0.1 will change in version 0.22 to "auto". This will change the predict method behavior.
```

```
FutureWarning)
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packages/sklearn/neighbors/lof.py:236: FutureWarning: default contamination parameter 0.1 will change in version 0.22 to "auto". This will change the predict method behavior.
```

```
FutureWarning)
```

Execution time of LOF applied on Shuttle (in seconds)

```
[19.592599153518677, 20.091093063354492, 17.522411108016968, 17.463611841201782, 20.06765127182007]
```

ROC AUC for LOF applied on Shuttle

```
[0.6446098725311001, 0.6446098725311001, 0.6446098725311001, 0.6446098725311001, 0.6446098725311001]
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packages/sklearn/neighbors/lof.py:236: FutureWarning: default contamination parameter 0.1 will change in version 0.22 to "auto". This will change the predict method behavior.
```

```
FutureWarning)
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packages/sklearn/neighbors/lof.py:236: FutureWarning: default contamination parameter 0.1 will change in version 0.22 to "auto". This will change the predict method behavior.
```

```
FutureWarning)
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packages/sklearn/neighbors/lof.py:236: FutureWarning: default contamination parameter 0.1 will change in version 0.22 to "auto". This will change the predict method behavior.
```

```
FutureWarning)
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packages/sklearn/neighbors/lof.py:236: FutureWarning: default contamination parameter 0.1 will change in version 0.22 to "auto". This will change the predict method behavior.
```

```
FutureWarning)
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packages/sklearn/neighbors/lof.py:236: FutureWarning: default contamination parameter 0.1 will change in version 0.22 to "auto". This will change the predict method behavior.
```

```
FutureWarning)
```

Execution time of LOF applied on Shuttle (in seconds)

```
[20.842701196670532, 24.88567304611206, 26.10126519203186, 23.518700122833252, 20.749629020690918]
```

ROC AUC for LOF applied on Shuttle

```
[0.6439855550504205, 0.6439855550504205, 0.6439855550504205, 0.6439855550504205, 0.6439855550504205]
```



```
/Users/thesard/anaconda3/lib/python3.7/site-packages/sklearn/neighbors/lof.py:236: FutureWarning: default contamination parameter 0.1 will change in version 0.22 to "auto". This will change the predict method behavior.
```

```
FutureWarning)
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packages/sklearn/neighbors/lof.py:236: FutureWarning: default contamination parameter 0.1 will change in version 0.22 to "auto". This will change the predict method behavior.
```

```
FutureWarning)
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packages/sklearn/neighbors/lof.py:236: FutureWarning: default contamination parameter 0.1 will change in version 0.22 to "auto". This will change the predict method behavior.
```

```
FutureWarning)
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packages/sklearn/neighbors/lof.py:236: FutureWarning: default contamination parameter 0.1 will change in version 0.22 to "auto". This will change the predict method behavior.
```

```
FutureWarning)
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packages/sklearn/neighbors/lof.py:236: FutureWarning: default contamination parameter 0.1 will change in version 0.22 to "auto". This will change the predict method behavior.
```

```
FutureWarning)
```

Execution time of LOF applied on Shuttle (in seconds)

```
[19.079163789749146, 19.068058013916016, 19.510679721832275, 20.462062120437622, 19.97934603691101]
```

ROC AUC for LOF applied on Shuttle

```
[0.6452341900117797, 0.6452341900117797, 0.6452341900117797, 0.6452341900117797, 0.6452341900117797]
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packages/sklearn/neighbors/lof.py:236: FutureWarning: default contamination parameter 0.1 will change in version 0.22 to "auto". This will change the predict method behavior.
```

```
FutureWarning)
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packages/sklearn/neighbors/lof.py:236: FutureWarning: default contamination parameter 0.1 will change in version 0.22 to "auto". This will change the predict method behavior.
```

```
FutureWarning)
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packages/sklearn/neighbors/lof.py:236: FutureWarning: default contamination parameter 0.1 will change in version 0.22 to "auto". This will change the predict method behavior.
```

```
FutureWarning)
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packages/sklearn/neighbors/lof.py:236: FutureWarning: default contamination parameter 0.1 will change in version 0.22 to "auto". This will change the predict method behavior.
```

```
FutureWarning)
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packages/sklearn/neighbors/lof.py:236: FutureWarning: default contamination parameter 0.1 will change in version 0.22 to "auto". This will change the predict method behavior.
```

```
FutureWarning)
```

Execution time of LOF applied on Shuttle (in seconds)

```
[19.98332905769348, 20.267674922943115, 29.37620520591736, 25.0815589427948, 22.414516925811768]
```

ROC AUC for LOF applied on Shuttle

```
[0.6454746177017341, 0.6454746177017341, 0.6454746177017341, 0.6454746177017341, 0.6454746177017341]
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packages/sklearn/neighbors/lof.py:236: FutureWarning: default contamination parameter 0.1 will change in version 0.22 to "auto". This will change the predict method behavior.
```

```
FutureWarning)
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packages/sklearn/neighbors/lof.py:236: FutureWarning: default contamination parameter 0.1 will change in version 0.22 to "auto". This will change the predict method behavior.
```

```
FutureWarning)
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packages/sklearn/neighbors/lof.py:236: FutureWarning: default contamination parameter 0.1 will change in version 0.22 to "auto". This will change the predict method behavior.
```

```
FutureWarning)
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packages/sklearn/neighbors/lof.py:236: FutureWarning: default contamination parameter 0.1 will change in version 0.22 to "auto". This will change the predict method behavior.
```

```
FutureWarning)
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packages/sklearn/neighbors/lof.py:236: FutureWarning: default contamination parameter 0.1 will change in version 0.22 to "auto". This will change the predict method behavior.
```

```
FutureWarning)
```

Execution time of LOF applied on Shuttle (in seconds)

```
[22.203749179840088, 22.69283699989319, 23.070982933044434, 22.550247192382812, 23.32349419593811]
```

ROC AUC for LOF applied on Shuttle

```
[0.6455513956598792, 0.6455513956598792, 0.6455513956598792, 0.6455513956598792, 0.6455513956598792]
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packages/sklearn/neighbors/lof.py:236: FutureWarning: default contamination parameter 0.1 will change in version 0.22 to "auto". This will change the predict method behavior.
```

```
FutureWarning)
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packages/sklearn/neighbors/lof.py:236: FutureWarning: default contamination parameter 0.1 will change in version 0.22 to "auto". This will change the predict method behavior.
```

```
FutureWarning)
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packages/sklearn/neighbors/lof.py:236: FutureWarning: default contamination parameter 0.1 will change in version 0.22 to "auto". This will change the predict method behavior.
```

```
FutureWarning)
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packages/sklearn/neighbors/lof.py:236: FutureWarning: default contamination parameter 0.1 will change in version 0.22 to "auto". This will change the predict method behavior.
```

```
FutureWarning)
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packages/sklearn/neighbors/lof.py:236: FutureWarning: default contamination parameter 0.1 will change in version 0.22 to "auto". This will change the predict method behavior.
```

```
FutureWarning)
```

Execution time of LOF applied on Shuttle (in seconds)

```
[22.011680126190186, 21.317906141281128, 23.827029943466187, 28.214295148849487, 24.37269616127014]
```

ROC AUC for LOF applied on Shuttle

```
[0.6433274582663202, 0.6433274582663202, 0.6433274582663202, 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.
```

```
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)

```
[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-packages/sklearn/neighbors/lof.py:236: FutureWarning: default contamination parameter 0.1 will change in version 0.22 to "auto". This will change the predict method behavior.
```

```
FutureWarning)
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packages/sklearn/neighbors/lof.py:236: FutureWarning: default contamination parameter 0.1 will change in version 0.22 to "auto". This will change the predict method behavior.
```

```
FutureWarning)
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packages/sklearn/neighbors/lof.py:236: FutureWarning: default contamination parameter 0.1 will change in version 0.22 to "auto". This will change the predict method behavior.
```

```
FutureWarning)
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packages/sklearn/neighbors/lof.py:236: FutureWarning: default contamination parameter 0.1 will change in version 0.22 to "auto". This will change the predict method behavior.
```

```
FutureWarning)
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packages/sklearn/neighbors/lof.py:236: FutureWarning: default contamination parameter 0.1 will change in version 0.22 to "auto". This will change the predict method behavior.
```

```
FutureWarning)
```

Execution time of LOF applied on Shuttle (in seconds)

```
[24.00037717819214, 23.512400150299072, 32.20188522338867, 25.832989931106567, 26.433369159698486]
```

ROC AUC for LOF applied on Shuttle

```
[0.6439846805862048, 0.6439846805862048, 0.6439846805862048, 0.6439846805862048, 0.6439846805862048]
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packages/sklearn/neighbors/lof.py:236: FutureWarning: default contamination parameter 0.1 will change in version 0.22 to "auto". This will change the predict method behavior.
```

```
FutureWarning)
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packages/sklearn/neighbors/lof.py:236: FutureWarning: default contamination parameter 0.1 will change in version 0.22 to "auto". This will change the predict method behavior.
```

```
FutureWarning)
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packages/sklearn/neighbors/lof.py:236: FutureWarning: default contamination parameter 0.1 will change in version 0.22 to "auto". This will change the predict method behavior.
```

```
FutureWarning)
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packages/sklearn/neighbors/lof.py:236: FutureWarning: default contamination parameter 0.1 will change in version 0.22 to "auto". This will change the predict method behavior.
```

```
FutureWarning)
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packages/sklearn/neighbors/lof.py:236: FutureWarning: default contamination parameter 0.1 will change in version 0.22 to "auto". This will change the predict method behavior.
```

```
FutureWarning)
```

Execution time of LOF applied on Shuttle (in seconds)

```
[28.55326795578003, 23.9446861743927, 26.600772857666016, 24.454368114471436, 25.80253291130066]
```

ROC AUC for LOF applied on Shuttle

```
[0.6426153945477606, 0.6426153945477606, 0.6426153945477606, 0.6426153945477606, 0.6426153945477606]
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packages/sklearn/neighbors/lof.py:236: FutureWarning: default contamination parameter 0.1 will change in version 0.22 to "auto". This will change the predict method behavior.
```

```
FutureWarning)
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packages/sklearn/neighbors/lof.py:236: FutureWarning: default contamination parameter 0.1 will change in version 0.22 to "auto". This will change the predict method behavior.
```

```
FutureWarning)
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packages/sklearn/neighbors/lof.py:236: FutureWarning: default contamination parameter 0.1 will change in version 0.22 to "auto". This will change the predict method behavior.
```

```
FutureWarning)
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packages/sklearn/neighbors/lof.py:236: FutureWarning: default contamination parameter 0.1 will change in version 0.22 to "auto". This will change the predict method behavior.
```

```
FutureWarning)
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packages/sklearn/neighbors/lof.py:236: FutureWarning: default contamination parameter 0.1 will change in version 0.22 to "auto". This will change the predict method behavior.
```

```
FutureWarning)
```

Execution time of LOF applied on Shuttle (in seconds)

```
[24.520621061325073, 25.380983114242554, 25.671968936920166, 26.67810082435608, 26.24145793914795]
```

ROC AUC for LOF applied on Shuttle

```
[0.6397022044593278, 0.6397022044593278, 0.6397022044593278, 0.6397022044593278, 0.6397022044593278]
```



```
/Users/thesard/anaconda3/lib/python3.7/site-packages/sklearn/neighbors/lof.py:236: FutureWarning: default contamination parameter 0.1 will change in version 0.22 to "auto". This will change the predict method behavior.
```

```
FutureWarning)
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packages/sklearn/neighbors/lof.py:236: FutureWarning: default contamination parameter 0.1 will change in version 0.22 to "auto". This will change the predict method behavior.
```

```
FutureWarning)
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packages/sklearn/neighbors/lof.py:236: FutureWarning: default contamination parameter 0.1 will change in version 0.22 to "auto". This will change the predict method behavior.
```

```
FutureWarning)
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packages/sklearn/neighbors/lof.py:236: FutureWarning: default contamination parameter 0.1 will change in version 0.22 to "auto". This will change the predict method behavior.
```

```
FutureWarning)
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packages/sklearn/neighbors/lof.py:236: FutureWarning: default contamination parameter 0.1 will change in version 0.22 to "auto". This will change the predict method behavior.
```

```
FutureWarning)
```

Execution time of LOF applied on Shuttle (in seconds)

```
[31.295750856399536, 27.675748109817505, 29.594388961791992, 28.73183512687683, 22.946579933166504]
```

ROC AUC for LOF applied on Shuttle

```
[0.6340622850379573, 0.6340622850379573, 0.6340622850379573, 0.6340622850379573, 0.6340622850379573]
```

/Users/thesard/anaconda3/lib/python3.7/site-packages/sklearn/neighbors/lof.py:236: FutureWarning: default contamination parameter 0.1 will change in version 0.22 to "auto". This will change the predict method behavior.

FutureWarning)

/Users/thesard/anaconda3/lib/python3.7/site-packages/sklearn/neighbors/lof.py:236: FutureWarning: default contamination parameter 0.1 will change in version 0.22 to "auto". This will change the predict method behavior.

FutureWarning)

/Users/thesard/anaconda3/lib/python3.7/site-packages/sklearn/neighbors/lof.py:236: FutureWarning: default contamination parameter 0.1 will change in version 0.22 to "auto". This will change the predict method behavior.

FutureWarning)

/Users/thesard/anaconda3/lib/python3.7/site-packages/sklearn/neighbors/lof.py:236: FutureWarning: default contamination parameter 0.1 will change in version 0.22 to "auto". This will change the predict method behavior.

FutureWarning)

/Users/thesard/anaconda3/lib/python3.7/site-packages/sklearn/neighbors/lof.py:236: FutureWarning: default contamination parameter 0.1 will change in version 0.22 to "auto". This will change the predict method behavior.

FutureWarning)

Execution time of LOF applied on Shuttle (in seconds)

[23.47481083869934, 23.13122034072876, 23.193423986434937, 822.1039469242096, 25.384517908096313]

ROC AUC for LOF applied on Shuttle

[0.6311600632292595, 0.6311600632292595, 0.6311600632292595, 0.6311600632292595, 0.6311600632292595]

```
/Users/thesard/anaconda3/lib/python3.7/site-packages/sklearn/neighbors/lof.py:236: FutureWarning: default contamination parameter 0.1 will change in version 0.22 to "auto". This will change the predict method behavior.
```

```
FutureWarning)
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packages/sklearn/neighbors/lof.py:236: FutureWarning: default contamination parameter 0.1 will change in version 0.22 to "auto". This will change the predict method behavior.
```

```
FutureWarning)
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packages/sklearn/neighbors/lof.py:236: FutureWarning: default contamination parameter 0.1 will change in version 0.22 to "auto". This will change the predict method behavior.
```

```
FutureWarning)
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packages/sklearn/neighbors/lof.py:236: FutureWarning: default contamination parameter 0.1 will change in version 0.22 to "auto". This will change the predict method behavior.
```

```
FutureWarning)
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packages/sklearn/neighbors/lof.py:236: FutureWarning: default contamination parameter 0.1 will change in version 0.22 to "auto". This will change the predict method behavior.
```

```
FutureWarning)
```

Execution time of LOF applied on Shuttle (in seconds)

```
[1755.7952139377594, 26.021297931671143, 36.12047481536865, 24.064188957214355, 24.732654094696045]
```

ROC AUC for LOF applied on Shuttle

```
[0.6276554604993521, 0.6276554604993521, 0.6276554604993521, 0.6276554604993521, 0.6276554604993521]
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packages/sklearn/neighbors/lof.py:236: FutureWarning: default contamination parameter 0.1 will change in version 0.22 to "auto". This will change the predict method behavior.
```

```
FutureWarning)
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packages/sklearn/neighbors/lof.py:236: FutureWarning: default contamination parameter 0.1 will change in version 0.22 to "auto". This will change the predict method behavior.
```

```
FutureWarning)
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packages/sklearn/neighbors/lof.py:236: FutureWarning: default contamination parameter 0.1 will change in version 0.22 to "auto". This will change the predict method behavior.
```

```
FutureWarning)
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packages/sklearn/neighbors/lof.py:236: FutureWarning: default contamination parameter 0.1 will change in version 0.22 to "auto". This will change the predict method behavior.
```

```
FutureWarning)
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packages/sklearn/neighbors/lof.py:236: FutureWarning: default contamination parameter 0.1 will change in version 0.22 to "auto". This will change the predict method behavior.
```

```
FutureWarning)
```

Execution time of LOF applied on Shuttle (in seconds)

```
[29.610510110855103, 25.375948190689087, 26.24496293067932, 26.375334978103638, 32.57053589820862]
```

ROC AUC for LOF applied on Shuttle

```
[0.6256837935396983, 0.6256837935396983, 0.6256837935396983, 0.6256837935396983, 0.6256837935396983]
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packages/sklearn/neighbors/lof.py:236: FutureWarning: default contamination parameter 0.1 will change in version 0.22 to "auto". This will change the predict method behavior.
```

```
FutureWarning)
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packages/sklearn/neighbors/lof.py:236: FutureWarning: default contamination parameter 0.1 will change in version 0.22 to "auto". This will change the predict method behavior.
```

```
FutureWarning)
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packages/sklearn/neighbors/lof.py:236: FutureWarning: default contamination parameter 0.1 will change in version 0.22 to "auto". This will change the predict method behavior.
```

```
FutureWarning)
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packages/sklearn/neighbors/lof.py:236: FutureWarning: default contamination parameter 0.1 will change in version 0.22 to "auto". This will change the predict method behavior.
```

```
FutureWarning)
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packages/sklearn/neighbors/lof.py:236: FutureWarning: default contamination parameter 0.1 will change in version 0.22 to "auto". This will change the predict method behavior.
```

```
FutureWarning)
```

Execution time of LOF applied on Shuttle (in seconds)

```
[28.53094506263733, 27.911957025527954, 27.77123212814331, 26.486833333969116, 28.033424854278564]
```

ROC AUC for LOF applied on Shuttle

```
[0.6253665878915988, 0.6253665878915988, 0.6253665878915988, 0.6253665878915988, 0.6253665878915988]
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packages/sklearn/neighbors/lof.py:236: FutureWarning: default contamination parameter 0.1 will change in version 0.22 to "auto". This will change the predict method behavior.
```

```
FutureWarning)
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packages/sklearn/neighbors/lof.py:236: FutureWarning: default contamination parameter 0.1 will change in version 0.22 to "auto". This will change the predict method behavior.
```

```
FutureWarning)
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packages/sklearn/neighbors/lof.py:236: FutureWarning: default contamination parameter 0.1 will change in version 0.22 to "auto". This will change the predict method behavior.
```

```
FutureWarning)
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packages/sklearn/neighbors/lof.py:236: FutureWarning: default contamination parameter 0.1 will change in version 0.22 to "auto". This will change the predict method behavior.
```

```
FutureWarning)
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packages/sklearn/neighbors/lof.py:236: FutureWarning: default contamination parameter 0.1 will change in version 0.22 to "auto". This will change the predict method behavior.
```

```
FutureWarning)
```

Execution time of LOF applied on Shuttle (in seconds)

```
[32.20329809188843, 33.18260097503662, 28.63064217567444, 28.9147789478302, 30.17589807510376]
```

ROC AUC for LOF applied on Shuttle

```
[0.6239314921747445, 0.6239314921747445, 0.6239314921747445, 0.6239314921747445, 0.6239314921747445]
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packages/sklearn/neighbors/lof.py:236: FutureWarning: default contamination parameter 0.1 will change in version 0.22 to "auto". This will change the predict method behavior.
```

```
FutureWarning)
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packages/sklearn/neighbors/lof.py:236: FutureWarning: default contamination parameter 0.1 will change in version 0.22 to "auto". This will change the predict method behavior.
```

```
FutureWarning)
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packages/sklearn/neighbors/lof.py:236: FutureWarning: default contamination parameter 0.1 will change in version 0.22 to "auto". This will change the predict method behavior.
```

```
FutureWarning)
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packages/sklearn/neighbors/lof.py:236: FutureWarning: default contamination parameter 0.1 will change in version 0.22 to "auto". This will change the predict method behavior.
```

```
FutureWarning)
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packages/sklearn/neighbors/lof.py:236: FutureWarning: default contamination parameter 0.1 will change in version 0.22 to "auto". This will change the predict method behavior.
```

```
FutureWarning)
```

Execution time of LOF applied on Shuttle (in seconds)

```
[33.00988006591797, 31.16098117828369, 29.51857304573059, 29.466418981552124, 28.89672613143921]
```

ROC AUC for LOF applied on Shuttle

```
[0.6199341913209777, 0.6199341913209777, 0.6199341913209777, 0.6199341913209777, 0.6199341913209777]
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packages/sklearn/neighbors/lof.py:236: FutureWarning: default contamination parameter 0.1 will change in version 0.22 to "auto". This will change the predict method behavior.
```

```
FutureWarning)
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packages/sklearn/neighbors/lof.py:236: FutureWarning: default contamination parameter 0.1 will change in version 0.22 to "auto". This will change the predict method behavior.
```

```
FutureWarning)
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packages/sklearn/neighbors/lof.py:236: FutureWarning: default contamination parameter 0.1 will change in version 0.22 to "auto". This will change the predict method behavior.
```

```
FutureWarning)
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packages/sklearn/neighbors/lof.py:236: FutureWarning: default contamination parameter 0.1 will change in version 0.22 to "auto". This will change the predict method behavior.
```

```
FutureWarning)
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packages/sklearn/neighbors/lof.py:236: FutureWarning: default contamination parameter 0.1 will change in version 0.22 to "auto". This will change the predict method behavior.
```

```
FutureWarning)
```

Execution time of LOF applied on Shuttle (in seconds)

```
[33.044429779052734, 29.72644305229187, 30.903799057006836, 29.281348943710327, 35.302117109298706]
```

ROC AUC for LOF applied on Shuttle

```
[0.6152138584689161, 0.6152138584689161, 0.6152138584689161, 0.6152138584689161, 0.6152138584689161]
```



```
/Users/thesard/anaconda3/lib/python3.7/site-packages/sklearn/neighbors/lof.py:236: FutureWarning: default contamination parameter 0.1 will change in version 0.22 to "auto". This will change the predict method behavior.
```

```
FutureWarning)
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packages/sklearn/neighbors/lof.py:236: FutureWarning: default contamination parameter 0.1 will change in version 0.22 to "auto". This will change the predict method behavior.
```

```
FutureWarning)
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packages/sklearn/neighbors/lof.py:236: FutureWarning: default contamination parameter 0.1 will change in version 0.22 to "auto". This will change the predict method behavior.
```

```
FutureWarning)
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packages/sklearn/neighbors/lof.py:236: FutureWarning: default contamination parameter 0.1 will change in version 0.22 to "auto". This will change the predict method behavior.
```

```
FutureWarning)
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packages/sklearn/neighbors/lof.py:236: FutureWarning: default contamination parameter 0.1 will change in version 0.22 to "auto". This will change the predict method behavior.
```

```
FutureWarning)
```

Execution time of LOF applied on Shuttle (in seconds)

```
[33.06908082962036, 34.36426019668579, 32.27237606048584, 31.718379020690918, 34.16162896156311]
```

ROC AUC for LOF applied on Shuttle

```
[0.6070766691248273, 0.6070766691248273, 0.6070766691248273, 0.6070766691248273, 0.6070766691248273]
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packages/sklearn/neighbors/lof.py:236: FutureWarning: default contamination parameter 0.1 will change in version 0.22 to "auto". This will change the predict method behavior.
```

```
FutureWarning)
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packages/sklearn/neighbors/lof.py:236: FutureWarning: default contamination parameter 0.1 will change in version 0.22 to "auto". This will change the predict method behavior.
```

```
FutureWarning)
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packages/sklearn/neighbors/lof.py:236: FutureWarning: default contamination parameter 0.1 will change in version 0.22 to "auto". This will change the predict method behavior.
```

```
FutureWarning)
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packages/sklearn/neighbors/lof.py:236: FutureWarning: default contamination parameter 0.1 will change in version 0.22 to "auto". This will change the predict method behavior.
```

```
FutureWarning)
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packages/sklearn/neighbors/lof.py:236: FutureWarning: default contamination parameter 0.1 will change in version 0.22 to "auto". This will change the predict method behavior.
```

```
FutureWarning)
```

Execution time of LOF applied on Shuttle (in seconds)

```
[29.008259057998657, 28.686951875686646, 37.20945692062378, 34.627143144607544, 31.784306287765503]
```

ROC AUC for LOF applied on Shuttle

```
[0.600604034907812, 0.600604034907812, 0.600604034907812, 0.600604034907812, 0.600604034907812]
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packages/sklearn/neighbors/lof.py:236: FutureWarning: default contamination parameter 0.1 will change in version 0.22 to "auto". This will change the predict method behavior.
```

```
FutureWarning)
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packages/sklearn/neighbors/lof.py:236: FutureWarning: default contamination parameter 0.1 will change in version 0.22 to "auto". This will change the predict method behavior.
```

```
FutureWarning)
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packages/sklearn/neighbors/lof.py:236: FutureWarning: default contamination parameter 0.1 will change in version 0.22 to "auto". This will change the predict method behavior.
```

```
FutureWarning)
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packages/sklearn/neighbors/lof.py:236: FutureWarning: default contamination parameter 0.1 will change in version 0.22 to "auto". This will change the predict method behavior.
```

```
FutureWarning)
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packages/sklearn/neighbors/lof.py:236: FutureWarning: default contamination parameter 0.1 will change in version 0.22 to "auto". This will change the predict method behavior.
```

```
FutureWarning)
```

Execution time of LOF applied on Shuttle (in seconds)

```
[30.09407091140747, 31.068660974502563, 31.05798602104187, 30.35109782218933, 30.627393007278442]
```

ROC AUC for LOF applied on Shuttle

```
[0.5925326552421332, 0.5925326552421332, 0.5925326552421332, 0.5925326552421332, 0.5925326552421332]
```

/Users/thesard/anaconda3/lib/python3.7/site-packages/sklearn/neighbors/lof.py:236: FutureWarning: default contamination parameter 0.1 will change in version 0.22 to "auto". This will change the predict method behavior.

FutureWarning)

/Users/thesard/anaconda3/lib/python3.7/site-packages/sklearn/neighbors/lof.py:236: FutureWarning: default contamination parameter 0.1 will change in version 0.22 to "auto". This will change the predict method behavior.

FutureWarning)

/Users/thesard/anaconda3/lib/python3.7/site-packages/sklearn/neighbors/lof.py:236: FutureWarning: default contamination parameter 0.1 will change in version 0.22 to "auto". This will change the predict method behavior.

FutureWarning)

/Users/thesard/anaconda3/lib/python3.7/site-packages/sklearn/neighbors/lof.py:236: FutureWarning: default contamination parameter 0.1 will change in version 0.22 to "auto". This will change the predict method behavior.

FutureWarning)

/Users/thesard/anaconda3/lib/python3.7/site-packages/sklearn/neighbors/lof.py:236: FutureWarning: default contamination parameter 0.1 will change in version 0.22 to "auto". This will change the predict method behavior.

FutureWarning)

Execution time of LOF applied on Shuttle (in seconds)

[30.898460865020752, 32.192503929138184, 31.596322774887085, 30.930474996566772, 32.383541107177734]

ROC AUC for LOF applied on Shuttle

[0.5804420381632174, 0.5804420381632174, 0.5804420381632174, 0.5804420381632174, 0.5804420381632174]

```
/Users/thesard/anaconda3/lib/python3.7/site-packages/sklearn/neighbors/lof.py:236: FutureWarning: default contamination parameter 0.1 will change in version 0.22 to "auto". This will change the predict method behavior.
```

```
FutureWarning)
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packages/sklearn/neighbors/lof.py:236: FutureWarning: default contamination parameter 0.1 will change in version 0.22 to "auto". This will change the predict method behavior.
```

```
FutureWarning)
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packages/sklearn/neighbors/lof.py:236: FutureWarning: default contamination parameter 0.1 will change in version 0.22 to "auto". This will change the predict method behavior.
```

```
FutureWarning)
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packages/sklearn/neighbors/lof.py:236: FutureWarning: default contamination parameter 0.1 will change in version 0.22 to "auto". This will change the predict method behavior.
```

```
FutureWarning)
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packages/sklearn/neighbors/lof.py:236: FutureWarning: default contamination parameter 0.1 will change in version 0.22 to "auto". This will change the predict method behavior.
```

```
FutureWarning)
```

Execution time of LOF applied on Shuttle (in seconds)

```
[31.535628080368042, 29.67800807952881, 31.008280038833618, 29.331932067871094, 29.513152837753296]
```

ROC AUC for LOF applied on Shuttle

```
[0.5716147216600389, 0.5716147216600389, 0.5716147216600389, 0.5716147216600389, 0.5716147216600389]
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packages/sklearn/neighbors/lof.py:236: FutureWarning: default contamination parameter 0.1 will change in version 0.22 to "auto". This will change the predict method behavior.
```

```
FutureWarning)
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packages/sklearn/neighbors/lof.py:236: FutureWarning: default contamination parameter 0.1 will change in version 0.22 to "auto". This will change the predict method behavior.
```

```
FutureWarning)
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packages/sklearn/neighbors/lof.py:236: FutureWarning: default contamination parameter 0.1 will change in version 0.22 to "auto". This will change the predict method behavior.
```

```
FutureWarning)
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packages/sklearn/neighbors/lof.py:236: FutureWarning: default contamination parameter 0.1 will change in version 0.22 to "auto". This will change the predict method behavior.
```

```
FutureWarning)
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packages/sklearn/neighbors/lof.py:236: FutureWarning: default contamination parameter 0.1 will change in version 0.22 to "auto". This will change the predict method behavior.
```

```
FutureWarning)
```

Execution time of LOF applied on Shuttle (in seconds)

```
[31.129746198654175, 29.830172061920166, 31.112814903259277, 30.072266101837158, 29.939199209213257]
```

ROC AUC for LOF applied on Shuttle

```
[0.5646713258786342, 0.5646713258786342, 0.5646713258786342, 0.5646713258786342, 0.5646713258786342]
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packages/sklearn/neighbors/lof.py:236: FutureWarning: default contamination parameter 0.1 will change in version 0.22 to "auto". This will change the predict method behavior.
```

```
FutureWarning)
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packages/sklearn/neighbors/lof.py:236: FutureWarning: default contamination parameter 0.1 will change in version 0.22 to "auto". This will change the predict method behavior.
```

```
FutureWarning)
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packages/sklearn/neighbors/lof.py:236: FutureWarning: default contamination parameter 0.1 will change in version 0.22 to "auto". This will change the predict method behavior.
```

```
FutureWarning)
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packages/sklearn/neighbors/lof.py:236: FutureWarning: default contamination parameter 0.1 will change in version 0.22 to "auto". This will change the predict method behavior.
```

```
FutureWarning)
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packages/sklearn/neighbors/lof.py:236: FutureWarning: default contamination parameter 0.1 will change in version 0.22 to "auto". This will change the predict method behavior.
```

```
FutureWarning)
```

Execution time of LOF applied on Shuttle (in seconds)

```
[31.273830890655518, 30.44507074356079, 37.11281681060791, 34.68531513214111, 31.82643485069275]
```

ROC AUC for LOF applied on Shuttle

```
[0.5561072480890957, 0.5561072480890957, 0.5561072480890957, 0.5561072480890957, 0.5561072480890957]
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packages/sklearn/neighbors/lof.py:236: FutureWarning: default contamination parameter 0.1 will change in version 0.22 to "auto". This will change the predict method behavior.
```

```
FutureWarning)
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packages/sklearn/neighbors/lof.py:236: FutureWarning: default contamination parameter 0.1 will change in version 0.22 to "auto". This will change the predict method behavior.
```

```
FutureWarning)
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packages/sklearn/neighbors/lof.py:236: FutureWarning: default contamination parameter 0.1 will change in version 0.22 to "auto". This will change the predict method behavior.
```

```
FutureWarning)
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packages/sklearn/neighbors/lof.py:236: FutureWarning: default contamination parameter 0.1 will change in version 0.22 to "auto". This will change the predict method behavior.
```

```
FutureWarning)
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packages/sklearn/neighbors/lof.py:236: FutureWarning: default contamination parameter 0.1 will change in version 0.22 to "auto". This will change the predict method behavior.
```

```
FutureWarning)
```

Execution time of LOF applied on Shuttle (in seconds)

```
[33.049050092697144, 35.441572189331055, 43.89703392982483, 41.15648293495178, 41.83665609359741]
```

ROC AUC for LOF applied on Shuttle

```
[0.547893280786862, 0.547893280786862, 0.547893280786862, 0.547893280786862, 0.547893280786862]
```



```
/Users/thesard/anaconda3/lib/python3.7/site-packages/sklearn/neighbors/lof.py:236: FutureWarning: default contamination parameter 0.1 will change in version 0.22 to "auto". This will change the predict method behavior.
```

```
FutureWarning)
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packages/sklearn/neighbors/lof.py:236: FutureWarning: default contamination parameter 0.1 will change in version 0.22 to "auto". This will change the predict method behavior.
```

```
FutureWarning)
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packages/sklearn/neighbors/lof.py:236: FutureWarning: default contamination parameter 0.1 will change in version 0.22 to "auto". This will change the predict method behavior.
```

```
FutureWarning)
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packages/sklearn/neighbors/lof.py:236: FutureWarning: default contamination parameter 0.1 will change in version 0.22 to "auto". This will change the predict method behavior.
```

```
FutureWarning)
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packages/sklearn/neighbors/lof.py:236: FutureWarning: default contamination parameter 0.1 will change in version 0.22 to "auto". This will change the predict method behavior.
```

```
FutureWarning)
```

Execution time of LOF applied on Shuttle (in seconds)

```
[33.169673919677734, 34.13337707519531, 34.74171185493469, 33.59257698059082, 33.5199248790741]
```

ROC AUC for LOF applied on Shuttle

```
[0.5385403613206189, 0.5385403613206189, 0.5385403613206189, 0.5385403613206189, 0.5385403613206189]
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packages/sklearn/neighbors/lof.py:236: FutureWarning: default contamination parameter 0.1 will change in version 0.22 to "auto". This will change the predict method behavior.
```

```
FutureWarning)
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packages/sklearn/neighbors/lof.py:236: FutureWarning: default contamination parameter 0.1 will change in version 0.22 to "auto". This will change the predict method behavior.
```

```
FutureWarning)
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packages/sklearn/neighbors/lof.py:236: FutureWarning: default contamination parameter 0.1 will change in version 0.22 to "auto". This will change the predict method behavior.
```

```
FutureWarning)
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packages/sklearn/neighbors/lof.py:236: FutureWarning: default contamination parameter 0.1 will change in version 0.22 to "auto". This will change the predict method behavior.
```

```
FutureWarning)
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packages/sklearn/neighbors/lof.py:236: FutureWarning: default contamination parameter 0.1 will change in version 0.22 to "auto". This will change the predict method behavior.
```

```
FutureWarning)
```

Execution time of LOF applied on Shuttle (in seconds)

```
[34.08888387680054, 32.08362698554993, 32.52544093132019, 35.860275745391846, 36.32122993469238]
```

ROC AUC for LOF applied on Shuttle

```
[0.5299433786918755, 0.5299433786918755, 0.5299433786918755, 0.5299433786918755, 0.5299433786918755]
```

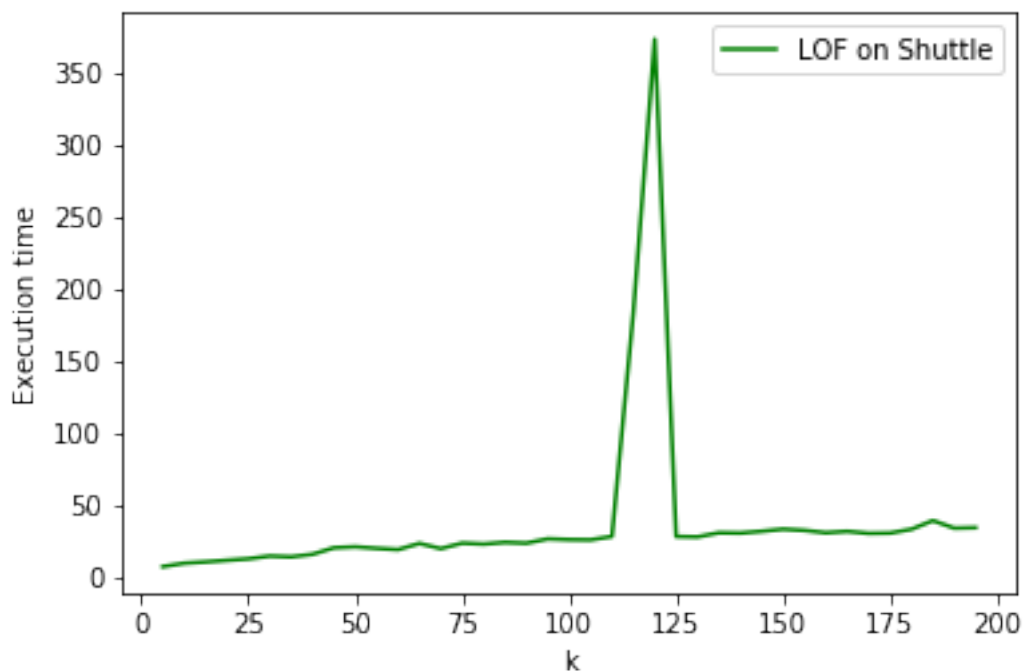
## Résultat de LOF sur shuttle

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_Shuttle, "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 second)

```
[7.105000638961792, 9.470937967300415, 10.382023334503174, 11.516179704666138, 12.53296880722046, 14.459516763687134, 13.901182174682617, 15.654523229598999, 20.202440357208253, 20.87505211830139, 19.806928157806396, 18.947473287582397, 23.219593715667724, 19.619861936569215, 23.424657011032103, 22.768262100219726, 23.948721504211427, 23.40040817260742, 26.39620432853699, 25.871125602722167, 25.698626375198366, 28.048860597610474, 183.45758399963378, 373.3467659473419, 28.035458421707155, 27.746878480911256, 30.621443653106688, 30.410515880584718, 31.651627588272095, 33.11714501380921, 32.26322345733642, 30.639841747283935, 31.600260734558105, 30.213400220870973, 30.416839694976808, 33.06869368553161, 39.07615904808044, 33.83145294189453, 34.17589149475098]
```



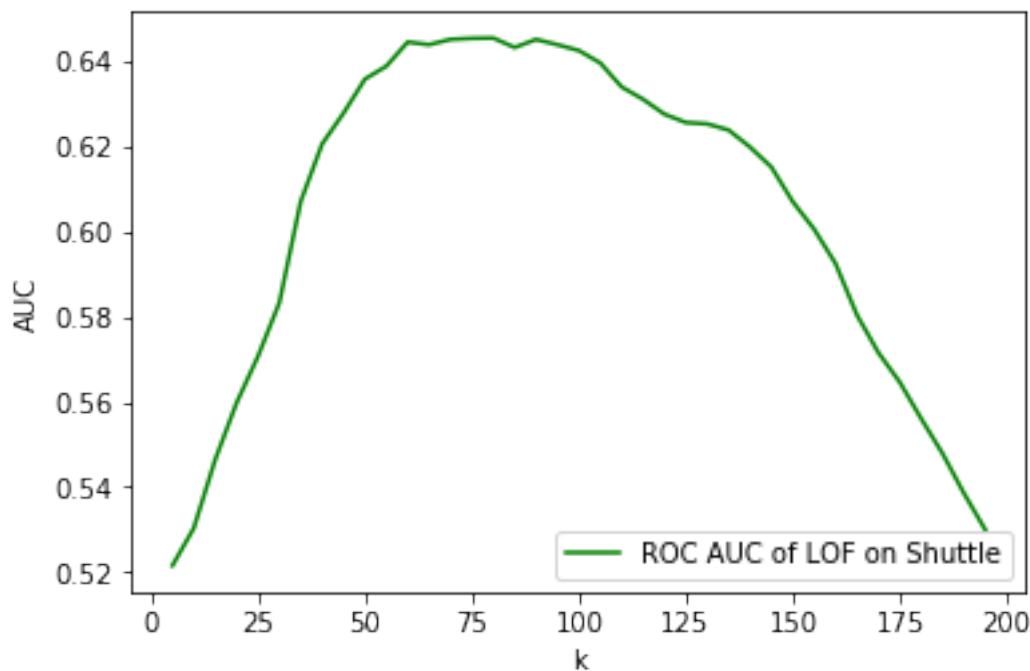
In [52]:

```
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_Shuttle))+" à l'index "+str(averages_roc_auc_LOF_Shuttle.index(max(averages_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'exécution 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'aberrance 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
ax_samples=max_samples)
```

```

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

```

```
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-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.
```

```
FutureWarning)
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packages/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-packages/sklearn/ensemble/iforest.py:417: DeprecationWarning: threshold_ attribute is deprecated in 0.20 and 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-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)
```

```
Confusion Matrice OC-SVM
```

```
[[ 831    47]
 [18058 27528]]
```

```
/Users/thesard/anaconda3/lib/python3.7/site-packages/sklearn/neighbors/lof.py:236: FutureWarning: default contamination parameter 0.1 will change in version 0.22 to "auto". This will change the predict 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]:

```
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

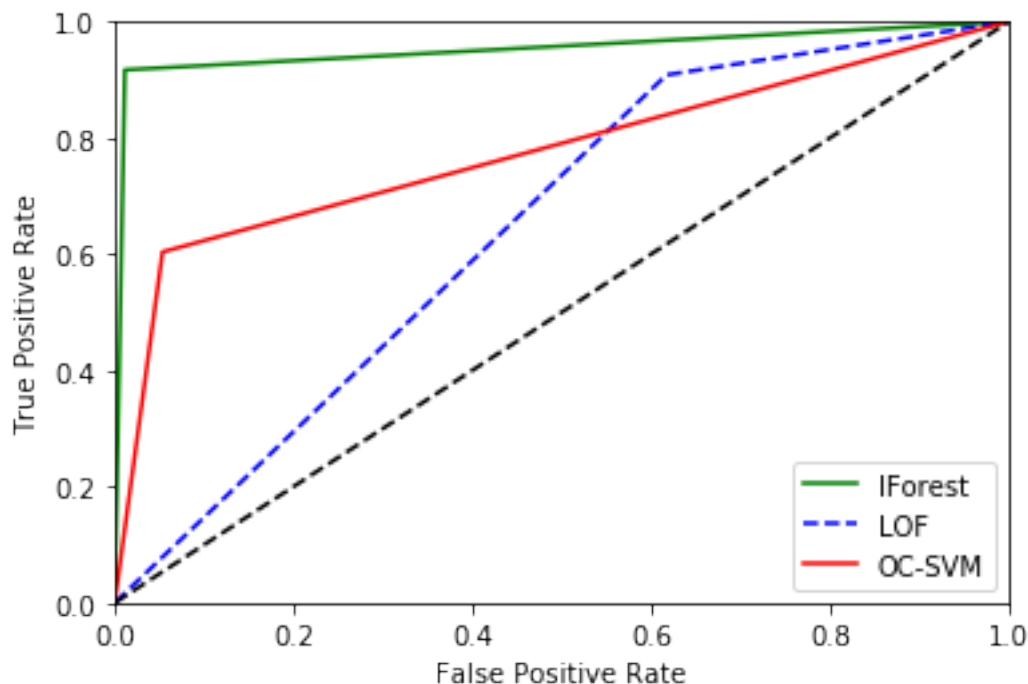
In [64]:

```
fpr_IF_Shuttle, tpr_IF_Shuttle, thresholds_IF_Shuttle = roc_curve(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]:

```
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 corrélation positive avec respectivement le nombre de voisins et nombre de d'estimateurs. Par contre, le temps d'exécution serait en corrélation négative avec nu.

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